## TECHNICAL SPECIFICATION

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TS–01
CIVIL WORKS
DESIGN & CONSTRUCTION SPECIFICATIONS

SECTION I: CIVIL WORKS

1.0 INTRODUCTION

The purpose of this document is to specify the design basis and criteria & construction specification for the Terminal Building, ATC Building, Pavement Works (Approach Roads & Car Park) & other works outside terminal as mentioned in the scope.

Terminal Building, ATC Building, Pavement Works and other works outside terminal shall be designed in compliance with this design & construction specification mentioned in this document. If the specification for a material/product is not provided in this document, then contractor will submit the specification for such material/product and obtain AAI's prior approval before use of such material/product for the works.

The AAI’s Design shall be developed to further and completed by the contractor to achieve its function, performance and quality in accordance with this specification. The contractor shall validate the tender drawings against the AAI’s Requirements and then develop the Designs to completion.

This includes but not limited to:

i) Architectural design
ii) Civil & Structural design
iii) Façade design
iv) Interior design
v) HVAC design
vi) Water supply and Drainage design
vii) Electrical design (High Voltage and Low Voltage)
viii) Extra Low voltage systems design
ix) Lighting design (Interior, Exterior and Façade)
x) Acoustics design
xi) Public Address system, FIDS, CCTV, EPABX design
xii) Signage design
xiii) Fire Fighting (Internal and external), Gas suppression, Fire Detection & Alarm system
xiv) Solar Plant, STP
xv) Safety and Security System
xvi) IT Systems Design
xvii) Concessionaire Works
xviii) Internal Roads and Car Park (Rigid)
ix) Landscape (Design & Execution)
xx) Artwork (Design & Execution)

All related research, survey and other information gathered, organized and performed by the Contractor should support to carry out the same design along with the requirements described herein. The final product of all design including related structure and services shall be confirmed with best and appropriate quality and
performance in all aspect of function and aesthetics by the Contractor.

2.0 TECHNICAL SPECIFICATIONS (CIVIL)

PREAMBLE

These technical specifications shall be read in conjunction with the various other documents forming the contract, namely Notice Inviting Tender & Instructions to Tenderers, Conditions of Contract, Special Conditions of Contract and other related documents, together with any addendum issued thereto.

Absence of terms such as providing, supplying, laying, installing, fixing etc. in the description does not even remotely suggest that the contractor is absolved of such providing, supplying etc. unless an explicit stipulation is made in this contract. The owner shall bear no costs of materials, equipment’s duties, taxes, royalties etc.

The specifications may have been divided in different sections/sub-head for convenience only. They do not restrict any cross-reference. The Contractor shall take in to account interrelations between various parts of works/trades. No claim shall be entertained on basis of compartment interpretations.

Any builder’s work required as part of electrical and other installation shall be executed by the Contractor as directed under this contract.

The Contractor shall be required to submit and take approval from the Engineer-in-Charge/Consultant of shop drawings of the items of work specified in the specifications or as directed from time to time. No extra payment shall be made for the same. Shop drawings shall be in metric units and shall be prepared in a format approved by the Engineer-in-Charge.

The Contractor shall prepare and submit as-built drawings by way of making modifications/changes carried out with respect to the construction drawings issued prior to the construction of respective elements.

No walls, terraces shall be cut for making any opening after waterproofing has been done without approval of the Engineer. Cutting of waterproofing when authorized by the Engineer in writing shall be done very carefully so that no other portion of the waterproofing is damaged. On completion of the work at such places, the waterproofing membrane shall be made good and ensured that the opening/cutting is made fully waterproof as per specifications and details of waterproofing approved by the Engineer at no extra cost. No structural member shall be cut or chased without the written permission of the Engineer.

All materials intended to be used at site shall be tested prior to its use in an approved manner. A list of tests including frequency of tests on construction materials is included in the special specifications. Cost of all such tests and any other tests felt necessary by the Engineer shall be deemed to be included in the price of respective materials quoted by the Contractor. Any defective materials brought to site shall be returned without any extra cost for the same.
Performance tests shall be carried out as the discretion of the Engineer on all/any items, of work as directed by the Engineer. Should any item shall fail to pass the tests, the Contractor shall be given opportunity to take corrective measures and have the same re-tested to the satisfaction of the Engineer, he may at his sole discretion order dismantling of the whole or part of the works done and order the Contractor to reconstruct the same. The cost of all these operations and materials shall be borne by the Contractor without any extra claim.

The Contractor may make a special note of the strictness of the concrete mix to be adopted in items of maximum water-cement ratio, minimum slump, control of total chloride and sulphate contents, use of admixtures etc.

Minimum cement contents are given purely from durability point of view. Larger contents shall have to be provided if demanded by mix design.

Provision of cement slurry to create bond between plain/reinforced concrete surface and subsequent applied finishes (floor, plaster, dado, skirting etc.) shall not be paid extra.

Mix design using smaller aggregate of 10mm down shall also be done in advance for the use in junction having congested reinforcement.

All full-fledged laboratories shall be established at site to start of construction and shall also stock all relevant codes like BIS, EN, ASTM, MORTH, ICAO etc. as per the requirements of the special specifications/Technical specification.

Procedure of mixing the admixtures shall be strictly as per manufactures recommendations if not otherwise directed by the Engineer.

The batching plant for all concrete shall be used. Alternatively, use of ready mix concrete from an approved source shall be permitted. Concrete shall be transported using concrete pumps of adequate capacity including necessary stand by.

All the water tanks and other liquid retaining concrete structures shall undergo hydro-testing as per special specifications.

Special benches shall be provided at site for stacking reinforcement bars of different sizes as per the specifications.

Form work for beams of RCC areas shall be designed in such a way that the form work of the adjacent slabs can be removed without disturbing the props/supports of the beams.

Wherever there are tension/suspended concrete members, which are suspended from upper level structure members, the shuttering/scaffolding of such members at lower level shall have to be kept in place till upper level supporting members gain minimum required strength. Cost of such larger durations of keeping in place the shuttering/scaffolding shall be deemed to be included in the price quoted for respective structural members.

In the mobilization period, the Contractor shall carry out expeditiously and without delaying the following works:

a) Material testing and mix design of concrete as contemplated in the specifications.

b) Setting up of full-fledged site laboratory as per the requirement of these specifications.
c) Any other pre-requisite items required for final execution.

The specifications for market rate items to be executed under this contract are enclosed. Items, which are not covered under the specifications, shall be executed; as per latest CPWD specifications & relevant IS codes, MORTH specifications, ICAO recommendations & Guidelines under the directions of Engineer-In-Charge.

3.0 SCOPE OF WORK

The work to be carried out under this contract shall consist of various heads as per Scope of Work.

The item unless otherwise specified also include compliance with/supply of the following:

a) General works such as setting out, clearance of site before setting out and clearance of works after completion.

b) A detailed program for the construction and completion of works (using CPM/PERT techniques) including updating of all such activities on the basis of decisions taken at the periodic site review meetings as directed by the Engineer-in-Charges.

c) Samples of various materials proposed to be used on the work for conducting tests thereon is required as per the provisions of the contract.

d) Design of mixes as per relevant clauses of the specifications given proportions of ingredients, source of aggregates and binder along with accompanying trial mixes to be submitted to the Engineer-in-Charge for his approval before use on the works.

e) Setting of field-testing laboratory with all required apparatus and staffs for conducting day-to-day quality control tests.

4.0 OBLIGATIONS OF THE CONTRACTOR

In order to ensure that the contract work is executed strictly in accordance with this Agreement and in time, the Contractor shall have the following obligations at no extra cost to the Engineer-in-Charge in addition to such other obligations and responsibilities as have been specified elsewhere in this Contract.

i. Provision of adequate number of constructional Plant and machinery for mechanized system of construction, handling and transportation.

ii. Provision of special magazine at the site for storage of explosives, if necessary, for which required license shall be obtained from the concerned authorities. However, controlled blasting/chemical blasting shall be permitted by AAI subjected to other guideline instead of chiseling where blasting is prohibited, but no extra cost shall be paid on this account.

iii. Fulfill all the Contractor’s labour regulations i.e. fair wages, display of notices regarding wages, payment of wages, labour records, attendance cards-cum-wage slips, labour welfare etc. as per standard practices and norms applicable at site.

All fossils, gold, silver, oil and other minerals, precious stones, coins, articles of value, of antiquity and structures and other remains/things of geological or archaeological interest discovered on the site of the works shall be notified by the Contractor immediately to the Engineer-in-Charge for onward information to the concerned authorities.
The Contractor shall take all reasonable precaution to prevent his workmen or any other person from removing or damaging any such article(s) or thing(s) and protect the same till the removal as per the instructions of the Engineer-in-Charges.

Clearance of the site of all rubbish, debris, vats, tanks, materials, temporary structures, plant and machinery, scaffoldings and filling of all pits, excavation and hand over the site in a tidy and cleaned condition.

Opening up of covered work if instructed by the Engineer, if such covering was done before inspection by the Engineer or without permission/ approval from the Engineer-in-Charge.

5.0 GENERAL

5.1 The works will be executed as indicated in the nomenclature and technical specifications as given hereunder as made applicable to this contract.

5.2 In the absence of any definite provision in the technical specifications contained herein, reference may be made to the latest CPWD, MORTH, IRC, CPCB, GRIHA, NBC, ICAO, AAI Specifications and IS codes, in that order. Wherever these are silent, the construction and completion of the works shall conform to sound engineering practice and in case of any dispute arising out of the interpretation of the above, the decision of the Engineer-in-Charge shall be final and binding on the Contractor.

5.3 In addition, to abbreviations CPWD, IRC, MORTH, BIS, BS, ICAO, ASTM, AASHTO, CPCB, GRIHA, NBC, AAI shall be considered to have the following meaning: -

CPWD : Central Public Works Department
IRC : Indian Road Congress
MORTH : Ministry of Road Transport & Highways, Government of India.
BIS : Bureau of Indian Standards
BS : British Standard of the British Standard
ICAO : International Civil Aviation Organization
AASHTO : American Association of State Highway and Transportation Officials.
CPCB : Central Pollution Control Board.
GRIHA : Green Rating for Integrated Habitat Assessment.
NBC : National Building Code
AAI : Airports Authority of India

5.4 All the codes of practice, standards and specifications applicable shall be the latest editions with up to date correction slips etc. or as directed by the Engineer-in-Charges.

6.0 TESTING

It is made clear that cost of testing, cost of material for testing, all field apparatus required for sampling and testing as per CPWD/IS codes and manpower incident to such testing will be provided along with necessary transport arrangement to and fro to the approved testing agency or laboratory by the Contractor during the construction phase of the work and defect liability period. The expenditure in this regard shall be borne by the Contractor and nothing extra shall be payable by AAI on this account. Field laboratory with all the required apparatus
and staffs shall be established by the Contractor at site of work at his cost for carrying out field tests at stipulated frequencies.

7.0 SAMPLING, TESTING AND MOCK-UP

7.1 The Contractor or his accredited representative shall be present during sampling/testing and signify his concurrence for sampling / testing carried out by signing the test records. The Contractor shall be liable of all actions consequent to the test and their results as if he himself attended to the tests. The Contractor is duly advised to be present himself for sampling and testing or in the alternative, have fully qualified duly authorized Engineer for this purpose.

7.2 The Contractor or his accredited representative shall prepare shop drawings of all specialized works thereafter prepare mock-up as per approved shop drawings for specialized works and all finishing items in specified colors and shade (minimum three options) as specified by Consultant/Engineer in Charge and shall execute the same on based on approved mock-up. The Contractor shall be liable of all actions consequent to the mock-up and their results as if he himself attended to the mock up. The Contractor is duly advised to be present himself for mock-up, in the alternative have fully qualified duly authorized Engineer for this purpose.

8.0 GENERAL LIST OF CODES, STANDARDS AND SPECIFICATIONS ADOPTED IN THE TENDER DOCUMENTS

1.1 The following IRC standards and IS, ASTM, British Standards, Codes, CPWD and AAI Specifications have generally been adopted in the tender documents. This list however does not limit the use of any other relevant code or standards by the Engineer-in-Charge solely at his discretion either referred to in the tender documents or not, to achieve the desired quality of work. All the codes practice, standards and specifications applicable shall be the latest edition with all correction slips, etc. or as directed by the Engineer-in-Charge.

<table>
<thead>
<tr>
<th>NUMBER/ DESIGNATION</th>
<th>TITLE</th>
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<tr>
<td>IRC SPECIFICATION</td>
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<tr>
<td>IRC:10-1961</td>
<td>Recommended Practice for Borrow pits for Road Embankments Constructed by Manual Operation</td>
</tr>
<tr>
<td>IRC:19-1977</td>
<td>Standard Specifications and Code Practice for Water Bound Macadam (Second Revision)</td>
</tr>
<tr>
<td>IRC:5P II-1977</td>
<td>Hand Book of Quality Control for Construction of Roads and Runways (First Revision).</td>
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<td>IS:460-1985(Part-I to III)</td>
<td>Testing Sieves</td>
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IS:1124-1974 Method of test for water absorption, apparent specific gravity and porosity apparent specific gravity and porosity of Natural Building Stone.

IS:1199-1959 Methods of sampling and analysis of concrete

IS:2386-1963 Methods of test for aggregate for concrete (Part-I)-1963 Particle size and shape

Part-II)-1963 Estimation of deleterious materials and organic Impurities.

Part-III)-1963 Specific gravity, density, voids, absorption and bulking.

Part-IV)-1963 Mechanical Properties

Part-V)-1963 Soundness

Part-VI)-1963 Measuring mortar making properties of fine aggregates.

Part-VII)-1963 Alkali Aggregate reactivity

Part-VIII)-1963 Petrographic examination

IS:2720 Methods of test of Soils

Part-III)-1973 Determination of water contents


Part-III)- Section-II 1980 Determination of specific gravity fine medium and coarse grained soils

Part-IV)- 1985 Grain size analysis

Part-V)- 1985 Determination of liquid and plastic limit


Part-XVI)- 1987 Laboratory determination of CBR

Part-XXVII-1977 Determination of total soluble sulphate.

Part-XXVIII-1974 Determination of dry density of soils in place by the sand
replacement methods.

Part-XXIX-1975  Determination of dry density of soils in place by core cutter method.

IS-5640-1970  Method for determining the aggregate impact value of soft coarse aggregate.

IS-6241-1971  Method of test for determination of stripping value of road aggregate.

IS:8112-1989  43 grade ordinary Portland cement

IS 1489 (part 1): 1991  43 grade Portland Pozzolona Cement

IS:12118-1987 (Part I & II)  Two parts polysulphide based sealants.

IS 3812-2003  Fly Ash

ASTM/BS STANDARDS / SPECIFICATIONS


ASTM:D-2172-1975  Extraction quantitative of Bitumen from bituminous paving mixtures

ASTM : E-11-39  Sieves for testing purpose “Wire Cloth sieve round hole and square” hole plate screen or sieves.

BS:410-1969  Test Sieves.

MOST Specification  “Specifications for Road and Bridge works” second revision reprinted in July 1993. Issued by Ministry of Surface Transport (Roads Wing) and Published by Indian Roads Congress.

ASTM- A653  Galvanized Steel

BS – 2989  Galvanized Steel

BS – 476  Fire propagation & surface spread of flames

ICAO  Recommendations & Guidelines

Annexure 14  Pavements

Design Manual Part – I, II & III  Pavement Design

9.0 FIELD LABOURATORY AND LIST OF EQUIPMENT:
9.1 The contractor at his own cost shall set up a fully furnished and adequately equipped field laboratory at site within 15 days from the schedule date of start of work and maintain the same by providing adequate technical and upkeep staff. The laboratory should have office space for engineers to do testing and store for storage of samples. The remaining space shall be provided for the installation of equipment, laboratory tables and cupboards, working space for carrying out tests, besides a wash basin, toilet facility. The following minimum equipment shall be provided in the laboratory:

a) Determining Liquid Limit (1 complete set)
   i) Liquid limit device (Casagrande type) 1 Set
   ii) Grooving tools 1 No.
   iii) Evaporating dish 1 No.
   iv) Spatula 100mm blade 1 No.
   v) Laboratory balance, capacity 500 gm, (sensitivity 0.01 gms.) 1 No.
   vi) Wash bottle, capacity 500 ml. 1 No.
   vii) Moisture cans, capacity 50 ml. 24 Nos.

b) Determining Plastic Limit (1 complete set)
   i) Evaporating dish 1 No.
   ii) Spatula 100mm blade 1 No.
   iii) Glass plate 250mm x 250mm x 12mm 2 No.
   iv) Moisture cans, capacity 50 ml. 12 No.
   v) Stainless steel rods, 3 mm dia. 2 Nos.

C) Determining Moisture Content (1 complete set)
   i) Micro Oven, capacity 35 liters, control temperature Up to 200 °c 1 No.
   ii) Balance, capacity 200 gm., sensitivity 0.01 gm. 1 set
   iii) Lab. Tongs 1 No.
   iv) Moisture cans 75ml. with lid 36 Nos.

d) Compaction Characteristics (1 complete set)
   i) Standard compaction mould 100mm dia. 1 No.
   ii) Modified compaction mould 150mm dia. 1 No.
   iii) Standard compaction Rammer, 2.5 kg. 1 No.
   iv) Modified compaction Rammer, 4.5kg. 1 No.
   v) Straight edge 300mm long 1 No.
   vi) Sample ejector for 100mm and 150mm mould 1 No.
   vii) Sample tray 60 x 60 x 8 cm 3 Nos.
   viii) Wash bottle, 500 ml. 2 Nos.
   ix) Moisture cans 250 ml. 24 Nos.

e) Density of soil in-place by sand cone method (2 complete set)
i) Sand density cone apparatus, 150mm
   2 Nos.

ii) Plate, 300mm x 300mm with centre hold 150mm
    2 Nos.

iii) Glass jug for sand cone
     2 Nos.

iv) Chisel 25mm x 150mm
    2 Nos.

v) Hammer
   2 Nos.

vi) One-gallon field cans
    24 Nos.

vii) Sampling spoon
     2 Nos.

viii) Soft hair brush
     2 Nos.

ix) Moisture cans 250 ml.
    48 Nos.

f) Sieve Analysis

i) Sieve shaker (portable)
   1 unit

ii) Coarse sieves in Sizes from 100mm to 10mm
    1 set

iii) Fine Sieves #4, #8, #16, #30, #40, #50, #100, #200 each
     1 set

iv) Pans & Covers as required

g) Specific Gravity and Absorption of Coarse Aggregate

i) Wire basket, 200mm dia.
   5 No

ii) Heavy duty suspension balance, 20 kg x 1 gm with
    accessories for weight in water
   1 set

iii) Suitable water container
    1 No

h) Unit Weight of Aggregate

i) Balance, 100 kg. Capacity with 10 gm. precision
   1 No.

ii) Tamping rod 16mm diameter x 600mm long
    1 No.

iii) Measuring containers (3, 10, 15, 30 liters)
    1 each

i) Flakiness and Elongation

i) Flakiness gauge, elongation index
   1 set

j) Stone Aggregate Impact Value Test Apparatus
   1 set

k) Soundness Test

i) Sodium Sulphate
   25 kgs

ii) Soaking tank
    1 No.

iii) Balance, Capacity 3 kg., Sensitivity 0.1 gm.
    1 set

iv) Sieves: Coarse
    1 set

v) Sieves: Fine
    1 set

l) Concrete

i) Buckets for concrete sampling
   6 Nos.

ii) Slump cone
    6 Nos.

iii) Tamping rod
    6 Nos.

iv) Base plate
    6 Nos.
v) Mixing pan for concrete 2 Nos.
vii) Concrete thermometer 1 No.
viii) Concrete cylinder mold, 150mm * 300mm; 100mm * 300mm 10 each
ix) Concrete cube mold, 100mm cube & 150mm cube 10 each
x) Adjustable spanners for dismantling cube molds 6 Nos.
xi) Capping set 2 Nos.
xii) Capping compound as required
xiii) Concrete curing tank with capacity for 60 cubes, temperature Controlled, with circulation system drain and lockable cover 3 Nos.
xiv) Schmidt test hammer 1 No.
xv) Compression Testing machine (Electrical/ simple hand operated) 1 No.
xvii) Temperature chart recorder 1
xvii) Flexural Strength Testing Machine 1
m) Miscellaneous
i) Vernier calipers to measure up to 200mm, with elongated jaws 5 Nos.
ii) Steel rule, 300mm long graduated 2 Nos.
iii) Rubber gloves 10 pr.
iv) Cotton working gloves 20 pr.
v) First aid kit 1
vi) Wire brush 6
vii) Steel tape, 3m, 5m, 30m 3
viii) Ballpein hammer, 1 kg 2
ix) Paint scraper. Approx. 100mm wide 8
x) Float, steel Approx. 280mm x 120mm 8
xi) Sack barrow 1
xii) Shovel: Square Mouthed 1
xiii) Shovel: Round Mouthed 2
xiv) Comprehensive tool kit. To include screwdrivers, pliers, 1
xv) Claw hammer, multi-grips, spanners (adjustable) 1
n) Surveying instrument
9.2 In addition to tools, equipment, apparatus and instruments as described above, if any, additional tool equipment apparatus and instrument is required for laboratory and execution of work as per technical specification of NIT the same shall be provided by contractor. Nothing extra shall be payable to contractor on this account.

9.3 The Engineer-in-charge may at his discretion, check the test results obtained at contractor laboratory by independent test at an approved laboratory. The cost of such material, transport, cost of testing etc. shall be borne by the contractor.

9.4 In the event of failure to setup laboratory and provide equipment/ apparatus mentioned in clause no. 8.1 as mentioned above or substitute/ replaced the equipment/ apparatus on account of maintenance / breakdown Rs. 200.00 per day per equipment / apparatus shall be debited to the contractors account.
NOTE :-

1. To achieve the scheduled/ Planned progress of work as per completion schedule, additional plants and machinery if required, to be arranged by the agency and no extra payment to be made on this account.

2. To Maintain and record of the T&P received & the dates when it has been received at site also to keep track of the receipt of the material at site, workmen / staff deployed works diary shall be maintained jointly by the Engineer-in-charge and the agency to maintain a daily record of these activities to form basis of any analysis of this kind or in case any dispute occurs at a later date.

10.0 PRE – CONSTRUCTION ANTI-TERMITE TREATMENT WORKS

Scope

These specifications cover the application of pre-constructional anti-termite treatment to the structures.

Providing Pre-constructional anti-termite treatment and creating a chemical barrier to the building by injecting chemical emulsion of required concentrations under grade slab and Grade beam, around the footings, column pits, trenches, pits, tunnels, wall trenches, back fill, plinth filling, junction of wall and floor, Retaining / side walls of basement floor, external perimeter of building, surrounding of pipes, expansion joints, below UG sump and Retaining / side walls etc. as per instructions of chemical manufacturer and all as directed. The treatment shall be carried out strictly in accordance with the technical specification and conforming to IS 6313 or equivalent BS specification. The chemical to be used as insecticides for the treatment shall be 50% EC (Imdachloropid 30.5 SC) and the application shall be dilute one part of chemical 50% EC with 49 parts of water to get 1% emulsion and strictly in accordance with the manufacturer’s specification, as specified by consultants appointed by the contractor.

General

The provision of the latest Indian Standards listed below form part of these specifications:

<table>
<thead>
<tr>
<th>IS: 6313</th>
<th>Code of Practice for Anti-termite Measures in Buildings Part-2 : Pre-constructional chemical treatment measures</th>
</tr>
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<tbody>
<tr>
<td>I.S. 8944</td>
<td>Specification for Chloropyrofos Emulsifiable Concentrates.</td>
</tr>
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</table>

Other I.S. Codes not specifically mentioned here but pertaining to the use of the application of pre-constructional anti-termite treatment to the structures form part of these specifications.

Materials

The chemicals used for the soil treatment shall be any one or combination of the following with the concentration shown against each aqueous emulsion:
Chemicals used should be procured from approved vendor along with details such as manufacturer’s certificate, date of manufacture and date of expiry of chemicals. On completion of treatment in all respects, the contractor shall furnish a guarantee in the format as prescribed by the AAI’s Representative, that the building is safe from all species of termite infestation for a period of 10 years.

Workmanship

The application of chemicals shall be carried out conforming to the code of Practice for Anti-termite measures in Building, IS 6313 : Part-2 : Pre-constructional chemical treatment measures. Roding equipment & pressure pumps shall be used to carry out spraying operations to facilitate proper penetration of chemicals into the earth.

The work should be carried out through an approved specialised agency having adequate experience in dis-infestation of termites in buildings in the past. The work should be of first quality and should be carried out under strict supervision of the Employer’s Representative.

11.0 GENERAL SPECIFICATION FOR STRUCTURAL STEEL WORK

11.1 FABRICATION OF STEEL STRUCTURES

11.1.1 Drawings

The Contractor shall prepare fabrication drawings, erection drawings, bill of materials, drawing office dispatch lists/shipping documents, schedule of bolts and nuts and as built drawings. All drawing work shall be in metric system and all writing work shall be in English.

The fabrication drawings shall show full length with all connecting members and connections marked thereon. The fabrication drawings shall include all the necessary blown-up details required for the correct fabrication of the structures to meet the design requirement. These drawings shall be made in conformity with the best modern practices and with due regard to speed and economy in fabrication and erection. Each erection piece shall be clearly identified by an erection mark in these drawings.

The preparation / detailing of fabrication drawing shall be complete in all respects. In the case of bolted connections, the bolt dia, the hole dia, the actual location of holes and the coordinating scheme with connecting / matching elements shall be clearly indicated. As far as possible, uniformity in the bolt dia shall be maintained where HSFG bolts are used; method of surface preparation shall be indicated. In case of welded constructions, the size and length of welds along the relevant weld lines should be distinctly marked. The length specified shall be the effective length excluding end crates. For all butt welds, details of appropriate edge preparation shall be indicated.

Detailing of structural steel members subjected to dynamic loading shall be so as to keep the stress concentration to a minimum. Cross welding shall be avoided as far as practicable.
For bolted connections subjected to dynamic loading, lock nuts or spring washers shall be used in addition to plain washers.

Erection drawings shall consist of line diagrams showing every detailed member in position with the respective erection mark. Erection marks shall appear on the left end of the members as detailed. All steel members shall be erected with marks in the same relative position as shown in plan or elevation. All loose members shall either be given part marks or wired on to the main erection mark for dispatch.

The erection clearances for cleat-connected ends of member’s connection steel to steel shall preferably not be greater than 10 mm. at each end. The erection clearance at ends of beams shall not be more than 20 mm. at each end but where for particular reasons greater clearance is necessary, suitably designed seats shall be provided.

The fabrication drawings shall be prepared in such a manner that structures are dispatched with maximum transportable lengths and work involved at site is minimum. Steelwork shall be shop-fitted and ship-assembled as far as practicable.

All edge preparations for welding shall conform to IS: 9595

The Contractor shall ensure correctness & completeness of fabrication drawings.

11.1.2 Material of Construction

All steel and other materials used for steelwork and in association with steelwork shall conform to appropriate Indian standards. Only tested materials shall be used unless written authority is obtained for the use of untested materials for certain secondary structural members.

Unless otherwise specified in the drawings
a) All rolled sections and plates up to & including 20 mm thickness shall conform to Grade “A” as per IS: 2062
b) Plates of thickness above 20 mm and Plated structures subjected to dynamic loading shall conform to Grade “B” as per IS: 2062
c) For High Tensile steel requirements, materials conforming to IS: 8500 or SAIL-MA (HYA or HYB) shall be used.

Steel sheets shall conform to IS: 1079

Steel tubes for structural purpose shall conform to IS: 1161/4923 (of Grade Yst 310)

Translucent sheets shall be fiberglass reinforced polyester sheets of matching profile as per IS: 12866.

Colour coated sheets shall be as per appropriate standard.

Gutters shall be of copper bearing steel conforming to Grade “A” as per IS: 2062
All black bolts, nuts and locknuts shall conform to IS: 1363 and IS: 1364 (for precision and semi precision hexagonal bolts) of property class 6.4 unless otherwise specified. Washers shall conform to IS: 6610

All tapered washer shall be as per IS: 5372 for channels, and IS: 5374 for Joists Spring washers shall conform to IS: 3063

All HSFG bolts shall conform to IS: 3757. Assembly of joints using HSFG bolts shall conform to IS: 4000. Nuts and washers of HSFG bolts shall be as per IS: 6623 & IS: 6649 respectively.

Covered electrodes for arc welding shall conform to IS: 814. Coding of electrodes shall be as follows:

a) ER421 'C' X for mild steel of Grade 'A' and Grade 'B' as per IS: 2062
b) EB 542 'C' H3X for Mild steel of Grade 'B' as per IS: 2062 for dynamically loaded structures (arising out of crane, vibratory screen, equipments etc.) 'C' is the value of the current as recommended by the electrode manufacturer.

Certified mill test reports of materials used in the work shall be made available for inspection by the Engineer-In-charge upon request.

All materials shall be straight and if necessary before being worked shall be straightened and/or flattened by pressure including de-coiling of plates unless required to be of curvilinear form and shall be free from twists.

The MS / GI gratings shall be electro-forged and shall be of approved brand and manufacturer unless otherwise agreed to by the Engineer-In-charge. The type of grating selected shall be based on the loading in the area in which the grating is provided and shall be subject to approval of Engineer-In-charge.

11.1.3 Material Preparation

Cut edges shall be finished smooth by grinding or machining wherever necessary. Sufficient allowance (3 mm to 5 mm) should be kept in the items in case machining is necessary.

Cutting may be effected by gas cutting, shearing, cropping or sawing. In gas cutting of high tensile steel, special care is to be taken to leave sufficient metal to be removed by machining so that all metal that has been hardened by flame is removed.

Sufficient shrinkage allowance (@1mm/M) shall be kept wherever heavy welding is involved.

Straightening and bending shall be done in cold condition as far as practicable.

If required, straightening and bending may be done by application of heat between 900ºC and 1100ºC. Cooling down of the heated item shall be done slowly.

11.1.4 Drilling and Punching of Holes
Drilling and punching of holes for bolts shall be done as per clause no. 11.4.4 of IS: 800:1984, unless otherwise specified by the Owner.

Drifting of holes for bolts during assembly shall not cause enlargement of holes beyond permissible limit or damage the metal.

Holes of bolted connection should match well to permit easy entry of bolts. Gross mismatch of holes shall be avoided.

Permissible deviation in holes for mild steel bolts of normal accuracy and high strength bolts are given in the ANNEXURE-A.

11.5 Assembly for Fabrication

Fabrication of all structural steel work shall be in accordance with IS: 800-1984 and in conformity with various clauses of this specification, unless otherwise specified in the drawings.

Fabrication of structures shall preferably be taken up as per the sequence of erection.

All erection units shall bear erection mark no. and reference drg. no. at a prominent location on the structures for easy identification at site.

Fabricated structures shall conform to tolerance as specified in this standard and in IS: 7215-1974. In case of contradiction, tolerances specified in this standard shall prevail.

All the components of structures shall be free from twist, bend, damage etc.

Assembly of structures shall be carried out by using suitable jigs and fixtures in order to obviate distortion during welding.

Cutting of items specially for truss, bracing, bunker, hopper, galleries surge girder, portal etc, shall be done only after checking of sizes as per layout.

Surface, wherever machining is specified, shall be either planed or milled or ground to ensure maximum contact.

If end-milling or machining is planned after the assembly is over, sufficient allowance(5 mm to 15 mm) shall be kept in the items where milling/machining is to be done.

If pre-bending of the plate is required to avoid welding distortion; it shall be done in cold condition.

Sufficient trial assembly of fabricated components (dispatch elements) shall be carried out in the fabrication works to control the accuracy of workmanship.

Where necessary, washers shall be tapered or otherwise suitably shaped to give the heads of nuts and bolts satisfactory bearing.
The threaded portion of each bolt shall project through the nut at least by one thread.

Tolerance of assembled components of structures are given in IS: 7215: 1924

Permissible deviations from designed (true) geometrical form of the dispatch elements shall be in accordance with IS: 7215-1974.

11.1.6 Method of Construction

The method of construction shall be either by welding or by bolting limiting the site work to the minimum possible.

Bolt diameter shall not be less than 16mm. except for bolts securing roof and wall sheeting, windows, doors and stitching of thin coverings. For bolted joints, min two bolts shall be used.

The size of fillet welds shall not be less than 5mm for load-bearing joints.

Main structural elements shall be welded continuously. Intermittent welds shall be used only on secondary members, which are not exposed to weather or other corrosive influence.

Connections and splices shall be made by welding, or by bolting with high tensile turned and fitted bolts. Black bolts shall be used in connections and attachments of secondary members such as purlins, wall girts, etc. Bolts shall be prevented from loosening by means of lock nuts, single coil spring washers or similar devices.

Method of splicing shall be similar to the method of construction adopted for structures. All splices shall be full-strength splice unless exception is specified.

Roof and wall sheets shall be fixed to purlins and wall girts by stainless steel top speed screws/galvanized I-hook bolts, each complete with neoprene and stainless steel/galvanized washers. The connections shall ensure water tightness into the buildings. The spacing of these screws/bolts shall be sufficient to prevent uplift of sheets by suction. The roof and wall sheets shall be stitched together at their edges by using studs, rivets or screws. The end and side overlaps of sheeting shall be sufficient to prevent ingress of rainwater. End lap shall not be less than 75mm and side lap shall not be less than one half corrugation for GCS sheets. For troughed aluminium sheets manufacturer’s recommendations shall be followed.

11.1.7 Structural Steel connection

The Contractor shall be responsible for the design and the detailing of all connections. The design of connections shall provide for adequate strength for the transfer of force in the structural elements indicated on the design drawings. For purposes of detailing of connections, the allowable stresses in material, bolts and welds shall be as per IS: 800 and IS: 816 or as specified in the design drawings.

For all full strength butt welding of plates and sections thicker than or equal to 10mm, edge preparation shall be done and got approved by the Engineer-In-charge.
Two numbers of washers shall be used for all bolted connections, one washer bearing against the head and other bearing against the nut.

The magnitude of forces shown on design drawings shall be used at face values with no reductions for connections.

If extra joints are to be provided in column, crane girder etc., prior approval on the same shall be obtained from the Engineer-In-charge. However, as general guidance, the following is suggested:

a) Splice joint on column and crane girder shall be of full strength but weld, and, wherever possible, shall be located at the section of minimum or substantially lesser stress.

b) Splice joints of web and flange should be sufficiently staggered in position.

All penetration for piping, conduit, cable trays, etc., through grating or plate flooring shall be cut and suitably banded in the field, except when such penetrations are dimensioned in the drawings in which case they shall be shop cut and banded.

11.1.8 Fabrication

Fabrication of all structural steelwork shall be in accordance with IS: 800 or their equivalent foreign national standard of the country of origin of supply unless otherwise specified, and in conformity with various clauses of the Technical Specification.

Wherever practicable and wherever perfect matching of parts is required at site, members shall be shop assembled before dispatch to minimize site work. Parts not completely assembled in the shop shall be secured, to the extent possible, to prevent damage during dispatch.

All pieces shall be properly identified and bundled for transportation to work site. Care shall be exercised in the delivery, handling and storage of material to ensure that material is not damaged in any manner. Materials shall be kept free of dirt, grease and foreign matter and shall be protected from corrosion. All materials shall be stored properly on skids above the ground which shall be kept clean and properly drained. Girders and beams shall be placed upright and stored. Long members such as columns and chord members shall be supported on skids spaced near enough to prevent damage due to deflection.

Bolts shall be furnished according to bolt lists showing the location of their use and additional bolts shall be supplied to cover wastage.

All fabricated pieces shall bear erection mark numbers painted/punched according to appropriate erection and shop drawings at a prominent location on the structure for easy identification.

All workmanship shall be in accordance with the best practice in modern structural shops. Greatest accuracy shall be achieved in the manufacture of every part of the work and all identical parts shall be strictly interchangeable.
Shearing or flame cutting may be used at the Contractor’s option provided that a mechanically controlled cutting torch is used for flame cutting and that the resulting edges are clean and straight.

Unless clean square and true to shape all flame cut edges shall be planed/cleaned by chipping or grinding. Where machine flame cutting is permitted of high tensile steel, special care shall be taken to leave sufficient margin and all flame hardened material shall be removed by machining/edge grinding.

Wherever shearing is used for cutting to size, sheared members shall be free from distortions at sheared edge.

The ends of all girder stiffeners shall be in contact with the compression flange and shall be planed or ground to fit tightly against flange plates unless otherwise stated on the drawings. Care shall be taken to ensure full bearing of the stiffeners at the supports by machining the contact surfaces of both bearing stiffeners and bearing plates. The ends shall not be drawn or caulked.

Column splices and butt joints of struts and compression members depending on contact for stress transmission shall be accurately machined and close butted over the whole section with a clearance not exceeding 0.1mm locally at any place.

In column cap and bases, the ends of shafts, should be accurately machined so that the parts connected butt over the entire surface of contact. Care should be taken so that these connecting members are fixed with such accuracy that they are not reduced in thickness by machining by more than 1.0mm. On secondary members, where sufficient gussets and welds are provided to transmit the entire loading. The column ends may not be machined subject to the approval of the Engineer-In-charge.

Holes for permanent black bolts shall not be more than 1.5mm larger than the nominal diameter of the back bolts unless specified otherwise. All holes for turned and fitted bolts shall be sub punched or drilled and reamed at site under assembly of connected parts to a tolerance of +.3mm unless specified otherwise.

Holes in purlins, side-sheeting runners, packing plates and lacing bars may be punched full size. Holes in light framing with the exception of joint holes may be punched full size. All punching and sub-punching shall be clean and accurate and all drilling free from burrs. In block/batch drilling, parts shall be separated after drilling and burrs removed. No hole shall be made by gas cutting process.

The component parts shall be so assembled that they are neither twisted nor otherwise damaged and specified cambers, if any, shall be provided. No drifting of hole shall be permitted except to draw the parts together. Drifts used shall not be larger than the nominal diameter of the bolt.

Drifting done during assembling shall not distort the metal or enlarge the holes. Sufficient trial assembly shall be carried out in the fabrication works to prove the accuracy of workmanship of the and the number of such trials required shall be at inspector’s discretion.
Where necessary, washers shall be tapered or otherwise suitably shaped to give the heads and nuts of bolts a satisfactory bearing. The threaded portion of each bolt shall project through the nut by at least one thread.

In all cases where the full bearing area of the bolt is to be developed, the bolt shall be provided with a washer of sufficient thickness, under the nut so as to avoid any threaded portion of the bolt being within the thickness of the parts bolted together. Column bases and caps, shall be in one solid piece, and except when cut from plates with true surfaces, shall be accurately machined over the bearing surfaces, and shall be in effective contact over the whole area of the machine end of the stanchion.

Each piece shall be distinctly marked before delivery in accordance with an approved marking diagram and shall bear such other marks as well to facilitate erection. For easy identification at site a small distinguishing mark for each building shall be painted at each end of every member before dispatch from fabrication shop. The fabricated steel work shall be dispatched in sequence as per agreed programme and for such portion as may be found convenient for erection or as ordered by the Engineer-In-charge.

The Contractor shall provide suitable packing wherever necessary to guard against damage during handling and transportation to site. All fabricated parts shall be adequately braced to prevent damage during transit.

The tolerance for fabrication of steel structures shall generally conform to IS: 7215 and to suit the technological requirements as specified by the equipment supplier.

Any fabrication work which is considered not to be in keeping with the Technical Specification forming the Contract, or in absence of Technical Specification with recognized good practice, shall be rectified/replaced/corrected at the Contractor’s expense as directed by the Engineer-In-charge. Site fabrication work shall also conform to all specifications, stipulations, terms and conditions applicable for shop-welded structures as mentioned above.

11.1.9 Dispatch Instructions

Each dispatchable structure shall bear mark no. along with reference drawing number at two prominent locations (e.g. on flange and bottom of base plate of a column).

“As built” drawing shall be prepared after fabrication is completed to indicate additions/alterations made during the process of fabrication.

Control assembly of important structures shall be done in the shop floor before dispatch to avoid mismatching. For all such important structures, match marking shall be given at the control assembly stage in the shop floor as such match markings shall be made clearly visible while assembling the structures at site.

Centre lines of column flanges and both sides of web shall be punched preferably at top and bottom to facilitate alignment after erection.

11.2 ERECTION OF STEEL STRUCTURE
11.2.1 Scope

The scope of work under erection includes in addition to provision of erection and transport equipment, tools and tackles, consumables, materials labour and supervision the following.

a) Storing and stacking at site of erection of all fabricated structural components/units/assemblers at the time of erection.

b) Transportation at the site of structures.

c) Receiving at site of structures including site handling/movement, unloading, storing at site of erection of technological structures such as bunkers and the related structure.

d) All minor rectification/modification such as:
   i) Removal of bends, kinks, twists etc. for parts damaged during transportation and handling.
   ii) Cutting, chipping, filling, grinding etc. if required for preparation and finishing of site connections.
   iii) Reaming for use of next higher size bolt for holes which do not register or which are damaged.
   iv) Welding of connections in place of bolting for which holes are either not drilled at all or wrongly drilled during fabrication.

e) Other rectification work such as:
   i) Re-fabrication of parts damaged during fabrication beyond repair during transportation and handling or incorrectly fabricated.
   ii) Fabrication of parts omitted during fabrication by oversight or subsequently found necessary.
   iii) Plug welding and re-drilling of holes which do not register and which cannot be reamed for use of next higher size bolt.
   iv) Drilling of holes which are either not drilled at all or are drilled at incorrect position during fabrication.

f) Fabrication of minor items/missing items or such important items as directed by the Engineer-In-charge.

g) Assembly at site of steel structural components wherever required including temporary supports and staging.

h) Making arrangements for and providing all facilities for conducting ultrasonic X-rays or gamma ray tests on welds, getting the tests conducted, reports and interpretation.

i) Rectifying at site damaged portions of shop primer by cleaning and touch-up paint.

j) Erection of structures including making connections by bolts/high strength friction grip bolts/welding.

k) Alignment of all structures true to line level plumb and dimensions within specified limits of tolerances as per IS : 12843 “Tolerance for Erection of Steel Structures”

l) Application of second coat of primer paint and two coats of finishing paint at site after erection.

m) Grouting of all columns bases after proper alignment of columns and only after obtaining clearance from Engineer-In-charge.

n) Supply of labour in sufficient numbers where necessary, as directed by the Engineer-In-charge.
o) Conducting preliminary acceptance and final acceptance tests.
p) Preparation of as built drawings, preparing of sketches/drawings to suit field engineering decisions, availability of material, convenience of fabrication, transportation and erection and changes during fabrication and erection.
All such works are subject to approval by the Engineer-In-charge.

1.2.2 Erection Drawings

The erection drawings prepared by the Contractor and any approved arrangement drawings specifications or instructions accompanying them shall be followed in erection of structures and miscellaneous connected items throughout the project.

1.2.3 Storing and handling

The fabricated materials on receipt at site shall be carefully unloaded, examined for defects, checked, stored out for each building and stacked securely on skids above level ground which shall be kept and properly drained. Girders and beams shall be placed upright and stored. Long members, such as columns and chord members shall be supported on skids spaced near enough to prevent damage from deflection.

The fabricated materials shall be verified with respect to markings on the marking plan or shipping list which shall be supplied by the Contractor.

Any material found damaged or defective shall be stacked separately and the damaged or defective portions shall be painted in distinct colour for identification. Such materials shall be dealt with as ordered by the Engineer-In-charge.

The handling and storing of the component parts of a structure shall involve the use of materials and applications not likely to produce injury by twisting, bending or otherwise deforming the structures. No member slightly bent or twisted shall be put in place until the defects are corrected. Members seriously damaged in handling shall be rejected.

1.2.4 Defects in material fabrication

All materials shall be straight unless required to be of curvilinear from and shall be free from twists. All cold straightening shall be done by pressure only.

During assembly and during erection of the units to position, the Contractor shall compare the structure with drawings to ensure that there are no fabrication omissions or errors. Should any omission or defect be found the same shall be brought to the notice of the Engineer-In-charge who will issue necessary instructions for the rectification.

1.2.5 Setting out

The Contractor shall prepare geodetic survey of all embedded parts and holding down bolts and submit the same to Engineer-In-charge. The Contractor shall inform the Engineer-In-charge about any discrepancy with approved design drawings well in advance of erection and if necessary shall make necessary adjustments at site during fabrication of structures.
The Contractor shall assume, full responsibility for the free and correct setting out of all steel work and erection correctly in accordance with position, alignment, dimensions and levels shown on the approved drawings and plumbing vertical members. Particular care shall be taken to ensure free expansion and contraction wherever provided. Notwithstanding any assistance rendered to the Contractor by the Engineer-In-charge if at any time during the progress of the work, any error should appear or arise therein, on being required to do so, the Contractor at his own cost shall remove and amend the work to the satisfaction of the Engineer-In-charge.

1.2.6 Assembly and Erection

Before starting erection, the Contractor shall submit to the Engineer-In-charge for his approval the method he propose to follow and the number of types of equipment and temporary works he propose to use for the erection.

The approval of drawings by the Engineer-In-charge will not relieve the Contractor from the basic approach to design as regards the loads which the erection equipment and temporary work shall be called upon to carry and support. Adequate allowance and provisions shall be made for lateral forces and wind loads.

If in the opinion of the Engineer-In-charge, the tools, tackles, plant and equipment, instruments, apparatus etc. arranged by the Contractor are not sufficient or are inadequate for the fulfillment of the contractual obligations of the Contractor within the stipulated period, the Engineer-In-charge will have the right to order the Contractor and the Contractor shall comply with the order to bring /arrange such additional tools, tackles, plant and equipment instruments, apparatus etc. to the site and employ the same to complete the work in time. All charges in connection thereof shall be borne by the Contractor.

Proper consideration shall be given to the following items during erection.

i) Frame of building to be true and plumb.
ii) Temporary guying and bracing shall be used to align the framing during erection if required.
iii) Temporary bracing may be required to sustain forces due to erection loads and equipment. Erected parts of the structures shall be made stable during all stages of erection. The stability of structure subjected to the action of wind, dead weight and erection forces shall be attained by observing specified sequence of erection of vertical and horizontal structural members and by installing permanent and temporary bracings.
iv) Erection members shall be held securely in place by bolts to take care of dead load, wind load and erection load.
v) Free expansion and contraction wherever provided.
vi) No final bolting or welding of joints shall be done until the structure has been properly aligned and consent obtained from Engineer-In-charge.

vii) Erection tools and machinery shall be suitable capacity for handling the materials furnished and must be in safe operating conditions at all times to avoid danger to materials and personnel.

viii) In positioning beams, columns or other steel members the use of steel sledges shall not be permitted.

ix) The Contractor shall report all failures of the fabricated steel to fit together properly to the Engineer-In-charge and shall obtain approval prior to taking corrective measures.

x) Steel members shall not be allowed to fall or be subject to shock or impact due to other members being swung into position or for any other cause.

xi) All exposed bolts holes not required shall be plugged.

Erection shall be carried out according to the best modern practices and as laid down in the IS: 800-1984 and other relevant standards referred to therein and according to this erection specification together with approved erection drawings and technical specifications.

The Contractor shall design, manufacture, erect and provide false work, staging, temporary supports etc. required for safe and accurate erection of structural steel work and shall be fully responsible for the adequacy of the same.

The Contractor shall, if so required by the Engineer-In-charge, get his drawings, erection schemes and designs for such false work, staging etc. approved by the Engineer-In-charge, but such approval by the Engineer-In-charge shall not relive the Contractor of any of his responsibilities for the safety of such works. As far as possible, assemblies of structures shall be made on the ground itself.

The Contractor shall provide adequate supervision at all stages of the work and examine each portion of the work for accuracy before commencing the erection of the next structural member. The Contractor shall also provide facilities such as adequate temporary access ladders, tools and tackles, instruments etc. satisfactory to Engineer-In-charge / Consultant for his inspection at any stage during erection.

Instrumental checking for correctness of initial setting out of structures and adjustment shall be carried out in sequence at different stages as determined by design as against checking and adjustment of alignment in one stage after completion of entire erection. The final leveling and alignment shall be carried out immediately after completion of each section of a building or when called for by the Engineer-In-charge.

All structural members shall be erected with erection marks in the same relative position as shown in the appropriate erection and shop drawings.

1.2.7 Field connections

The holes of erection joints required to be machine bolted shall be filled with temporary bolts and plugs after mounting the structures. The number of bolts and plugs shall be determined by design but shall not be less than 50% of the total number of holes. In
joints where the number of holes is equal to 5 or less, not less than 3 holes shall be filled. The number of plug shall be about 20% of the holes filled.

The number of washers on permanent bolts shall not be more than two (and not less than one) for nut and one for the bolt head. Wooden rams or mallet shall be used for forcing members into position in order to protect the metal from injury and chipped edges shall be finished with a file and all short corner and hammered rough faces shall be rounded off. Chipping with the use of sledge hammer shall only be permitted in exceptional cases and shall be done without resulting in fractured edges.

Where bolting is specified on the drawings, the bolts shall be tightened to the maximum limit. The threaded portion of each bolt shall project through the nut by at least one thread. Tapered washers shall be provided for all heads and nuts having bearing on beveled surfaces. Use of special bolts, such as high strength friction grip bolts, shall be according to the relevant Indian or other recognized standards and shall be subject to the prior approval of the Engineer-In-charge before use.

Spring washers or lock nuts shall be provided as specified in the design/shop drawings. All machine fitted bolts shall be perfectly tight and the ends shall be checked to prevent nuts from becoming loose. No unfitted holes shall be left in any part of the structures. All field assembly and welding shall be executed in accordance with the requirements for shop fabrication. Where the steel has been delivered painted, the paint shall be removed before field welding for a distance of at least 50 mm on either side of the joints.

Erection bolts shall be retained in position permanently even after site welding.

1.2.8 Assembly by high strength friction grip bolts

The mating surface shall be absolutely free from grease, lubricant, dust, rust etc. and shall be thoroughly cleaned before assembly. The preparation of mating surface shall be done as specified in the design drawings.

Nuts shall be tightened up to the specified torque with the help of torque wrench or by half turn method with the help of pneumatic wrench lever. Torque value has to be specified in design/fabrication drawings itself. The direction of tightening of the nuts shall be from the middle towards the periphery of the joint. The bolt head, nuts and edges of the mating surface shall be sealed with a coat of paint to obviate entry of moisture. As far as possible, the diameter of bolts and nature of mating surface preparation shall be kept uniform to have specified unique torque.

1.2.9 Bedding and grouting

Base plate shall be set to elevations shown in the drawings supported and aligned using steel wedges and shims or any other approved method. The supply of wedges, shims and any other materials for alignment shall be the responsibility of the Contractor as part of his work. Plates shall be leveled properly positioned and the anchor bolts properly tightened. The bedding/grouting shall not be carried out until a sufficient number of columns have been properly aligned, plumbed and sufficient girders, beams, trusses and bracing to the satisfaction of the Engineer-In-charge.
Grouting shall be done before casting of elevated RCC floor, if equipment’s contributing to the loading on columns are placed moving equipment shall be tested and no trial run of any equipment before grouting has been done and cured to the satisfaction of the Engineer-In-charge.

Grouting shall be minimum M-25 grade or one grade higher that the concrete with 10 mm and below graded coarse aggregate. Ready mixed free-flow grout from recognized manufacturer as approved by the Engineer-In-charge shall be used with pressure grouting as technique to ensure up of all void spaces underneath the base plate. Manufacturer’s recommendation/instruction shall be followed for proper application of grout materials.

The Contractor shall inform the Engineer-In-charge when the work is ready for grouting for their verification. The Contractor shall be responsible for the final vertical and horizontal alignment of all the base plates.

1.2.10 Painting after erection.

The painting shall be as per painting specifications and instructions and in GS for painting works.

1.2.11 Acceptance of work

Acceptance of erected steel structures shall be either after erection of the whole building or in blocks.

Intermediate acceptance certificate will be given in the following

i) Any steel work or part thereof embedded in concrete.
ii) Steel structures which are to be covered in the process of further work.

The following documents shall be prepared and produced at the time of acceptance of erected steel structures:

i) Documents showing approved deviations made during erection of work.
ii) Documents showing acceptance of embedded structures
iii) Certificate/documents on control checking and tests of nuts and welds.
iv) Data and results of geodetic measurement while checking of structures.
v) Copies of ‘As built Drawings’ showing thereon all alterations.

11.3 Welding specifications

11.3.1 General

The welding and welded work shall conform to IS: 816 and other relevant codes unless otherwise specified. Electrodes shall conform to IS: 814 and shall be approved by the Engineer-in-charge.
Welding shall be done by Electrical Arc Process. Automatic welding shall be employed for important structures as specified in the drawings. Generally submerged arc. Automatic & Semi automatic welding shall be employed. Only where it is not practicable. Manual Arc. Welding may be restored to. In case of Manual Arc. Welding, recommendation of electrode manufacturer are to be strictly followed.

Welding shall not be done under weather conditions which might adversely affect the efficiency of the welding and where necessary, effective protection and other safeguard shall be provided.

Only qualified welders suitable for the job shall be employed. The Engineer-In-charge at his discretion can order periodic tests in accordance with IS: 817 of the welders and/or of the welds produced by them at no extra cost. Welding shall be done using requisite jigs and fixtures to avoid distortions or damage to members during/after welding. Welds on exposed work shall be finished uniformly smooth to present a neat appearance.

The layouts and sequence of operations shall be arranged so as to eliminate distortion and shrinking stress to the satisfaction of the inspector. Welding work shall be under constant supervision of competent welding supervisor and shall be done in a properly organized manner with the approved quality welding sets and with automatic welding machines. Detailed welding procedure shall be submitted to the Engineer-In-charge and approval of the same shall be obtained before fabrication is commended.

1.3.2 Welding procedure

Welding procedure to be prepared by the Contractor shall include the following.

i) Type and size of electrodes.
ii) Current and voltage (for automatic welding)
iii) Length of run per electrode or (for automatic welding) speed of travel.
iv) Number and arrangement of rungs in multi-run welds.
v) Position of welding
vi) Preparation of set up parts
vii) Welding sequence
viii) Pre or post heating
ix) Specifications and thickness of steel
x) Welding process (manual arc. /submerged arc. Welding)
xi) Pre and post heating requirement
xii) Weather condition – restriction thereof
xiii) Use of jigs and fixtures
xiv) Type of non-destructive testing to be carried out
xv) Inspection procedure to be followed
xvi) Sequence and process to be followed in different multiple pass butt welding for different plate thickness.

The welding procedure shall be arranged to suit the details of the joints as indicated in the drawings and the position in which the welding is to be carried out. The welds shall meet the requirement of quality specified.
All electrodes for use in the work to which the specification relates shall be kept under dry conditions. Electrodes which are damaged by moisture shall not be used unless it is certified by the manufacturer that when it is properly dried there shall be no determinable effect. Any electrode which has part of its flux coating broken away or is otherwise damaged shall be discarded.

Low hydrogen electrode and flux for submerged arc. Welding shall be dried at 250-300 deg. C for one hour in drying oven before use.

At site the electrode shall be kept in proper coves while using them for welding.

For multi-run weld deposit the succeeding run shall be done only after the preceding run is cleaned of all slag and flux deposit.

The Contractor shall prepare the edge with an automatically controlled flame cutting torch followed by grinding correctly to the shape, size and dimensions of the groove, prescribed in the design and shop drawings. In case of U-groove joint, the edges shall be prepared with an automatic flame cutting torch in two passes following a bevel cut with a gouging pass or by machining.

The welding surface shall be smooth, uniform and free from fins, tears, notches or any other defect which may adversely affect welding. Welding surface or the surrounding surface within 50 mm of weld shall be free from loose scale, slag, rust, grease, paint, moisture or any other foreign materials. Pre-bending of plates for three plate welded sections shall be done where found necessary.

Manipulators may be used where necessary and shall be designed to facilitate welding and to ensure that all welds are easily accessible to the operators. Where full strength built welds are specified run-on pieces shall be used. The welding shall be such that the face of weld deposit at all places be proud of the surface of the parent metal by 1 to 1.5 mm. Where a flush surface is required the surplus weld metal shall be ground and dressed off.

After completing each run of weld all slag shall be thoroughly removed and the surface cleaned before starting the next run of weld. The weld metal as deposited (including lack welds if to be incorporated) shall be free from cracks, slag, inclusions, gross porosity, cavities and other deposition faults. The weld metal shall be properly fused with the parent metal without serious undercutting or overlapping at the toes of the weld. The surface of the weld shall have a uniform and consistent contour and uniform appearance.

All weld runs found defective shall be cut by using either chipping hammer gouging torch or suitable grinding wheel in such a manner that adjacent materials is not injured in any way. Peeling of the welds involving deformation of the weld surface either during deslagging or thereafter shall not be allowed.

Arc.-strikes on parent surface of structures shall be strictly avoided.
1.3.3 Control in welding

The extent of quality control in respect of welds for structural elements for both statically and dynamically loaded structure shall be as follows and shall be conducted by the Contractor at his own cost.

a) Visual Examination - All welds shall be 100% visually inspected to check the following.
   i) Presence of under cuts
   ii) Visually identifiable surface crack in both welds and base metal
   iii) Unfilled craters
   iv) Improper weld profile and size
   v) Excessive reinforcement in weld
   vi) Surface porosity

   Before inspection, the surface of weld metal shall be cleaned of all slag, spatter, beads, scales etc. by using wire brush or chisel.

b) Dye Penetration Test (DPT) – This shall be carried out for all important fillet welds and groove welds for both statically and dynamically loaded structures to check the following
   i) Surface cracks
   ii) Surface porosities

   Dye Penetration Test shall be carried out in accordance with American National Standard ASTME-166

c) Ultrasonic Testing – Ultrasonic test shall be conducted for all groove welds and heat affected zone in dynamically loaded structures and for other important load bearing butt welds in statically loaded structures as desired by the Engineer-In-charge to detect the following.
   i) Cracks
   ii) Lack of fusion
   iii) Slag inclusions
   iv) Gas porosity

   Ultrasonic testing shall be carried out in accordance with American National Standard ANSI/AWS DI.1-96. Before ultrasonic test is carried out, any surface irregularity like undercuts, sharp ridges etc. shall be rectified. Material surface to be used for scanning by probes must allow free movement of probes. For this purpose, surface shall be prepared to make it suitable for carrying out ultrasonic examination.

d) Radiographic Testing (X-ray and Gamma-Ray Examination)

   This test shall be limited to 2% of length of welds for welds made by manual or semi automatic welding and 1% of length of weld if made by automatic welding machines.
The location and extent of weld to be tested by this method will be decided by the Owner to detect the following defects.

i) Gas porosity  
ii) Slag inclusion  
iii) Lack of penetration  
iv) Lack of fusion  
v) Cracks

Radiographic testing shall be conducted in accordance with American National Standard ANSI/AWS Di 1-96. Any surface irregularity like undercuts, craters pits etc. shall be removed before conducting radiographic test. The length of weld to be tested shall not be more than 0.75xfocal distance. The width of the radiographic film shall width of the weld joint plus 20mm on either side of the weld.

The Contractor shall provide testing equipment for conducting non-destructive tests for confirming the integrity of welding wherever necessary as directed by the Engineer-In-charge.

Acceptable Limits of Defects of Weld

Limits of acceptability of welding defects shall be as follows:

a) Visual inspection and Dye Penetration Test

   The limit of acceptability of defects detected during visual inspection and Dye Penetration Test shall be in accordance with American National Standard ANSI/AWS D1-96.

b) Ultrasonic Testing – The limits of acceptability of defect detected during ultrasonic testing shall be in accordance with American National Standard ANSI/AWS D1-96.

c) Radiographic Testing – The limit of acceptability of defects during Radiographic testing shall be in accordance with American National Standard ANSI/AWS D1-96.

General guidelines for permissible deviations in welding have been given in section 11.0 of this document.

1.3.4 Rectification Defects in Welds

In case of detection of defects in welds, the rectification on the same shall be done as follows.

i) All craters in the weld and breaks in the weld run shall be thoroughly filled with weld.
ii) Undercuts, beyond acceptable limits shall be repaired with dressing so as to provide smooth transition of weld to parent metal.

iii) Welds with cracks and also welds with incomplete penetration, porosity, slag inclusion etc. exceeding permissible limits shall be rectified by removing the length of weld at the location of such defects plus 10mm from both ends of defective weld and shall be re-welded. Defective weld shall be removed by chipping hammer gouging torch or grinding wheel. Care shall be taken not to damage the adjacent material.

11.4 PAINTING OF BUILDING STEEL STRUCTURES

All steel structure work shall be painted as follows unless otherwise stated in the drawing/technical specifications. Relevant sections of the GS shall be referred for further guidelines on painting.

11.4.1 Surface preparation for encased columns

The steel surface which is to be painted will be cleaned of dirt and grease and the heavier layer of rust shall be removed by chipping prior to actual surface preparation to a specified grade.

Prior to paint application all surfaces should be assessed and treated in accordance with ISO 8504:1992. Oil or grease should be removed in accordance with SSPC-SP1 solvent cleaning.

Abrasive blast cleans to Sa 2-1/2 (ISO 8501-1:1988) or SSPC-SP6. If oxidation has occurred between blasting and application, the surface should be re-blasted to the specified visual standard. Surface defects revealed by the blast cleaning process, should be ground, filled, or treated in the appropriate manner.

11.4.2 Paints and Painting

Guidelines stipulated here shall be considered along with those specified in General Specifications separately for painting.

Manufacturer of paints, mixing of paints etc. shall be generally according to the relevant IS codes of practice and as per guidelines in the General Specification in the relevant chapter.

In the event of conflict between this General Specification for painting and the paint manufacturer’s specifications, this conflict shall be immediately brought to the notice of the Engineer-In-charge. Generally in case of such conflict, manufacturer’s specification/recommendations shall prevail.

Generally compatibility between primer intermediate and finishing paint shall be certified by the paint manufacturer supplying the paints. Before the Contractor buys the paint in bulk, it is recommended to obtain sample of paint Control Areas of Painting on Control Area, surface preparation and painting shall be carried out in the presence of the manufacturer of paint.

11.4.3 Inspection and Testing of Welds
The extent of quality control in respect of welds for structural elements shall be as follows.

11.5 **Visual Examination**

11.5.1 All welds shall be 100% visually inspected to check the following:
   i) Presence of undercuts
   ii) Surface cracks in both welds and base metals.
   iii) Unfilled craters
   iv) Improper weld profile and size
   v) Excessive reinforcement in weld
   vi) Surface porosity

Before inspection, the surface of weld metal shall be cleaned of all slag, spatter matter, scales etc. by using wire brush or chisel.

11.5.2 **Dye Penetration Test (DPT)**

This shall be carried out for all important fillet welds and groove welds to check the Surface cracks and Surface porosities

Dye Penetration Test shall be carried out in accordance with American National Standard ASTME 165.

11.5.3 **Ultrasonic testing:**

Ultrasonic test shall be conducted for all groove welds and heat affected zone in dynamically loaded structures and for other important load bearing butt welds in statically loaded structures as desired by OWNER to detect the following:
   i) Cracks
   ii) Lack of fusion
   iii) Slag inclusions
   iv) Gas porosity

Ultrasonic Testing Shall Be Carried Out In Accordance With American National Standard ANSI / AWS Dl -92 Chapter 6 : Part C.

Before Ultrasonic test is carried out, any surface irregularity like undercuts, sharp ridges etc. shall be rectified. Material surface to be used for scanning by probes must allow free movement of probes. For this purpose, surface shall be prepared to make it suitable for carrying out ultrasonic examination.

11.5.4 **Radiographic Testing (X — ray and Gamma — ray Examination)**

This test shall be limited to 2% of length of welds for welds made by manual or semi-automatic welding and 1% of length of weld if made by automatic welding machines. The location and extent of weld to be tested by this method shall be decided by OWNER to detect the following defects:
   i) gas porosity
   ii) slag inclusions
iii) lack of penetration  
iv) lack of fusion  
v) Cracks  

Radiographic testing shall be conducted in accordance with American National Standard ANSI / AWS D1.1-92.

Any surface irregularity like undercuts, craters, pits etc shall be removed before conducting radiographic test. The length of weld to be tested shall not be more than 0.75 x focal distance. The width of the radiographic film shall be width of the welded joint plus 20 mm on either side of the weld.

11.5.5 CONTRACTOR shall provide testing equipment for conducting non destructive tests for confirming the integrity of welding wherever necessary as directed by the purchaser / consultant.

11.5.6 Acceptable Limits of defects of weld

i) Visual inspection & Dye Penetration Test  
The limits of acceptability of defects detected during visual inspection and Dye Penetration Test shall be in accordance with clauses 8.15.1 & clauses 9.25.3 of American National Standard ANSI / AWS D1.1-92 respectively, for statically and dynamically loaded structures.

ii) Ultrasonic Testing  
The limits of acceptability of defects detected during ultrasonic testing shall be in accordance with clause 8.15.4 & clause 9.25.3 of American National Standard ANSI / AWS D1.1-92 respectively, for statically and dynamically loaded structures.

iii) Radiographic Testing  
The limits of acceptability of defects detected during Radiographic testing shall be in accordance with clause 8.15.3 & 9.25.2 of American National Standard ANSI / AWS D1.1-92 respectively for statically and dynamically loaded structures.

11.5.7 Rectification of Defects in Welds

The rectification of defects in welds shall be done as follows:

i) All craters in the weld and breaks in the weld run shall be thoroughly filled with weld  
ii) Undercuts, beyond acceptable limits, shall be repaired with dressing so as to provide smooth transition of weld to parent metal.  
iii) Welds with cracks and also welds with incomplete penetration, porosity, slag inclusion etc. exceeding permissible limits shall be rectified by removing the length of weld at the location of such defects plus 10 mm from both ends of defective weld and shall be re-welded. Defective weld shall be removed by chipping hammer gouging torch or grinding wheel. Care shall be taken not to damage the adjacent material.
GUIDELINE FOR INSPECTION OF WELDING

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Inspection or Test</th>
<th>Coverage</th>
<th>Procedure</th>
<th>Evaluation findings &amp; remedy of defects</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Inspection of weld seams appearances</td>
<td>All welds</td>
<td>Naked eye or lens.</td>
<td>All faulty welds shall be rectified.</td>
</tr>
<tr>
<td>2.</td>
<td>Checking of sizes</td>
<td>At least one for each weld seam</td>
<td>Ordinary measuring instruments (rule, templates)</td>
<td>Should faulty weld be found all welds shall be checked and all defects shall be rectified.</td>
</tr>
<tr>
<td>3.</td>
<td>Mechanical tests for welding procedure performance &amp; electrodes</td>
<td>As per IS 9595.</td>
<td>As per IS 9595.</td>
<td></td>
</tr>
</tbody>
</table>

11.6 SHOP INSPECTION AND APPROVAL

11.6.1 General

The Engineer-in-charge or his representatives shall have free access at all reasonable times to the fabrication shop and shall be afforded all reasonable facilities for satisfying himself that the fabrication is being undertaken in accordance with drawings and specifications.

Technical approval of the steel structures in the shop by the Engineer-in-charge is mandatory.

The Contractor shall not limit the number and kinds of test, final as well as intermediate tests or extra tests requested by the Engineer-in-charge. All necessary tools, gauges, instruments etc. and technical and non-technical personnel shall be furnished for shop tests to the Engineer at contractor's cost as and when required by the Engineer-in-charge.

11.6.2 Shop Acceptance

The Engineer-in-charge shall inspect and approve at the following stages -

a. Intermediate approval of work that can not be inspected later.

b. Partial approvals.

c. Final approval.

a. Intermediate approval of work shall be given when a part of the work performed can not be inspected later or when inspection would be difficult to perform and results would not be satisfactory.

b. Partial approval in the shop is given on members and assemblies of steel structures before the primer coat is applied and include:

   - Approval of field joints.
   - Approval of parts with planned surfaces.
Test erection
Approval of members
Approval of markings.
Inspection and approvals of special features like rollers, loading platform mechanism etc.
During the partial approval, intermediate approvals as well as all former approvals, shall be taken into considerations.
c. Final Approval in the shop.
The final approval refers to all elements and assemblies of the steel structures, with shop primer coat, ready for delivery from shop, to be loaded for transportation or stored.
The final approval comprises of -
Partial approvals.
Approval of shop primer coat
Approval of mode of loading and transport, approval of storage (for materials stored)

11.7 INSPECTION ON SITE

11.7.1 General
Contractor shall give due notice to Engineer-in-charge in advance of structural members or workmanship getting ready for inspection. All rejected material shall be promptly removed from the shop and replaced with new material for Engineer-in-charge's approval.

The fact that certain material has been accepted shall not invalidate final rejection at site by Engineer-in-charge if it fails to be in proper assembly. No material shall be painted or despatched to site without inspection and approval by Engineer-in-charge.

Shop inspection by Engineer-in-charge or submission of test certificate and acceptance thereof by Engineer-in-charge shall not relieve Contractor from the responsibility of furnishing fabricated material conforming to requirements of these specification nor shall it invalidate any claims which Engineer may make because of defective, unsatisfactory workmanship.

For fabrication work carried out on the field, the same standard of supervision of quality control shall be maintained as in shop fabricated work. Inspection and testing shall be conducted in a manner satisfactory to Engineer-in-charge.

Members shall be inspected at all stages of fabrication and assembly or verify that dimensions, tolerances, alignment, surface finish etc. are in accordance with the requirements shown on drawings and as per IS codes.

In the event of any failure of members to meet an inspection or test requirement contractor shall notify Engineer-in-charge. The quality control procedure to be followed to ensure satisfactory repair shall be subject to approval by Engineer-in-charge. In such cases, Engineer has right to specify additional inspection or testing as deems necessary and the additional cost of such testing will be borne by Contractor.
Holes in members required for installing equipment or steel furnished by other manufacturers or other contractors shall be drilled in Contractor's shop as part of this contract the information for which will be supplied before fabrication of steel.

11.7.2 Packing, Transportation, Delivery After final shop acceptance and marking, the item shall be packed and loaded for transportation.

Packing must be adequate to protect items against warping during loading and unloading. Proper lifting devices shall be used for loading, in order to protect items against warping.

Slender projecting parts shall be braced with additional steel bars, before loading, for protection against warping during transportation rules. If certain parts cannot be transported in the lengths stipulated in the design, the position and type of additional splice joints shall be approved by Engineer-in-charge. Damaged parts and members due to transportation may be rejected by Engineer-in-charge and re fabricated at site or at shop and redelivered at Contractor's cost.

Items must be carefully loaded on platforms of transportation means to prevent warping, bending or falling, during transportation. The small parts such as fishplates, plates, gussets etc. shall be securely tied with wire to their respective parts.

Bolts, nuts and washers shall be packed and transported in crates. The parts shall be delivered in the order stipulated by the Engineer-in-charge and shall be accompanied by document showing:
- Quality and quantity of structure or members
- Position of member in the structure
- Particulars of structure
- Identification number / job symbol

11.7.3 Storage and Preparation of Parts prior to erection

The storage plane for steel parts shall be prepared and got approved by the Engineer-in-charge before the steel structures start arriving from the shop.

A platform shall be provided by the Bidder near the erection site for preliminary erection work.

The Contractor shall make the following verifications upon receipt of material at site:
- For quality certificate regarding material and workmanship according to the general specifications and drawings.

Whether parts received are complete without defects due to transportation, loading and unloading and defects, whether the defects if any are well within the admissible limit.

For the above work sufficient space must be allotted in the storage area. The storage area should be clean and free of water and moisture and should be approved by Engineer-in-charge.
Precautions shall be taken to prevent warping of items during unloading. The parts shall be unloaded, sorted and stored so as to be easily identified.

The parts shall be stored according to construction symbol and markings so that these may be taken out in order of erection / sequence. The parts shall be set at least 150 mm clear from ground on wooden or steel blocks for protection against direct contact with ground moisture. If minor rectification of members like straightening etc. are required, these shall be done in a special place allotted which shall be adequately equipped. The parts shall be clean when delivered for erection.

11.8 TOLERANCES

The dimensional and weight tolerances for rolled shapes shall be in accordance with IS 1852. The acceptable limits for straightens (sweep and camber) for rolled or fabricated member are:

Struts and columns = L / 1000 or 10 mm whichever is smaller.

all other members - L / 500 or 15 mm

where L : Length of finished member tolerances in specified camber of structural members shall be = 3 mm

Tolerance in specified length shall be:
for column finished for contractor bearing - 1 mm
other members upto 10 mm - 3 mm.

12 CHEMICAL/MECHANICAL ANCHOR

12.1 SCOPE OF WORK

The scope of works covers:
   a) Selection
   b) Installation
   c) Installation quality testing

12.2 RESPONSIBILITIES

The responsibility for the correct and safe execution of the works falls within the Design Management & Quality Department with delegated responsibilities to the Contractor.

12.3 CODES, STANDARDS AND OTHER REFERENCES

   a) ETAG 001, “European Technical Approval Guidelines of Metal Anchors for Use in Concrete”
   c) TR018, European Organisation For Technical Approvals (EOTA) Technical Report 29 on “Assessment of Torque-controlled Bonded Anchors”
d) TR045, European Organisation For Technical Approvals (EOTA) Technical Report 45 on “Design of Metal Anchors For Use In Concrete Under Seismic Actions”
e) IS 456: Plain and Reinforced Concrete-Code of Practice

12.4 POST-INSTALLED ANCHORS

Post-installed anchors are installed in hardened concrete as per IS 456 to form connection between new steel component and existing concrete. There are various types of post-installed anchors as follows:-

a) Adhesive anchor — Adhesive anchors consist of anchor rods or reinforcement bars, which are anchored in drilled holes by bonding the metal parts of the anchor/ reinforcement to the sides of the drilled hole with an adhesive. Tensile loads are transmitted to the concrete through bonding between metal parts & adhesive and between adhesive & concrete face of the drilled hole.

b) Displacement-controlled expansion anchor — It is set by expansion against the sides of the drilled hole through movement of an internal plug in the sleeve or through movement of the sleeve over an expansion element (plug). This is achieved by driving through hammer blows or by percussion of a machine. Once set, no further expansion can occur.

c) Screw anchor — It is set by screwing into pre-drilled hole.

d) Torque-controlled adhesive anchor— Anchor designed such that the anchor bolt can move relative to the hardened bonding compound resulting in follow-up expansion.

e) Torque-controlled Expansion Anchor — It is set by the expansion of one or more sleeves or other elements against the sides of the drilled hole through the application of torque, which pulls the cone(s) into the expansion sleeve(s). Tensile loading can cause additional expansion (follow-up expansion) after setting up of anchor.

f) Undercut Anchor — It is anchored mainly by mechanical (bearing) interlock provided by an undercut in the concrete. It is a type of anchor which derives its strength from mechanical interlock provided by an undercut in the concrete at the embedded end of the fastener.

12.5 DEFINITIONS

a) Fastening – Assembly of fixture and fasteners used to transmit loads to concrete
b) Base material – The concrete or masonry unit in which post-installed anchor is to be installed
c) Cracked concrete - Concrete in which there is probability of formation of cracks after installation of anchor or significant expansion of existing cracks during the service life of the anchors.

d) Minimum edge distance – Minimum allowable edge distance at which the anchor can be installed without damaging the concrete member

e) Minimum Spacing – Minimum allowable spacing at which the anchor can be installed without damaging the base material.

f) Effective embedment – It is effective load transfer length of anchor.

12.6 PERFORMANCE REQUIREMENT

a) Should be qualified system - The post-installed anchors are primarily tested and evaluated according to ETAG 001 and/or Technical Reports like TR029, TR018 etc. Depending on qualification requirements, an ETA report is issued by 3rd party testing/evaluation agency. These ETA reports are pre-requisite for design. For higher reliability, it is recommended to
opt for products qualified as per Option 1 of ETAG 001 as it is the most exhaustive amongst
the Assessment Options in ETAG 001.
b) Should be designed system – The post-installed anchor connection system should fulfil the
design load requirements along with other design considerations, if applicable. It is
mandatory to assume concrete to be cracked for design of post-installed anchors unless
specified otherwise (i.e. uncracked) by responsible structural consultant. Use of design
software like Hilti PROFIS is recommended.
c) Examples of other design consideration are listed below. Even if the parameter is not directly
used in design, it is mandatory to have at least an approval document demonstrating
performance under such conditions:-

i) Seismic (C1/C2 category as per TR045)
ii) Fatigue
iii) Fire
iv) Environmental / Exposure condition e.g. interior / exterior, dry / humid etc.
v) Displacement
vi) Shock
vii) Water suitability
viii) Water tightness
ix) Non-ideal installation conditions e.g. large annular gap, flooded hole etc.
x) Long term performance

12.7 DESIGN AND SYSTEM SELECTION

a) The connections formed using post-installed anchors should be designed according to ETAG
001 for structural and non-structural elements. The design provisions of ETAG 001 are
applicable only to anchors that have been suitably assessed using ETAG 001 and/or Technical
Reports like TR029, TR018 etc.
b) The design should be performed only by qualified engineer of firm or design team of
manufacturer.
c) Special care to be taken for designing of standoff fastenings.
d) Parameters like load, load direction, minimum edge distance, minimum spacing, member
thickness, installation temperature, choice of drilling method, condition of concrete etc. can
influence the design and should be given due consideration.
e) Only the post-installed anchor connection system that full fills the design requirements
should be selected and specified in the drawing. The tension, shear and resultant capacity
utilization should be less than or equal to 100%.
f) The drawing specification should contain details like the make, the diameter, the
embedment, location (along with edge and spacing), and installation notes/instructions.
Scanning, Drilling and Cleaning Methods or Safeset Hollow Drilling & vacuum cleaning
method should be mandatorily included in the design specification. It is recommended to
use SAFESET system to reduce probability of installation error. In case of high shear load, it is
recommended to specify a method to fill the annular gap between the plate and the anchor
or to specify use of Hilti seismic set for uniform load transfer.

12.8 MATERIAL

Various post-installed anchors are available. The appropriate solution can be selected
depending on the application:
Chemical anchor (Epoxy resin) for Base plate fixing:

Specification:
Providing and supplying epoxy mortar with threaded rod (5.8 & 8.8 grade). The product should be approved by ETA, ICC, CSTB, COLA, BZS with Shock approval, Seismic (C1 & C2) approval, Fatigue and Fire Approvals in anchors to use in cracked concrete, tested for service temperature of -40 deg. C to +80 deg. C. The chemical should have an ETA approval for 100 years age testing. The fastening should be designed as per guidelines of TR 029. Drilling hole with double flute type drill bits/ hollow drill bits to the required depth by rotary hammer drill, cleaning with brush and jet of clean air, filling resin and hardener using serrated nozzle to eliminate mixing error with standard battery dispenser along with piston plug. The installation and the setting instructions should be strictly followed as per the manufacturer’s recommendations. The adequate embedment depth & number of anchors to be calculated as per the code provision & the report to be submitted to the project manager/ design engineer for approval. Scanning before drilling to be done to avoid hitting existing rebars. For zones with high seismicity, seismic designs are mandatory.

Mechanical expansion anchors for Base plate fixing:

Specification:
Supplying, drilling/cleaning hole and fixing of Torque Controlled Expansion Anchor of sizes ranging from M8 to M24. The Anchor should be third party tested, possess ETA approval and should be pre-assembled with a galvanized bolt as per EN ISO 4042: 1999, ingenious expansion sleeve M10 and M16 (galvanized) and M8, M12, M20, M24 - Stainless Steel (EN ISO 4042: 1999), a nut of Strength Class 8 (EN ISO 20898-2:2012) and a galvanized washer (EN ISO 4042:1999). The anchor should be approved for use in Cracked Concrete. Anchor must be tested and approved as per Seismic C1 and C2 Category of TR045. ETA to have Fire Resistance values for up to 120 mins as per EOTA TR 020 and FM Approval (use in Pipe Hangers). Anchor shall be fixed at right embedment depth as per embedment mark and activated using adaptive torque tool module to ensure adequate torque as per manufacture’s torque tolerance published in ETA and same shall be documented and submitted to Project Manager at the time of inspection. Design of Anchor should be done as per ETAG 001 Annex C and TR045 and the report to be submitted to the project manager and design engineer for approval. Scanning before drilling to be done with to avoid rebar hits. Technical specification for each product is attached for reference.

EXECUTION

Post-installed anchors should be installed as per approval document and Instruction For Use (IFU) for the specified product as per installation condition by a skilled/trained installer under supervision.

Installer Qualification

a) Post-installed anchors shall be installed by a contractor/installer with at least 1 years of experience performing similar installations.

b) Installer should be trained on installation of specific post-installed anchor system. Training may be conducted by the manufacturer or the manufacturer’s representative for the
contractor/installer on the project. Training should consist of a review of the complete installation process for post-installed anchors and should include (but not limited to):

i) hole drilling procedure  
ii) hole preparation & cleaning technique  
iii) adhesive injection technique & dispenser training / maintenance  
iv) rebar dowel preparation and installation  
v) proof loading/torquing

**Equipment/Tools for Installation**

The equipment or tool depend on post-installed anchor system. Depending on the system selected, some of the following equipment may be used.

a) **Scanning equipment**

- Hilti PS 1000/equivalent
- Hilti PS 250/equivalent
- Hilti PS 50/equivalent

b) **Drilling equipment**

- hammer drill
- diamond core machine

c) **Hilti drill bit or core bit**

- Hilti TE-CX/equivalent
- Hilti TE-YX/equivalent
- hollow drill bit
- core bit

d) **Vacuum**
### e) Miscellaneous tools

<table>
<thead>
<tr>
<th>Tool Type</th>
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</thead>
<tbody>
<tr>
<td>Torque wrench</td>
<td></td>
</tr>
<tr>
<td>Hammer</td>
<td></td>
</tr>
<tr>
<td>Wire brush</td>
<td></td>
</tr>
<tr>
<td>Piston plug / extension nozzle</td>
<td></td>
</tr>
<tr>
<td>Manual dispenser</td>
<td></td>
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<tr>
<td>Battery operated dispenser</td>
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<tr>
<td>Hand pump / compressed air</td>
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<tr>
<td>Setting tool for Hilti HKD/equivalent</td>
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<tr>
<td>Hilti TE-YRT/equivalent</td>
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<tr>
<td>Hilti SIW 22/equivalent</td>
<td></td>
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<tr>
<td>Hilti – HRG Check Gauge/equivalent</td>
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</table>

### Installation Steps

Post-installed anchors should be installed as per manufacturer’s installation instruction. The following are typical installation steps.

**a) Check Suitability of Base Material**
The quality of base material before installation should be inspected. Unless otherwise specified, do not drill holes in concrete or masonry until it has achieved full design strength.

**b) Check Installation Condition**

Prior to installation, check all installation parameters (e.g., installation temperature, condition of base material (wet/dry), etc.) are in accordance with design and anchor system being used.

c) **Identification of Suitable Installation Location**

Identify position of reinforcing steel and other embedded items prior to drilling holes for anchors using Hilti scanning tools with magnetic induction or pulse radar technology. Exercise care in coring or drilling to avoid damaging existing reinforcing or embedded items. Notify the Engineer if reinforcing steel or other embedded items are encountered during drilling. Take precautions as necessary to avoid damaging prestressing tendons, electrical and telecommunications conduit, and gas lines. Location suitable for anchor installation should be marked.

d) **Drilling of Hole for Anchor Installation**

i) Drilled Holes: Drill holes with rotary impact hammer drills using carbide-tipped bits, hollow drill bit system and/or core drills using diamond core bits, as applicable. Drill bits shall be of diameters as specified by the anchor manufacturer. Unless otherwise shown on the drawings, all holes shall be drilled perpendicular to the concrete surface. Hole if drilled unnecessarily should be filled with a non shrink grout of suitable compressive strength.

ii) Cored Holes: Where anchors are permitted to be installed in cored holes, use core bits with matched tolerances as specified by the manufacturer. Properly clean cored hole per manufacturer’s instructions. It is recommended to use roughening tool like Hilti TE-YRT in case of diamond cored holes.

e) **Cleaning of Drilled Hole for Anchor Installation**

Clean holes in accordance with ETA and Instruction For Use (IFU).

f) **Installation of Post-Installed Anchor**

Perform anchor installation in accordance with manufacturer instructions.

i) For Mechanical expansion anchor:
   - Protect threads from damage during anchor installation.
   - Heavy-duty sleeve anchors shall be installed with sleeve fully engaged in part to be fastened.
   - Set anchors to manufacturer’s recommended torque, using a torque wrench.

ii) For chemical anchor (epoxy resin):
• Clean all holes per manufacturer instructions to remove loose material and drilling
dust prior to installation of adhesive or use a hollow drilling & vacuum cleaning
system.
• Inject adhesive into holes proceeding from the bottom of the hole and progressing
toward the surface in such a manner as to avoid introduction of air pockets in the
adhesive. Fill 2/3\textsuperscript{rd} of the drilled hole.
• Follow manufacturer recommendations to ensure proper mixing of adhesive
components.
• Sufficient adhesive shall be injected in the hole to ensure that the annular gap is
filled to the surface. Use of piston plug is recommended for ensuring injection of
adhesive without air pockets.
• Remove excess adhesive from the surface.
• Shim anchors with suitable device to centre the anchor in the hole.
• Do not disturb or load anchors before manufacturer specified cure time has elapsed.
• Observe manufacturer recommendations with respect to installation temperatures
for cartridge injection adhesive anchors.

g) Repair of Defective work

Remove and replace misplaced or malfunctioning anchors. Anchors that fail to meet proof
load or installation torque requirements shall be regarded as malfunctioning.

h) Additional Requirement

Holes in the plate to be done in the factory. Gas cutting at site should not be encouraged.
For heavy shear loads eg waler beam the annular gap between the plate and the anchor to
be filled with a necessary chemical of the required compressive strength or use a Hilti
seismic filling set.

TESTING / QUALITY ASSURANCE:

a) Delivery, Storage and Handling

Store anchors in accordance with manufacturer’s recommendations.

b) Installation Quality Test:

These tests shall be performed to validate the load carrying capacity of installed anchors. 1%
or 20 nos of each type (whichever is minimum) and size of post-installed anchor shall be
proof loaded by either the anchor manufacturer or an independent testing laboratory.

i) Tension testing should be performed in accordance with ETAG001.
ii) Torque shall be applied with a calibrated torque wrench. Adhesive anchors and
capsule anchors shall not be torque tested unless otherwise directed by the
Engineer.
iii) Proof loads shall be applied with a calibrated hydraulic ram.
iv) Minimum anchor embedments, proof loads and torques shall be as shown on
the drawings/manufacturer installation instruction.
v) Documentation:

For each test, the following information shall be recorded and submitted:
c) Installation Record

The documentation for installation shall as a minimum include installer firm details, test location, post-installed anchor detail (embedment, diameter, make etc.), installation supervisor details, anchor orientation, load and orientation information, test equipment information, test date, test result and number of tests.

ENVIRONMENT

Attention to be observed during the drilling & installation process so as that no adhesive mixtures contaminate the surrounding water.

HEALTH AND SAFETY PLAN

All relevant aspects of site Safety, Health and Environment will be complied with as well as required measures outlined in the Risk and Hazard Assessment.

SAFETY MEASURES

All relevant aspects of Management Procedure will be complied with as well as required measures outlined in the Risk and Hazard Assessment.

a) Personal Safety

Each member of the operating team has a shared responsibility for making sure that all necessary safety equipment is carried and is correctly used in appropriate circumstances.

b) Personal Protective Equipment (PPE)

All persons engaged in operations will be provided and should wear with appropriate Personal Protective Equipment i.e. Safety helmet, Safety googles, Safety footwear, Safety Gloves, High visibility vests, Masks etc.

c) Competent Personnel

Only competent operators will be engaged for operation of the main equipment.

d) Machinery Inspection & Maintenance

e) Lighting

Good lighting system will be provided inside the tunnel and around the works area during the night shift.
14 POST INSTALLED REBARS

a) PURPOSE

To ensure proper selection and installation of post-installed rebar.

b) SCOPE OF WORK

The scope of works covers:
   a. Selection
   b. Installation
   c. Installation quality testing

c) RESPONSIBILITIES

The responsibility for the correct and safe execution of the works falls within the Design Management & Quality Department with delegated responsibilities to the Contractor.

d) CODES, STANDARDS AND OTHER REFERENCES


c) IS 456: Plain and Reinforced Concrete-Code of Practice

d) Hilti HIT Rebar Method

POST-INSTALLED REBAR

Post-installed rebar is installed in hardened concrete (as per IS 456) to form connection between new concrete member and existing concrete. Post-installed rebar systems comprise of straight deformed reinforcing bar as per IS 456, which are embedded in bonding material manufactured from synthetic mortar, cementitious mortar or a mixture of the two including fillers and/or additives. The various types of post-installed rebar connections covered by TR023 are as follows:-

a) Lapping of post-installed rebar with existing reinforcement in a structural member.

b) Use of post-installed rebar to connect a slab or beam support joint designed as simply supported.

c) Use of post-installed rebar to form connection between structural elements stressed primarily in compression.

d) Use of post-installed rebar to cover the line of acting tensile force (as shown in Fig. 1).
TR023 does not cover applications which induce direct tension in concrete. For moment connection which induce direct tension in concrete, Hilti Hit-rebar method should be used. TR023 also does not permit to take advantage of higher bond of post-installer rebar systems in case of higher confinement. In case of higher confinement, Hilti Hit-rebar method may be used to take advantage of higher confinement and reduce required embedment depth.

a) DEFINITIONS

Anchorage/ embedment length – The depth of rebar required to form the connection.

b) PERFORMANCE REQUIREMENT

a) Should be qualified system - The post-installed rebar systems are primarily tested and evaluated according to Technical Report TR023. Depending on qualification requirements, an ETA report is issued by 3rd party testing/evaluation agency. These ETA reports are prerequisite for design and establish suitability for use of post-installer rebar systems.

b) Should be designed system – The post-installed rebar connection system should fulfil the design load requirements along with other design considerations, if applicable. Use of design software like Hilti PROFIS is recommended.

c) Examples of other design consideration are listed below. Even if the parameter is not directly used in design, it is mandatory to have at least an approval document demonstrating performance under such conditions:-

i. Fire

ii. Seismic (The product to be qualified for seismic must have ETA rebar, ETA anchor, ICC-ES report with qualification for seismic)

iii. Fatigue

c) DESIGN AND SYSTEM SELECTION

a) The connections formed using post-installed rebar (covered in scope of TR023) should be designed according to EC2 development length equation for cast-in rebar. The design
provisions of EC2 are applicable only to rebars that have been suitably assessed according to Technical Report TR023. For moment connection which induce direct tension in concrete, Hilti Hit-rebar method should be used. The use of Hilti Hit-rebar method helps ensure that direct tension is not induced in concrete.

b) The design should be performed only by qualified engineer of firm or design team of manufacturer.

c) Parameters like load, member thickness, installation temperature, choice of drilling method, condition of concrete etc. can influence the design and should be given due consideration.

d) Only the post-installed rebar connection system that fulfils the design requirements should be selected and specified in the drawing.

e) The drawing specification should contain details like the make, the diameter, the embedment, location (along with edge and spacing), and installation notes/instructions. Scanning, Drilling and Cleaning Methods or Safeset Hollow Drilling & vacuum cleaning method should be mandatorily included in the design specification. In case exact specification is not specified in structural drawings, it is mandatory to determine rebar depth using standard Hilti Profis software and get the generated design report approved by either responsible Project engineer/manager in charge or responsible structural consultant before actual installation at job site.

d) MATERIAL

a) Post-installed rebar systems:

Slow cure chemical Epoxy resin with rebar

“Providing and supplying heavy duty Epoxy resin with Rebar with a pre-defined ratio (3:1) of resin and hardener in a soft foil pack of 330ml or 500ml. The product should be approved by ETA, ICC, CSTB and COLA. Rebars to use in cracked/un-cracked concrete, tested for service temperature of -40deg C to +80 deg C. Application to be designed for Rebars as Simply Supported Moment or Splice as per EC2/TR23 or relevant tested and accepted rebar guidelines. LEED certified injection adhesive for rebar fixing in wet/dry flooded holes conditions for diameters. The chemical should have service life of more than 80 years and is to be tested for water tightness. Drilling hole with drill bits to the required depth by rotary hammer drill, cleaning with brush and jet of clean air, filling resin and hardener using serrated nozzle to eliminate mixing error with standard HDE A22 battery dispenser along with piston plug and extension hose for longer depths to ensure no air bubbles are in the hole and then fixing the re-bar, conducting occasional site inspection, executing work by trained personnel and occasional supervision from the manufacturer’s representative in India. The installation and the setting instructions should be strictly followed as per the manufacturer’s recommendations. The chemical for rebar application must have approval for Seismic, Fatigue and Fire.”

e) EXECUTION

Post-installed rebar should be installed as per approval document and Instruction for Use (IFU) for the specified product as per installation condition by a skilled/trained installer under supervision.
i) Installer Qualification

a) Post-installed rebars shall be installed by a contractor/installer with at least 01 years of experience performing similar installations.

b) Installer should be trained on installation of specific post-installed rebar system. Training may be conducted by the manufacturer or the manufacturer’s representative for the contractor/installer on the project. Training should consist of a review of the complete installation process for post-installed rebar and should include (but not limited to):

i. hole drilling procedure
ii) hole preparation & cleaning technique
iii) joint preparation technique
iv) adhesive injection technique & dispenser training / maintenance
v) rebar dowel preparation and installation
vi) proof loading
vii)

ii) Equipment/Tools for Installation

The equipment or tool depend on post-installed anchor system. Depending on the system selected, some of the following equipment may be used.

A. Scanning equipment

| Hilti PS 1000/equivalent | Hilti PS 250/equivalent | Hilti PS 50/equivalent |

B. Drilling equipment
### C. Hilti drill bit or core bit

<table>
<thead>
<tr>
<th>Hilti TE-CX/equivalent</th>
<th>Hilti TE-YX/equivalent</th>
<th>hollow drill bit</th>
<th>core bit</th>
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<tr>
<th>Hilti TE-YRT/equivalent</th>
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### D. vacuum

Vacuum and accessories

### E. Miscellaneous tools
f) Installation Steps

Post-installed rebar should be installed as per approval document and Instruction for Use (IFU). The following are typical installation steps.

g) Check Suitability of Base Material

The quality of base material before installation should be inspected. Unless otherwise specified, do not drill holes in concrete until it has achieved full design strength.

h) Check Installation Condition

Prior to installation, check all installation parameters (e.g., installation temperature, condition of base material (wet/dry), etc.) are in accordance with design and post-installed rebar system being used.

i) Identification of Suitable Installation Location

Identify position of reinforcing steel and other embedded items prior to drilling holes for rebar using rebar scanning tools. Exercise care in coring or drilling to avoid damaging existing reinforcing or embedded items. Notify the Engineer if reinforcing steel or other embedded items are encountered during drilling. Take precautions as necessary to avoid damaging prestressing tendons, electrical and telecommunications conduit, and gas lines. Location suitable for rebar installation should be marked.

j) Drilling of Hole for Rebar Installation

i) Drilled Holes: Drill holes with rotary impact hammer drills using carbide-tipped bits, hollow drill bit system and/or core drills using diamond core bits, as applicable. Drill bits shall be of diameters as specified by the anchor manufacturer. Unless otherwise shown on the drawings, all holes shall be drilled perpendicular to the concrete surface. Hole if drilled unnecessarily should be filled with a non-shrink grout of suitable compressive strength.

ii) Cored Holes: Where rebar is permitted to be installed in cored holes, use core bits with matched tolerances as specified by the manufacturer. Properly clean cored hole per manufacturer’s instructions. It is recommended to use roughening tool like TE-YRT in case of diamond cored holes.

k) Cleaning of Drilled Hole for Rebar Installation
Clean holes in accordance with manufacturer instructions. In case, hollow drill bit is used, this step may be skipped [Check installation instruction]

**l) Installation of Post-installed Rebar**
Perform rebar installation in accordance with manufacturer instructions.
- Clean all holes per manufacturer instructions to remove loose material and drilling dust prior to installation of adhesive or use a hollow drilling & vacuum cleaning system
- Inject adhesive into holes proceeding from the bottom of the hole and progressing toward the surface in such a manner as to avoid introduction of air pockets in the adhesive. Fill 2/3rd of the drilled hole
- Follow manufacturer recommendations to ensure proper mixing of adhesive components.
- Sufficient adhesive shall be injected in the hole to ensure that the annular gap is filled to the surface. Use of piston plug is recommended for ensuring injection of adhesive without air pockets.
- Insert rebar as instructed by manufacturer.
- Remove excess adhesive from the surface.
- Do not disturb installed rebar before manufacturer specified cure time has elapsed.
- Observe manufacturer recommendations with respect to installation temperatures for cartridge injection adhesive systems.

**m) TESTING / QUALITY ASSURANCE:**

a. Delivery, Storage and Handling

Store post-installed rebar adhesive system in accordance with manufacturer's recommendations.

b. Installation Quality Test:

These tests shall be performed to validate the load carrying capacity of installed rebar. 1% or 20 nos of each type (whichever is minimum) and size of post-installed rebar shall be proof loaded by either manufacturer of post-installed rebar or an independent testing laboratory.

i) Tension testing should be performed in accordance with ETAG001

ii) Proof loads shall be applied with a calibrated hydraulic ram.

iii) Minimum rebar embedments, proof loads etc. shall be as shown on the drawings/manufacturer installation instruction.

iv) Documentation:

For each test, the following information shall be recorded and submitted:
- Type of post-installed rebar system
- Testing equipment
- Location and installation records
- Applied testing loads and load-displacement record
- Interpretation and suggested action for failed pull out test.

c. Installation Record

The documentation for installation shall as a minimum include installer firm details, test location, post-installed rebar detail (embedment, diameter, make etc.), installation supervisor details, rebar orientation, load and orientation information, test equipment information, test date, test result and number of tests.

d. Working Hours
Work will be continuous (i.e. 24 hours per day)

e. Environment

Attention to be observed during the drilling & installation process so as that no adhesive mixtures contaminate the surrounding water.

f. Health And Safety Plan

All relevant aspects of site Safety, Health and Environment will be complied with as well as required measures outlined in the Risk and Hazard Assessment.

g. Safety Measures

All relevant aspects of Management Procedure will be complied with as well as required measures outlined in the Risk and Hazard Assessment.

i. Personal Safety

Each member of the operating team has a shared responsibility for making sure that all necessary safety equipment is carried and is correctly used in appropriate circumstances.

ii. Personal Protective Equipment (PPE)

All persons engaged in operations will be provided and should wear with appropriate Personal Protective Equipment i.e. Safety helmet, Safety googles, Safety footwear, Safety Gloves, High visibility vests, Masks etc.

iii) Competent Personnel

Only competent operators will be engaged for operation of the main equipment.

iv) Machinery Inspection & Maintenance

Lighting

Good lighting system will be provided inside the tunnel and around the works area during the night shift.

15 PASSIVE FIRE PROTECTION/FIRE STOP

1.0 PURPOSE

This document is intended to restore integrity of breached fire rated wall/floors in the buildings. Fire stop assembly are used to restore integrity of breached fire stop walls/floors. These breaches may be created due to passage of service utilities, joints etc. Fire stop is a fire-resistant material, or construction, having a fire resistance rating of not less than the fire separating elements, installed in concealed spaces or between structural elements of a building to prevent the spread/propagation of fire and smoke through walls, ceilings.

Fire stop assembly for through penetrations is a combination of fire stop compatible for use with the penetrant, penetration items such as cables, cable trays, conduits, ducts, pipes etc, and their means of support through the wall or opening that together restores the fire resistance rating of the fire separating elements in terms of its integrity and/or insulation.
properties. The selected system should be capable of accommodating anticipated movement (if any) in service.

Fire stop assembly for joints is the one where fire stop with movement capability is used to seal the linear joints between adjacent fire separating elements, which should be installed within its tested design limits with regard to size of joint, type of assembly, and anticipated compression and extension of the joint.

Fire stop systems shall be used in locations including, but not limited to, the following

2.0 SCOPe

This method statement describes a proper work procedure that shall be followed for firestopping applications as per site requirement, specification(s) and contract drawing(s). The scope of work covers:
(a) Penetrations for the passage of duct, cable, cable tray, conduit, piping, electrical busways and raceways through fire-rated vertical barriers (walls and partitions), horizontal barriers (floor/ceiling assemblies), and vertical service shaft walls and partitions
(b) Gap between edge-of-floor slabs and curtain walls
(c) Openings/joints between structurally separate sections of fire rated wall or floors
(d) Gaps between the top-of-walls and ceilings or roof assemblies
(e) Openings and penetrations in fire-rated partitions or walls containing fire doors
(f) Openings around structural members which penetrate floors or walls
The aspects covered in the scope of work are as follows:-
(a) Identification of breaches in fire rated walls/floors that need to be firestopped as per fire plan or site requirement.
(b) Identification and procurement of appropriate firestop assembly as per requirement of site, fire plan, specification(s) and/or contract drawing(s).
(c) Surface preparation as per requirement and installation of firestop assembly according to manufacturer’s instructions.
(d) Inspection and documentation of firestop assembly

3.0 Codes, Standards & References

The following codes, standards and documents have been referred to.

(a) NBC 2016, “National Building Code 2016”
(b) IS 12458, “Method of test of firestop”
(c) ASTM E 814, “Standard Method of Fire Tests of Through Penetration Firestops”
(d) UL 1479, “Fire Tests of Through Penetration Firestops”
(l) ASTM E 2174, “Standard Practice for On-site Inspection of Installed Firestops”

Definitions & Abbreviations:

(a) Through Penetration - A breach in both sides of a floor, floor-ceiling or wall assembly to accommodate an item passing through the breaches.
(b) Firestop System - A breach in both sides of a floor, floor-ceiling or wall assembly to accommodate an item passing through the breaches.
(c) Fire Compartment - A space within a building that is enclosed by fire barrier or fire resistant walls on all sides, including the top and bottom.

4.0 Technical Specification / Performance Requirement

4.1 Basic Requirement

d) Provide through penetration / joint firestop systems that comply with specified requirements of qualified tested systems as per design requirements.
e) Proposed firestop materials and methods shall conform to the National Building Code 2016 and applicable codes/laws.

f) Firestop system installation for through penetration must meet requirements of IS 12458, ASTM E 814 or UL 1479 tested assemblies that provide a fire rating equal to that of construction being penetrated.

g) Firestop system installation for joints in or between fire rated construction must meet requirements of ASTM E 1966 or UL 2079 tested assemblies that provide a fire rating not less than the fire resistance rating of the construction they will join.

h) Firestop system installation for joints at exterior curtain wall / floor constructions must meet requirements of ASTM E 2307 tested assemblies that provide a fire rating not less than the fire resistance rating of the construction they will join.

i) All the shaft openings shall be sealed by using Fire rated material of atleast 2 hours rating. All the Firestop product shall be age tested as per Dafstb and DIBT standards.

j) All the firestop product shall carry test certificate for mold resistance rating of 0 as determined by ASTM G21-96. The product shall be UL listed & classified and shall bear the UL approval logo on the packing. The UL tested system certificate or Engineering Judgements to be submitted based on actual application at site. Wherever repentration of electric cables or penetrators are required in future only preformed firestop systems like firestop speed sleeve or firestop blocks shall be used. All such firestop devices and blocks shall be movement tested with class A rating.

k) The concerned authorities should do the quantification of firestop requirement during concept /design phase. This should be checked and revised if necessary during execution phase.

l) Firestop systems do not re-establish the structural integrity of load bearing partitions/assemblies, or support live loads and traffic. Installer shall consult the structural engineer prior to penetrating any load bearing assembly.

m) For those firestop applications that exist for which no qualified tested system is available through a manufacturer, an engineering judgement derived from similar qualified tested system designs or other tests will be required to be submitted for review and approval prior to installation. Engineering judgement documents must follow requirements set forth by the International Firestop Council.

4.2 Performance Requirement

(a) Provide firestopping composed of components that are compatible with each other, the substrates forming openings, and the items, if any, penetrating the firestopping under conditions of service and application, as demonstrated by the firestopping manufacturer based on testing and field experience.

(b) Provide components for each firestopping system that are needed to install fill material. Use only components specified by the firestopping manufacturer and approved by the qualified testing agency for the designated fire-resistance-rated systems. Note that the fire rating corresponds to a firestop assembly; a firestop product does not have a fire rating.

(c) For penetrations in Fire-Resistance Rated Walls - Provide firestopping with ratings determined in accordance with UL 1479 or ASTM E 814. The F-Rating of the system should not be less than the fire-resistance rating of the wall construction being penetrated (refer NBC 2016).

(d) For penetrations in Horizontal Assemblies: Provide firestopping with ratings determined in accordance with UL 1479 or ASTM E 814. The F-Rating of the system should not be less than
the fire-resistance rating of the floor construction being penetrated (refer NBC 2016). In addition, system with T Rating (Optional) may be provided as per requirement.

(e) Firestopping materials are either “cast-in-place” (integral with concrete placement) or “post installed.” Provide cast-in-place firestop devices prior to concrete placement.

(f) For joints in or between Fire Rated Construction: Provide joint firestopping systems with ratings determined per UL 2079 or ASTM E 1966. F-Rating should not be less than the fire-resistance rating of the construction they will join.

(g) For joints at exterior curtain wall / floor intersections: Provide joint firestopping systems with ratings determined per ASTM E 2307. F-Rating should not be less than the fire-resistance rating of the construction they will join.

(h) All the firestop systems and joint systems shall have ageing resistance test completed for ensuring its performance for 30 years’ duration.

(i) Depending on the requirement, the following performance parameters should also be considered for selection (if applicable):

   i. Mold resistance
   ii. Air tightness for providing control of flow of smoke and toxic gases, infection control, energy saving, Pressure (+/-) control
   iii. Sound attenuation/ Acoustic
   iv. Movement as per ASTM E3037 for through penetrations and ASTM E1399 for joints
   v. LEED criteria

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<tr>
<th>Application</th>
<th>Reference pictures</th>
<th>Penetrants/Type of Opening</th>
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<tr>
<td>Through Penetration Fire Stop System – Electrical Opening</td>
<td><img src="image1" alt="Reference picture" /></td>
<td>Electrical Cable Tray Etc.</td>
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<tr>
<td>Through Penetration Fire Stop System - Mechanical / Plumbing Opening</td>
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<td>Mechanical / Plumbing/ Fire Fighting Pipes Etc.</td>
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<td>Cable Coating</td>
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<tr>
<td>Electrical Cables Etc.</td>
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1.0 Materials

(a) For through penetrations, use only firestop systems that have been IS 12458, UL 1479 or ASTM E 814 tested for specific fire-rated construction conditions conforming to construction assembly type, penetrating item type, annular space requirements and fire-rating for each separate assembly. For joints in or between fire rated construction use only systems that have been ASTM E 1966 or UL 2079 tested. For joints at exterior curtain wall / floor constructions, use only firestop systems that have been ASTM E 2307 tested.

(b) For factory assembled firestop devices for use with noncombustible and combustible pipes, conduit and/or cable bundles penetrating concrete floors, the following products are acceptable:
   i. Firestop Speed Sleeve for use with cable penetrations
   ii. Firestop Block
   iii. Cast-in device for plastic pipes
   iv. Cast-in device for metal pipes

(c) For sealants or foams for use with non-combustible items including steel pipe, copper pipe, rigid steel conduit and electrical metallic tubing (EMT), the following products are acceptable:
   i. Intumescent Firestop Sealant
   ii. Fire Foam
   iii. Flexible Firestop Sealant
   iv. cast-in device for plastic pipes
   v. cast-in device for metal pipes

(d) For sealants materials for use with sheet metal ducts, the following products are acceptable:
   i. Flexible Firestop Acrylic Sealant

(e) For intumescent sealants for use with combustible items (penetrants consumed by high heat and flame) including insulated metal pipe, PVC jacketed, flexible cable, Duct or cable bundles and plastic pipe, the following products are acceptable:
   i. Intumescent Firestop Sealant
   ii. Wrap
   iii. Collar

(f) For foams, intumescent sealants materials for use with flexible cable or cable bundles, the following products are acceptable:
(g) For wall opening protective materials for use with UL listed metallic and specified nonmetallic outlet boxes, the following products are acceptable:
   i. Firestop Putty Pad
   ii. Firestop Putty Pad

(h) For firestop collar or wrap devices attached to an assembly around combustible plastic pipe (closed and open piping systems), the following products are acceptable:
   i. Firestop Collar
   ii. Wrap Strips

(i) For materials used for large openings and complex penetrations made to accommodate cable trays and bundles, multiple steel and copper pipes or electrical busways in raceways, the following products are acceptable:
   i. Composite Sheet
   ii. Firestop Block
   iii. Firestop Mortar
   iv. Fire Foam

(j) For re-penetrable, round cable management devices for use with new or existing cable bundles penetrating gypsum or masonry walls, the following products are acceptable:
   i. Firestop Speed Sleeve with integrated smoke seal fabric membrane

(k) For Joints applications like top of wall joints, Dry wall joints the following products are acceptable
   i. Acrylic sealant

(l) For Fire rated expansion joint application or higher movement joints applications following products are acceptable
   i) Silicone sealant

(m) For Glass façade application, edge of slab application: to seal gap between glass façade assembly and edge of slab only following product is acceptable
   ii) Water based acrylic spray

Technical specification text for all products is attached for reference.

6.0 Execution
6.1 Installer Qualifications

(a) The work of installation of through penetration firestop and fire-resistive joint systems in the project should be assigned to a single sole source firestop specialty contractor. An experienced installer who is certified, licensed, or otherwise qualified by the firestopping manufacturer as having been provided the necessary training to install manufacturer’s products per specified requirements should be engaged.

(b) The specialty contractor should have at least one of the following qualifications:
   i. Accredited Firestop Specialty Contractor
   ii. UL Approved Contractor
   iii. FM 4991 Trained Contractor

(c) The specialty contractor engaged should have more than 1-years’ experience in firestop installation.
6.2 Preparation

(a) Verify penetrations are properly sized and in suitable condition/position for application of materials.
(b) Surfaces to which firestop materials will be applied shall be free of dirt, grease, oil, rust, laitance, release agents, water repellents, and any other substances that may affect proper adhesion.
(c) Provide masking and temporary covering to prevent soiling of adjacent surfaces by firestopping materials.
(d) Comply with manufacturer’s recommendations for temperature and humidity conditions before, during and after installation of firestopping.

6.3 Coordination

(a) Coordinate construction of openings, penetrations and construction joints to ensure that the firestop systems are installed according to specified requirements.
(b) Coordinate sizing of sleeves, openings, core-drilled holes, or cut openings to accommodate through penetration firestop systems. Coordinate construction and sizing of joints to ensure that fire-resistant joint systems are installed according to specified requirements.
(c) Coordinate to ensure that obstructions are not placed in the way prior to the installation of the firestop systems.
(d) Do not cover up through penetration firestop installations that will become concealed behind other construction until each installation has been inspected.

6.4 Installation

(a) Install firestop assembly in accordance with its design limits as indicated in test report or listing or engineering judgement by competent and qualified personnel.
(b) Comply with manufacturer’s instructions and/or UL listing for installation of all firestop assembly.
(c) Installation should be carried out by experienced and trained installer as required by section 5.1.
(d) Consult with relevant stakeholders to ensure that the firestop installation will perform.

7.0 QUALITY ASSURANCE

The work shall be inspected and tested in accordance with laid down inspection procedure. The conformance report sheet shall be used to verify compliance of the work.

7.1 DELIVERY STORAGE AND HANDLING

(a) Deliver materials undamaged in manufacturers clearly labeled, unopened containers, identified with brand, type and UL label where applicable.
(b) Coordinate delivery of materials with scheduled installation date to allow minimum storage time at job-site.
(c) Store materials under cover and protect from weather and damage in compliance with manufacturer’s requirements, including temperature restrictions.
(d) Comply with recommended procedures, precautions or remedies described in safety data sheets as applicable.
7.2 FIELD QUALITY CONTROL

(a) Examine sealed penetration areas/joints to ensure proper installation before concealing or enclosing areas.
(b) Keep areas of work accessible until inspection by applicable authorities concerned is completed.
(c) Inspection of through penetration firestopping shall be performed in accordance with ASTM E 2174, “Standard Practice for On-Site Inspection of Installed Firestops” or other recognized standard or available guidelines.
(d) In case of destructive inspection, perform patching and repairing of firestopping caused by cutting or penetrating of already installed firestop systems.
(e) During installation periodic inspections shall be provided to assure proper installation/application. After installation is complete, findings shall be submitted in writing.

7.3 IDENTIFICATION AND DOCUMENTATION

The documentation shall as a minimum include:

(a) Schedule of Firestopping i.e. list each type of penetration/joint, fire rating of the penetrated assembly/joint, and firestopping test or design number.
(b) Product Data: Provide data on product characteristics, performance ratings, and limitations.
(c) Qualification statements for installer.

7.3.1 Submittal by manufacturer

(a) Product Data: Manufacturer’s specifications and technical data for each material including the composition and limitations, documentation of qualified firestop systems to be used, documentation for other design considerations (see section 6.2) and manufacturer’s installation instructions.
(b) Engineering judgment: Manufacturer’s engineering judgment identification number and drawing details when no qualified tested system is available for an application. Engineering judgment must include both project name and contractor’s name who will install firestop system as described in document.
(c) Safety data sheet: Submit safety data sheets provided with product delivered to job-site.

7.3.2 Submittal by contractor / firestop applicator

A. The firestop contractor is to supply documentation for each single application addressed. This documentation is to identify each penetration and joint location on the entire project.

A.1 The Documentation form for through penetrations is to include:

1. A sequential location number
2. The project name
3. Date of installation
4. Detailed description of the penetration’s location
5. Tested system or engineered judgment number
6. Type of assembly penetrated
7. A detailed description of the size and type of penetrating item
8. Size of opening
9. Number of sides of assemblies addressed
10. Hourly rating to be achieved
11. Installer’s name
12. Each application must have picture before & after installation.

A.2 The Documentation form construction joints is to include:
   1. A sequential location number
   2. The project name
   3. Date of installation
   4. Detailed description of the construction joint’s location
   5. Tested system or engineered judgment number
   6. Type of construction joint
   7. The width of the joint
   8. The lineal footage of the joint
   9. Number of sides addressed
   10. Hourly rating to be achieved
   11. Installer’s name

Copies of these documents are to be provided to the general contractor at the completion of the project.

C. Identify through penetration firestop systems with labels. Attach labels permanently to surfaces of penetrated construction on both sides of each firestop system installation where labels will be visible to anyone seeking to remove penetrating items or firestop systems. Labels are not necessary for joints but may be provided as per requirement. Include the following information on labels:
   i. Date of installation.
   ii. Product name
   iii. Checked by
   iv. Installer’s name
   v. Contact no. of installer

D. A firestop documentation manager software shall be used to document, track, and maintain the passive firestop systems throughout the construction and maintenance phase of the project. The software solution shall be used to track and document every firestop system installed on the project and each subsequent addition, change, or removal of the firestop system. The documented data will be saved in one of the most reliable cloud-server which allows the installer to use a standard smartphone or tablet device (only Android) to capture the relevant installation pictures (pre-installed and post-installed) and the related data. The following data shall be tracked for each penetration within the facility: product installed, system installed, date of installation, location of the penetration including a notation on the 2D plan image, F-rating, name of installer, photo (pre-installation and post-installation) and inspection status. The owner and/or construction manager may designate additional items to be tracked. The firestop documentation manager software must perform the following basic functions:

1. Create multiple projects/facilities, add/create/remove users for each project, upload documents including UL tested systems, 2D floor plans, product data, engineering judgments, etc.
2. Define data to track using pre-defined input fields or creating custom input fields as desired.
3. Capture multiple photos for each penetration including a pre-installation and post-installation photo.
4. Scan QR Code on identification label to link the program data to a specific penetration location.
5. Annotate (mark) location of penetration on 2D floor plan.
6. Create reports by filtering data and utilizing report templates.
7. Online/offline (for use in areas where data service is unavailable) synchronization of data between mobile device, online application and cloud-based system
8. Ability to transfer ownership of projects from one customer to another from construction phase to facility maintenance
   Permanently attach identification labels to surfaces adjacent to and within 6 inches (150 mm) of firestopping edge so labels will be visible to anyone seeking to remove or change penetrating items or firestopping. Labels shall have a unique QR code for each penetration which can be scanned by the firestop documentation software to quickly identify the penetration attributes.

Acceptable Software: Documentation Software CFS-DM,

Substitutions: Not permitted.

Single Source: Obtain firestop documentation manager software and firestop systems for each type of penetration and construction condition indicated only from a single manufacturer.

16 BASEMENT WATERPROOFING

Scope of Work -

Providing and Laying 1.5 mm thick EPDM membrane based Waterproofing of Basement Raft Slab and Retaining Wall

The specified waterproofing is meant for the water tightness of covering the horizontal & the vertical surface of the Basement. The non-reinforced EPDM membrane should meets or exceeds the minimum requirements set forth by ASTM D4637 for Type I non-reinforced EPDM single-ply roofing, UL 2218 Class 4 Rating, and with Wide array of design choices that are UL and FM approved standard. The membrane should have British Board Of Agreement [BBA] for Non-Reinforced EPDM Underground Waterproofing Systems Schematic diagram of the waterproofing system is attached.

Product Specification

1.52mm thick non-reinforced black EPDM membrane specially formulated (Ethylene, Propylene, Diene Terpolymer) membrane with minimum Roll size of 20’ x 100’ ft or
nearest available with factory applied Secur Tape only on one side of the membrane. Membrane shall be able to resist 40mtr. head pressure, with tensile strength of > 11.0 mpa, elongation > 465% and Tear resistance to ASTM D624, Die C dimensional change< - 0.7%. 100% UV resistance, Ozone resistance according to ASTM D1149

<table>
<thead>
<tr>
<th>Physical Property</th>
<th>Result</th>
<th>Test Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thickness (mm)</td>
<td>1.5</td>
<td>ASTM D412</td>
</tr>
<tr>
<td>Specific Weight (kg/m2)</td>
<td>1.9</td>
<td>ASTM D412</td>
</tr>
<tr>
<td>Tensile strength (MPa)</td>
<td>11</td>
<td>ASTM D412</td>
</tr>
<tr>
<td>Elongation Ultimate, min (%)</td>
<td>465</td>
<td>ASTM D412</td>
</tr>
<tr>
<td>Brittleness Temp. (°C)</td>
<td>-45</td>
<td>ASTM D746</td>
</tr>
<tr>
<td>Factory Seam Strength, min</td>
<td>Membrane Rapture</td>
<td></td>
</tr>
<tr>
<td>Tear Strength, min (kN/m)</td>
<td>45 kN/m</td>
<td>ASTM D624</td>
</tr>
<tr>
<td>Resistance to Ozone</td>
<td>No Cracks</td>
<td></td>
</tr>
<tr>
<td>Flexibility Torsion DMA</td>
<td>225 MPa @ -40°F</td>
<td>ASTM D5279-08</td>
</tr>
<tr>
<td>Resistance to Water Absorption</td>
<td>+2.0</td>
<td>ASTM D471</td>
</tr>
<tr>
<td>Water Vapour Permeance* Max, perms</td>
<td>0.3</td>
<td>ASTM E96</td>
</tr>
</tbody>
</table>

**Basement Waterproofing**

The work Basement shall be carried out as per manufacturer’s specifications and executed through authorized applicator by manufactures specialized agency approved by Engineer-in-Charge.

The PCC should be Clean, dry, free of sharp egdes, loose or foreign materials and in smooth condition is to be ensured before applying the EPDM membrane.

As separation layer of 200gsm Geotextile mesh Membrane should be loosely laid over the prepared PCC surface which is smooth & dry, with the adjacent over lap of 100 mm. Then over the Geotextile, 1.5mm thick Sure Seal non reinforced EPDM membrane with factory applied Secur tape of 75mm on one side (length wise) shall be loose laid without stretching. The size of the laid sheet should be as large as possible to minimize the number of joints. Adjacent Sheets shall be laid in a similar fashion with an overlap of 75mm. Minimum 300 mm of the membrane should be left extra throughout outside the PCC area to make an overlap of Horizontal and vertical membrane to the make the building 100% watertight.

The EPDM membrane shall be covered by separation layer of 200 gsm Geotextile mesh Membrane and further protected with a protection screed of minimum 50mm thickness (minimum M10 grade) is poured to protect damage of Sure Seal EPDM against reinforcement bars and site traffic. The area of the membrane laid at any one time should not exceed that which can be protected by screed in the same period. Care should be exercised in the
sequence of laying screed to ensure that the membrane laid is not damaged due to site traffic or other trade works or any other reason.

Apply Bonding Adhesive on the RCC retaining wall as well as on the 4.5 mil EPDM membrane to make fully adhere to RCC wall. Allow the adhesive to dry until it is tacky but will not string or stick to a dry finger. The membrane shall then be rolled on the coated substrate avoiding any wrinkles. The size of the laid sheet should be as large as possible to minimize the number of joints. Adjoining membrane sheets shall be similarly installed with overlapping edges of 75 mm using secure tape and using HP 250 primer on both surfaces. Adhesives should not be applied to these splice areas. The adjacent sheets also should have 75mm overlap. Vertical section should be extended min. 300mm above or at the ground level. The vertical edge should be filled with Water Cut of Mastic sealant and terminated with Aluminium termination bar and fasteners. The gap between the fasteners shall be 300mm. The termination bar edge shall be filled with Lap sealant.

Protecting the EPDM Membrane while back filling with Protection Layer which is HDPE Protection Board, spot bonded to the EPDM membrane with compatible adhesive. The HDPE drainage board shall be fixed above the waterproofing layer at a distance of 100mm. This HDPE layer will act as sacrificial layer.

Once the waterproofing treatment has been finished there should be no activity which may damage the treatment. The back fill soil should be free from any sharp stones or Boulders. While the compaction of back filling soil the pressure should not bring the membrane down.

Membranes Over Lapping:

The edge lap of rolls carry a pre applied factory tape of 75mm at the one side of the rolls length wise. After placing the second roll without the factory applied tape side and apply HP 250 primer for 75 mm along the length of the roll using long rug back and forth scrubbing strokes, parallel to the seam along the length of the splicing area, until the surface becomes dark grey in colour and become tacky. Now release the PE film from the tape, first fold back the top sheet and peel the PE Film off the Splice Tape, by pulling it away from the seam at a 90° angle to the tape. Pull the PE Film at a steady pace and keep it low to the roof surface as it is removed to reduce air pockets. Mate the entire length of the seam by hand, when the release PE Film is being removed.

Roll the seam with a 50 mm wide silicone rubber hand roller, both across the seam and along its entire length above both edges of the tape.

Membrane Termination:

Keep a minimum space of 5 mm between two adjoining bars. The termination bar must be installed directly to the wall surface, not to existing flashings, sheet metal, etc. Pre-drill holes into the brick, masonry or concrete and not into the soft mortar joint. A Termination Bar must be cut at inside and outside corners. Do not bend the bar around the corners. Prior to installation of the Termination Bar, pull back the topside of the membrane flashing 20 mm and apply a bead of Water Cut off mastic between the membrane and the wall.
Install the Termination Bar with an acceptable hammer plug system at 300 mm o.c. A continuous compression is required and may need additional fastening. Each Termination Bar must be fastened a maximum of 25 mm from the end. Apply a bead of Lap Sealant on the topside of the bar. At all locations where base flashings end, install the Termination Bar vertically. Apply Lap Sealant to both sides of the bar.

17 **STP TANK WATERPROOFING (ON THE INTERNAL SIDE)**

1 **SCOPE**

The scope of work covers supply, application, testing and guarantee waterproofing system for STP tank (On Internal Side)

2 **GENERAL**

2.1 Quality assurance

All products shall meet the key performance properties listed below against each and shall be sourced from a manufacturer with a certified QA system such as, ISO 9001 or an established and proven QA system that has ensured consistent products.

2.2 Approved sources:

All products in the specified system shall be sourced from a single manufacturer, from amongst the list of approved products and sources for each.

2.3 Installation:

All the products/systems shall be installed by a Specialist Applicator approved by the manufacturer strictly in accordance to the written application guide by the manufacturer and as approved by the Engineer-in-Charge.

2.4 Multiple sources and compatibility:

Should the Specialist Applicator or the Contractor want products from different sources, they shall submit proof of compatibility between the products of different sources.

2.5 Alternate equivalents:

Should the Specialist Applicator or Contractor prefer to use alternative equivalent product(s) to the approved list, it can only be after obtaining a written approval by the Engineer-in-Charge.

2.6 Substrate preparation:

Before starting to install the specified waterproofing system, the substrate shall jointly be inspected by the Contractor and the Specialist Applicator for soundness; any defects shall first be repaired utilising products and systems compatible with the specified waterproofing system.

2.7 Submittals

i) Product Data: Include manufacturer’s written instructions for evaluating, preparing and treating substrate, technical data and tested physical and performance properties of waterproofing.

ii) Shop Drawings: Show locations and extent of waterproofing. Include details for substrate joints and cracks, sheet flashings, penetrations, inside and outside corners, tie-ins with adjoining waterproofing and other termination conditions.

a) Include setting drawings showing layout, sizes, sections, profiles, and joint details.

b) Samples : For the following products:

a) 300 x 300 mm square of waterproofing including all material components
iii) Installer Certificates: Signed by manufacturers certifying that installers comply with requirements.

v) Qualification Data: For Installer

vi) Product Test Reports: Based on evaluation of comprehensive tests performed by a qualified testing agency.

vii) Warranties: Special warranties / guarantees specified in this Section.

2.8 Delivery, Storage and Handling

a) Deliver materials to Project site in original packages with seals unbroken labeled with manufacturer’s name, product brand name and type, date of manufacture and directions for storing and mixing with other components.

b) Store rolls according to manufacturer’s written instructions.

c) Protect stored materials from weather conditions

3.0 THE WATERPROOFING SYSTEM

The specified waterproofing system for the STP Tank for vertical & horizontal surface; each generic product specified shall meet the key performance properties mentioned below:

Waterproofing system for Horizontal and Vertical Surface

Apply 3 coats of two component acrylic modified cementitious coating applied by brush, roller or trowel to waterproof and resurface concrete, surface.

Pitch Epoxy Coating

The high – build pitch epoxy coating shall be of a two component, solvent free, pitch extended epoxy resin system to provide a high build coating that protects concrete and metal substrates from a wide range of aggressive chemicals. It shall be applied using short nap roller, shorthaired brushes or by airless spray on Concrete substrate

The High build, pitch extended epoxy coating shall be 100% solids, solvent free, tough abrasion resistant protective coating. The product shall exhibit excellent bond strength with the substrate at least exceeding 2.5 MPa, when tested as per ASTM D4541. The product shall be formulated to have high build thickness exceeding 150 microns per coat on average and shall be applied to achieve overall thickness of 300 microns in two coats. The product shall be formulated to resist exposure to accelerated weathering test as per ASTM D4587 and shall not exhibit any flaking or blistering.

4.0 KEY PERFORMANCE PROPERTIES OF THE SPECIFIED PRODUCTS

4.1 Waterproofing System for Horizontal & Vertical Surface

All exposed concrete surfaces shall be prepared and are to be coated with two component reactive polymer composite. The product shall be applied in minimum two coats @ 3.9 Kg/m² to achieve total DFT of 2mm.

<table>
<thead>
<tr>
<th>Sr No</th>
<th>Properties</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Mixed Density</td>
<td>1940 kg/m³</td>
</tr>
<tr>
<td>2</td>
<td>Mixing Ratio , by weight</td>
<td>3:1 (powder: Liquid)</td>
</tr>
<tr>
<td>3</td>
<td>VOC Content</td>
<td>0.5 g/L (HK prod code P10-17)</td>
</tr>
<tr>
<td>4</td>
<td>Elongation %</td>
<td>&gt; 5% (Unbonded)</td>
</tr>
<tr>
<td>5</td>
<td>Water</td>
<td>7 bars - no leakage (at 2mm DFT)</td>
</tr>
</tbody>
</table>
penetration (DIN 1048)

The horizontal protection over the waterproofing coating shall be minimum 50 mm thick screed mixed with approved Waterproofing Compound.
The vertical protection over the waterproofing coating shall be with 15 mm thick plaster mixed with approved Waterproofing Compound.

5.0 TREATMENT FOR CUT OUTS
The Cut Out Treatment shall be done by applying one layer of swelling polymeric paste on the external periphery of the PVC sleeve and sealing the cut out with ready to use approved Dual shrinkage compensated micro concrete or with approved Dual Shrinkage Compensated Mortar.
The properties of Swellable polymeric paste that shall be applied on external periphery of PVC sleeve are as below:

<table>
<thead>
<tr>
<th>Sr No</th>
<th>Properties</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Base</td>
<td>Hydro swelling polymeric paste</td>
</tr>
<tr>
<td>2</td>
<td>Mix Density</td>
<td>1.5 Kg/ Litre</td>
</tr>
<tr>
<td>3</td>
<td>Re-swelling capacity</td>
<td>&gt; 80% in potable water</td>
</tr>
<tr>
<td>4</td>
<td>Setting time</td>
<td>5 – 6 Hours</td>
</tr>
</tbody>
</table>

The sealing of cut out shall be done using Dual Shrinkage Compensated free flow Micro Concrete having the following Physical Properties.

<table>
<thead>
<tr>
<th>Sr No</th>
<th>Properties</th>
<th>Test Method</th>
<th>Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Fresh Wet Density</td>
<td>ASTM C 109, 7mm cube</td>
<td>15 MPa at 1 Day</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>25 MPa at 3 Days</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>35 MPa at 7 Days</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>40 MPa at 28 Days</td>
</tr>
<tr>
<td>2</td>
<td>Compressive Strength</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Water/Powder Ratio by Weight</td>
<td>0.14</td>
<td></td>
</tr>
</tbody>
</table>

6 TREATMENT FOR CRACK & JOINTS
Cracks and construction joint shall be treated with special re-swellable resin through nin – returnable. The property of metha-acrylate re-swellable resin used for injecting for treating construction joints and cracks as below:

<table>
<thead>
<tr>
<th>Sr No</th>
<th>Properties</th>
<th>Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Chemical Base</td>
<td>Acrylate Polymer</td>
</tr>
<tr>
<td>2</td>
<td>Mixed Density</td>
<td>1.065 Kg/Ltr</td>
</tr>
<tr>
<td>3</td>
<td>Viscosity</td>
<td>&lt; 40 CPS @ 20º C</td>
</tr>
<tr>
<td>4</td>
<td>Setting time</td>
<td>1-2 Hours</td>
</tr>
</tbody>
</table>

7 POTABLE GRADE EPOXY LINING

The potable grade epoxy coating shall have the following physical properties.

<table>
<thead>
<tr>
<th>Sr No</th>
<th>Properties</th>
<th>Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Base</td>
<td>Water Base</td>
</tr>
<tr>
<td>2</td>
<td>Volume Solids</td>
<td>65 + 3%</td>
</tr>
<tr>
<td>3</td>
<td>Density</td>
<td>1.25 Kg/ Ltr</td>
</tr>
<tr>
<td>4</td>
<td>Pot Life</td>
<td>50 min at 20ºC</td>
</tr>
<tr>
<td></td>
<td></td>
<td>25 min at 40ºC</td>
</tr>
</tbody>
</table>

18 WATERPROOFING OF UNDER GROUND WATER STORAGE TANKS ON THE INTERNAL SIDE

1.0 SCOPE

This specification covers the waterproofing system for underground water tank (On Internal Side).

2.0 GENERAL

Quality assurance:
All products shall meet the key performance properties listed in Section A against each and shall be sourced from a manufacturer with a certified QA system such as, ISO 9001 or an established and proven QA system that has ensured consistent products.
Approved sources:
All products in the specified system shall be sourced from a single manufacturer, from amongst the list of approved products and sources for each in Section B.
Installation:
All the products/systems shall be installed by a Specialist Applicator approved by the manufacturer strictly in accordance to the written application guide by the manufacturer and as approved by the Engineer-in-Charge.
Multiple sources and compatibility:
Should the Specialist Applicator or the Contractor want products from different sources, they shall submit proof of compatibility between the products of different sources.
Alternate equivalents:
Should the Specialist Applicator or Contractor prefer to use alternative equivalent product(s) to the approved list, it can only be after obtaining a written approval by the Engineer-in-Charge.
Substrate preparation:
Before starting to install the specified waterproofing system, the substrate shall jointly be inspected by the Contractor and the Specialist Applicator for soundness; any defects shall first be repaired utilising products and systems compatible with the specified waterproofing system.

Submittals
Product Data: Include manufacturer’s written instructions for evaluating, preparing and treating substrate, technical data and tested physical and performance properties of waterproofing.
Shop Drawings: Show locations and extent of waterproofing. Include details for substrate joints and cracks, sheet flashings, penetrations, inside and outside corners, tie-ins with adjoining waterproofing and other termination conditions.
Include setting drawings showing layout, sizes, sections, profiles, and joint details.
Samples: For the following products:

- 300 x 300 mm square of waterproofing system including all material components
- Installer Certificates: Signed by manufacturers certifying that installers comply with requirements.
- Qualification Data: For Installer
- Product Test Reports: Based on evaluation of comprehensive tests performed by a qualified testing agency.
- Warranties: Special warranties / guarantees specified in this Section.
- Delivery, Storage and Handling
Deliver materials to Project site in original packages with seals unbroken labeled with manufacturer’s name, product brand name and type, date of manufacture and directions for storing and mixing with other components.
Store rolls according to manufacturer’s written instructions.
Protect stored materials from weather conditions

3.0 THE WATERPROOFING SYSTEM

The specified waterproofing system for the underground water tank for vertical & horizontal surface; each generic product specified shall meet the key performance properties mentioned below:

- Waterproofing system for Horizontal and Vertical Surface
  Applying 3 coats of approved two component acrylic modified cementitious coating applied by brush, roller or trowel to waterproof and resurface concrete, surface.
- Potable Grade Epoxy Coating
  The high–build, water based epoxy coating of two-component, water dispersed epoxy formulation. The product shall be of high-solids, not less than 65% by volume. The product shall be applied at 150 microns dry film thickness in two-three coats. The product shall exhibit adhesive bond strength to concrete of 1.5 Mpa minimum, when tested to ASTM D4541 test method.
  It provides a protective coating which is impermeable to liquids, abrasion resistant, prevent growth of bacteria and fungus and easy to clean.

4.0 KEY PERFORMANCE PROPERTIES OF THE SPECIFIED PRODUCTS

- Waterproofing System for Horizontal & Vertical Surface
All exposed concrete surfaces shall be prepared and are to be coated with two component reactive polymer composite. The product shall be applied in minimum two coats @ 3.9 Kg/m² to achieve total DFT of 2mm.

<table>
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<tr>
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<th>Properties</th>
<th>Results</th>
</tr>
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<tbody>
<tr>
<td>1</td>
<td>Mixed Density</td>
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<td>2</td>
<td>Mixing Ratio , by weight</td>
<td>3:1 (powder: Liquid)</td>
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<td>3</td>
<td>VOC Content</td>
<td>0.5 g/L (HK prod code P10-17)</td>
</tr>
<tr>
<td>4</td>
<td>Elongation %</td>
<td>&gt; 5% (Unbonded)</td>
</tr>
<tr>
<td>5</td>
<td>Water penetration (DIN 1048)</td>
<td>7 bars - no leakage (at 2mm DFT)</td>
</tr>
</tbody>
</table>

The horizontal protection over the waterproofing coating shall be minimum 50 mm thick screed mixed with approved water-proofing compound.

The vertical protection over the waterproofing coating shall be with 15 mm thick plaster mixed with approved water-proofing compound.

5 TREATMENT FOR CUT OUTS

The Cut Out Treatment shall be done by applying one layers of swelling polymeric paste on the external periphery of the PVC sleeve and sealing the cut out with ready to use approved dual shrinkage compensated micro concrete.

The properties of Swellable polymeric paste that shall be applied on external periphery of PVC sleeve are as below:-

<table>
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</tr>
<tr>
<td>4</td>
<td>Setting time</td>
<td>6 – 6 Hours</td>
</tr>
</tbody>
</table>

The sealing of cut out shall be done using Dual Shrinkage Compensated free flow Micro Concrete having the following Physical Properties

<table>
<thead>
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<th>Properties</th>
<th>Test Method</th>
<th>Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Fresh Wet Density</td>
<td>ASTM C 109, 7mm cube</td>
<td>2250 Kg/m³</td>
</tr>
<tr>
<td>2</td>
<td>Compressive Strength</td>
<td>15 MPa at 1 Day</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>25 MPa at 3 Days</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>35 MPa at 7 Days</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>40 MPa at 28 Days</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Water/Powder Ratio by Weight</td>
<td></td>
<td>0.14</td>
</tr>
</tbody>
</table>

6.0 TREATMENT FOR CRACK & JOINTS

Cracks and construction joint shall be treated with special re-swellable resin through nin – returnable The property of metha-acrylate re-swellable resin used for injecting for treating construction joints and cracks as below:-
### Sr. No | Properties | Values
--- | --- | ---
1 | Chemical Base | Acrylate Polymer
2 | Mixed Density | 1.065 Kg/Ltr
3 | Viscosity | < 40 CPS @ 20º C
4 | Setting time | 1-2 Hours

### 7.0 POTABLE GRADE EPOXY LINING

The potable grade epoxy coating shall have the following physical properties.

<table>
<thead>
<tr>
<th>Sr. No</th>
<th>Properties</th>
<th>Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Base</td>
<td>Water Base</td>
</tr>
<tr>
<td>2</td>
<td>Volume Solids</td>
<td>65 + 3%</td>
</tr>
<tr>
<td>3</td>
<td>Density</td>
<td>1.25 Kg/ Ltr</td>
</tr>
<tr>
<td>4</td>
<td>Pot Life</td>
<td>50 min at 20ºC 25 min at 40ºC</td>
</tr>
</tbody>
</table>

### 19 ALUMINIUM STANDING SEAM ROOFING SHEET

Design, Supply, Fabrication, erection & Installation of on-site manufactured single length PVDF 2 coated, Standing seam profile of approved make, double insulated STANDING SEAM, seam Al roofing system; of nominal 400 mm effective cover width with three micro ribs and standing seam height of 65mm. The panel shall be concealed fixed, mechanically seam for increased weather durability and greater resistance to wind uplift. The Build up of the roof shall consists of Top layer –Sheet of approved make 65/400 as suitable, STRAIGHT profiled sheeting manufactured from Aluminum Alloy AlMn1Mg1- as specified in BS EN 1396:2015 (comparable AA 3004), minimum material thickness of 0.9 mm and PVDF2 finish coated from approved paint suppliers PPG/BECKER / AKZONOBEL / VALSPAR. The external PVDF2 coating shall be of 23-25 microns thickness and shall have protective guard film to prevent scratches during roll forming & handling. Back coat shall be 5 microns primer coat.

The material properties are as follows:- Ultimate tensile strength: minimum 200 N/mm² 0.2% Proof Stress: minimum 185 N/mm² Modulus of elasticity:70,000 N/mm². Aluminum ST clips – in grade 6061- T6, of suitable height and Aluminum clips with thermal barrier pads to be fixed to the purlins with SS 304 screws only, and minimum 4 Nos per clip. Detailed structural calculations shall be provided by the manufacturer for the Clip Pull out force. Each aluminum clip shall come with a 5mm height black polyamide thermal barrier pad. Other relevant accessories such as Ridge closures and foam filler at ridge and eves, drip angle for water tightness, Gable end channels, Tolerance clips, gable end clips should be used wherever required etc.,

The standing seam sheet panel of approved make shall be fixed on to the purlin using extruded structural Aluminum clips. The head of clips shall be fixed accurately to ensure the roof sheeting to expands and contracts freely during thermal movement. The concealed clip and bottom panel profile sheet shall be fastened with min 4 no’s of Stainless steel fasteners approved make. The fasteners size shall be calculated as per the design. The supplier and shall have the necessary ISO 9001:2000, certification.

The rockwool insulation shall be 150 mm thick (laid in three layers of 50mm each) and density of 60kgs/m³ with thermal conductivity of K=0.038 W/mk at 20 degrees Celsius when tested to ASTM C518. A single layer film reinforced polyester yarn a six layer double sided
Vapor control barrier, consisting of lamination of pure aluminum foil, aluminum film and high quality kraft paper reinforced with polyester yarn, thickness of 180-200 microns thickness, with tensile strength of N/25 mm in the machine direction of 150-170 and Water Vapor Transmission tested as per ASTM F1249 @ 0.08 - 0.2 g/m2/day. Sub girt Top Hat and top hat bracket as required in 1.6 mm thick and 2mm thick Galvanized steel hat section. The Liner shall be Solid 35/200 Galvalume steel deck liner, 550 MPa, 0.5mm TCT 1000 mm total cover width 35mm deep ribs spanning up multiple spans. Purlin Spacing shall be advised by the roofing manufacturer for the wind loads mentioned below The finish to the exposed surface of the liner will be polyester coating with film thickness of 23µm +/- 2 µm.

The minimum U value of the build up considering thermal bridging shall be 0.31 W/m2 K and acoustical performance STC shall be of 39dB with a negative tolerance of -2dB. The measurement shall be based on finished/covered surface area. The rate shall include all other relevant accessories like, Ridge closures, gable end channels, tolerance clips, gable end clips, foam fillers etc. to be included as appropriate and wherever necessary. sealants etc. and work shall carried out by specialized agency. Vendor shall jointly work with the System Provider Company, Architect, Main Contractor & AAI to ensure a weather-tight solution at Expansion Joints, including if necessary, co-ordination with Siphonic Drainage System Provider & Structural Design Engineer, Structural Fabrication Agency, and any other agency involved. The rate shall include all accessories for the expansion joint, nut bolts, panels, and welding as required. (The erection / fixing /installation shall be done by specialized agency as per approved list.

The roof shall be designed for a wind suction of 2.42KN/m2 for the field area and 3.28 KN/m2 for the peripheral area calculated on the basis of IS 875 Part-3. The proposed Aluminium Roofing System must have the approval of FM and must have passed the minimum wind uplift test in the classification of Class 1-75 (3.591 KN/m2). / FM /or any other suitable agency, etc. for the above-mentioned wind suction and purlin spacing as suggested by the manufacturer. As required, Seam enhancement accessories like wind clamp etc. in Aluminum material only, to avoid bimetallic corrosion (similar to wind ties) shall be provided to meet the wind suction in peripheral area. The above seam enhancement accessories should be designed to allow for free movement of the aluminum roof panels during thermal expansion and contraction to avoid failures, like overturning of clips, tearing of sheets, etc. Roofing System manufacturer and Specialized Roofing Agency shall provide detailed Design Calculations and justify the Purlin spacing & location required for them to successfully deliver the Roofing solution.

**Canopy roof** - Aluminium standing seam roofing for Canopy - Same as above mentioned specification, but with Rockwool Insulation of thickness 50 mm and density 60 Kgs/m3. The remaining items shall be provided as required by the design and approved by manufacturer. The U value, and STC values shall not be applicable for this roof area and the steel structure shall accommodate the difference in Build up height as required by the manufacturer.

**Flashings**  *Aluminum Flashing 0.9 mm thick:* Flashings manufactured from aluminum alloy AA 3004 (AlMn1Mg1) as specified in BS EN 1396: 2015 minimum material thickness of 0.9 mm and Fluorocarbon PVDF finish on the exposed surface. The material shall be of the same color of panels. Girth – 400mm to 600mm.
Skylight / roof extractor penetration Flashing 2mm thick girth 600mm: Flashings from Aluminum Alloy AlMn1Mg1 - as specified in BS EN1396:2015 (comparable AA 3004), minimum material thickness of 2.0mm and PVDF-2 finish in same color as of panels, for a total girth of 600 mm including higher density insulation of the required width with 120 Kgs/m2 density. Special Care shall be taken at Skylight and Roof Sheet interface, and flashing of 2mm thickness of minimum girth 600 mmm shall be installed, on top of High Density Rigid Insulation of 120Kg/m3. Interface between Skylight Interface & Standing Seam Aluminum Roofing Sheet shall be welded. Integrity of Weld Joint shall be demonstrated by a Dye Penetration Test. Aluminum panels have weldability and shall be welded using suitable aluminum filler rods to the aluminum alloy of panels. The welded joints shall be crack and defect free and accommodate thermal movement of the panels. Welded joints are tested and must pass Dye Penetration test.

Single Skin Gutters (gutters outside building): Gutters - supply and fixing of gutters as per detailed drawings consisting and aluminum gutter of 2mm in mill finish thickness, fabricated as per the sizes required. Supply and fixing of single skin 2 mm Aluminum gutter, GRADE AA 1100/AA1200 ALLOY with EPDM Expansion joints for every 8.0mtr length, Down take spout die 150 mm at every 10 m gutter length, & other accessories and welding at joints. The Girth of gutter would be maximum 1200 mm.

FALL ARREST SYSTEM: Supply & Installation of Latchways Constant Force Post System as per EN 795 Class C:2012. -1762 Constant Force Post system will be capable of taking load of 3 users.

Systems Specifications

Systems Type & Length- Latchways Constant Force Post System- on 400 mm roof sheets. Systems Certification- EN 795 Class C and ATEX Approved. Testing has been done with 300 Kg weights to prove CFP’s compliance for 3 simultaneous users. should include 1000 hours of corrosion testing in Acetic acid Salt spray test to worthiness for minimum 5 years. Material- SS 316 Marine grade, 17/4 pH stainless steel for Cast components and 5084 treated aluminum alloys. Latchways CFP absorbs 4,500 Joules of ensuring that it can take a maximum load of 3 users simultaneously. All CFP systems have omni-directional performance ensuring that load can be taken in 360 degrees rather than just in the direction of wire. Product marking complies to EN 795 and EN 365. CE certificate mark and EC declaration of conformation.

WALKWAYS: Supplying & Fixing of safe Walkway system of approved make for safe walking over the roof on standing seam profile roof system of FRP Gratings - FRP Pultruded Grating is made up of a mixture of Resin, Roving, woven matt, Pigment, surface veil etc. It consists of 'I' Section 38 mm Height with Bearing Bar C/c 40mm & Cross Bar of 12mm Dia Round Bar C/c 150mm. It is manufactured From Isophthalic resin. The FRP gratings fulfil the load and deflection conditions as per EN-516. Width of Walkways – 500mm Walkways System Accessories:

i) Seam clip made of Aluminum Alloy 6063/T5 Temper mill finished and will be as per BS EN 755-2 specifications
ii) Aluminum L-Angle of thickness 4.0mm thick made of Aluminum Alloy 6063/T6 Temper mill finished and will be as per BS EN 755-2 specifications

Fasteners used are of Stainless Steel Grade 304
STEP WALKWAYS: Supplying & fixing of STEP Walkway system. The complete system shall be planned, designed and fixed at site to cater all along the roof periphery, exhaust fan, louvers, skylights and gutters of the roof etc., complete all, as per the direction of Engineer-in-charge. The specification of the system is as mentioned

Steps: The Adjustable steps are made in uncoated cast aluminum Brackets Aluminum alloy, with Nut & Bolts of Stainless Steel 304 of sufficient size. Size of Steps 460 x 250mm and thickness of aluminum tread is minimum 4.0mm with angle adjustment 0 – 45 degrees and shall be of a aluminum alloy. The system to be tested and certified to EN 516 and by BIA The system components shall conform the following: - A. STEPS The steps can be adjusted in an angle between 0 to 45° to ensure the user is in a level plane while climbing. Size 460 x 250mm.

Material: Cast Aluminum B. BRACKETS Holds the steps on the standing seam. The angle of the brackets can be adjusted from 0 to 45° to negotiate the gradient of the roof and make the steps in an even plane. Size 460 x 250mm Material Aluminum Alloy.

ROOF HATCH:

Roof Hatch - Single Leaf
Ideal for applications requiring roof access
- Make: BILCO, USA / Nystrom
- Size: 914mm x 914mm
- Material: Shall have aluminum cover and frame of 11 gauge (2.3mm).
- Cover: Shall have break formed, hollow-metal design with 1” (25.4mm) concealed fiberglass insulation, 3” (76mm) beaded, overlapping flange, fully welded at corners, and internally reinforced for 40 puff (195 kg/m2) live load.
- Curb: Shall be 12” (305mm) in height with integral cap flashing, 1” (25.4mm) fiberboard insulation, fully welded at corners, and 3-1/2” (89mm) mounting flange with 7/16” holes (11mm) provided for securing frame to the roof deck.
- Gasket: Shall have extruded EPDM rubber gasket permanently adhered to cover.
- Hinges: Shall have heavy-duty pintle hinges with 3/8” (9mm) type 316 stainless steel hinge pins.
- Latch: Single leaf: Shall have slam latch with interior and exterior turn handles and padlock hasps.
- Lift Assistance: Compression spring operators shall be enclosed in telescopic tubes. Shall have automatic hold-open arm with grip handle release.
- Performance Ratings: Shall comply with UL 790 Class A (burning brand test).
- Hardware: Shall have Aluminum engineered composite compression spring tubes. Shall have steel compression springs with electro coated acrylic finish.

System Performance
The Self Supported Standing Seam Roof System should have the following characteristics:
Appearance
No external fastener fixing exceed at ridge, gable, eaves & penetration details
Continuous sheets with no joints. If the end laps are unavoidable due to the design or construction constraints, the detailing should be provided by manufacturer and approved by Qualify Person (Architect or Engineer) to ensure that the end laps are weather tight.
The height of standing seam rib should be at 65 mm.
The design details that provided by manufacturer should present a uniform and smooth appearance free of unsightly irregularities for overall building geometry.

Structure
The sheet should be designed & detailed to accommodate all movements of the building structure.
The Self Supported Standing Seam Roof sheet should support all applied loadings (e.g. snow, wind, live load, foot traffic), and transmit these loadings to spaced structural supports.
The structural performance of product should be approved by the independent third party, like German Institute of Building Technology / British Board of Agreement.
The structural calculation of roof system should be provided and approved by Professional Engineer.
The Self Supported Standing Seam Roof system should accommodate the following movements without any permanent deformation or reduction in the specified performance:
Deflection under design loads
The effects of repeated wind and internal pressure loading.
Changes in dimension and shape of components arising from building movements, including settlement, creep, twisting and racking.
Movement of any joint whether designed to permit movement or not.
Thermal movements.
Loading from maintenance personnel.
Dead Loads
The Self Supported Standing Seam Roof system should be capable of accommodating the following dead loads without any reduction in performance:
The Self Supported Standing Seam Roof system’s own dead load to be accommodated locally, and without causing deflections or movements in the panels.
The dead loads derived from permanent fixtures like roof hatch, wall arrest system, walkways, lightening arrestors or services attached (to be defined by architect, if required) to external surfaces of the Self Supported Standing Seam Roof system.
When calculating loads the worst combination should be considered, taking account of the fact that the pressure coefficients at various locations may determine more than one design criteria.
Live Loads
The Self Supported Standing Seam Roof system should be capable of accommodating the following live loads without any reduction in its performance:
All loads resulting from movements of the roof support structure.
Vertically and horizontally applied loads acting on the surface of the panels arising from maintenance and cleaning operations. The Self Supported Standing Seam Roof system should sustain safely, without reduction in performance and without permanent deformation to any component.
Impact loads, or transferred impact loads, that occur during its service life, without deterioration in its performance and without sustaining non-repairable damage.
When calculating loads, it should be ensured that the worst combination load cases have been considered, bearing in mind that the pressure coefficients at various locations may determine more than one design criteria.
The Roof panel and concealed clips shall be capable of supporting a minimum uniform live load of 0.75 kPa
The roof shall be designed for a wind suction of 2.42 KN/ m² for the field area and 3.28 KN/m² for the peripheral area calculated on the basis of IS 875 Part-3. The proposed Aluminium Roofing System must have the approval of FM and must have passed the minimum wind uplift.
test in the classification of Class 1-75 (3.591 KN/m²). / FM /or any other suitable agency, etc. for the above-mentioned wind suction and purlin spacing as suggested by the manufacturer. The manufacturer shall submit test certificates of wind uplift test conducted by FM (USA) on test rigs and having passed this criterion. The test certificates shall be submitted at the time of tender submission.

Deflections
All components, couplings and fixings should be capable of accommodating all the above deflection without permanent distortion, deformation or failure.

The maximum allowable deflection of Self Supported Standing Seam Roof sheet when under imposed load combination shall not exceed L/200. Under wind load combination, the deflection of the standing seam roof shall not exceed L/90, where L is the clear span in a direction normal to the plane of the element.

The Self Supported Standing Seam Roof sheet shall not deflect under loading in any way that is detrimental to any element of the Self Supported Standing Seam Roof system or adjacent structural or building elements.

In-Plane Thermal Movement
The Self Supported Standing Seam Roof sheet should be designed to accommodate in-plane thermal movement resulting from the maximum and minimum ambient temperature differentials ranging 18 to 45°C. The design should cater for all temporary and permanent conditions envisaged for the works.

The Self Supported Standing Seam Roof sheet should be capable of accommodating changes in dimension and shape of its components resulting from the varying surface temperatures without any reduction in the specified performance criteria.

Durability
The natural finish of Self Supported Standing Seam Roof sheet has 25 years life expectancy in aggressive marine conditions & 40 years life expectancy in normal environment conditions as certified in British Board of Agreement (BBA).

The Self Supported Standing Seam Roof sheet should have an evaluation report regarding the durability performance after long-term exposure (≥ 35 years) at different locations.

Weather & Water Penetration Resistance
The Self Supported Standing Seam Roof sheet should be weather tight in accordance with: AAMA 501.1 where the roof sheet is tested at 500 Pa pressure with water sprayed at a rate of approximately 3.4 litre/min/m² for 15 minutes have no water leakage during the test duration.

Approved by independent third party, German Institute for Building Technology
Approved by independent third party, British Board of Agreement (BBA)

Fire Resistance
The Self Supported Standing Seam Roof system is classified as Ext. F AA when tested in accordance with BS 476-3: 2004 (Classification and method of test for external fire exposure to roofs).

The external & internal layers of Self Supported Standing Seam Roof system should be classified as Class 0 in accordance to BS 476 Part 6 & Part 7.

Fire & smoke stopping: Contractor should be responsible for the provisions of all cavity barriers in the external wall and fire stopping at the junction of the external wall with other fire resisting elements of the structure.

Thermal Performance (U-value)
The thermal performance of U-value for completed Self Supported Standing Seam Roof system considering thermal bridging should be equal or lesser than 0.31W/m² K. The value of U-value should be clarified either by finite element analysis.
Acoustic Performance
The Standing Seam Roof system should have following acoustic performance:
Sound Reduction Index (Rw) of 39 dB with - 2 dB tolerance in accordance with ISO 717 Part 1 &
together with the independent test report.

Warranty
The Self Supported Standing Seam Roof system will be guaranteed for 15 years with regards to
its material composition, surface finish and system performance. In addition, the installation
Contractor must be fully trained and approved by the standing seam manufacturer. The
trained & approved Roof Contractor should provide 5 years’ warranty stating that the roof
system should be weatherproof and watertight.

Material Specification
Roof Construction from bottom to top
The general roof construction should comprise from the bottom to top

<table>
<thead>
<tr>
<th>Material</th>
<th>Steel Liner</th>
<th>Pre Painted Galvalume</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minimum Yield Strength, N/mm²</td>
<td>550</td>
<td></td>
</tr>
<tr>
<td>Modulus of Elasticity, N/mm²</td>
<td>210 000</td>
<td></td>
</tr>
<tr>
<td>Elongation, %</td>
<td>17</td>
<td></td>
</tr>
<tr>
<td>Nominal Thickness (Steel Substrate + Metallic Coating)</td>
<td>0.50</td>
<td></td>
</tr>
</tbody>
</table>

Metallic Coating
- Material: Al Zinc
- Coating Thickness, µm: (20+5+5)
- Coating Designation: AZ150
- Coating Mass at Both Surface, g/m²: 150

Product Geometry
- Cover Width, mm: 1000
- Pitch, mm: 200
- Depth, mm: 35

Top Hat
Top Hat Bracket & Top Hat | Material Specification
----------------------------|-----------------------|
Materials                 | Galvanized Steel     |
Nominal Thickness, mm     | Minimum 1.6 and 2mm  |
Minimum Yield Strength, N/mm² | 245         |
Modulus of Elasticity, N/mm² | 205 000     |
Metallic Coating          |                       |
- Material: Zinc          |
- Coating Designation: Z275 |
- Coating Mass at Both Surface (g/m²) | 275        |
### Vapor Control Layer

<table>
<thead>
<tr>
<th>VCL</th>
<th>Material Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Material</td>
<td>Double sided Aluminum</td>
</tr>
<tr>
<td>Thickness, microns</td>
<td>180-200</td>
</tr>
<tr>
<td>Tensile Strength- MD N/25 mm</td>
<td>150 - 170</td>
</tr>
<tr>
<td>Moisture Vapor Transmission, g/m²/24hr as per ASTM F1249</td>
<td>0.08- 0.2</td>
</tr>
</tbody>
</table>

### Insulation

Make - Rock wool/ Roxul

<table>
<thead>
<tr>
<th>Insulation – (60 kg/m³)</th>
<th>Material Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Density, kg/m³</td>
<td>60Kgs/m³</td>
</tr>
<tr>
<td>Fire Classification</td>
<td>BS 476 Part 4</td>
</tr>
<tr>
<td>Thermal conductivity, W/mK at 20°C</td>
<td>Max 0.037</td>
</tr>
<tr>
<td>Thickness, mm</td>
<td>150</td>
</tr>
</tbody>
</table>

Note: Insulation around skylights, at eaves edges, and at ridge, for a width of 1000 mm - shall be of higher density of 120kgs/m³ and shall be of the same thickness as the roof to avoid ponding due to traffic during maintenance at these locations.

### ST-Clip

<table>
<thead>
<tr>
<th>ST-clip</th>
<th>Material Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Material</td>
<td>AA6061 &amp; Temper-T6</td>
</tr>
<tr>
<td>Clip Designation</td>
<td>As suitable</td>
</tr>
<tr>
<td>Min Ultimate tensile strength</td>
<td>260 MPA</td>
</tr>
<tr>
<td>Min Elongation at 50 mm gauge, %</td>
<td>8</td>
</tr>
</tbody>
</table>

**Thermal Barrier**

5mm height black polyamide thermal barrier pad. This material shall have a minimum tensile strength of 80 MPa and maximum tensile elongation of 10% in room temperature.

**Fasteners to fix the clip** shall be of SS304 4 Nos per clip.

### Standing seam roof panel -65/400 PVDF Coated

<table>
<thead>
<tr>
<th>Panel 65/400</th>
<th>Material Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Material</td>
<td>Aluminum Alloy</td>
</tr>
<tr>
<td>Aluminum Alloy Designation</td>
<td>EN AW 3004</td>
</tr>
<tr>
<td>Minimum Tensile Strength, N/mm²</td>
<td>200</td>
</tr>
<tr>
<td>Minimum Yield Strength, N/mm²</td>
<td>185</td>
</tr>
<tr>
<td>Property</td>
<td>Value</td>
</tr>
<tr>
<td>----------------------------------------------</td>
<td>---------------------------------</td>
</tr>
<tr>
<td>Modulus of Elasticity, N/mm²</td>
<td>70 000</td>
</tr>
<tr>
<td>Minimum Elongation in 50mm, AI = 50%</td>
<td>3</td>
</tr>
<tr>
<td>Thickness, mm</td>
<td>1mm</td>
</tr>
<tr>
<td>Finish</td>
<td>PVDF on exposed side and primer on rear side</td>
</tr>
<tr>
<td>Paint suppliers for the coating</td>
<td>PPG / BECKER / AKZONOBEL / VALSPAR</td>
</tr>
<tr>
<td>Thickness of PVDF, µm excluding primer &amp; adhesive coatings</td>
<td>18 – 25</td>
</tr>
<tr>
<td>Product Geometry</td>
<td>Straight</td>
</tr>
<tr>
<td>- Cover Width, mm</td>
<td>400</td>
</tr>
<tr>
<td>- Depth, mm</td>
<td>65</td>
</tr>
</tbody>
</table>

PS: Seam enhancement accessories like wind clamp / alternative accessories in Aluminum material only, to avoid bimetallic corrosion (like wind ties) shall be provided to meet the wind suction (7.56 KN/m²) in peripheral area. The above seam enhancement accessories should be designed to allow for free movement of the aluminum roof panels during thermal expansion and contraction to avoid failures, like overturning of clips, tearing of sheets, etc.

Accessories for Self Supported Standing Seam Roof System
- Extruded aluminium alloy BS EN AW 6063 Gable End Channel
- Extruded aluminium alloy BS EN AW 6063 Gable End Clip
- Extruded aluminium alloy BS EN AW 6063 Tolerance Clip
- Extruded aluminium alloy BS EN AW 6063 Zed Spacer
- Extruded aluminium alloy BS EN AW 6063 Drip Angle
- Fabricated aluminium alloy BS EN AW 3004 Ridge Closure
- Closed cell cross-linked polyethylene ridge foam filler with tearing strength of 1.2. kg/cm
- Closed cell cross-linked polyethylene eave foam filler with tearing strength of 1.2. kg/cm
- Fabricated aluminium alloy flashing should be same quality, grade, and colour from the roofing elements

Fluorocarbon Coating System
The exterior finish coat should be PDVF paint system containing at least 70% of PVDF resin in dry paint film, as required by approved licensed coating formulations. The PVDF resin should be either Kynar 500® or Hylar 5000®. In order to minimise appearance differences; all requirements should be processed in one production run using the same batch of paint.

Gloss – standard colours will have a nominal gloss level of 20 to 35% (60°) - subject to choices of colours.

The coated finish of flashing and roof sheet should have the following properties:
- Humidity Resistance tested accordance to ASTM D2247-94 (1000 Hours) with no influence.
- Acid Salt Spray tested accordance to ECCA T8 (1000 Hours) with creep age on scribe to bare metal maximum 2 mm.
- Resistance to cracking on bending tested to ECCA T7. No crack at ≤ 2T.
- Pencil hardness conforming to ECCA T4 with min F hardness grading.
- Reverse Impact tested accordance to ECCA T6 with loss of adhesion index: Gt ≤ 1.
Heat resistance tested accordance to ECCA T13. No influence in 0.6 hour by 60°C continuous metal temperatures.
Resistance to accelerated weathering topcoat tested accordance to ECCA T10. After 2000 hours, $DE \leq 4$ & gloss retention $\geq 70\%$ max chalk = rating of 8.

Fillers
The type(s) supplied by the cladding manufacturer should accurately match the sheet profile.
Where shown on the design drawings and wherever necessary, corrugation cavities should be closed off from the outside and inside of the building. Ensure a tight fit and leave no gaps.
The material should be closed cell cross-linked polyethylene with a minimum density of 0.035 g/cm³.
The material should have minimum compression strength and tearing strength of 0.4 kg/cm² and 1.2 kg/cm² respectively.
The material must be durable and will not deteriorate under heat, UV exposure and weathering conditions.

Flash & Capping
Flashing and capping to the roof will be manufactured from the same quality grade and colour of material as the roof elements.

Accessories
General
Capping’s, closure pieces, flashings, trims sills, gutters, fillers, spacers, tapes, sealant, fixing etc. where not specified should be types recommended by the manufacturer.

Gutters
Gutter’s shall be or 2mm thick aluminium in mill finish. The aluminium flashing is to be same specifications as the material used for the Self-supported standing seam roof top skin. Vapour control layer should as specify in the gutter areas should be extended to over the gutter liner and into the down pipe. Gutters as per detailed drawings consisting and aluminium gutter of 2mm in mill finish thickness, fabricated as per the sizes required, shall be of single skin 2 mm Aluminium gutter, GRADE AA 1100/AA1200 ALLOY with EPDM Expansion joints for every 8.0mtr length, Down take spout die 150 mm at every 10 m gutter length, & other accessories and welding at joints. The Girth of gutter shall be as advised by the MEP consultants.

Sealing Laps
The Sheet Manufacturer should recommend sealant type(s) for the purpose.
The position of sealing laps should be in straight unbroken lines immediately below fixing positions and parallel to the edges of sheets. They should be placed into corrugation and not allowed to stretch or sag in position.
Ensure continuity and effectiveness of seal especially at corners of sheets. Do not over compress.

Fixing Bolts, Anchors, Brackets, Screws, Rivet and Nuts
Stainless steel to be grade 300 series unless specified in the drawing.
Type, size and positioning of all bolts & nuts, anchors, screws and rivets should be shown on the Contractors Drawing, together with full details of their installation technique and torque settings where appropriate.
Where it is not possible to conceal fixings, a maximum of five-exposed bolt/stud threads should be used, subjected to approval from the Architect.

Fall Arrest System (Optional only if required –by client)
Make Latchways / Checkline
The Fall Arrest System on Self-Supported Aluminium Standing Seam Roof sheet is developed to be a part of “complete” system and it should be used for maintenance and access purpose.
Anchor posts are locked onto the upper seam of the Self-Supported Aluminium Standing Seam Roofing System, providing a unique, user friendly system which does not threaten the waterproofing integrity of the roof.

This post shall be an aluminium polyester powder coated base plate, secured to the external roof top sheet via 4 x aluminium split clamps that allow for the thermal movement of the roofing system.

The powder coated post body, containing the stainless-steel energy absorbing coil, is to be manufactured from aluminium with an electro polished stainless-steel dome. Both the base plate and body need to be tested to the following standards and results:

- **1000-hour Salt Spray to ASTM D1186 Method B** – With the result being: No signs of corrosion or delamination or reduction in gloss.
- **1000-hour Acetic Acid Salt Spray in accordance with BS EN ISO 2360:2003** – With the result being: No signs of corrosion over any area of the coating.

The post shall be installed by a Registered Installer strictly in accordance with the manufacturer’s requirements and specification.

All posts will be placed at a minimum of 6m to a maximum of 10m apart from each other.

All top fittings, brackets, integral tension indicator and critical castings are to be manufactured from stainless steel and electro polished where applicable.

The Trans fastener® travelling device will allow for hands free operation either side of the line without detachment from the system.

Performance of Fall Arrest System:

The complete system to be capable of supporting three users working simultaneously at any point along the 8mm 7x7 stainless steel cable, even in the same span.

The manufacturer shall demonstrate that an individual post can absorb a direct single dynamic load of 300kg dropped through 1.5m without damaging the standing seam roof system. This shall be evidenced by an independent notified test body report (including photographs) indicating peak loads when tested in combination with the roof.

The manufacturer shall demonstrate that the individual post works primarily in a shear force condition and not with a turning moment force, which could seriously damage the roof.

The manufacturer shall demonstrate that each post is capable of absorbing a static load of 20kN held for three minutes.

Once installed, the post shall be capable of absorbing the above load requirements in any direction and evidenced by full scale testing.

The energy absorption of an individual post should not be less than 5000J.

The Fall Arrest System shall comply to the following requirement:

- The system shall hold a valid CE Mark and shall hold EC declarations of conformity.
- The post shall have an individual serial number clearly marked on the product.
- The post shall be independently tested by a notified body in accordance with the European Standard EN795:2012 for Protection against falls from height – anchor devices – requirements and testing to both EN795 Class A & Class C.
- The manufacturer should hold a valid ISO 9001 certificate.
- The manufacturer shall provide evidence that batch conformance tests using periodic X-rays of components and periodic static and dynamic tests are carried out to prove component quality.
- The manufacturer shall provide an independent test report detailing fall protection tests conducted with Self-Supported Standing Seam Roofing with the aluminium clip. The report shall reference the loads attained and include detailed photographic evidence.

**Installation**

**Workmanship**

All works should be true to detail with continuous profiles which should be free from marks, defects, flaws, steps, waves or damage of any nature.
All elements of framework and associated beads and strips should be stored on Site such that they will not be damaged, distorted or weathered unevenly.

All roof panels, sealants and gaskets should be stored on Site in accordance with the manufacturer’s recommendations.

Dimensions and levels of the structure should be verified using total station.

Setting out should be such that aluminium panels are installed in the correct position, within tolerance, and in the correct relationship to the building structure.

All aluminium panels should be correctly mounted so that they are all consistently orientated.

All fixing bolts and anchors should be installed in accordance with the manufacturer’s recommended procedures.

Materials should be carefully stored on site and remain dry until fixed.

Approval should be obtained from the Engineer before drilling or cutting parts of the structure, other than where shown on the approved Shop Drawings.

Isolating tape, plastic washers, or other suitable means to prevent bi-metallic corrosion between dissimilar metals should be used throughout the project.

ST Clips should be set out at evenly spaced centres, straight, parallel and truly aligned with other features, where shown on the Shop Drawings.

The finished work should be square, regular, true to line, level and plane, with a satisfactory fit at all junctions.

The Self Supported Standing Seam/ Flashings system should be laid, making due allowance for the sequencing of the whole and all interfaces. A secure free draining and completely weather tight roof should be provided.

The installation team should be fully trained approved and certified by the Self Supported Standing Seam Roof system manufacturer. In the event that the installation team is not approved by the manufacturer, the manufacturer reserves the right to reject the inspection for the roof and not provide any warranty for the entire roof system. All printed instructions and installation manuals and directives issued by the Self Supported Standing Seam Roof system manufacturer should be strictly adhered to.

Tolerances

Account should be taken of the installation tolerance requirements of the Self Supported Standing Seam Roof System.

The erected steel purlin top level should be suitable for installation of the roofing system and be within the allowable level difference of + / - 10 mm.

The Self Supported Standing Seam Roof system should be erected plumb and true in proper alignment and relation to established lines and grades as shown on the approved Shop Drawings. The erected system should present true and accurate lines and flat planes.

A method statement should be submitted detailing proposals for achieving the specified tolerances. This should demonstrate that a clear understanding of the construction method and the fabrication method of the panels is possessed.

A detailed list of tolerances to which the Self Supported Standing Seam Roof system will be installed, within the requirements of the Performance Specification for the overall geometric requirements should be submitted before any starting any installation work. All tolerances should be submitted for review by the Engineer. As a minimum the statement of tolerances should include the following:

Thickness.
Position on plan.
Level.
Alignment.
Joints between panels.
Diagonal.
Eccentricity.
Inclination.
Allowance for sufficient analysis of the erection sequence should be made, thus ensuring and satisfying the Engineer that the installation tolerances stated above will be met.
At the time of handover, the visual requirements of the Self Supported Standing Seam Roof system are as follows:
The roofing panels should be horizontal/vertical and geometrically shaped as shown on Design Drawings.
All joints should be of equal size and at equal centres, unless shown otherwise on the Design Drawings.
The Self Supported Standing Seam Roof sheet should present true and accurate straight lines and slat panels within the plane of the elevations and geometry.
Dimensional Checking: Before work begins on Site the proposed methods of dimensional setting-out and cross-checking with adjacent trades and elements, to satisfy the accuracy requirements, should be submitted to the Engineer’s/Architect’s discretion, provided they are agreed in advance of the manufacture of components.
Work should be within the tolerances stated herein and no revisions to the tolerances allow inadequate control should be permitted.
The Self Supported Standing Seam Roof sheet when installed should not be subjected to warping or twisting, should be strictly rigid, firm, free from vibration, knocking rattles, squeaks and other noises when subject to the worst combination of environmental conditions and wind loads.
Quality Assurance
Unless accepted otherwise by the Engineer/Architect, use manufacturers and installers that employ a Quality Management System complying with the program described in BS EN ISO 9001-2008 or similar system.
Installer Qualifications:
Engage experience installer, with minimum experience in installing Aluminum Self Supported Standing Seam Roof system in India.
Applicator should be an approved agency, certified by the system manufacturer of the aluminum standing seam and should hold valid certificate issued by the manufacturer.
The applicator should have successfully executed and completed at least one airport project with 70% of the roofing area indicated in the tender / any other three projects with 50 percent of the roofing area indicated in the tender, with the same roofing system manufacturer. and the completed roof should have performed well for at least two monsoon years.
The installer to provide PO copy / Completion certificate & TDS documents for area verifications
Roofing manufactures Credential
The roofing manufacturer shall possess the following manufacturing credentials and capabilities:
Minimum 45 years’ experience in manufacturing of Aluminium Self Supported Standing Seam Roof sheet.
Track record to include a minimum of 3 airport projects of same or more size in India.
Should possess Site Manufactured facility in India with more than 5 mobile roll formers in India at the time of tender
References
British Board of Agreement for standing seam secret Fix Roofing Systems
Deutches Institute fur Bautechnik General Building Inspectorate Approval Z-14.1-181
ISO Certificate (ISO 9001)
The proposed Aluminium Roofing System must have FM Approval certification in India

Submittals – Installer
General:
Submit listed submittals in accordance with Conditions of the Contract
Product Data:
Submit manufacturer’s specifications, standard details, (and installation manual.)
Shop Drawings:
Show roof panel system with flashings and accessories in plan and elevation; sections and details. Include metal thicknesses and finishes, panel lengths, joining details, anchorage details, flashings and special fabrication provisions for termination and penetrations. Indicate relationships with adjacent and interfacing work.
Do not proceed with manufacture of roofing materials prior to review of shop drawings and field verification of all dimensions.
Samples:
Submit sample board consisting of panel section, 300mm long x full width panel, showing proposed metal gauge, finish and seam profile. And all accessories including panel clip and gable clip. Ridge accessories and fasteners / and end fillers
Test Reports:
Submit copies of design test reports for each of the performance testing standards listed in Section 4 - e of this specification.
Test reports shall be performed by an independent, accredited testing laboratory.
Calculation:
Submit engineering calculations defining cladding loads for all roof areas based on design criteria
Calculation shall clearly indicate clip type, spacing of clips by roof zones, and fastener requirements.
Compute uplift loads on clip fasteners with recognition of prying forces and eccentric clip loading
Calculate pull-out/shear strength of fasteners in accordance with test data published by the fastener manufacturer, utilizing applicable material safety factors.
Compute thermal calculation for expansion/contraction forces due to total temperature differential of 30 degrees C.
Compute panel fixed point attachment forces and required fasteners.
Compute in-plane clip forces and indicate required attachment fasteners
Miscellaneous
Preparation
Roof Installer to submit a program schedule to include (non-exhaustive)
Material procurement
Drawing submission
Method statement
Material approval
Installation
Roof Installer to submit a detailed documentation to include (non-exhaustive)
Quality Assurance and Quality Control plan
Manpower allocation
Method statement
Safety plan pertaining to the roof installation
20 POLYCARBONATE ROOFING
Providing and Fixing 22mm thick Polycarbonate sheet roofing for Skylight:

Design, Manufacture and Installation of skylight system, a complete assembly of extruded cellular structure UV protected polycarbonate panels incorporated with angular daylighting concept into a complete system. Co-extruded UV protected polycarbonate panel system of minimum 22mm thickness to ensure best performance for wind uplift and visual appearance. Panels shall be manufactured with vertical offset standing seam at both sides of the panel. The width of the panels shall be minimum 600mm - 1200mm and panels with maximum width shall be preferred to minimize junctions and to ensure a leak proof system. Panels shall have minimum five to seven layers for better strength with truss bracing cell structure. Panels shall be fixed on Purlins with SS Trapezoidal Fasteners / Aluminum spacers and connected with polycarbonate U connectors to interlock the panels with snap on / click-on / grip lock mechanism to ensure maximum uplift capacity. Panels will be sealed with mill finished aluminium U profiles at the ends. Polycarbonate panels also shall have Yellowness Index as per ASTM D 1925 when tested on a sample exposed to UV for 500 Hours as per ASTM G 155. The polycarbonate panels must satisfy Dart drop impact test as per IS 14443-97 shall show no sign of breakage on. Polycarbonate sheets which have been exposed to UV for a min. of 500 Hours as per ASTM G 155. The panels shall be fixed over structural steel / MS purlins and be secured with Snap-On connectors at all levels including all accessories like screws, trims etc. complete to make a water tight skylight system conforming to specifications and directions of Engineer-in-Charge. End-cap/Aluminium U-profile (mill finish) for ends.

MATERIAL PROPERTIES
a) U-Value :shall not be more than 1.8 W/m2/k as per EN ISO 10077-2:2018.

b) Panels shall be fixed over structural steel/ MS purlins conforming to the technical specifications and as per approved drawings.

c) Price: 3800/- INR per SQM + GST+ Transportation

21 POST TENSIONING WORKS
Design, material, supply and execution of post tensioning works to all floors including decoiling the strands, cutting to the required lengths, supplying and laying of HT strands, sheathing (GI corrugated ducts 80mmx20mm, 0.30mm thick jointing with couplers and inserting the strands, profiling, fixing live end anchorages including the supply of stressing anchorages suitable for 5-5 and 5-4 Tendons, grout vents, making dead end anchorages including flowerimg the strands, fixing Tendon support bars, supervising the fixing of anti brusting reinforcement, stressing the cables, end trimming grouting the cables with cement and admixtures with required plant and machineries, tools and tackles, consumables etc.

General
The Post Tensioning bonded Beam slab system shall consist of High Tensile strands of 12.70 mm (0.5"dia) /15.20 mm dia (0.6 " dia) and contained in a flat slab GI duct of 80 mm x 20 mm. Each strand in anchored by means of wedge and individually stressed by means of a mono strand Jack. The prestressing force is transferred to the concrete by a flat anchorage.
Prestressing systems
The pre-stressing system is incorporating strands with 12.70 mm dia strand /15.20 mm dia strand.

<table>
<thead>
<tr>
<th>Materials</th>
<th>0.5&quot;</th>
<th>0.6&quot;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strands</td>
<td>0.5&quot;</td>
<td>0.6&quot;</td>
</tr>
<tr>
<td>Nominal Diameter</td>
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<td>15.2mm</td>
</tr>
<tr>
<td>Nominal Area</td>
<td>98.7mm</td>
<td>139mm²</td>
</tr>
<tr>
<td>Nominal weight</td>
<td>0.775 kg/m</td>
<td>1.101 kg/m</td>
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<tr>
<td>Tensile strength</td>
<td>1860 N/mm²</td>
<td>1860 N/mm²</td>
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<tr>
<td>Modulus of elasticity</td>
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<td>195 N/mm²</td>
</tr>
<tr>
<td>Min breaking load of strand</td>
<td>184kN</td>
<td>184kN</td>
</tr>
<tr>
<td>Strand quality in accordance with</td>
<td>IS 14268</td>
<td>IS 14268</td>
</tr>
</tbody>
</table>

Sheathings
The sheathings for bonded tendons shall be spirally wound galvanized iron tubing made from galvanized iron strips of 0.3 mm thickness.

The sheathings shall be mortar tight to prevent entrance of cement grout during concreting and shall be corrugated for better bonding.

The sheathings shall be sufficiently strong to retain shapes and to resist damages during construction.

The round sheathings with various outer diameters from 68mm to 135 mm have been widely used in Multiplane anchorage systems.

Ducts
The sheathing consists of corrugated spiral ducts made from galvanized iron strips of 0.3 mm thick.

Anchorages
The type of anchorages commonly used is Flat Anchorage (FA), Multiplane Anchorages (MA), Bond Head (Dead End) Anchorages. The purpose of the anchorages are when the strands are stressed, the tendon force would be transferred to the concrete. Bursting reinforcement is provided behind the anchorage to distribute the stressing force.

Design data for friction / elongation calculation
Friction coefficient $u : 0.2$ } or as per the Design/AAI Recommendation

- Wobble factor $k : 0.0017/m$ } design parameters
- Draw in of wedge : 6mm (approximately)
- Stressing anchorage : Type FA, MA
- Loss in jack : Varies from 0 to 2.0% for various type of jacks

**Handling and storage of materials**

The pre-stressing strands shall be free of grease and corrosion enhancing properties. No flame cutting of strands is allowed. Care should be taken during handling of construction work in order to avoid mechanical damage to the strands. Strands should be raised above ground level to prevent ingress of soil. Suitable ropes or slings shall be used for loading and unloading in order to avoid mechanical damage to the strand coil. The component must be handled and stored such that any contamination, mechanical damage or corrosion can be avoided.

**General Working Procedures**

Post Tensioning tendons shall be installed in accordance with the “Approved Drawings issued for Construction”. For Post Tensioning slabs construction:
- Install bottom slab reinforcement when the slab formwork is ready.
- Provide sufficient cover to the bottom slab reinforcement.

**Method Statement of Post-Tensioning System**

- Install top slab reinforcement for Post Tensioning beams construction.
- Install bottom and side reinforcements and links. No capping links shall be installed at this stage.
- Install tendons in accordance with the shop drawings.
- Install top reinforcements and capping links of the beams.

**Guidelines for Tendons Installation**

Tendon alignment and height shall take precedence over reinforcement whenever there is a clashing point. All dimensions measured shall be based on the formwork level. Therefore an accurate formwork level is necessary. The tolerances of formwork shall be $\pm 5$ mm or in accordance to the specifications. The Multiplane Anchor is fixed to the end formwork by support bars to avoid any displacement during concreting. The Multiplane Anchor must be orientated perpendicularly to the cable axis and with the
Grout connection at the top of the duct.

Tolerances for vertical tendon profiles are ±10mm for all high and low points. Tolerances for horizontal profiles are ±150mm (to avoid small M&E openings or other obstructions). Specialist designer shall be consulted for tolerances bigger than ±150mm.

Handle ducts with care to avoid damage.

Support bars and bar-chairs are placed at intervals of each 1m (approx) and secured with binding wire to avoid any movement during concreting.

Duct joints are sealed with tape.

Care should be taken during concreting to avoid grout hoses from being embedded in concrete or removed completely.

Avoid stepping on ducts placed.

Care should be taken to avoid damaging ducts with tie bars of the formwork.

Tendon support and bar – chairs are placed at 1m interval and secured with binding wire to avoid movement during concreting.

Check visually on the ducts straightness and do necessary adjustment before concreting.

Grout hoses must be protected from being embedded or removed during concreting.

Any defect found in the bulb of strands such as breakage of ply should be replaced with new bulb.

Compressive strength required for commencing stressing operation shall be 75% of the concrete grade used or minimum of 26N/mm²

Preparation for stressing

Removal of formwork and polyfoam / plastic block out from the anchorage blackout.

Placing of wedge plate and wedges. It is important that this operation be carried out after concreting so that the anchorage is not fouled by grout or dirt.

Ensure that the protruding strand length is sufficient for stressing.

The theoretical elongation calculations must be approved by the consultant before stressing.

For Multistrand Jacks (Multiplane Anchor)

At the beginning of stressing the strands are locked in the jack pulling head.

The pressure of the manometer and the measured elongation are recorded in the stressing report.

When the jack has reached the end of its stroke or the desired force has been obtained, the pressure in the jack is released and the strands become locked uniformly by the wedges in the wedge plate.

The jack piston returns.

Stressing is continued in as many stages as are necessary to obtain the required force.

For Monostrand Jack (Flat Anchor)

Initial stressing of 25% of the total designed force can commence anytime after the concrete has minimum cube strength of 8N/mm². The purpose of initial stressing is to take the slack of the strands in the tendon.

A spray mark is made on the strands.

Proceed with the full 100% stressing of the total designed force after the concrete has attained its minimum strength as per the specifications.

Measure the difference in length from the spray mark to the wedge plate. This will reflect the elongation per strand from 25% to 100%. (Assume this to be X mm in length.)

Add the wedge draw in which is approximately 6mm to the elongation.
By extrapolation the full measurement can be calculated and compared against theoretical elongation.
Therefore the full elongation for one-end stressing will be = (X + 6mm) x 100
------- % = (X + 6mm) x 1.3333 75
Similarly for tendons with two ends stressing, the tendons may be stressed from one end followed by another. Sum of elongations from both ends is then compared with total theoretical extension.
Assuming the far end elongation is Y.
The total elongation will be:
\[(X + 6mm) + (Y + 6mm)] x 100
------- % 75
Sample of Stressing Reports are as shown in Appendix A.4
After approval by consultants / main contractor the protruding strands are to be cut off to a minimum of 10mm from the wedge plate.
All stressing results shall be tabulated on a stressing record and submitted for approval by the engineer. The pressure gauge and jack no’s shall also be indicated.
If the average stressing result of the whole pour is within ±8% it shall be deemed as satisfactory.
In accordance to the Federation Institute of Prestressing (FIP) code, the average shall be within ±8%. If any individual tendon of a pour falls outside this, then the average extension over the whole respective pour should be checked and this falls within the tolerance of ±8%, then the stressing operation is considered satisfactory.
Stripping of formwork can be carried out after full stressing of beam / slab is completed.

**Grouting**

Grouting shall not commence unless the consultant has approved the stressing result

**Preparation of Grouting**

Cut the protruding strands (stressing length) to a minimum of 10mm from the wedge plate.
The anchorage blackouts shall be filled with the approved cementations material.
Proposed grout mix
Cement in standard 50kg package (Ordinary Portland cement)
Water = 0.45 x 50kg = 22.5 kg
= 22.5 liters
Admixture = 0.4% weight of cement (50 kg) = 200gm
(Conplast Fosrac)
Mixing sequence = water - additive – cement
Min mixing time = 3-4 min

**Tests for grouting**

Measurement for compressive strength of grout cubes
During trial mix period, compressive strength test shall be carried out.
6 samples per grouting session are required.
After 18 to 24 hours, remove cubes from mould and store in water storage tank.
Compressive strength shall be measured for 7 & 28 days.
According to specification, compressive strength of cube shall be:
Grouting of tendons

After the trial mix is done and a suitable mix is determined, the grouting is ready to proceed. Prior to grouting, all anchorage block outs are to be patched up by cement / mortar or equivalent approved mortar based material. After this is completed and the mix is ready, start injecting grout from the inlet hose of the tendon. When grout outflow appears at the intermediate vents, close vents in direction of grout flow. Grout must flow out from outlet until visible residual water and entrapped air has been removed. Lock the outlet hose. Continue pumping until the desired pressure of 3-5 bars is achieved. Close the inlet hose and proceed to the next tendon.

Precautions to be taken during grouting.

Pressure should be duly controlled so as not to cause segregation of grout. Excessive mixing (especially at high temperatures) can stiffen the grout already in the mixing drum. In case of interruption (more than 45 minutes) the grout shall be flushed out of the tendon using water and compressed air.

Scope of work:

The scope of work shall include but not limited to:

i) Submission of detailed design and corresponding calculations vetted by IIT(Indian Institute of Technology) for the Beam slab by post tensioning system in accordance with the design parameters specified by the Consultant, the codal requirements of BIS (Bureau of Indian Standards) latest versions and National Building Code to the Engineer in Charge/Consultant.

ii) Prepare detailed shop drawings for the post tensioning work to be carried out by showing clearly all the dimensions, spacing and all other required constructions details and obtaining approvals of same from Consultants well in advance to have sufficient time for procurement and delivery of material and equipment and to carry out the work in accordance with the requirement of overall construction schedule.

iii) To assist and guide the civil contractor for any works directly or indirectly related to or consequential to the post tensioning of the Beam slabs.

iv) Prepare and submit three sets of As Built drawings for each post tensioned slab showing clearly the profile and location of each tendon.

Prime Responsibilities of Post-Tensioning Contractor

The Post Tensioning contractor shall ensure the following during each stage of work and shall remain entirely responsible for the same.

1) Design calculations (vetted by IIT (Indian Institute of Technology)) shall be submitted and got approved by Consultants/Engineer-in-charge prior to commencement of work
2) Ensure that the tendons are not disturbed while concreting. In case they are disturbed their position shall be reinstated immediately contractor shall post their supervisors and workers for this purpose at site to remain in full attendance during concreting operation. Contractor alone shall remain fully responsible for placing the tendons and ducts in accurate profile and maintain the same during and after concreting of slabs.

3) Contractor shall independently ascertain that concrete has achieved necessary strength before tendons are stressed and anchorages are jacked against the slabs.

Specifications

All the work shall be of the highest possible workmanship and best available material as approved by Engineer in charge. The materials used for the work shall be strictly in accordance with the specification as above.

Quality Assurance Procedure of PT Structure

Materials

Concrete
Concrete mix and design strength required for prestressed concrete work shall be as provided in the drawings and in the specifications. Concrete work shall conform to the Concrete work specification. Trial batch shall be made and tested at 1, 3 and 28 days to prove the specified design mix before construction commences. The contractor shall assess the age at which the concrete mix will reach the required transfer strength for stressing operation.

Prestressing Steel

Steel strands used in post-tensioning tendons shall conform to BS 5896:1980/Class II 14268-1995 for Uncoated Seven-Wire stress-Relieved strand for prestressed Concrete or ASTM A416. Unless otherwise stated the ultimate tensile strength shall be 1860 N/mm². Oil tempered strands shall not be used. High strength alloying steel bars shall be cold stretched Proof stressed during manufacture, to the minimum yield strength. After stretching, all bars shall be subjected to a stress-relieving heat treatment to produce the required physical properties.

Bonded Prestressing Systems

Anchorages
Anchorages for bonded tendons shall develop of the minimum specified ultimate strength of the prestressing steel, tested in an unbounded state without exceeding the anticipated set, the anchorage being so arranged that the prestressing force of the tendon may be verified prior to the removal of the stressing equipment, if so desired. All Post-Tensioning anchorages shall have gone through stringent testing in the laboratory.

Sheathing
Sheathing material for bonded tendons shall be spirally wound-galvanised steel tubing unless otherwise specified and shall be strong enough to retain shape and to resist unrepairable damage during construction. Round ducts or oval ducts/flat shall be used for beams unless otherwise approved by the Engineer. Such sheathing material shall prevent the entrance of cement paste from the concrete and sheathing shall be corrugated for better bonding.
Grout
The grout for bonded post-tensioned concrete members shall be a neat cement grout made with ordinary Portland cement, water and admixture approved by the Engineer in charge. The grout shall have a minimum, compressive strength measured on 100mm cubes as 17N/mm² at 7 days and 30 N/mm² at 28 days. Two sets of three cubes shall be taken on each day of grouting, one set shall be tested at 7 days and one set shall be tested at 28 days. The grout shall be sufficiently fluid and of a uniformly colloidal consistency to enable the cable ducts to be grouted using maximum pressure of 0.5N/mm². Pressure should not be lower than 0.2 N/mm². The grout shall have a maximum cement ratio of 0.45, except where otherwise agreed in writing by the Engineer in charge. Other additives, which reduce shrinkage and/or increase workability, may be used subject to the written approval of Engineer in charge. All ducts shall be clean and free of deleterious materials that would impair the bonding of the grout or interfere with grouting procedures. Each duct shall be thoroughly flushed and blown out with water and compressed air prior to grouting.

General
Standards and Codes of Practice
Unless otherwise stated, Indian codes and standards are used herein to lay down the minimum standards required for prestressed concrete work, in particular, the specifications, standards, tests and recommended methods prescribed by IS code of practice shall determine the quality of material and the method of work. In cases where above standard are not available, FIP (Federation Institute of Prestresssing) guidelines shall be used as reference.

System of Prestressing
The system of prestressing used, shall be the Post-Tensioning systems as approved by the Engineer. The system shall be used strictly in accordance with the written recommendations of the manufacturer. The effective prestressing force has been calculated using the parameters shown on the drawings and based on the Post-Tensioning systems. The Bursting and spilling reinforcement has been designed and detailed considering the dimensions of the Post-Tensioning systems. Storage of Prestressing Components
Prestressing components shall be stored in clean conditions, and shall be cleaned and free from pitting and loose rust at the time of fixing in position and subsequent concreting.

Materials Tests
Required Submittals for Prestressing Steel
The contractor shall submit to the Engineer in charge, Mill’s certificated from the manufacturer of prestressing steel showing that prestressing steel meet IS Specifications and are suitable for the purpose intended.

Laboratory Tests.
A 1.0m long of strand shall be tested by testing Authority and test certificate shall be submitted to the Engineer in charge. The Contractor shall ensure that all prestressing steel shipped to the site are assigned...
individual lot numbers and tagged for identification.

Prestressing Operation
General

Prestressing shall be carried out by approved method and equipment related to generally accepted system of prestressing. Variations of such generally accepted methods and equipment shall be permitted provided the Engineer is satisfied that equal results can be obtained. Prestressed concrete work shall be carried out under the immediate control and close supervision of a person experienced in this type or work.

Prestressing Strands

The length of tendons shall be determined accurately to facilitate installation without changing of forms. Where the lengths of tendons cannot be determined from the Drawings, site measurements shall be taken.

Sheaths

All sheaths shall be maintained in correct positions during the placing of the concrete. The sheaths shall be rigidly supported at points no more than 1.50 m apart. Where sheaths are used, the number of joints shall be kept to a practicable minimum. Each joint shall be adequate sealed against the ingress of any material and shall be mortar tight. Sheaths shall be kept free on any matter detrimental to the bond between the sheath and grout and, except for material sealing a sheath joint, between the sheath and the concrete. The number and position of grout vents for entry and outlet points, shall be adequate provided. Standard PVC $\frac{3}{4}$" diameter hose shall be used to act as grout hose.

Jacks for Prestressing

All jacks used for prestressing shall be of the type applicable to the system adopted. All jacks and gauges to be used for the project shall be calibrated by an approved testing authority. The validity of each calibration record is set at 1 Year. Jacking shall be performed from either one end or both ends of post-tensioned prestressing strands, as stated on the shop drawings.

Post-Tensioning Procedure

The tendons shall be stressed when the concrete reached a minimum strength as specified on the Drawings. Unless otherwise permitted by these specifications, concrete shall not be stressed until it has reached at least the age at which test cubes taken there from attain the specifies transfer strength. The test cubes shall be made and tested but shall be cured in similar conditions to the concrete to which such relate. The Contractor shall cast sufficient cubes to demonstrate that the required strength of the concrete at transfer strength has been reached. The force in the tendons shall be obtained form readings on a pressure gauge, and the extension of the tendons measures. The two readings shall conform to the limits set by the engineer but in any case the force in the tendon as computed form the extension measurement shall be within $\pm 8$ percent of the force (as mean value of all tendons in that
particular pour). Please refer to the method of statement Post-Tensioning systems manual for the interpretation of stressing results.
Over length of strands at anchorages shall be cut off and patched with approved mortar after completion and approval of stressing operation by Engineer in charge.
Safety precautions shall be taken to prevent workers from standing behind the jacks, when strands are being tensioned.
The Contractor shall keep full records of all tensioning operations, copies of these records shall be supplied to the Engineer in charge after each tensioning operation. Full records are to include the following data:-

i. Identification number of gauges and jacks.
ii. Identification particulars of tendons.
iii. Identification of the structural member where the tendon is used.
iv. Initial force (or pressure) whereon tendons are marked for measurement of elongations.
v. Final force (or pressure) and elongations obtained on completion of tensioning.
vi. Hydraulic pressures.
vii. Elongation obtained at suitable intervals during tensioning together with corresponding force(or pressure) if and when required by the Engineer.

Grouting of Ducts

Ducts shall be grouted as soon as practicable after the tendons have been stressed and the Engineer in charge permission to commence has been obtained. Grout shall be injected in one continuous operation, and allowed to flow from the vents until the consistency is equivalent to that being injected.
The ducts shall be completely filled with grout.
Vents shall be sealed consecutively in the direction of flow.

Inspection

The Engineer in charge shall be notified before any concrete in slabs or beams is cast, so that inspection of the tendons and reinforcement can be made.

Shop Drawings

The Contractor shall submit for the Engineer in charge is approval, before the commencement of construction, shop drawing showing the location, number of strands in tendons.

Safety

i. Hand Tools must be double insulated.
ii. All the electrical items shall be protected with 30MA ELCB.
iii. All the cutting machines shall have protection guard for the blade.
iv. All the PPE (personal protective equipment) shall be used in the site.
v. All the works like stressing, cutting etc shall be carried out from the proper scaffolding only.
vi. Do not stand at the jack and on the direct line of the tendon being stressed.
vii. In addition secure the complete area by adequate restriction and with a DANGER SIGN.
22 LOUVERS AND VENTS

SECTION INCLUDES

This section includes requirements of fixed, external extruded-aluminum louvers.

DEFINITIONS

a) Louver terminology: Definitions of terms for metal louvers contained in AMCA 501 apply to this section unless otherwise defined in this section or in referenced standards.

b) Horizontal louver: Louver with horizontal blades; i.e., the axes of the blades are horizontal.

c) Drainable-blade louver: Louver with blades having gutters that collect water and drain it to channels in jambs and mullions, which carry it to bottom of unit and away from opening.

d) Storm-resistant louver: Louver that provides specified wind-driven rain performance, as determined by testing according to AMCA 500-L.

SUBMITTALS

a) Product data:
   Product data shall be submitted for each type of product indicated.

   For louvers specified to bear AMCA seal, include printed catalog pages showing specified models with appropriate AMCA certified ratings seals.

b) Shop drawings: Shop drawings shall be submitted for louvers and accessories which include plans, elevations, sections, details, and attachments to other work. Show frame profiles and blade profiles, angles, spacing and shall comprises of Show weep paths, gaskets, flashing, sealant, and other means of preventing water intrusion.

   Show mullion profiles and locations.

   Wiring diagrams: For power, signal, and control wiring for motorized adjustable louvers.

c) Samples for initial selection shall be submitted for units with factory-applied color finishes.

d) Samples for verification shall be submitted for each type of metal finish required.

e) Provide delegated-design submittal for louvers complying with structural and seismic performance requirements and design criteria, including analysis data.

f) Informational submittals

   Product test reports: Based on evaluation of comprehensive tests performed according to AMCA 500-L by an accredited testing agency or by manufacturer and witnessed by an accredited testing agency, for each type of louver and showing compliance with performance requirements specified.

MATERIALS
a) Aluminum extrusions shall conform to ASTM B 221, Alloy 6063-T5, T-52, or T6.
b) Aluminum sheet shall conform to ASTM B 209, Alloy 3003 or 5005 with temper as required for forming, or as otherwise recommended by metal producer for required finish.
c) Fasteners: Use fasteners of types and sizes to suit unit installation conditions as detailed below:
   i) Use hex-head or pan-head screws for exposed fasteners unless otherwise indicated.
   ii) For fastening aluminum, use aluminum or 300 series stainless-steel fasteners.
   iii) For fastening galvanized steel, use hot-dip-galvanized steel or 300 series stainless-steel fasteners.
   iv) For fastening stainless steel, use 300 series stainless-steel fasteners.
   v) For color-finished louvers, use fasteners with heads that match color of louvers.
d) Post-installed fasteners for concrete and masonry: Provide Torque-controlled expansion anchors, made from stainless-steel components, with capability to sustain, without failure, a load equal to 4 times the loads imposed, for concrete, or 6 times the load imposed, for masonry, as determined by testing per ASTM E 488, conducted by an accredited testing agency.
e) Bituminous paint shall be cold-applied asphalt emulsion complying with ASTM D 1187.

FABRICATION

a) Louvers shall be assembled in factory to minimize field splicing and assembly. Disassemble units as necessary for shipping and handling limitations. Clearly mark units for reassembly and coordinated installation.
b) Vertical Assemblies: Wherever height of louver units exceeds fabrication and handling limitations, units shall be fabricated to permit field-bolted assembly with close-fitting joints in jambs and mullions, reinforced with splice plates.
c) Maintain equal louver blade spacing, including separation between blades and frames at head and sill, to produce uniform appearance.
d) Frames shall be fabricated including integral sills, to fit in openings of sizes indicated, with allowances made for fabrication and installation tolerances, adjoining material tolerances, and perimeter sealant joints.
e) Include supports, anchorages, and accessories required for complete assembly.
f) Provide vertical mullions of type and at spacings indicated, but not more than recommended by manufacturer, or 1830mm centre to centre whichever is less.
g) Provide extended sills for recessed louvers.
h) Join frame members to each other and to fixed louver blades with fillet as standard with louver manufacturer unless otherwise indicated or size of louver assembly makes bolted connections between frame members necessary.

FIXED, EXTRUDED-ALUMINIUM LOUVERS

a) Horizontal storm-resistant louver:

   i) Louver
   ii) Double banked weatherproof
   iii) Louver depth: 100mm.
   iv) Frame and blade nominal thickness: Not less than 1.5mm for blades and 2.0mm for frames.
v) Louver performance ratings:

- Free area: Not less than 50% perforation or as approved by the Engineer-in-Charge.
- Air performance shall not be lower than 0.3 airflow coefficient.
- Wind-driven rain performance shall not be less than 80 percent effectiveness when subjected to BSRIA or AMCA standard of testing.

vi) AMCA seal: Mark units with AMCA certified ratings seal.

FINISHES

Comply with NAAMM’s "Metal finishes manual for architectural and metal products" for recommendations for applying and designating finishes.

ALUMINIUM FINISHES

a) Finishes to louvers shall be carried out after the assembly of the system.

b) Color anodic finish shall conform to AAMA 611, or thicker.

i) Color shall be as selected by Engineer-in-Charge as per industry colors and color densities.

c) PVDF2 Fluorocarbon 3 coat paint system shall be prepared and applied in accordance with the following performance requirements and standards:

i) Meet or exceed the performance requirements of the AAMA605.2 “Specification for high performance organic coatings on Architectural extrusion and panels”

ii) Application of the finish shall be performed under specifications issued by the licensed formulator and by an applicator specifically approved by one (or more) of the formulators. Applicator shall provide written notification of approval by a formulator prior to application of the finish.

iii) The fluorocarbon 3 coat system shall consist of:

• First coat: Inhibitive primer, with a dry film thickness averaging 5-7 microns.

iv) The total minimum dry film thickness of the fluorocarbon coating shall be 40 microns. This coating system shall be spray-applied and thermocured at 230-250 C or as specified by paint manufacturer. The micron thickness shall be measured in accordance with ASTM B 244-29.

v) Batch testing of paint finish shall be carried out by supplier including:

• Crosshatch adhesion list.
• Bending test for cracking or flaking.
• Impact testing to check for cracking or flaking.
• Gauge testing to check micron thickness.

vi) Color and gloss shall be as selected by Engineer-in-Charge as per manufacturer’s catalogue.

23 GLASS PARTITIONS
Providing and Fixing of Slim Glass internal partition using 12 mm Toughened Glass (Saint gobain/AASHI or equivalent) and Aluminium profiles of DORMA Alexa System-45 Frames or approved equivalent to a height of maximum 3m. The Fixed glass to be fixed using DORMA Alexa BP45 Profiles or equivalent at Top & Bottom & fixed frame cleat. The profile size shall be 45x25MM to be fixed on to the floor/ceiling as per the requirements and the H Junction profile to be used at all Glass to Glass vertical joints and 90 degree L/T Junction profiles at required necessary areas as per design. The profile shall be made of 2 mm Gauge thick matt natural anodized Aluminium and having Minimum anodic coating 20 micron.

GENERAL

DESIGN CRITERIA

The above system shall meet the following design parameters, and will also comply with BS / Indian Standard Specifications and Codes of Practice.

VISUAL APPEARANCE

Aesthetically the design of the Glazing system should give uniform appearance.

DESIGN LOADINGS

a) The glazing system design shall be capable of accommodating dead load and wind loads and other movements without reducing its performance or causing permanent damage.
b) The glazing’s own dead loads and the loads occurring due to wind forces acting on them shall be transferred to the structure/ground at its anchorage points.
c) The glazing system shall be designed to withstand a minimum wind pressure in accordance with IS: 875 in that zone.
d) The vertical movements occurring due to thermal expansion/contraction and structural roof members deflection shall be accommodated as per the design of the building.

TEMPERATURE DIFFERENCE

The system design shall accommodate a standard temperature range of +100°C to +700°C.

EARTHQUAKE FORCE

The system design shall be capable of incorporating seismic joints, to deal with earthquakes in that zone.

DEFLECTION

The Glazing system shall allow a standard deflection of L/175 and shall also accommodate variable deflection limits.
MODULE / SIZE OF PANEL

The glazing system shall be as per detailed drawings and details.

THERMAL AND ACOUSTIC PROPERTIES

The Glazing system shall achieve and meet the standard thermal and acoustic performance for glazing in accordance with the industry norms and building regulations.

FIRE AND SMOKE STOPS

The systems design to have provision for incorporating fire and smoke stops.

AIR / WATER PENETRATION RESISTANCE

The Glazing system shall be designed to withstand test pressures as specified in BS and Indian Standards or ASTM (E283-91 and E330-93)

STATIC / STRUCTURAL PERFORMANCE

The Glazing system shall be capable of withstanding a positive and negative pressure (100%) for 10 seconds and (1.5 x design load) for a further 10 seconds if tested in a test lab.

MATERIAL

CLEAR AND TINTED FLOAT GLASS

Float glass used for glazing shall be of approved quality conforming to BS 952 Part-I for clear and tinted and BS 6206 for toughened glass and of the thickness specified in the item. The tolerance in thickness shall be + 0.3 mm for 4 to 6mm and + 0.6mm for 8 to 12mm thick glass.

TOUGHENED GLASS

Toughened glass is 4 to 5 times stronger than its equivalent thickness of normal annealed float of sheet glass. It offers great resistance to sudden temperature changes and sudden impacts.

Float glass on international quality conforming to BS 952 Part – I for clear and tinted glass and of the thickness specified in the item shall be used for manufacturing toughened glass. Toughening, which shall be carried out horizontally (without tong-marks), shall conform to ASTM 1048.

All works such as cutting, grounding, drilling etc. On glass shall be carried out prior to toughening. Once tempering is done, no work will be allowed on the glass.
MATERIAL HANDLING & STORAGE

Glass shall be securely and safely crated for delivery, handling and storage. Cushions shall be provided at edges of glass to prevent damage. Glass faces shall be protected from scratches and abrasions. It shall be stored in a dry, well-ventilated location, carefully protected at all times from soiling, atmospheric.

GLAZING WORK

The glass panes shall be of the type and thickness specified in the item. Their sizes shall be as shown in the drawings. The glass panes shall be of approved quality and make. They shall have properly squared corners and straight edges. Damaged or defective glass shall be replaced with new glass at no additional cost. Each piece of glass shall be delivered with factory labels intact, indicating glass type, quality and thickness. Labels shall not be removed until installation has been accepted. Glass is to be protected from breakage immediately upon installation by applying suitable warning markings.

Sealants of high quality, silicone, as specified by the manufacturers shall be used.

REPLACEMENT OF GLASS

In case of glass breakage after installation, the glass will have to be replaced by deglazing the glass at site & the re-glazing of the new glass will have to be done at site without any extra cost.

STRUCTURAL SEALANT

Structural sealant should have minimum tearing strength 6.0N/mm, sore A hardness 44 (ISO:868), tensile strength (ISO :8339-A) 1.06 N/Sqmm and one part. Joint movement capability + 25% (As per ASTM C-920), one part natural cure equivalent to SG 18 of Sikka (Wacker), 995 of Dow Corning or equivalent.

WEATHER SEALANT

The Silicon weather proofing sealant is designed for sealing expansion and control joints, pre-cast concrete panel joint, non-structural curtain wall mullion joints, stress cracks and joints in parapet wall. The sealant forms durable, flexible, water tight bonds with most building materials in any combination, in particular, ceramics, stone, masonry, wood, steel, anodized.

Weather sealant should have minimum tearing strength 4.0N/mm, sore hardness 20 (ISO 868), joint movement capability +15% (s per ASTM C-920), one part natural core equivalent to Sika Elastosil 305, DOW corning 791P or equivalent.

FINAL CLEANING
Protective coating and warning markings shall remain undisturbed until final acceptance. Immediately prior to final inspection, temporary protective covering or coating shall be removed and surfaces shall be washed with a suitable thinner and left in a finished condition having approved uniform appearance and free from all marks and blemishes. Both faces of the glass shall be washed and polished.

24 ENTRANCE VESTIBULE GLAZING

1. GENERAL

Design, providing, fabricating, protecting, packaging, delivering (jobsite), installing and fixing in position Entrance Vestibule Glazing System comprising of SS 316 grade U-channel (polished/satin finish) on M.S. Structure and Laminated Glass Unit supported from SS 316 grade U-channel as indicated in the drawings.

2. MATERIAL

Glass

17.52mm Laminated Non-Performance Vision Glass panels comprising of 8mm thick clear, fully tempered glass (heat soak) + 1.52mm thick Clear Structural Interlayer + 8mm thick clear fully Tempered glass. The laminated glass shall be assembled in the factory/workshop of the approved glass processor.

Hardware & Sealants:

All fastening materials Anchors, screws, nuts, bolts, rivets, washers, etc. required for fixing the framing shall be stainless steel SS 316 grade. HDG-75microns brackets & angle brackets shall be provided.

All concealed aluminium surfaces any extruded aluminium cleats shall be finished with CHROME-FREE pre-treatment primer coating. The Structural silicone sealant shall be of DC 995/795/983, shade as per PMCs requirement. Weather silicone sealant shall be DC 789 of approved shade along the vertical and horizontal groove.

3. INSTALLATION

1.1 Glazing Work:

The glass panes shall be of the type and thickness as per the design. The sizes of the glass panes shall be as shown in the drawings. The glass panes shall be of approved quality and make. The glass panes shall have properly squared corners and straight edges. Damaged or defective glass shall be replaced with new glass at no additional cost. Each piece of glass shall be delivered with factory labels intact, indicating glass type, quality and thickness. Labels shall not be removed until installation has been accepted. Glass is to be protected from breakage immediately upon installation by applying suitable warning markings. Sealants of high quality, silicone, as specified by the manufacturers shall be used.

1.2 Installing S.S. U-Channel.
Determine channel position. Mark the M.S. Framing indicating the centreline of the glass and determine exactly where the channel is going to be installed.

Cut the U-Channel using a hacksaw or circular saw with a carbide blade so that they fit the spaces. Sand or file the ends to remove any saw marks. Drill holes in the channel where desired and use a countersink to rout out the holes so that stainless steel screws sit flush with the bottom of the channel. Secure the top, bottom and side U channels with flat head screws.

Put a small bead of silicone on the back side of the U channel to add structural strength to the installation and a small amount of silicone on the top of each anchor to seal the screw holes. Wipe off any silicone which might squish out from under the U channel. Inspect each screw to make sure it is flush with the bottom of the U channel.

1.3 Structurally Adhering the S.S. U-Channel

Wet Set Type of U-Installation, is a method which is when you put silicone inside the U channel and then the glass is set into the silicone. A wet set install is required for strength of the panel. Two setting blocks of required thickness under each panel are placed both as a cushioning and leveling device. Superglue the blocks to the inside of the channel so they won’t move during installation. Do not set the blocks over the screw heads. Slide in glass panel, gently lowering it onto the setting blocks. Do not silicone over the setting blocks. Do final Alignment.

1.4 Secure The Panel:

With the panel in the correct position put a strip of masking tape so it is half the glass and half on the U channel. It takes several days for the silicone to cure to full strength. Do Not adjust the panel position after the cure cycle has started. Disturbing the silicone bond half way through the cure process will reduce the strength. The last step of the installation is to do the final seal of all the panels. First thing is to make sure the areas you are going to apply the silicone are clean and dry. A cap bead should also be applied to the inside & outside top edge of the channel where it meets the glass.

1.5 Handling & Storage:

Glass shall be securely and safely crated for delivery, handling and storage. Cushions shall be provided at edges of glass to prevent damage. Glass faces shall be protected from scratches and abrasions. It shall be stored in a dry, well-ventilated location, carefully protected at all times from soiling, atmospheric.

1.6 Waterproofing:

A bead of silicone to be run around the entire perimeter of the U-Channel edge where it meets the glass.
1.7 Silicone clean up:

No matter how carefully the glass is set into the U-Channel, a certain amount of silicone will flow out between the glass and the channel. Wait 30-60 minutes after siliconing before taking a single edge razor blade to trim excess silicone. Once this is done run your cap bead.

1.8 Replacement of Glass:

In case of glass breakage after installation, the glass will have to be replaced by deglazing the glass at site & the re-glazing of the new glass will have to be done at site without any extra cost.

1.9 Final Cleaning:

Protective coating and warning markings shall remain undisturbed until final acceptance. Immediately prior to final inspection, temporary protective covering or coating shall be removed and surfaces shall be washed with a suitable thinner and left in a finished condition having approved uniform appearance and free from all marks and blemishes. Both faces of the glass shall be washed and polished.

25 STEEL DOORS, WINDOWS, VENTILATORS & COMPOSITE UNITS (FIRE & NON-FIRE RATED DOORS)

1. SCOPE INCLUDES

Architectural hollow metal doors and frames as shown on the Drawings and as specified herein.

1. Flush Steel Doors

2. Flush Steel Fire rated doors as per Indian & British standard

   a. Insulated doors
   b. Un-insulated doors
   c. Steel frames

2. REFERENCES

   Indian Standard

   IS 277 Standard specification for steel sheet, Zinc Coated (Galvanized) IS 3614 Part 1 Specifications for fire check doors
   IS 3614 Part 2 Metallic and non-metallic fire check doors – Resistance test and performance criteria
   IS 513 Standard Specification for Steel Sheet, carbon, Cold rolled Commercial Quality.

   International Standard
ISO 834-1: International standard for fire resistance tests – Elements of building construction – Part 1

British Standard

BS 476 Part 22:1987 Standard methods of test of fire door assemblies

3. SUBMITTALS

Product Data: Submit manufacturer’s specifications for fabrication and installation, including data substantiation that products comply with requirements. Certificates:
1. Manufacturers Certification that products comply with referenced standards.
2. Evidence of certificates as listed.

Shop Drawings: Submit for fabrication and installation of metal doors and frames. Include details of each frame type, elevations of door detailing types, conditions at openings, details of construction, location and installation requirements of finish hardware and reinforcements, and details of joints and connections. Show anchorage and details of joints and connections. Indicate door elevation, internal reinforcement, closure method, and cut-outs for glass lights and louvers. Show anchorage and accessory items. Provide schedule of doors and frames using same reference numbers for details and openings as shown on Drawings. Samples: Submit 300 mm x 300 mm cut away sample door with provisions for lockset, hinge and corner section of the frame.

4. TRANSPORTATION, HANDLING AND STORAGE

A. Deliver, store and handle hollow metal work in a manner to prevent damage and deterioration.

B. Provide packaging such as cardboard or other containers, separators, banding, spreaders and paper wrappings to protect hollow metal items.

C. Store doors and frames upright, in a protected dry covered area, at least 100 mm or more above ground or floor and at least 6 mm between individual pieces.

D. Doors and frames are to have a metal tag with the door number thereon.

E. Should door wrapper becomes wet, remove immediately.

5. QUALITY ASSURANCE

General: Unless otherwise specified, provide doors and frames complying with the Indian standard and the British standard for stability, integrity and insulation
Fire-Rated Door Assemblies: Provide Fire Doors and Frames tested at approved national and international laboratory
1. Labelled Fire doors and frames in accordance with IS 3614 for stability and integrity Fire tests of Door Assemblies.
2. Where insulation is the criteria supply labeled Fire doors and frames in accordance with IS 3614 for stability, integrity and Insulation Fire tests of Door Assemblies

3. Complying with ISO 834-1 or BS476 part 22: 1987 and which are labeled and listed by national or internationally accredited laboratory.

4. Manufacture doors and frames under the third party inspection program and in strict compliance to standards and provide the degree of fire protection, heat transmission.

5. Affix a physical label or approved marking to each fire door or fire door frames at any authorized facility as evidence of compliance and test conducted by approved agency.

6. Conform to applicable codes for fire ratings. It is the intent of the specification that hardware and its application comply or far exceeds the standard for fire doors.

7. Manufacturer: Provide doors, frames and hardware from a single manufacturer approved by the Engineer.

Installers: Minimum three years documented experience installing products of similar nature.

6. MANUFACTURER

   a. Any acceptable manufacturer who has the manufacturing capability and can supply the complete door set as an assembly, tested and certified.

   b. ISO 9001:2015 certified company

   c. Has the ability to prepare door and hardware schedule with proper detailing and certifications.

7. MATERIALS

   a. Cold-Rolled Steel Sheets: Commercial quality carbon steel, complying with IS 513

   b. Galvanized Steel Sheets: Zinc-coated carbon steel sheets of commercial quality, complying with IS 277 zinc-coating, mill phosphatized.

   c. Supports and Anchors: Fabricated of 1.25 mm thick, galvanized sheet steel.

   d. Inserts, Bolts and Fasteners: Manufacturer’s standard units, except hot-dip galvanize items to be built into exterior walls

   e. Shop Applied Paint: Rust-inhibitive self etching primer and polyurethane paint as per manufacturer specification and coating.

   f. Grain tech sheets to be used for doors with surface wood finish. Minimum sheet thickness shall be 1.6mm
8. FABRICATION – GENERAL

a. Fabricate metal door and frame units to be rigid, neat in appearance and free from defects (warp or buckle). Wherever practicable, fit and assemble units in manufacturer’s plant. Clearly identify work that cannot be permanently factory-assembled before shipment, to assure proper assembly at project site.

b. Fabricate exposed faces of doors and panels, including stiles and rails of non-flush units, from only Galvanized steel.

c. Fabricate frames, concealed stiffeners, reinforcement, edge channels, louvers and moldings from Galvanized steel.

d. Fabricate exterior doors, panels, and frames from galvanized sheet steel. Close top edges of all doors as an integral part of the door construction or by addition of inverted steel channel.

e. Exposed Fasteners: Unless otherwise indicated, provide countersunk flat heads for exposed screws and bolts.

f. Finish Hardware Preparation

g. Prepare doors and frames to receive mortised and concealed finish hardware in accordance with Hardware Schedule and templates provided by hardware supplier.

h. Reinforce doors and frames to receive surface-applied hardware. Drilling and tapping for surface-applied finish hardware may be done at project site.

i. Locate finish hardware as shown on final shop drawings or, if not shown, in accordance with Recommended Locations for Builder’s Hardware.

j. Shop Painting – Primer

k. Clean, treat, and paint exposed surfaces of steel door and frame units, including galvanized surfaces.

l. Clean steel surfaces of mill scale, rust, oil, grease, dirt, and other foreign materials before application of paint.

m. Apply shop coat of prime paint of even consistency to provide a uniformly finished surface ready to receive finish paint.

9. PRESSED METAL FRAMES

General: Provide continuous type pressed metal frames, including glazing stops and reinforcement, of various profiles to suit conditions detailed on the drawings and be constructed of new prime quality, Galvanized sheet steel. All frames shall be fabricated from zinc-coated sheet chemically treated after fabrication for optimum paint adhesion.

Materials: Provide pressed metal frame of the following minimum thickness:
Exterior / interior Frames: 1.6 / 1.2 mm thick sheet respectively. Sheets lesser than 1.2mm are not acceptable for frames.

Wall Anchors: Same thickness and material as frame.

Hinge Reinforcement: Manufacturer’s Standard 5mm thick unless recommended otherwise by the door manufacturer.

Strike Reinforcement: Manufacturer’s Standard unless recommended otherwise by the manufacturer.

Closer and Holder Reinforcement: 1.6 mm by the required length and width.

Frames: Provide frames that have joints die-mitered with integral tabs for reinforcement and interlocking of the jambs to head. Frames shall be knockdown or equivalent, with self-aligning tabs and slots for securely locked corners. Single rebate or double rebate profile shall be provided based on application and manufacturer recommendation. Minimum depth of frame shall not be less than 85mm, and max shall be 350mm. Recommended profile shall be part of the tested assembly. For applications recommended frames shall be grooved to take appropriate seal for air leakages and dust control. (See frame drawings as detailed)

Construction: The finished work shall be strong and of rigid construction neat in appearance and free from warp, wave and buckle. Molded members shall be clean cut, straight and true. Miters shall be well formed and in true alignment. Fastenings shall be concealed where practicable.

Door Silencers: Except on weather stripped frames, drill stops to receive 3 rubber silencers on strike jamb of single-swing frames and 4 silencers on heads of double-swing frames.

Anchors
Unless otherwise indicated on drawings, anchor frame in concrete and masonry walls by means of galvanized expansion shields and flat-head machine screws. Screw heads shall be countersunk in soffit of jamb. Machine screws shall be approved type, 9 mm diameter by minimum 75 long of zinc plated or dichromated steel with 9 mm diameter by minimum 44 mm long malleable iron or steel expansion shield. Reinforce jamb at each expansion screw location with 5 mm by 38 mm wide steel fitting into inside of stop and welded to backbends. Anchors shall be located not more than 150 mm from top and bottom of each jamb with intermediate anchors spaced at a maximum of 650 mm on center.

Anchors for plaster partitions with truss stud framing shall be Z-clip type, to be secured to studs and welded to back of frames above each hinge reinforcement and just below the top hinge reinforcement. Anchors on the strike side shall occur directly opposite to those on the hinge side.

Provide at least 4 anchors for each jamb for frames up to 2.28 m in jamb height; 5 anchors up to 2.40 m; and one additional anchor for each 0.6 m fraction thereof over 2.4 m jamb height.

10. HOLLOW METAL DOOR SHUTTER (Door Leaf)

a. General:
Construct exterior or interior doors to the following details and gauges: Full flush -1.2mm or 0.8mm sheet thickness as approved
Full flush/ Rail & Stile -1.2mm sheet thickness

1. Interior Doors: Fabricate interior hollow metal doors of 2 outer sheets, 0.8mm (22guage) thick galvanized sheet steel, free from rust, scale, pits and surface defects. Unless otherwise indicated on Drawings, hollow metal door thickness shall be minimum 46mm.

2. Exterior Doors: Fabricate exterior hollow metal doors of 2 outer sheets, 1.2mm (18guage)
thick galvanised steel sheet. Unless otherwise indicated on Drawings, hollow metal door thickness shall be 46mm.

3. **Glass Lite on doors:** Fabricate glass lite of approved sizes and rating based on the door schedule. The material shall be 20 gauge galvanized steel with face fixing countersunk screws.

4. **Louver on Doors:** Shall be manufacturer’s standard product fabricated of 20 gauge cold-rolled sheet metal, free from rust, scale, pits and surface defects. Door thickness shall be 46 mm. Stile channels, stiffener channels and other construction members shall be of sizes as recommended by the manufacturer. For fire doors the louvers are not applicable.

5. **Service Heavy-Duty Doors:** Fabricate service doors using minimum 1.2 mm (18 Gauge) same sheet facing thickness as that for exterior doors as per door location. Provide additional reinforcing stiffeners for the door construction.

b. **Door Construction**

1. **Full Flush Doors (Non-fire rated)**

   Door leaf shall be constructed from minimum 0.8 mm (22 Gauge) galvanised sheet pressed formed with interlock joints on stile edges.

   Door leaf to have internal reinforcing channels or z-shaped members of 1.6 mm thick steel, on top and bottom. Door stiles to be interlocked on both sides with a bending radius of 1.4 mm.

   Hollow portions of doors shall be filled completely with expanded honeycomb core glued on either inside surface for stability and integrity. If it is mineral wool minimum 100 kg density per sq.m, shall be the infill material.

   Door thickness should be minimum 1-3/4” (46mm)

   Vertical edge seams: Provide doors with continuous vertical edges and mechanical interlocking joints at lock and hinge edges.

   Provide single swing doors with not more than 3 mm clearance at jambs and heads and not more than 6 mm clearance at meeting edges of pair of doors (3 mm on fire rated doors).

   Where required as indicated on door type schedule drawing, provide doors with grills and vision glass panels of thickness indicated on drawings. Manufacturer’s standard steel assembly, one side integral with door and the other side equipped with applied steel stops of minimum 20 gauge steel, 1-piece lengths, secured within 76 mm of ends and maximum 306 mm centers between with cross-slotted flat-head countersunk screws.

   Fire Rating: Supply door units bearing Labels for fire ratings indicated in Door Schedule for the locations indicated.
c. **Rail & Stile Doors:**

Door leaf shall be constructed from minimum 0.8mm (22 guage) galvanised sheet pressed formed with interlock joints on stile edges.

Door leaf to have internal reinforcing channels or z-shaped members of 1.6 mm thick steel, on top and bottom. Door stiles to be interlocked on both sides with a bending radius of 1.4mm.

Hinge stile and lock stile size of (Maximum 150 x 46mm) Plus 16mm for glass beed and stop.

Top Rail size shall be (Maximum 150 x 46mm) Plus 16mm for glass beed and stop.

Bottom Rail size should be (Maximum 250 x 46mm) Plus 16mm for glass beed and stop.

Intermediate Rails size should be (Maximum 150 x 46mm) Plus 16mm for glass beed and stop

Door thickness should be 1-3/4" (46mm)

Mechanical fastened hairline flush vertical joints on the inside and interlocking joints at lock and hinge edges.

Glazing beed should be 16mm high with countersunk screws.

d. **Fire rated Doors: Insulated**

All fire doors shall be manufactured as per the test certificate and the original product prototype for minimum of 60minutes and maximum of 120minutes as per NBC 2016 requirement.

It should comply with the specification in terms of sheet thickness and frame details. Door frame and leaf sheet thickness can be on the higher side of the specification but not otherwise and shall be fully compliant in terms of construction details and finish. Minimum recommended sheet thickness for frame shall be 1.6mm (16guage) and shutter shall be 1.2mm (18guage).

All fire doors should be tested for stability, integrity and insulation. Doors shall be tested for 120minutes integrity and 30minutes insulation.

The infill material shall be high density insulation material tested for minimum 30minutes insulation. The internal construction of the door shall be rigid reinforcement for stability and integrity.

Fire doors shall be tested as a complete assembly including Frame, door leaf, vision lite and hardware.

Intumescent seal is mandatory for all insulated doors. This is independent of the addition smoke seal if required. Smoke seal cannot be used as an alternative for the intumescent seals.

Products tested and certified shall be from approved labs of national or international repute. Third party certified products under a labeling program shall be acceptable provided the test certificates are valid and in line with the door and hardware.
All fire doors supplied by the manufacturer shall also be acceptable to the Local authority or AHJ (Authority Having Jurisdiction)

Doors tested without vision panel shall not be used if it is not covered as a assembly in the related test certificate

The Maximum size of the glazing shall not exceed the overall glass sq.mt tested.

All hardware used shall be in line with minimum and maximum fire rating for which it is tested and approved. The hardware supplier shall provide relevant certificates to the door manufacturer and agree in writing if the material is not tested along with the door.

Door manufacturer shall be fully responsible for manufacturing, supplying of material in compliance with the standard and certification. Any deviation there off shall be documented and approved by competent authority before the supplies are affected.

e. Fire rated Doors: Un-Insulated

All fire doors shall be manufactured as per the test certificate and the original product prototype for minimum of 60minutes and maximum of 120minutes as per NBC 2016 requirement.

It should comply with the specification in terms of sheet thickness and frame details. Door frame and leaf sheet thickness can be on the higher side of the specification but not otherwise and shall be fully compliant in terms of construction details and finish. Minimum recommended sheet thickness for frame shall be 1.6mm (16guage) and shutter shall be 1.2mm (18guage)

All fire doors should be tested for stability, and integrity. Doors shall be tested for 120minutes stability and integrity.

The infill material shall be resin bonded honeycomb craft paper of higher density. The internal construction of the door shall be rigid reinforcement for stability and integrity.

Fire doors shall be tested as a complete assembly including Frame, door leaf, vision lite and hardware.

Products tested and certified shall be from approved labs of national or International repute. Third party certified products under a labeling programme shall be acceptable provided the test certificates are valid and in line with the door and hardware.

All fire doors supplied by the manufacturer shall also be acceptable to the Local authority or AHJ (Authority Having Jurisdiction)

Doors tested without vision panel shall not be used if it is not covered as a assembly in the related test certificate

The Maximum size of the glazing shall not exceed the overall glass sq.mt tested.

All hardware used shall be in line with minimum and maximum fire rating for which it is tested and approved. The hardware supplier shall provide relevant certificates to the door manufacturer and agree in writing if the material is not tested along with the door.
Door manufacturer shall be fully responsible for manufacturing, supplying of material in compliance with the standard and certification. Any deviation there off shall be documented and approved by competent authority before the supplies are affected.

f. **Glazed Fire rated Doors: Insulated**

All glazed fire doors shall be manufactured as per the test certificate and the original product proto type for maximum rating of 120minutes as per NBC 2016 requirement.

It should comply with the specification in terms of sheet thickness and frame details. Door frame and leaf sheet thickness can be on the higher side of the specification but not otherwise and shall be fully compliant in terms of construction details and finish. Minimum recommended sheet thickness for frame shall be 1.6mm (16guage) and shutter shall be 1.2mm (18guage)

All fire glazed doors should be tested for stability, integrity and insulation. Doors shall be tested for 120minutes integrity and 30minutes insulation.

The infill material shall be high density insulation material tested for minimum 30minutes insulation. The internal construction of the door shall be rigid reinforcement for stability and integrity.

Fire doors shall be tested as a complete assembly including Frame, door leaf, glazing glass with intumescent seal and hardware.

Intumescent seal is mandatory for all insulated doors. This is independent of the addition smoke seal if required. Smoke seal cannot be used as an alternative for the intumescent seals.

Products tested and certified shall be from approved labs of national or international repute. Third party certified products under a labeling program shall be acceptable provided the test certificates are valid and in line with the door and hardware.

For doors with side and top partitions, the certificate shall satisfy the requirement for maximum size of the partition and sq.mt area.

For continuous side partition, the detailing approval shall be based on valid assessment report indicating the maximum and minimum allowable glass in each panel. Manufacturer test certificate for specimen door may not be sufficient; it should be supported by valid assessment report from accredited lab for continuity of the system.

Glass manufacturer certificate may not be acceptable as they are just part of the assembly. Door manufacturer test certificate is mandatory.

**NBC 2016, requires all**

All fire doors supplied by the manufacturer shall also be acceptable to the Local authority or AHJ (Authority Having Jurisdiction)

Doors tested without vision panel shall not be used if it is not covered as a assembly in the related test certificate

The Maximum size of the glazing shall not exceed the overall glass sq.mt tested.

All hardware used shall be in line with minimum and maximum fire rating for which it is tested and approved. The hardware supplier shall provide relevant certificates to the door manufacturer and agree in writing if the material is not tested along with the door.
Door manufacturer shall be fully responsible for manufacturing, supplying of material in compliance with the standard and certification. Any deviation there off shall be documented and approved by competent authority before the supplies are affected.

**SHOP FINISH**

Carry out shop finishing of metal doors and frames as follows:

Chemically treat non galvanized, non bonderized metal surfaces with a phosphate compound to assure maximum paint adherence.

Thoroughly clean all metal surfaces of all rust, scale, grease, rough spots and other foreign matter which may prevent proper paint adhesion.

Apply spray powder coat of rust-inhibitive self etching powder on all surfaces of frames and on exposed surfaces of doors and panels. Door set shall be baked on in accordance with manufacturer’s recommendations for developing maximum hardness and resistance to abrasion; paint dry film thickness not less than 50 microns.

In case of primed surfaces shall be smooth and suitable to receive the finish coats.

**FINAL FINISH**

Painted Doors: All doors and frames can either to painted at site with suitable aliphatic grade paint polyurethane base. Powder coated frames and shutters are also acceptable if specified in the item description. Provide a final painted doors and frames of approved shade. Paint surface shall be tested for minimum 250 hours of salt spray test.

Wood grain finish: Provide wood finish on the grain tech surface of the door and frame. Doors to be hand finished and stained with approved wood finishes.

**HARDWARE PREPARATION**

General: Hollow metal doors and pressed metal frames shall be prepared at the manufacturer's plant for all hardware in accordance with templates furnished and shall be drilled and tapped to receive hardware as indicated on the hardware templates.

Mortised and concealed hardware: Mortise, reinforce, drill and tap for mortised and concealed hardware.

Locations: Locate hardware as shown on the drawings and conform to standards established by the door hardware manufacturers.

**INSPECTION**

Examine the substrates and the conditions under which hollow metal doors and frames shall be installed and correct any unsatisfactory conditions.

Do not proceed with the work until unsatisfactory conditions have been corrected in a manner acceptable to the Engineer.

**INSTALLATION**

General: Install metal doors, frames, and accessories in accordance with final shop drawings and manufacturer's data, and as specified in this section.
Placing Frames: Shall comply with provisions Recommended Erection Instructions For Steel Frames, unless otherwise indicated.

Door Installation: Fit hollow metal doors accurately in frames, within clearances specified. Finish Hardware: Conform to recommended hardware installation manual.

Anchors for installation shall be recommended by manufacturer based on kind of construction and fire rating.

Grouting of frames shall be done once the doors are fully aligned with approved grouting material.

**ADJUST AND CLEAN**

Prime Coat Touch-Up: Immediately after erection, sand smooth any damaged areas of prime coat and apply touch-up of compatible air-drying primer.

Protection Removal: Immediately prior to final inspection, remove protective plastic wrappings from prefinished doors.

Final Adjustments: Check and readjust operating finish hardware items leaving steel doors and frames undamaged and in complete and proper operating condition.

**FIRE RATED HARDWARE**

a) Door closer shall be SS 316 grade & confirming to CE & EN 1154 and B.S. – 476, Part-22, two hours fire rated (Approved make –dorma / yale / Inox (Assa Abloy))

b) Panic Exit Device – Single / Double leaf shall be SS 316 grade & confirming to CE & EN 1154 and B.S. – 476, Part- 22, two hours fire rated (Approved make –dorma / yale / Inox (Assa Abloy))

c) Mortice Lock with lever handle shall be SS 316 grade & confirming to CE & EN 122090/DIN 18251 and B.S.-476, Part-22 , two hours fire rated (Approved make –dorma / yale / Inox (Assa Abloy))

d) Stainless steel ball bearing hinges 4 nos. on each side of Steel Fire door shutters size 100 mm x 100 mm x 3 mm with screws etc. complete. (Approved make –dorma / yale / Inox (Assa Abloy))

e) Vision panel: Minimum 5 mm thick Pyron /pyrobeck / Central/Saint Gobain/ schcott Fire Rated Clear Non Wired Glass of 120 minutes rating one on each leaf of size 300 x 300mm.

**TESTING**

The fire doors shall be tested by CBRI/ National Test House (Govt. of India) in accordance with BS 476 part 22. Galvanized steel to be used conforming to IS 277 (2003). The supply should be made along with valid test report from CBRI/NTH. One number door shutter along with frame and fittings of each type shall be tested from CBRI Roorkee/NTH for fire rating as per required standards and nothing extra for additional door shutter and testing charges shall be paid on this account.
STANDARDS
a) The Door Hardware specification, performance, quality and finishes shall be in accordance with the following standards as indicated on the design drawings or in the particular specification.

- British (BS) Standards
- BS EN Standards
- German (DIN) Standards
- European (CEN) Standards
- ISO Standards

b) Door Hardware supplied shall be manufactured in factories accredited with BS EN ISO 9000 to ensure quality control.

c) All Door Hardware manufacturers and principal source suppliers shall be affiliated to and comply with the requirements of the guild of architectural ironmongers in London, U.K. and/or their respective European counterpart bodies.

d) Door Hardware of a specialized nature not covered by any of the above standards shall, as far as possible, be constructed from components manufactured to these standards, in terms of performance, quality and finish.

MATERIALS

I General

a) Door Hardware shall be supplied with all necessary components and ancillary fittings and including all matching fixing screws, bolts, of correct size and capacity to suit the particular installation function and loading. Non-corrosive materials shall be utilized throughout.

b) All Door Hardware shall be supplied with the manufacturer’s fitting instructions, which must be strictly adhered to in all cases.

c) The woodwork Contractor, in liaison with the Door Hardware supplier, is responsible for ensuring the correct operation of the Door Hardware after installation.

II Function

All items of Door Hardware shall be suitable for the purpose shown on the design drawings and detailed in the specification and shall comply with BS 476 and BS 5588.

III Finish

All materials used in the components of an item of Door Hardware shall be of best quality material and shall be resistant to corrosion, in accordance with BS EN 1670.

Lacquer coating to polished brass finish etc. is not required.

When PVD (diamond/ultra) finish is specified the PVD process shall be carried out to all items specified by a single source, to maintain consistent colour throughout for the particular project. PVD finish shall be warranted for a minimum of 15 years against corrosion and tarnishing.
All stainless steel Door Hardware products shall be manufactured from 316 grade satin stainless steel to BS EN Standard except where detailed in the following paragraph.

Internal Door Hardware for kitchens, pantries and services shall be manufactured from 316 grade satin stainless steel to BS EN standard. This shall also include adjacent Washrooms/Toilets for use by kitchen/catering staff, whilst at work.

All aluminium Door Hardware shall conform to BS EN 12373 latest revisions.

The Door Hardware manufacturer/supplier shall comply with the requirements of this specification in respect of Operating and Maintenance Manuals.

IV Samples of all Door Hardware

After award of the Door Hardware Contract a sample of each item of Door Hardware with all its accessories shall be provided to the woodwork Contractors to evaluate its fixing.

These samples inclusive of all accessories etc. need not be of the specified finish, but shall be typical in all other respects to the specified item to be used in the Works.

HINGES

I) General

a) Hinges shall comply with BS EN 1935.

b) Hinges and their screws shall be suitable for the application and shall be of similar material and finish.

c) PVD finish can be proposed in lieu of polished brass finish.

d) Doors fitted with overhead Closers, shall be fitted with hinges manufactured in satin stainless steel double ball bearings.

II) Door hinges

a) Hinges shall be one of the following types as indicated on the design drawings

• Stainless steel with double ball bearings.

b) For service areas hinges shall be one of the following types, as indicated on the design drawings

• 316 grade satin stainless steel with double ball bearings.

III) External window and internal screen hinges

a) Hinges shall be one of the following types as indicated on the design drawings

• Stainless steel with double ball bearings.
• The largest size required will be 95 x 19 x 26mm deep, unless otherwise indicated on the design drawings.
b) For service areas hinges shall be one of the following as indicated on the design drawings

- 316 grade satin stainless steel with double ball bearings.

FLOOR SPRINGS

I) General

a) All external main entrance doors and all internal thoroughfare doors shall have floor springs with hold open, adjustable closing speed, back check, delayed action and latch action facilities, unless otherwise indicated on the design drawings.

b) The floor spring and all its components, shall be manufactured to BS EN 1154, BS 6459 and BS 5750 and be of suitable capacity for its intended purpose, and shall function without undue opening effort.

c) Floor springs shall not be used on bathroom or toilet doors unless indicated on the design drawings. Where required the spring strength shall be weak and the hold open facility deactivated or removed.

II) Application

a) Centre pivoted floor springs shall not be used for external door application, unless detailed on the design drawings.

b) External doors shall be set in a traditional 90° rebated frame, with minimum 20mm rebate depth, using 5mm offset components, unless otherwise indicated on the design drawings.

c) All other internal main thoroughfare and main rooms entrance doors shall be provided with 5mm offset components, unless indicated otherwise on the drawings.

III) Function

a) All floor springs shall be supplied with variable closing speed, back check, hold open, delayed action and latch action facilities unless otherwise indicated on the design drawings.

b) The floor box cover plate shall be without raised bevelled edges.

c) Door stops shall always be use in conjunction with floor springs.

IV) Finish

When door furniture is in satin stainless steel finish the exposed components of the floor spring shall be manufactured in 316 grade as appropriate.

OVERHEAD DOOR CLOSERS

I) General

a) Overhead door closers and all of their components shall be to BS EN 1154, BS 6459 & BS 5750 and be suitable for their intended purpose, and shall function without undue effort in use.
II) Application

a) The minimum required thickness of door leaf when using a concealed overhead door closer is 55mm.

III) Function

a) Overhead door closers shall be supplied with adjustable closing force, adjustable back check, latch action, limit function and hold open facilities, unless otherwise indicated on the design drawings.

b) Door closers shall be used in conjunction with door stops.

IV) Finish

When door furniture is in satin stainless steel finish the exposed components of the closer shall be manufactured in 316 grade as appropriate.

DOOR STOPS

I) General

Door stops are required for all doors, regardless of method of door hanging, pivoting or closer method.

II) Type

a) The floor door stop shall include both floor pin and screw fitting to the floor.

b) Door stops shall be floor mounted of semi-dome type with shielded base of 50 x 45mm and projection of 25mm to the rubber door buffer insert, unless otherwise indicated on the design drawings.

c) Where floor door stops are not practical wall mounted door stops, having a suitable projection from the wall, shall be provided.

III) Application

a) Fixing to the floor or wall shall allow the maximum opening angle of the door leaf without making contact with any wall finish. The door stop rubber buffer insert shall be aligned to make full face contact with the door leaf bottom rail in the case of floor mounted door stops.

b) Floor door stops must be positioned on the finished floor to avoid any possible encroachment of thoroughfare access, to the door opening when in the open position or within the room when door leaf is in closed position.

IV) Finish

The door stop finish shall match the door furniture and/or other DOOR HARDWARE finishes previously described.
LEVER ACTION FLUSH BOLTS

I) General

a) Lever action flush bolts to BS EN 12051 shall be used on the dead leaf, at top and bottom of the inside rebated edge, on all double leaf doors and windows.

b) The bolt shall have a minimum 15mm throw to provide sufficient penetration and security into the frame head keep plate and floor socket.

c) Lever action flush bolts width size shall be 19mm except for thick door or gate leaves where larger width shall be used as indicated on the design drawings.

d) For window/screens with small section timber stiles, narrower lever action bolt widths or sunken slide bolts shall be used as indicated on the design drawings.

II) Function

The criteria for lever action flush bolts size; for double leaf doors or windows shall be as follows:

- Bottom bolt size: 152 x 19mm shall be fitted in the internal side of the meeting stile rebate check of the dead leaf.

- Top bolt size: width equal to bottom bolt, length to suit leaf height and accessibility. The length of top bolt shall normally be pre-determined by the lever action being accessible within the range of 1800mm to 1950mm above finished floor level.

- For double leaf windows that are not accessible from finished floor level the top bolts shall be of the same minimum length as bottom bolts.

III) Finish

The bolt finish shall match the door furniture and/or other Door Hardware finishes previously described.

FLOOR BOLT SOCKETS

I) General

a) Easy-clean bolt sockets shall be provided for bottom bolts of double leaf doors, and/or double leaf windows/screens with non-timber cill.

b) The bolt socket shall be to the corresponding size of the lever action bottom shoot bolt diameter.

II) Type

Floor bolt sockets shall be suitable for setting into the floor finish.

III) Function

Windows and doors with timber cill do not require a floor socket; the keep plate supplied with the lever action flush bolt shall be used.
**IV) Finish**

Floor bolt sockets finish shall be match the other Door Hardware and/or furniture on the door, shall only be carried out if instructed.

**LOCK CASES**

I) **General**

a) All lock cases shall comply with BS 5872 and/or DIN 18251.

b) Mortise lock cases shall be centralised in the leaf thickness, unless shown otherwise indicated on the design drawings.

II) **Type**

a) All lock cases that are key operated shall be of Euro-Profile (PZ) type to suit cylinder locks, unless otherwise indicated on the design drawings, or as specified.

b) Key operated mortise cylinder lock cases for use with lever handle or knob furniture when particularly specified, shall be at 72mm centres and suitably sprung for lever handle/knob return action.

c) External main entrance double leaf doors and internal main Thoroughfare corridor double leaf doors that are on floor springs together with internal double swing action doors on centre pivot shall be provided with a „Euro-Profile“ mortise deadlock case.

d) All hinged doors without closer mechanism shall have mortise cylinder lock case with latch action, with the exception being toilet and bathroom doors, which shall be provided with latch only lock case and „croft“ doorbolt.

III) **Forends and strike plates**

a) The latch action protection area of all strike plates used with latch action lock cases shall project beyond the jamb no more than 2mm.

b) This shall also apply to mortice latch only lock cases.

IV) **Rebate sets**

a) Lock cases for double leaf doors or windows shall be supplied with a proprietary rebate set of either 15mm or 20mm or 25mm. The rebate set shall be supplied by the lock case manufacturer to ensure matching material and finish.

b) For centre pivoted internal double swing action double leaf doors with curved meeting edges a deadlock case shall be used.

c) For extra large external doors the lock case manufacturer shall supply a larger rebate set.

V) **Backsets**
a) Lock cases shall have backsets available in 5mm increments.

b) The backset of the lock case shall be fitted to ensure the door furniture is centred on both faces of the door leaf lock-stile flat face when the door is in the closed position.

c) Double leaf doors backset shall be measured as half the flat face on the rebated side of the lock stile, (outside the room being entered), plus the full rebate depth of the lock stile, i.e. 15, 20 or 25mm.

d) Main entrance double leaf doors with plant-on door stop Mullions to the meeting stiles shall be measured at half the flat face on the rebated side of the lock stile, (outside the room being entered), plus the full rebate depth of the lock stile as stated above, but including the necessary lock stile overlay of the plant-on doorstop mullion as shown on the design drawings.

e) For doors with carved stiles, the carving module or pattern shall determine the backset, with similar allowance for double leaf doors as described above.

VI) Finish

Exposed components of lock cases, (i.e. forends, strike plates and rebate sets) shall be finished to match other Door Hardware and/or furniture on the door.

CYLINDER LOCKS

I) General

a) All cylinder locks shall be of „Euro-Profile“ (PZ) type unless otherwise indicated on the design drawings or as specified.

b) Cylinder locks shall comply with BS EN 1303 and/or DIN 18254.

c) The cylinder lock specification shall include the following features

- 6 pin Tumblers.
- Anti-picking devices.
- Hardened anti-drilling devices.
- Master-keyed and sub-mastered applicable to the project.

d) All cylinder locks shall be supplied with a lifetime warranty.

II) Individual cylinder differ keys and GMK / SMK system keys

a) Cylinder locks shall be supplied with THREE (3 No.) differ keys per cylinder lock.

b) All cylinder key systems shall be of a manufacturer/type so that the keys cannot be duplicated locally.

c) Grand Master Keyed (GMK) and Smart Master Keyed (SMK) key quantity shall also be THREE (3 No.) unless otherwise stated.

d) A GMK, and as necessary SMK, system key schedule of key accessibility to individual differs/doors shall be provided by the Engineer-in-Charge for all cylinder lock systems.
e) Immediately upon completion of the project contract a final „As Built“ system key schedule shall be provided to the Engineer-in-Charge. This final key schedule shall be issued before actual project handover to Engineer-in-Charge by the joinery or Contractor.

III) Cylinder lock length

a) All double cylinder locks shall be of equal length on both sides of centre point; that is of equal incremental extension. Single cylinder locks shall be centred on the leaf thickness.

b) The Cylinder lock projection beyond the face of the door furniture shall be not more than 3mm maximum for security reasons along with practical aesthetics. They shall not be underflush.

IV) Finish

The finish shall match that of the adjacent furniture. However due to constraints in manufacturing materials, certain finishes shall be subject to submission for approval by the Engineer-in-Charge.

V) Cylinder knobs and privacy cylinders

Where keyless knobs are required, these shall be of „figure of eight“ (8) pattern as per EVVA- Werk system, unless otherwise instructed by the Engineer-in-Charge.

‘CROFT’ DOOR BOLT

I) General

Croft door bolts shall be used on all toilets and bathrooms doors when indicated on the design drawings or in the specifications.

II) Type and application

a) The barrel length shall be 95mm long x 25mm wide, unless otherwise indicated on the design drawings or in the specification.

b) The bolt shall be of the straight shoot type, unless indicated otherwise on the design drawings.

c) The keep plate shall be of solid brass surface mounted enclosed type with a matching beaded edge detail as the barrel. Edge mounted keep/strike plate shall not be used unless incorporated on the original design drawings or in the specification.

III) Finish

The Croft door bolt shall be manufactured from stainless steel as described in Clause 7.03.02 Para IV.
LEVER ACTION DOOR FURNITURE

I) General

a) Unless indicated otherwise on the design drawings, internal doors shall be provided with lever action furniture. Door furniture shall comply with BS EN 1906.

b) Dead leaves of internal double leaf doors shall have „Dead-fixed“ latch only lever furniture without key-hole as indicated on the drawings.

c) Double leaf doors in service areas shall only have furniture to the dead leaf when indicated on the drawings.

d) All internal doors lever furniture shall be on back-plate, unless otherwise indicated on the design drawings or in the specification.

e) All lever handle furniture, shall be with pivot centre point at 970mm AFFL on the lock stile/s, unless otherwise indicated on the design drawings.

II) Back-plates on 72mm centres for cylinder lock

Unless indicated otherwise on the design drawings, all back-plates for lockable door furniture shall be on the European Standard of 72mm centres for mortice euro-profile (PZ) cylinder lock cases.

III) Follower spindles

a) All proprietary follower spindles, for lock cases with latch action, shall be supplied to suit the door leaf thickness, and be fully inserted within the lever handle/s.

b) Unless otherwise indicated on the design drawings all follower spindles shall be of the standard 8mm square.

c) The follower spindles shall be supplied by the door furniture manufacturer and will be of a non-corrosive metal.

IV) Securing lever latch action handle to back-plate

The method of securing lever latch action handle to the back-plate shall incorporate grub screw fixing from the underside of the lever onto the follower spindle and a blue steel non-corrosive spring circlip retaining the lever handle on the rear side of the back-plate/rose.

V) Finishes

a) Finish shall be as specified for internal, external and use.

d) Stainless steel furniture shall be in satin finish of 316 grade for the areas as noted previously.

b) Where aluminium furniture is required, it shall be in satin anodised finish to BS 1615.
CENTRE DEAD KNOB DOOR FURNITURE

I) General

a) Knob mortice lock furniture shall comply with BS EN 1906 and shall not be used with latch action lock cases for doors, unless indicated on the design drawings. In which case knob diameter shall not exceed 57mm and the lock case must be suitably sprung for use with knob furniture.

b) When indicated, dead-fixed knob furniture of the same maximum diameter with back-plate or rose and escutcheon may be used on lock stiles with an Euro-Profile mortice dead lock case.

II) Dead-fixed centre door knobs

a) Generally decorative dead-fixed centre door knobs shall only be used on the outside face of double leaf entrance doors, which are provided with floor spring and deadlock lock case. In such cases pull handles or dead-fixed lever furniture shall be used on the inside face.

b) Decorative dead-fixed centre door knobs may be used on both sides of entrance gates, with back-to-back fixing method.

c) Knob and rose diameters or back-plate size, and design, shall be as shown on the design drawings or indicated in the Programme.

d) Location of decorative dead-fixed centre door knobs shall be as indicated on the design drawings, to suit adjacent carving designs.

e) Decorative dead-fixed centre door knobs shall be provided with a Euro-Profile mortise deadlock case to the lock stile with matching design escutcheon/s to the stile face/s at location shown on the design drawings.

III) Fixing

a) Where centre door knobs are to both faces of the leaf and are concentric, back-to-back fixing shall be used. In all other instances, where door face design permits, concealed bolt through method should be used.

b) Where the door face design does not allow for the bolt through method, or lever action furniture is to be used on the internal face lock stile, a secure and robust secret fixing method of the centre door knob shall be used to approval of the Engineer-in-Charge.

IV) Finish

Dead-fixed centre door knobs shall be as per the design drawings or as specified.

PULL HANDLES AND PUSH PLATES

I) General

a) Pull handles and push plates shall be used for double leaf doors in main thoroughfare corridors or entrances, when indicated on the design drawings only.
b) Pull handles and push plates shall also be used for single leaf doors in other locations as indicated on the design drawings or as specified.

c) When pull handles and push plates are used they shall be provided with a Euro-Profile mortice deadlock lock case to the lock stile only, with Euro-Profile piercing below the handle or with matching design escutcheon/s to the stile face/s at the location shown on the design drawings, or as specified.

II) Fixing

a) Where pull handles are to both faces of the door and are concentric, back-to-back fixing shall be used. When push plates are provided to the outside face of the door the pull handles shall be of the bolt through fixing type and bolts shall be covered by the push plates on the outside face of the door.

b) Where door face design permits, the concealed bolt through method shall be used. When door face design does not allow for bolt through method, or lever or knob furniture is to be used on the outside face lock stile, a secure and robust secret fixing method of the pull handle shall be used to approval of the Engineer-in-Charge.

c) Pull handles shall be positioned between 1200 and 1350mm on centre of their height above AFFL, unless particularly shown otherwise on the design drawings.

d) Push plates shall be positioned on the outside face of the lock stile concentric with the pull handle.

III) Finish

Pull handles and push plates shall finished to match the furniture on adjacent doors in the room.

CYLINDER ROSES / ESCUTCHEONS

I) General

Cylinder roses/escutcheons shall be of matching design, shape and finish with the dead-fixed centre door knob, pull handles, or other door furniture.

II) Type

Unless otherwise indicated on the design drawings, all cylinder roses/escutcheons shall be of „Euro-Profile“ piercing to conform with the design requirements. The overall diameter and other dimensions and design shall comply with the design concept of the door stile.

III) Finish

The design and finish shall match that of the adjacent door furniture.
WINDOW / SCREEN KNOBS

I) General

a) Knobs for windows/screens shall be either round or oval shape and of the size indicated on the design drawings.

b) Where window/screen knobs are to be made from timber to match the window/screen finish they shall not from part of the Door Hardware supply scope, but will be included in the joinery scope of work.

c) Window lever furniture may be specified for external windows for use with adjustable backset budget locks, or window casement fasteners for use with casement stays.

d) Windows shall not have any furniture externally, unless otherwise indicated on the design drawings.

II) Type

a) The knobs shall be on a rose to suit the available flat width of the window stile unless otherwise indicated on the design drawings.

b) Window/screen knobs, and any other window furniture, shall match the design of the door furniture in the room, unless otherwise on the design drawings.

c) For window screens the maximum diameter of a knob shall be 38mm.

d) Full height, walk-through type, glazed French windows shall be lockable from inside only and may have lever or mortise knob action furniture.

III) Finish

The finish shall match that of the adjacent door furniture.

ADJUSTABLE ROLLER CATCHES

I) General

a) Spring activated ball or double ball catches shall not be used for windows.

b) Roller catches for windows/screens etc. shall be of adjustable type with barrel depth of 43mm x 19mm diameter, or where indicated on the design drawings adjustable magnetic catches may be used.

II) Function and installation

Adjustable roller catches for windows/screens shall be recessed into frame head or cill or both, with the keep plate fixed into the leaf, as indicated on the design drawings. Keep plates shall not project beyond the leaf/frame edge face by more than 2mm.
III) Finish

Roller catches finish shall match other Door Hardware and/or furniture on the window/screen.

WINDOW LOCKS & BOLTS

I) General

a) External Windows, and where indicated internal window screens, shall be provided with a lock accessible from inside only. The locks shall comply with BS EN 12051.

b) External windows and internal screens shall not be provided with mortise lock case, except full height, walk through type glazed French windows. In such instances the lock shall only be accessible from inside.

II) Type

a) All external windows shall have either or both the following lock type, dependent on the teakwood timber stile member section size as indicated on the design drawings.

- Budget locks with 10 to 22mm adjustable backset where lever or knob action furniture is required on the inside.

- Chubb type security bolt of suitable backset with star key, and budget lock as above, but with tee key where lever or knob action furniture is not required.

b) Internal window screens shall be held in closed position by adjustable roller catches and chubb type security bolt of suitable backset, and/or adjustable backset budget locks to top and bottom of the screen leaf.

III) Finish

The finish shall match the hinges, with the escutcheon or ferrule if specified to match the leaf furniture.

NEOPRENE DOOR AND WINDOW/SCREEN SEALS

I) General

a) Neoprene seals, which comply with BS 7386 shall be used as specified in the design drawings.

b) The seals shall be fitted to the frame and not to the leaf except in special circumstances. Double leaf doors shall also have seals at the meeting stiles.

c) Heavy duty sound proofing seals will be required to all opening edges and meeting stiles for plant room frames/doors, whether they form part of the in work or otherwise.

II) Neoprene compression seal

a) All frames with hinged or offset pivoting leaves shall be provided with Sealmaster ARH neoprene compression seal (or approved equivalent) to jambs, head, (and cill for windows), unless particularly specified otherwise.
b) Plant room doors shall be fitted with seal master CA neoprene compression seal, to the jambs, head and cill of the frame, along with the meeting stiles of the door leaves.

**III) Neoprene wiper seal**

a) External frames with hinged or offset pivoting leaves shall also be provided with Sealmaster ARK wiper seals (or approved equivalent) to jambs and head, (and cill for windows), unless specified otherwise. This also includes external or internal plant room doors, unless specified with N30 or N60 intumescent seals.

b) For external frames of extra tall and/or wide or extra thick leaves alternative seal types, similar to Sealmaster ARL, ARM, PEFA/PEFS or a combination of these shall be used.

c) External fire rated door and window sets may not require ARK wiper seal, dependent on thickness, as similar blade is already incorporated in the Seal master Intumescent fire and smoke seal.

**IV) Double action internal door seals**

a) Internal doors with curved edges to the pivot stiles on a centre pivoted action, shall be fitted with Sealmaster PEFA/PEFS neoprene seals (or approved equivalent), centralised on the frame jambs, scalloped rebate, frame head, and for double leaf doors at the meeting stiles.

b) Where indicated on the design drawings a PEFS seal will not be required at the frame head/top of door. The PEFA seal shall only be used at the frame head, depending on the design detailing.

c) All Doors with PEFA/PEFS neoprene seals; operating in a scalloped lockset frame jamb in the case of single leaf, or curved edge meeting stiles in the case of double leaf; shall be provided with a closing mechanism.

d) The closing mechanism shall be floor spring, or concealed overhead cam action closer for door leaves of 55mm minimum thickness. For service areas surface mounted closers shall be used.

e) These doors shall have deadlock bolt action only, or where called for on the design drawings an additional adjustable roller bolt action.

**V) Intumescent fire and smoke seals**

a) Fire rated doors frames shall be fitted with Sealmaster intumescent fire and smoke seals (or approved equivalent) to BS 476 and certifire approval No. CF142. The seal shall incorporate an angled self-extinguishing elastomeric replaceable wiper blade, which matches the fire rating of the door.

b) Where double leaf door and window sets meeting stiles are not rebated or the

c) section detail cannot accommodate N30 or N60 seals, then Sealmaster IMN/IMP for FD30S rating, or N60S/IMP for FD60S rating shall be fitted.
d) For FD60S rated door and window sets the N60 Intumescent Seal elastomeric wiper blade shall be flame retardant and Sealmaster intumescent plugs shall be fitted to hinges, locks, and other Door Hardware, which breaks the continuity of the seal.

e) Glazing to FD30S fire rated door or window set panes shall be provided with either a bedding of sealmaster FireGlaze compound or Sealmaster G30 glazing strips as appropriate. For FD60S rating they shall be provided with both Sealmaster GL60 FireGlaze liner and Fire Glaze compound.

f) To achieve FD60S integrity Sealmaster gap filling compounds, such as intumescent compound or masterseal will be required at all door/windowframesets joints between the building structure, and around all Door Hardware cutouts.

g) Sealmaster N30 and N60 fire and smoke seals may take the place of Sealmaster ARK wiper seals on external doors or windows where prevalent, depending of leaf thickness.

h) Under no circumstances whatsoever shall fire only seals be used.

VI) Seals aluminium channel finish

a) All types of Sealmaster seals shall incorporate aluminium carrier channel for general thoroughfare areas.

VII) Automatic door bottom seal

i) General

a) All external doors to all main buildings shall have automatic door bottom seal. These seals shall also be fitted to external doors of other buildings where indicated on the design drawings.

b) Automatic door bottom seal shall also be fitted to plant rooms with noise emitting equipment such as an AHU, whether internal or external to the main buildings.

c) Where an automatic door bottom seal is required for internal doors it will noted on the design drawings or as specified

d) Automatic door bottom seals shall not be used on service or staff Buildings, unless specified.

ii) Type

Automatic door bottom seals shall be mortise type from either Zero International, Athmer, Ventura or Hafele ranges to suit the door construction and pivoting method.

iii) Application

a) All mortise type Automatic door bottom seals shall be concealed fixing and grooved into the door bottom rail. The black or grey neoprene element of the seal must extend to full width of the door leaf, and in the case of double leaf doors must meet together
at the meeting stiles.

b) Where it is not possible to accommodate the mortise type, surface mounted Automatic door bottom seals be considered.

iv) Finish
The mortise fixed concealed Automatic door bottom seal shall be in the manufacturer’s standard mill finish for the aluminium carrier.

RECEIVING AND DELIVERY

I) General

a) It is the responsibility of the Door Hardware Contractor to check all items before delivery.

b) Checking shall include ensuring related items are kept together and that the items function correctly.

c) The Engineer-in-Charge shall be notified when missing or faulty components are likely to delay the works.

II) Packaged sets

a) The Door Hardware Contractor shall supply the Door Hardware packaged in sets, identified by door/window No. and type or furniture unit and type along with the relevant Door Hardware schedule page/s for the particular door/window or Furniture Unit per package.

b) The packaged sets of Door Hardware shall be delivered, to the respective door Contractors factory stores, unless otherwise instructed by the Engineer-in-Charge.

III) Itemised delivery note

a) Each delivery shall be recorded on the Door Hardware supplier’s standard format delivery note, listed by set number and door no. or furniture unit type.

b) Deliveries of a single item in full project quantity shall not be made, unless at the request of the Engineer-in-Charge.

IV) Operation and Maintenance Manual

a) The Door Hardware Contractor shall supply O&M Manuals in accordance with this specification.

b) These O&M Manuals shall be delivered to the Engineer-in-Charge, together with covering letter copied to all relevant parties.

26 ARCHITECTURAL EXPANSION & SEISMIC JOINT COVER ASSEMBLIES:

1 GENERAL

1.1 Description
A Section specifies floor, wall and ceiling, seismic and building expansion joint assemblies.
B Furnish and install complete Expansion Joint Cover Systems.
i. Interior Floor expansion joint covers.
ii. Interior Wall expansion joint covers.
iii. Interior Ceiling expansion joint covers.
iv. Exterior Floor expansion joint covers.
v. Exterior Wall expansion joint covers.
vi. Roof expansion joint covers.
vii. Fire Rated Assemblies.

1.2 Related Work

Refer Sections: Plain and Reinforced Concrete & Structural Steel Works.

1.3 Quality Assurance

A Manufacturer: Obtain joint cover assemblies through one source from a single manufacturer.

i. Manufacturer shall be ISO 9001:2000 Certified.

a) The Manufacturer shall have documented management and control of the processes that influence the quality of its products.

b) The Manufacturer shall have documented management and control of the processes that influence the quality of its customer service.

ii. Manufacturer shall have a minimum of ten (10) years of experience in the fabrication of expansion joint cover assemblies.

1.4 Delivery Storage and Handling

A Provide temporary protective cover on anodized aluminum, stainless steel, bronze finished surfaces.

B Deliver joint covers to jobsite in new, clean, unopened crates of sufficient size and strength to protect materials during transit.

C Store components under cover in original containers in a clean, dry location, off the ground.

1.5 Submittals

A Submission must be made as below prior to start of work:

i. Submit manufacturer’s specifications and technical data, including Material Safety Data Sheets, installation instructions, and, as required, catalog cuts and templates to explain construction and to provide for incorporation of the product into the project.

ii. Submit certificates, copies of independent test reports, or research reports showing compliance with fire resistance rating and other specified performance requirements.

iii. Submit three (3) samples of minimum 150 mm size of all specified systems.

B Shop drawings

i. Showing full extent of expansion joint cover assemblies; include large-scale details indicating profiles of each type of expansion joint cover assembly, splice joints between section,
joiners with other type assemblies, special end conditions, anchorages, fasteners and relationship to adjoining work and finishes.

ii. Include description of materials and finishes and installation instructions.

1.6 Applicable Publications

A. Publications listed form part of this specification to extent referenced. Publications are referred to in text by basic designation only.

<table>
<thead>
<tr>
<th>B</th>
<th>American Society for Testing and Materials (ASTM): A36/A36M-08 Structural Steel</th>
</tr>
</thead>
<tbody>
<tr>
<td>A167-99 (R2009)</td>
<td>Stainless and Heat-Resisting Chromium-Nickel Steel Plate, Sheet, and Strip</td>
</tr>
<tr>
<td>A283/A283M-07</td>
<td>Low and Intermediate Tensile Strength Carbon Steel Plates</td>
</tr>
<tr>
<td>A666</td>
<td>Stainless Steel type 304</td>
</tr>
<tr>
<td>A786/A786M-05(R2009)</td>
<td>Rolled Steel Floor Plates</td>
</tr>
<tr>
<td>B36/B36M-08</td>
<td>Brass, Plate, Sheet, Strip, and Rolled Bar</td>
</tr>
<tr>
<td>B121-01(R2006)</td>
<td>Leaded Brass Plate, Sheet, Strip and Rolled Bar</td>
</tr>
<tr>
<td>B209M-07</td>
<td>Aluminum and Aluminum-Alloy Sheet and Plate (Metric)</td>
</tr>
<tr>
<td>B221M-08</td>
<td>Aluminum and Aluminum-Alloy Extruded Bars, Rods, Wire, Shapes, and Tubes (Metric)</td>
</tr>
<tr>
<td>C864-05</td>
<td>Dense Elastomeric Compression Seal Gaskets, Setting Blocks, and Spacers</td>
</tr>
<tr>
<td>D2287-96 (R2010)</td>
<td>Non-rigid Vinyl Chloride Polymer and Copolymer Molding and Extrusion Compounds</td>
</tr>
<tr>
<td>E119-10</td>
<td>Fire Tests of Building Construction and Materials</td>
</tr>
<tr>
<td>E814-11</td>
<td>Fire Tests of Through-Penetration Fire Stops</td>
</tr>
<tr>
<td>B455</td>
<td>Bronze alloy 385 for extrusions</td>
</tr>
<tr>
<td>B36</td>
<td>Bronze alloy 280 for sheet and plate</td>
</tr>
<tr>
<td>ASTM D2000</td>
<td>Silicone extruded elastomeric flat seal.</td>
</tr>
</tbody>
</table>

PVC Vinyl: Extruded flexible wall and ceiling joint cover.

Santoprene:

i) Face Seals to be installed in exterior conditions shall be UV resistant.

ii) Black/Colorable extruded wall and ceiling joint cover system face seals.

iii) Neutral extruded wall and ceiling joint cover system back seals.

• Abrasive: Two (2) part Epoxy combined with aluminum oxide grit.

• Water Barrier:
  a) PVC reinforced fabric with water-proofness @200Psi, IS7016
  b) Flexible EPDM, Class I, ASTM D4637, 45 mils thick (minimum)

• Fire Barrier:
  a) Single/double package membrane type fire barrier required for indicated fire resistance. Asbestos is not acceptable.
  b) Sprayable fire rated mastic for expansion joints which meets 500 cycles requirement (Class II and III Approval) (ASTM E 1966 and UL 2079)

• Flame Sealant: Flame sealant shall permit joint movement and shall, upon exposure to heat, increase in volume to resist penetration of fire through voids in construction.
Fasteners, accessories and other materials required for complete installation in accordance with the manufacturer’s installation instructions.

<table>
<thead>
<tr>
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<tbody>
<tr>
<td>Underwriters Laboratories Inc. (UL): 263-11</td>
<td>Fire Tests of Building Construction and Materials</td>
</tr>
</tbody>
</table>

## 2 PRODUCTS

### 2.1 Materials

A Stainless Steel: ASTM A167, Type 304.  
B Structural Steel Shapes: ASTM A36.  
C Steel Plate: ASTM A283, Grade C.  
D Rolled Steel Floor Plate: ASTM A786.  
E Aluminum:  
   i. Extruded: ASTM B221, alloy 6063-T5.  
F Bronze:  
   i. Extruded: ASTM B455  
   ii. Plate: ASTM B121.  
G Brass: ASTM B36.  
H Elastomeric Sealant:  
   i. ASTM C920, polyurethane.  
   ii. Type.  
   iii. Class 25.  
   iv. Grade P or NS.  
   vi. Shore A hardness 25, unless specified otherwise.  
I Thermoplastic Rubber:  
   i. ASTM C864.  
   ii. Dense Neoprene or other material standard with expansion joint manufacturers having the same physical properties.  
J Vinyl Inverter Sealant Water stops: Manufacturers’ standard shapes and grade.  
K Fire Barrier:  
   i. Designed for indicated or required dynamic structural movement without material degradation or fatigue.  
   ii. Tested in maximum joint width condition as a component of an expansion joint cover assembly in accordance with UL 263 NFPA 251, UL 2079 NFPA 251, or ASTM E119, ASTM E1966 and E814, including hose steam test at full-rated period.  
M Accessories:
i. Manufacturer’s standard anchors, fasteners, set screws, spaces, flexible secondary water stops or seals and filler materials, drain tubes, adhesive and other accessories as indicated or required for complete installations.

ii. Compatible with materials in contact.

iii. Water stops.

2.2 Fabrication

A. General

i. Use ceiling and wall expansion joint cover assemblies of same design as floor to wall and floor to floor expansion joint cover assemblies. Unless shown otherwise.

ii. Provide expansion joint cover assemblies of design, basic profile, materials and operation indicated required to accommodate joint size variations in adjacent surfaces, and as required for anticipated structural movement.

iii. Deliver to job site ready for use and fabricated in as large sections and assemblies as practical. Assemblies identical to submitted and reviewed shop drawings, samples and certificates.

iv. Furnish units in longest practicable lengths to minimize number of end joints. Provide mitered corners where joint changes directions or abuts other materials.

v. Include closure materials and transition pieces, tee-joints, corners, curbs, cross-connections and other assemblies.

vi. Fire Performance Characteristics:

a. Provide expansion joint cover assemblies identical to those of assemblies whose fire resistance has been determined per ASTM E119, E1966 and E814, NFPA 251, or UL 263, UL 2079 including hose stream test at full-rated period.

b. Fire rating: Not less than rating of adjacent floor or wall construction.

vii. Fire Barrier Systems:

a. Material to carry label of approved independent testing laboratory, and be subject to follow-up system for quality assurance.

b. Include thermal insulation where necessary, in accordance with above tests, with factory cut miters and transitions.

c. For joint widths up to and including 150 mm supply barrier in lengths up to 15000 mm to eliminate field splicing.

d. For joint widths of 175 mm wider, supply barrier 3000 mm modules with overlapping ends for field splicing.

e. For joints within enclosed spaces such as chase walls, include 1 mm thick galvanized steel cover where conventional expansion joint cover is not used.

viii. Seal Strip factory - formed and bonded to metal frames and anchor members.

ix. Compression Seals: Prefabricate from thermoplastic rubber or dense neoprene to sizes and approximate profiles shown.

B. Floor-to-Floor Metal Plate Joints

i. Frames on each side of joint designed to support cover plate of design shown.
a. Continuous frame designed to finish flush with adjacent floor of profile indicated with seating surface and raised floor rim to accommodate flooring.
b. Provide concealed bolt and steel anchors for embedment in concrete.
c. Designed for filler materials between raised rim of frame and edge of cover plate where shown.
d. Frame and cover plates of some metal where exposed.

1) Design cover plates to support 600 Kg per 0.3 square meters
2) Cover plates free of rattle due to traffic.
3) No gaps or bulges occur on filler material during design movement of joint.
4) Provide manufacturer's continuous standard flexible vinyl water stop under floor joint cover assemblies.

C. Floor-to-Wall Metal Plate Joints:
   i. Provide one frame on floor side of joint only. Provide wall side frame where required by manufacturer's design.
   ii. Angle Cover Plates: Provide angle cover plates for joints to wall with countersunk flat-head exposed fasteners for securing to wall unless shown otherwise.
   iii. Space fasteners as recommended by manufacturer.

iv. Match cover of adjacent floor to floor cover.

D. Interior Wall Joint Cover Assemblies:
   i. Surface Mounted Metal Cover Plates:
      a. Concealed frame for fastening to wall on one sides of joint.
      b. Extend cover to lap each side of joint and to permit free movement on one side.
      c. Provide concealed attachment of cover to frame for cover in close contact with adjacent finish wall surfaces.
      d. Use angle cover plates at intersection of walls.
      e. Use smooth surface cover plates matching floor plates.
   f. Use expansion fire inserts in fire rated walls, rated same as hour rating of wall.

E. Exterior Wall Joint Assemblies:
   i. Variable movement with seal designed to prevent water and air infiltration.
   ii. Use vinyl seal strip as secondary seal behind primary seal.
   iii. Cover Plate Assemblies:
      a. Surface mounted cover plate.
      b. Concealed frame for fastening to wall on one side of joint.
      c. Extend cover to lap each side of joint and to permit free movement on one side.
      d. Provide concealed attachment of cover to frame for cover in close contact with adjacent finish surfaces.
      e. Use angle cover plate of intersection of walls.
   iv. Extruded thermoplastic rubber joint assemblies
      a. Aluminum frames both sides of joint.
      1) Designed to receive flexible rubber primary seal on exposed face after installation of frame.
      2) Designed to receive continuous secondary vinyl sheet seal.
      3) Anchor spaced at ends and not over 600 mm.
b. Variable movement extruded rubber primary seal designed to remain in aluminum frame, throughout movement of joint.
   1) Flush mounted seal minimum 3mm thick with dual movement grooves designed for plus or minus 50 percent, movement of joint width.
   2) Seismic seal minimum 3 mm thick with multi-movement grooves designed for plus or minus 100 percent movement of joint width.
   3) Recessed front face seal minimum 3 mm thick with no movement grooves, designed for plus or minus 50 percent movement of joint width.

c. Provide factory heat welded transitions where directional changes occur to ensure a watertight system.
d. Provide pantographic wind load supports, maximum 2400 mm on center to support seal systems of 300 mm and wider.

F. Ceiling and Soffit Assemblies:
   i. Variable movement vinyl insert in metal frame on both sides of joint.
   ii. Designed for flush mounting with no exposed fasteners.
   iii. Vinyl insert locked into metal frame.
   iv. Vinyl insert semi rigid either flush face or accordion shape as showed to span joint width without sagging.

G. Preformed Sealant Joint: Factory installed elastomeric sealant between extruded aluminum angle frames both sides.
   i. Elastomeric Sealant: Two part polyurethane sealant with movement capability of +/- 25% of joint width per ASTM-C-920, Type M, Grade P, Class 25, Shore A hardness of 25+/-.5.
      a) Color:
      ii. Frame: Extruded Aluminum: Clear, Bronze, anodized - as per item description.
      iv. Anticipated movement shall be as per the description of item given in the schedule of quantity.

2.3 Metal Finishes

A General:
   i. Apply finishes in factory after products are fabricated.
   ii. Protect finishes on exposed surfaces with protective covering before shipment.

B. Aluminum:
   i. Floors and Roofs – Mill finish.
   ii. Walls and Ceilings – Clear anodized, Class II, AA-M12 C22 A31; 204-R1/Color anodized to match -Prime painted as per the item description.
   iii. In contact with concrete – Prime painted.

C. Steel shall be galvanized in accordance with ASTM A123.

D. Bronze: Satin finish. Provide lacquer coating for wall and ceiling joint covers.

E. Stainless Steel: Matte finish, sanded, NAAMM- AMP 503, Finish NO.2B
F. Vinyl: Gray (standard). Optional white or black is available for some products.
G. Santoprene: Black, White, Gray, Tan, [Select Color].
H. Abrasive: Black (standard), Select color (Optional colors available).
I. Filler Strips: Gray (standard).

3 EXECUTION
1.1 Examination

A Verify that field measurements and blockout dimensions are as shown on shop drawings prior to releasing materials for fabrication by the manufacturer.
B Installer shall examine conditions under which work is to be performed and shall notify the contractor in writing of unsatisfactory conditions. Installer shall not proceed until unsatisfactory conditions have been corrected in a manner acceptable to the installer.

1.2 Preparation
A Verify measurements and dimensions at job site and cooperate in coordination and scheduling of work with work of related trades.
B Give particular attention to installation of items embedded in concrete and masonry so as not to delay job progress.
C Provide templates to related trade for location of support and anchorage items.

1.3 Installation
A. Install shall be in accordance with manufacturer’s installation instructions unless specified otherwise.
B. Provide stainless steel (grade 304) anchorage devices and fasteners for securing expansion joint assemblies in-place construction including threaded fasteners with drilled-in fasteners for masonry and concrete where anchoring members are not embedded in concrete. Provide metal fasteners of type and size to suit type of construction indicated and provide for secure attachment of expansion joint cover assemblies.
C. Perform cutting, drilling and fitting required for installation of expansion joint cover assemblies.
D. Install joint cover assemblies in true alignment and proper relationship to expansion joint opening and adjoining finished surfaces measured from established lines and levels.
E. Allow for thermal expansion and contraction of metal to avoid buckling.
F. Set floor covers at elevations flush with adjacent finished floor materials unless shown otherwise.
G. Material and method of grouting floor frames set in prepared recesses in accordance with manufacturer’s instructions.
H. Locate wall, ceiling and soffit covers in continuous contact with adjacent surfaces. Securely attach in place with required accessories.
I. Locate anchors at interval recommended by manufacturer, but not less than 75 mm from each end, and, not more than 600 mm on centers.
J. Maintain continuity of expansion joint cover assemblies with end joints held to a minimum and metal members aligned mechanically using splice joints.
K. Cut and fit ends to produce joints that will accommodate thermal expansion and contraction of metal to avoid buckling of frames or plates.
L. Flush Metal Cover Plates:
i. Secure flexible filler between frames so that it will compress and expand.
ii. Adhere flexible filler materials to frames with adhesive or pressure-sensitive tape as recommended by manufacturer.
M. Fire Barriers:
i. Install in compliance with tested assembly.
ii. Install in floors and in fire rated walls.
iii. Use fire barrier sealant or caulk supplied with system.

N. Sealants:
i. Install to prevent water and air infiltration.

O. Vertical Exterior Extruded Thermoplastic Rubber.
i. Install side frames mounted on sealant or butyl caulk tape with appropriate anchors 600 mm on center complete with independent continuous PVC back seal.
ii. Install primary seals retained in extruded aluminum side frames.

P. Installation of Extruded Thermoplastic Rubber or Seals:
i. For straight sections, provide preformed seals in continuous lengths.

ii. Vulcanize or heat-seal field splice joints to provide watertight joints using manufacturer's recommended procedures.

Q. Installation of Preformed Elastomeric Sealant Joint:
i. Locate joint directly over joints in wall or floor substrates.
ii. Full length shall be fastened to substrate using a construction adhesive.

ii. Install flush or slightly below finish material.

3.4 Protection

A. Take proper precautions to protect the expansion joint covers from damage after they are in place.

B. Cover floor joints with plywood where wheel traffic occurs.

3.5 Warranty

A. Submit manufacturer’s warranty in approved proforma that materials furnished will perform as specified for a period of not less than ten (10) year when installed in accordance with manufacturer’s recommendation.

27 STRUCTURAL STEEL PAINTING:

Supplying and applying water based Fire intumescent paint fire tested in accordance with BS 476 Parts 20-22 as approved make @ DFT dependent on HP/a ratio of structural steel with zinc phosphate primer to give additional anti-corrosive protection having VS of 73% - 83% as approved applied over abrasive blasted surface and surface preparation up to a standard of Sa2.5 (ISO 8501-1:1988) or SSPC-SP6 at 75 micron and LEED V4 Compliant for VOC Content and VOC Emissions polyurethane finish paint as approved having volume solid of 72% - 73% @ 50 micron of the required shade over Structural Steel Works at all levels including storage, surface preparation by sand blasting, degreasing, cleaning, drying, providing temporary staging, scaffolding, testing etc., all complete with all respect as desired and as per manufacturer specification and direction of Engineer in charge. The above products should confirm to Green Building norms. Application to be carried out by authorized manufacturer applicator or any other trained applicator as approved by the manufacturer and direction of Engineer in charge.
For Two hrs fire rating

<table>
<thead>
<tr>
<th>1.1 GENERAL</th>
<th>Fireproof Intumescent Coating</th>
</tr>
</thead>
<tbody>
<tr>
<td>1&lt;sup&gt;st&lt;/sup&gt; Coat (Primer)</td>
<td>Providing &amp; applying Two Component Zinc Phosphate Epoxy Primer polyamide cured with minimum Volume Solids of 70%. The minimum recoat interval shall not be more than 2 hrs at 23 Deg C. The primer shall have a DFT range of 60 – 250 microns achievable in one coat. DFT - 75 microns.</td>
</tr>
<tr>
<td>2&lt;sup&gt;nd&lt;/sup&gt; Coat (Waterborne Firproof Intumescent Coating)</td>
<td>Providing and applying One component waterborne acrylic thin film intumescent coating with approximate Volume Solids 69% confirming to BS 476 Part 20-21, EN 13381 Part 8.</td>
</tr>
<tr>
<td>Finishing Coat (to be applied in a single coat)</td>
<td>Providing and applying component chemically curing aliphatic acrylic polyurethane coating. The coating shall have a VOC not more than 250 gms/ltr. The coating shall have a minimum Volume Solids of 73% and a DFT range of 60 – 100 microns achievable in one coat. The coating shall contribute to satisfying the following credit(s): - Indoor Environmental Quality (IEQ) under LEED® 2009 - Environmental Quality (EQ) and Materials and Resources (MR) under LEED® v4 DFT – 50 microns</td>
</tr>
</tbody>
</table>

DFT Measurement should be in accordance with SSPC SPA 2. The entire paint system shall be of same manufacturer.

1.2 Surface Preparation & Comments

Abrasive blast cleans to Sa 2.5 (ISO 8501-1:1988) or SSPC-SP6. If oxidation has occurred between blasting and application, the surface should be re-blasted to the specified visual standard. Surface defects revealed by the blast cleaning process, should be ground, filled, or treated in the appropriate manner.

All surfaces to be coated should be clean, dry and free from contamination. Prior to paint application all surfaces should be assessed and treated in accordance with ISO 8504:1992. Oil or grease should be removed in accordance with SSPC-SP1 solvent cleaning.

1.3 Painting of Structural Steel Work:-

All Paints delivered at site shall be ready mixed in original sealed containers, as packed by the paint manufacturer. The structural steel element shall not be painted when its surface temperature is below 4°C and above 50°C or when the relative humidity is above 75% and ambient temperature is 10°C and below.

For Spray Application:
The spraying equipment shall be compatible with the paint material and provided with necessary gauges and controls. The equipment shall be cleaned of dirt, dried paint, foreign matter and solvent before use.

1.4 Summary of Paint Specification:

Anticorrosive Protection for CS category as per ISO 12944 classifications.

<table>
<thead>
<tr>
<th>FUNCTION</th>
<th>VOC Compliance</th>
<th>CHEMISTRY TYPE</th>
<th>DFT (Dry Film Thickness in microns)</th>
</tr>
</thead>
<tbody>
<tr>
<td>PRIMER</td>
<td>&lt;254gm/litre</td>
<td>Zinc Phosphate</td>
<td>75 minimum</td>
</tr>
<tr>
<td>Fireproof Intumescent Coatings</td>
<td>&lt;24gm/litre</td>
<td>Waterborne Fire intumescent paint fire tested in accordance with BS 476 Parts 20-22</td>
<td>As per the Hp/A table for the product</td>
</tr>
<tr>
<td>FINISH</td>
<td>&lt;243gm/litre</td>
<td>LEED V4 Compliant for VOC Content and VOC Emissions polyurethane</td>
<td>50</td>
</tr>
</tbody>
</table>

1.5 Product Characteristics:

<table>
<thead>
<tr>
<th>Description</th>
<th>Zinc Phosphate Primer</th>
<th>Waterborne Fireproof Intumescent Coating</th>
<th>Polyurethane Paint</th>
</tr>
</thead>
<tbody>
<tr>
<td>Volume Solids</td>
<td>73% (Min)</td>
<td>69% (Min)</td>
<td>72% - 73%</td>
</tr>
<tr>
<td>VOC</td>
<td>Less than 254 gm/litre</td>
<td>Less than 24 gm/litre</td>
<td>Less than 320gm/litre</td>
</tr>
<tr>
<td>Colour</td>
<td>Grey</td>
<td>White</td>
<td>As per RAL Standard / or as approved by E-I-C</td>
</tr>
<tr>
<td>Typical DFT Thickness</td>
<td>75µ (in single coat)</td>
<td>As per DFT Loading Tables</td>
<td>50µ</td>
</tr>
<tr>
<td>Theoretical Coverage (minimum)</td>
<td>9.73 m²/litre @ 75 µ DFT</td>
<td></td>
<td>14.6 m²/litre @ 50µ DFT</td>
</tr>
</tbody>
</table>
Stainless Steel Q-Management systems

Stainless Steel Q-Management systems with retractable tape head Mechanism consisting of Polyester tape of desired colour of minimum 45 mm width, with minimum 2.75 metre retractable length, with desired logo and name in desired colour, with pole 1000mm total height, 63 mm dia. with thickness 1.5 mm of Stainless Steel Grade -304. Stainless Steel pole fixed to S.S. base 350 mm dia. with S.S. cover 45 mm high and bottom with rubberized or ABS or suitable base. Approx. weight should be 10 Kgs.

28 SPECIFICATIONS FOR PROCUREMENT OF SS-DUSTBINS

Procurement of SS-Dustbins Single cylinder

Supplying Dustbins made of 18 gauge, SS-304 grade stainless steel hairline finish of 400 mm external dia. 750 mm high with 300 mm dia round opening at top with PU coating including 125 mm high AAI Blue colour Logo, colour coded waste description sticker and Neoprene gasket ring at bottom. The dustbin should have removable cover and provision of clipping poly bags complete as per design, drawing no.-PLG/A9/STD/DB/01 and directions of Engineer in-charge. The dustbin shall display sticker indicating type of garbage and the top shall be finished with approved shade of PU coating as per the instructions of Engineer-in-charge.

Material

Grade 304 stainless steel is a type of Cr-Ni-Mn stainless with similar properties to A240/SUS 302 stainless steel. The toughness of grade 304 at low temperatures is excellent.

It is one of the most widely used precipitation hardening grades, and possesses good corrosion resistance, toughness, high harness, and strength.

The following datasheet provides an overview of grade 304 stainless steel.

Chemical Composition

The chemical composition of grade 304 stainless steel shall be as per IS 6911 or relevant IS Code.

Mechanical Properties

The mechanical properties of grade 304 stainless steel shall be as per IS 6911 or relevant IS Code.

Modular matting:

Providing and laying 3 M or Euronics or approved equivalent make Modular matting (whipping & scrapping -moisture & dirt recessed ) for areas like main entry/ exit or wherever required as per the technical specification and direction of Engineers in charge.

Introduction to Modular Matting System:

The new modular matting system combines high performance with flexible design options and easy on site installation. This matting system is made up of two tile versions, each incorporating a
2mm drainage foot on the bottom surface. The large open scraper profiles incorporate ‘heel steps’ to prevent heel trapping. Traffic rated at 5000 crossings per day.

The new modular matting system combines high performance with flexible design options and easy on site installation.

The new modular matting system is made up of 2 tile versions. Each tile is 300x300mm square and 17mm deep incorporating a 2mm drainage foot on the bottom surface. The large open scraper profiles incorporate ‘heel steps’ to prevent heel trapping.

The Nomad 8900 Aqua Tile combines the scraper elements with large central textile infill of Nomad Aqua 8500 dual fibre matting. This tile will scrape, remove and hold moisture.

**MATERIAL**

Material shall be of approved quality and confirming to specification as specified in Description of item and CPWD Specification 2009 Vol 1&2 with up to date correction slip and relevant IS code.

**INSTALLATION TECHNIQUE**

Installation shall be done as specified in Description of item and as per manufacturer specification and direction of Engineer in charge.

**29 STAINLESS STEEL BOLLARDS**

Fabrication, Supply & Installation of SS Bollard as Approved make of Stainless Steel 304 grade Bollard, Height-900mm, Diameter – 114mm, thickness of bollard - 2mm, Base plate dia –210mm, fixed to floor with Chemical fasteners as per attached drawing and manufacturer specifications complete with all respect as desired and direction of Engineer in charge.

**MATERIAL**

**PROPERTIES**

<table>
<thead>
<tr>
<th>Element</th>
<th>304-Grade</th>
<th>Implications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carbon</td>
<td>0.08</td>
<td>Increase in percentage decreases the corrosion resistance.</td>
</tr>
<tr>
<td>Silicon</td>
<td>1.00</td>
<td>-</td>
</tr>
<tr>
<td>Manganese</td>
<td>2.00</td>
<td>Affects the magnetic Characteristic and hardness of Iron</td>
</tr>
<tr>
<td>Phosphorus</td>
<td>0.045</td>
<td>-</td>
</tr>
<tr>
<td>Sulphur</td>
<td>0.03</td>
<td>-</td>
</tr>
<tr>
<td>Chromium</td>
<td>18.0 to 20.0</td>
<td>Addition of 12% forms stainless steel from ordinary steel. Removes the corrosive effect of carbon. Forms a passive film which prevents oxidation &amp; consequent corrosion.</td>
</tr>
<tr>
<td>Molybdenum</td>
<td>NIL</td>
<td>Molybdenum increases the corrosion resistance. It has a superior tensile strength at high temperature as compared to 304 Grade Steel. This element can resist major chemical reaction and thus being a very costly element.</td>
</tr>
</tbody>
</table>
Nickel provides corrosion resistance, increases strength in both high & low temperature, increases toughness in low temperature and lowers the effects of work hardening. Thus higher percentage makes the steel superior in quality.

- **Corrosion Resistance:**
  - Nickel: improves corrosion resistance, formability and weld ability, higher Percentage makes steel more Corrosion Resistance & superior in quality. Thus as given in Table with 8 to 10.5% of Nickel AISI 304 is highly Non Corrosive
  - Magnetism out of the Grades of Stainless Steel given above the AISI 304 is having the highest non Magnetic characteristics.
  - Passivation: The chromium forms a passive film on the surface of material which prevents oxidation & consequent corrosion of Stainless Steel. It also helps Stainless Steel to withstand the Corrosion caused by atmospheric / environmental or major chemical reactions.

**SURFACE FINISH**

Surface finish of all the stainless steel materials will be in 304 grade satin finish / matt Finish. The contractor shall submit the certificate from stainless steel manufacturer about grade of stainless steel. Random samples shall be sent for testing of grade and other properties.

**ACCESSORIES**

Fixing will be done by stainless steel expansion bolts of approved size and make as per direction of Engineer-in-charge and welding to be done by using organ welding rods and the surface being duly finished and cleaned by K2passiGSTion, which is nitric acid plus Floric acid solution treatment by which the chances of corrosion will be eliminated and any burn out makes on the metal will also be eliminated.

**COATING MASS**

All stainless steel material will have to be coated by a solution of Inox to avoid finger in prints and avoidance of settlement of environment / atmospheric dust. The coating thickness will be 224 microns.
SS Bollard Details

30 APPLICATION OF POLYSULPHIDE JOINT SEALING COMPOUND

Materials

Sealant: It shall be cold Polysulphide sealant of approved make conforming to BS: 5212-1990 or IS: 11433-1995.

Back-up Rod: Type of material shall be Expanded closed cell Polyethylene foam and shall conform to ASTM C-5249-95 or ASTM D 3575.

Primer: It shall be applied on the concrete faces of the joints. It shall be single component primer suitable for use with Polysulphide joint sealant, as approved by the Engineer-in-Charge.
**Joint Filler Board:** The joint filler shall be Synthetic joint filler board of approved make. It shall be 25mm thick within a tolerance of \(+\ 1.5\text{mm}\) and of a firm compressible material and complying with the requirements of IS: 1838 (Part 3):2011 with a compressibility more than 25%. It shall be provided to the full width between the side forms. If two pieces are joined to make up full width, the joint shall be taped such that no slurry escapes to the joint. The physical requirement of filler shall be as per the table given below:

<table>
<thead>
<tr>
<th>Sl No.</th>
<th>Characteristics</th>
<th>Requirement</th>
<th>Method of test, Ref. to IS</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Resistance to handling</td>
<td>Filler strips shall not be deformed or broken by twisting, bending or other types of ordinary handling when exposed to atmospheric condition (see note)</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Recovery</td>
<td>90% min.</td>
<td>10566</td>
</tr>
<tr>
<td>3</td>
<td>Compression</td>
<td>a) Load required to compress the specimen to 50% of its original thickness before the test shall be (i) 7 kgf/cm², min. (ii) 53 kgf/cm², max.</td>
<td>-do-</td>
</tr>
<tr>
<td>4</td>
<td>Extrusion</td>
<td>Amount of extrusion of the free edge shall not exceed 6mm</td>
<td>-do-</td>
</tr>
<tr>
<td>5</td>
<td>Water Absorption</td>
<td>1%, max.</td>
<td>-do-</td>
</tr>
<tr>
<td>6</td>
<td>Density</td>
<td>100 + 10 kg/m³, min.</td>
<td>-do-</td>
</tr>
<tr>
<td>7</td>
<td>Weathering</td>
<td>a) shall show no sign of disintegration, delamination or separation after the test b) shall satisfy the requirement of recovery, compression and extrusion after the test</td>
<td>-do-</td>
</tr>
</tbody>
</table>

Note: Pieces of joint filler that have been damaged shall be rejected. In order to ensure that sides of the PQC pavement in the portion of above expansion joint filler board do not get dirty and this space does not accumulate pieces of aggregates and other foreign materials, precaution is required to be taken as indicated in note 1 given below.

**Note:**

1. Expansion joint filler board should be provided up to the top of finished pavement surface. At the time of filling the joint with sealant material and backing polyethylene rod, the required depth of joint filler board from the top up to the bottom of polyethylene backing rod should be cut & removed. For easy removal of top filler board and to avoid damage to the filler board, a pre-cut in the expansion joint filler board shall be provided at a suitable depth so that back-up rod & sealant could be filled after removal of the top cut portion of the filler board. Nothing extra shall be paid for the filler board from top up to the bottom of polyethylene backing rod.

2. As the period for the test will be around three weeks, advance planning is required to avoid any delay on this account.
PROCEDURE

Preparation of Surface: All the joint surfaces to which the sealant is to be applied should be clean, dry and free from any loose material, dirt, dust, scale, protective lacquer, grease.

Expansion joint filler material must be checked to ensure that it is tightly packed and no gaps or voids exist at the base of the joint slot.

Sealant should be prepared as per manufacturer’s specifications.

Before sealant is applied, primer shall be applied to secure better adhesion between sealant and the concrete surface. The surface shall be allowed to dry for at least 30 minutes but no longer than 3 hours before the sealant is applied.

To prevent accidental spillage of sealant on the top surface and to give a neat finish, masking tape should be applied along the edge of joint before the sealant material is filled.

Immediately after filling the joints, the sealant should be tooled either with a stainless steel or wooden spatula of the size of the joint to give a smooth surface. While tooling, the spatula should be wetted with a wetting agent like soap water. Masking tape shall be removed immediately after the sealant has been tooled. By tooing, the sealant is compressed with the result that air bubbles if any, are broken up and the sealant becomes free of voids and there is a proper adhesion of the sealant to the sides of the joints.

Sealant of approved make shall be filled only after complete curing of concrete i.e., after 28 days. Sealant shall be applied slightly to a lower level than the slab with a tolerance of 3+1mm as shown in Appendix –‘A’.

Sealant of approved make shall be filled up for a depth as specified in item. The rate of application of sealant may be calculated on the basis of the following formula:

Number of 1 Kilogram tins required = 0.0015 x L x W x D
where L = Length of joint in meters
W = Width of joint in mm.
D = Depth of joint in mm.

Manufacturer’s certificate shall be produced for establishing that the sealant is not more than six months old or the shelf-life of the sealant. For storage, preparation of sealant, health and safety precautions etc., manufacturer’s specifications shall be applicable.

A typical sketch showing details of filling of joints is enclosed as Appendix-‘A’.
APPENDIX A

EXPANSION JOINT

CONTRACTION / DUMMY JOINT

CONSTRUCTION JOINT

DETAILS OF FILLING OF JOINTS IN RIGID PAVEMENTS
LIST OF MINIMUM EQUIPMENT TO BE PROVIDED IN THE FIELD TESTING LABORATORY BY THE CONTRACTOR AT HIS OWN COST

CONCRETE SECTION:

1. Sieve analysis for combined grading of aggregates
   Sets of I.S. Sieves of sizes 63mm, 45mm, 22.4mm, 11.2mm, 5.6mm, 2.8 mm, 1.4 mm, 710 micron, 355 micron and 180 micron.

2. Sieve analysis for coarse aggregates
   Sets of I.S. Sieves of sizes 63mm, 40mm, 20mm, 12.5mm, 10mm, 4.75 mm, 2.36 mm

3. Sieve analysis of fine aggregate
   Sets of I.S. Sieves of sizes 10mm, 4.75mm, 2.36mm, 1.18mm, 600micron, 300 micron and 150 micron.

4. Silt content of sand
   Graduated glass cylinders 500 C.C. capacity.

5. Bulkage of sand
   a) Graduated glass cylinders 250 C.C. capacity
   b) Graduated glass cylinders 500 C.C. capacity.

6. Slump test/ Compacting Factor Test
   a) Slump cones
   b) Slump rods 3/8" dia. 24" long bullet pointed.
   c) Steel plates 24" x 24"
   d) Steel scales
   e) Compacting Factor Apparatus

7. For making beam specimens for flexural strength
   a) Beam moulds size 70x15x15cm
   b) Tamping rods.

8. Testing flexural strength of concrete:
   100 ton capacity compressive strength testing i/c hand operated in two numbers with flexure test attachment.

9. Other miscellaneous items
   a) Physical balance with set of weights
   b) PAN balances
   c) Spring balances
   d) Glass measuring jar
   e) Beakers
   f) Towels, glass plates etc.
   g) Apparatus for testing flakiness index, Impact value and Los Angeles Abrasion value of coarse aggregates.
SECTION II: ROADS, PAVEMENTS, ELEVATED ROADS, RAMPS & STORM WATER DRAINAGE SYSTEMS

1.0 CONSTRUCTION SPECIFICATION FOR ROAD WORKS.

General
This document is the Specifications for the At Grade Roads stipulating minimum standards for design of the roadways which should be read in conjunction with the Design Basis Report and the Design Drawings.

Relevant Codes and Standards
This shall comprise the MORTH specifications for Road and Bridge Works (Fifth Revision) 2013 with latest Addendum / Corrigendum / revision (if any), published by Indian Roads Congress, New Delhi and shall be deemed to be bound into this document unless otherwise mentioned herein.

All the codes of practice, standards and specifications applicable shall be the latest editions with all correction slips, addenda, corrigendum and amendments. In general if no definite provisions contained in all the outline specifications indicated herein, reference may be to the MORTH 5th revision, latest CPWD, and relevant IRC/IS Codes of latest revisions. In case the works are not covered by the above mentioned codes, refer to the relevant IS codes.

The following table will provide minimum reference for the work.

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Clause/ Section</th>
<th>Clause No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>General</td>
<td>100</td>
</tr>
<tr>
<td>2</td>
<td>Site clearance</td>
<td>200</td>
</tr>
<tr>
<td>3</td>
<td>Earthwork, erosion control, drainage (including Turfing)</td>
<td>300</td>
</tr>
<tr>
<td>4</td>
<td>Sub bases, Bases &amp; shoulders (Non bituminous)</td>
<td>400</td>
</tr>
<tr>
<td>5</td>
<td>Bases &amp; surface courses (Bituminous)</td>
<td>500</td>
</tr>
<tr>
<td>6</td>
<td>Concrete Pavement</td>
<td>600</td>
</tr>
<tr>
<td>7</td>
<td>Traffic signs, Markings &amp; other road appurtenances</td>
<td>800</td>
</tr>
<tr>
<td>8</td>
<td>Quality control for works involved</td>
<td>900</td>
</tr>
<tr>
<td>9</td>
<td>Materials for structures (RCC works)</td>
<td>1000</td>
</tr>
<tr>
<td>10</td>
<td>Formwork</td>
<td>1500</td>
</tr>
<tr>
<td>11</td>
<td>Steel Reinforcement</td>
<td>1600</td>
</tr>
<tr>
<td>12</td>
<td>Structural concrete</td>
<td>1700</td>
</tr>
<tr>
<td>13</td>
<td>Structural steel</td>
<td>1900</td>
</tr>
<tr>
<td>14</td>
<td>River training work and protection work</td>
<td>2500</td>
</tr>
<tr>
<td>15</td>
<td>Wearing coat &amp; appurtenances (Railing, crash barrier, weep holes, Approach slab, Drainage spouts etc)</td>
<td>2700</td>
</tr>
</tbody>
</table>
The QA/QC Plan

a) Demonstrate to the satisfaction of the Employer’s representative the suitability of source of pavement materials like soil, aggregates, bitumen and other materials, before the finalization of the mix design and maintain detailed records of source, testing and compliance with quality standards as applicable.

b) Concrete batching plant shall be finalized in consultation with EIC representative. Concrete batching plant shall be of Automatic Weigh Batch Mix type with printer facility to print batch sheets. Batch sheets shall be furnished for all batches of concrete mix produced.

c) Necessary calibration shall be carried out of the batch mix plant before starting production for the Works and same shall be verified and when required recalibrated, depending upon the quality of mix delivered to the site.

d) Mix design shall be performed as per specification requirements; laboratory and field trials should be carried out before final acceptance.

e) All necessary quality testing shall be carried out on daily basis. Gradation test, bitumen content and necessary corrections shall be carried out if required, by the Contractor. Proper documentation of tests shall be maintained for review and submission to client.

f) Construction Specification

2.0 AMENDMENTS /MODIFICATIONS/ ADDITIONS TO EXISTING CLAUSES OF SPECIFICATIONS FOR ROAD AND BRIDGE WORKS, MoRTH (FIFTH REVISION)

The entire works, as described in Scope of Work shall be done in accordance with the Technical specifications. These technical specifications shall comprise the following.

Part I - General Specifications:

Part – I shall comprise the "Specification for Road and Bridge Works "Fifth Revision - with latest Addendum / Corrigendum / revision (if any), published by Indian Roads Congress, New Delhi-2013, on behalf of Government of India, Ministry of Surface Transport (Road Wing), and shall be deemed to be bound into this document and becomes part and parcel of the agreement.

Part II- Supplementary Specifications:

Part-II shall comprise various substitutes. Modified and Additional Clauses to the "Specification for Road and Bridge Works" referred to in Part I (to cover specific aspects of the particular works not covered) and accordingly, the said specifications amended shall form part of the contract.
CLAUSE 106: Construction Equipment:
(Addition)
Add the following sub Para (l) after sub Para (k):

l) All measuring devices and gauges shall be in good working condition.

Measuring devices that can affect product quality shall be calibrated prior to use and at prescribed intervals (clause 103) against certified equipment. Calibration procedures shall be established, maintained and documented and corrective actions taken when results are unsatisfactory and submitted for approval from Employer’s representative prior to use Accuracy and fitness of measuring devices shall be ensured by proper maintenance”.

SECTION 300 Earthwork, Erosion Control And Drainage: CLAUSE

301: Excavation For Roadway & Drains:

Clause 301.3.11 Disposal of excavated materials
(Substitution)
Delete this Sub-Clause and replace with:

“All the excavated materials shall be the property of the Employer. Suitable material obtained from the excavation of the roadway, shoulders, verges, drains, cross drainage works, etc. shall be used for:

i) Filling roadway embankment.
ii) Filling existing pits/ponds in the right of way as directed by the Employer’s representative, including levelling and spreading, with all lifts and leads.
iii) For landscaping of the road as directed by the Employer’s representative, including levelling and spreading, with all lifts and leads.

Unsuitable and surplus material, which, in the opinion of the Employer’s representative cannot be used in the works, shall be removed from site by the Contractor and disposed at the nearest dip or other approved location in accordance with all statutory requirements.”

SECTION 400 SUBBASES, BASES (NON-BITUMINOUS) AND SHOULDERS

Clause 401 Granular sub-base

Clause 401.1 Scope
(Modification)
The second sentence of this clause shall read as follows.

The Granular Sub-base shall be provided by using crushed rock close graded material, mixing in a Mechanical mix plant, carriage of mixed materials to work site, laying in uniform layers with mechanical paver or Motor Grader and compacting with vibratory power roller to achieve desired density as necessary according to lines, grades and cross-section shown on the drawings or as directed by the Employer’s representative.

Clause 401.2 Materials

Clause 401.2.2 Paragraph 1 of this Clause shall read as under: (Addition)
Add the following
“Granular Sub-base serves as a drainage layer in addition to being a part of the structural pavement, the material must satisfy drainage criteria. For such requirement, the grading of material should be as per Table 400-1 (Grading – I) and CBR should be Minimum 30%.

Clause 401.3 Construction Operations Clause 401.3.2 Spreading and compacting (Modification)

Add the following in the first Para after second sentence.

“Granular Sub-base shall be prepared in an approved mixing plant like pug mill, concrete batching plant or concrete mixer located at Plant / Laboratory area. The mixed materials shall be carried to work site by Tipper / dumper. If so desired by the Employer’s representative, trial runs with the equipment shall be carried out to establish its suitability for the work.”

The third paragraph of this Clause shall read as under:

“The Granular sub-base material shall be spread in layers of uniform thickness of 200 mm compacted thickness over the entire width of sub-base. Immediately thereafter, rolling shall start with the help of a vibratory roller of 100 KN static weights with plain drum or heavy pneumatic tyred roller of 300 KN weight. Rolling shall commence at the lower edge and proceed towards the upper edge longitudinally for portions having unidirectional cross fall and super elevation and shall commence at the edges and proceed towards the centre of portions having cross fall on both sides.”

Clause 406 Wet Mix Macadam Sub C Base/Bases Clause 406.1 Scope

(Modification)

Delete “in one or more layers” and replace with “in two uniform layers” in the last sentence of first paragraph.

Read “125mm” in place of “200mm” in the last sentence of second paragraph.

Clause 406.2 Materials

Clause 406.2.1 Aggregates

Clause 406.2.1.1 Physical Requirements

(Modification)

Add at the end of first paragraph:

“The fraction of materials passing through 4.75 mm sieve shall be crusher run screening only.”

Clause 406.3 Construction operations Clause 406.3.4 Spreading of Mix (Addition)

Add at the end of first paragraph:

“The first layer of mix shall be spread by paver finisher. The second or final layer of mix shall be spread by paver finisher preferably in full width of the pavement including hard shoulder.”

Clause 406.3.5 Compaction

(Deletion & modification)

Delete second sentence of first paragraph.

Read “125mm” in place of “200mm” in the third sentence of first paragraph.
Clause 406.4 Opening to Traffic
(Modification)
The clause shall read as:
“No vehicular traffic of any kind should be allowed on the finished wet mix macadam surface till it has dried and covered up to the 2nd layer of DBM”.

CLAUSE 409 Cement Concrete Kerbs and Kerb with Channel Clause
409.5 Construction Operations
Clause 409.5.2 Add the words “or to accommodate drainage pipes” at the end of the paragraph (Modification) after the words “drainage openings”.

SECTION 500 BASE AND SURFACE COURSES (BITUMINOUS)

Clause 501 General Requirements for Bituminous Pavement Layers Clause
501.2 Materials
Clause 501.2.2 Coarse Aggregates
(Modification& deletion)
The first sentence of paragraph 1 shall read as:
“The course aggregates shall consist of crushed rock and shall be obtained through the use of Cone crusher, Vertical Shaft Impactor and vibratory screens of suitable capacity.”
The third paragraph of this Clause shall be deleted.

Clause 501.5 Lying

Clause 501.6 Compaction
(Addition)
Add at the end of 6th paragraph:
“Rolling shall be continued till the density achieved satisfies the requirements of Clause 903.4.2 and all roller marks are eliminated.” Clause 501.8 Preparation of Surface Clause 505

Dense Bituminous Macadam Clause 505.2 Materials
The Bitumen shall be Viscosity grade paving bitumen complying with the Indian standard specification IS: 73. Bitumen VG.30 shall be use.

Clause 505.2.2 Coarse Aggregates
(Modification)
The first sentence of paragraph 1 shall read as:
“The course aggregates shall consist of crushed rock and shall be obtained through the use of Cone crusher, Vertical Shaft Impactor and vibratory screens of suitable capacity.”
The second paragraph of this Clause shall be deleted.

Clause 505.4 Construction Operations Clause 505.4.9 Rolling
(Addition)
Add after the last paragraph:
“Rolling shall be continued till the density achieved is at least 98% of the Marshall Density.
Clause 507 Bituminous Concrete Clause 507.1
Scope
(Modification)
The last sentence of this Clause shall read as:
“A single layer shall be 40mm in thickness (Grade 1).”
Clause 507.2 Materials
The Bitumen shall be Viscosity grade paving bitumen complying with the Indian standard specification IS: 73. Bitumen VG.30 shall be use.
Clause 507.2.5 Aggregate Gradation
(Modification)
This Sub Clause shall be read under:
When tested in accordance with IS: 2386 Part I (Wet grading method), the combined grading of the coarse and fine aggregates shall fall within the limits shown in Table 500-17 for grading 2.
SECTION 800 TRAFFIC SIGNS, MARKINGS & OTHER ROAD APPURTENANCES
Clause 801 Traffic Signs
Clause 801.3 Traffic Signs having Retro-Reflective Sheeting Clause
801.3.1 General Requirements
(Modification)
In this clause, the 5th sentence shall be read as:
“The retro-reflective sheeting shall be micro prismatic grade retro-reflective element material as specified in clause 801.3.4.3”
Clause 801.3.8 Colour for Signs Add
the following in the clause
“All the facility information and place identification signs shall have colours specified in IRC 67.”
Clause 801.4 Installation
Clause 801.4.1
(Modification)
Last sentence of the sub-clause shall read as follows:
All signposts shall be embedded in concrete (M-15) for stability and safeguard against theft. The cost of excavation, concrete and backfill, if any shall be deemed to be included in the signboard.
Clause 801.4.2 Add the following Sentence to the clause
(Addition)
“Alternate band of Black and white Painting for the posts to be done and the cost thereof is included in the Sign boards Installation items.”
Clause 802 Overhead Signs

**Clause 802.4 Materials for Overhead Sign and Support Structures** Clause 802.4.3 Replace “1.5mm” with “2.0mm” in the last sentence. (Modification)

Clause 802.4.6 This Clause shall be read as under: (Modification)

“All Overhead signs shall be of retro-reflective micro prismatic sheeting confirming to ASTM D4956, Type XI, fixed over aluminum sheeting as per these specifications.”

Clause 803 Road Markings

Clause 803.2 Materials (Deletion)
Delete “of ordinary road marking paint,” from the 1st line of this clause.

Clause 803.3 Ordinary Road Marking Paint (Deletion)
This Clause shall be “deleted”.

Clause 803.6 Application

Clause 803.6.1 The first sentence of this clause shall read as: (Modification)

“The road marking shall be made with the appropriate road marking machinery as approved by the Employer’s representative.”

Clause 806 Road Delineators

**Clause 806.2 This clause shall read as under:**

(Modification)

Road way indicators shall be made of crash proof material of the type approved by Employer’s representative. Hazard markers and object markers shall be as shown in the relevant drawing and the materials to be used for the markers and the locations shall be as approved by Employer’s representative. The reflective sheeting shall conform to Clause 801.

Crash barrier (Concrete or Steel) markers shall be of the type approved by Employer’s representative.

Clause 811 Crash Barrier

**Clause 811.2 Concrete Crash Barrier**

811.2.1 Materials

**Clause 811.2.1.2 This Clause shall be read as under:**

(Modification)

Concrete barriers shall be constructed with M-40 grade concrete and with High Yield Strength deformed reinforcement conforming to IRC: 21.
Clause 811.3 Metal Beam Crash Barrier Clause 811.3.1
 Materials

Clause 811.3.1.3 Add at the end of this Clause:
(Addition)
“The size of the concrete foundation block for embedding the posts and grade of concrete shall be as shown on the drawing.”

Clause 811.3.3 Installation of Posts
(Modification)
This Clause shall be substituted as under:
“The posts shall be embedded in the concrete foundation block of size and grade of concrete along with the depth of embedded post as shown in the drawing.

SECTION 900 QUALITY CONTROL FOR ROAD WORKS

Clause 901 General
Clause 901.1 (Modification)
This Clause shall read as under:
“All materials to be used, all methods adopted and all works performed shall be strictly in accordance with the requirements of these Specifications. The Contractor shall set up a field laboratory at locations approved by the Employer’s representative and equip the same with adequate equipment and personnel in order to carry out all required tests and Quality Control work as per Specifications and/or as per Clause 120 and/or as directed by the Employer’s representative. The list of laboratory equipment and the facilities to be provided shall be as per Clause 120 and shall be approved by the Employer’s representative in advance.”

Clause 902 Control of Alignment, Level and Surface Regularity Clause
902.3 Surface Levels
(Modification)
This Clause shall read as under:
The levels and or thickness of the sub grade and different pavement courses as constructed shall not vary from those calculated with reference to the longitudinal and cross profile of the road shown on the drawings or as directed by the Employer’s representative beyond the tolerances mentioned in Table 900-1.
Add at the end of first sentence “or as desired by the Employer’s representative” in the last paragraph.

SECTION 1000 MATERIALS FOR STRUCTURES

1006 Cement
The Contractor shall test the soil and ground water samples for sulphates and chlorides. The type of cement to be used shall be based on the observations of this test and shall comply with specifications.

Clause 1007 Coarse Aggregates
(Modification)
For plain and reinforced cement concrete (PCC and RCC) or pre-stressed concrete (PSC) works, Coarse aggregate shall consist of clean, hard, strong, dense, non-porous and durable pieces of crushed stone obtained through the use of Cone crusher, Vertical Shaft Impactor and vibratory screens of suitable capacity.

Add the following at the end of 2nd paragraph:

"Cost of all tests shall be borne by the Contractor."

The maximum value of elongation index and flakiness index for plain, reinforced and pre-stressed concrete should not exceed 15% each taken separately, and not to exceed 25% taken together. The flakiness and elongation index should be measured using methods as per IS: 2386."

Clause 1008 Sand/Fine Aggregates

(Addition)

Add the following at the end of 2nd paragraph:

"The alkali aggregate reactivity should be measured and reported for obtaining approval for the source."

Clause 1009 STEEL

Clause 1009.3 Reinforcement /
tensioned Steel (Addition)

The following shall be added to this clause:

Thermo Mechanically Treated (TMT) steel from primary producers is used with prior approval from Employer’s representative. The steel shall be procured only from the manufacturers as mentioned in the approved list of manufacturers.

Each diameter & each lot shall be tested in third-party laboratory and test reports to be furnished to Employer

Clause 1012 Concrete Admixtures

Clause 1012.1 General

(Addition)

Add the following at the end of paragraph 2 of Clause 1012.1:

"Admixtures shall not impair the durability of concrete; they shall not combine with the ingredients to form harmful compounds or endanger the protection of reinforcement against corrosion. Only chloride free admixtures shall be used."
Clause 1014 Storage of Materials

Clause 1014.3 Aggregates (Addition)

The following shall be added to this Clause:

"Aggregates shall be stored or stockpiled in their respective size in such a manner that the various sizes will not become intermixed before proportioning. They shall be stored, stockpiled and handled in such a manner that will prevent contamination by foreign materials."

Clause 1015 Tests and Standard of Acceptance

(Addition)

Add following after paragraph 2:

"Independent testing of Prestressing steel shall be carried out by the Contractor for each consignment from each source at site in the laboratory approved by the Employer’s representative before use. The tests shall be carried out for the properties as listed in clause 7.2.1 of BS-5896 (latest version). These tests are in addition to the tests carried out by the manufacturer."

SECTION 1500 FORMWORK

Clause 1501 Description

(Substitution)

This Clause shall be substituted as under:

"The Contractor shall prepare a formwork mobilization and utilization plan and submit the plan for Employer’s representative’s approval at least -15 days before the commencement of construction of structures. The requirement of formwork shall be worked out considering the overall construction program of all the structures in the contract. Sufficient formwork shall be mobilized, to enable the structure to be cast with minimum construction joints as shown in drawings in one or more stages, as specified in the drawings. The plan shall take into account the time required for erection of formwork, retention in position, stripping, removal and subsequent use in the next and subsequent structures.

Clause 1506 Precautions

(Addition)

Add the following as items (vii) and (viii) to the end of this clause:

vii. Adequate support against sideway and lateral loads due to construction operations and wind shall be provided.

viii. Forms shall be rigid and of adequate section to reduce deflections. Forms shall have sufficient rigidity to resist horizontal pressures caused by flowing concrete resulting from use of Super plasticizers. The formwork shall resist the lateral pressure caused due to fast rate of placement by concrete pumps.

Clause 1508 Removal of Formwork

(Addition)
Add the following at the end of paragraph 3 of Clause 1508
“Field cure cubes strength to be checked for respective structural items before removing their form work.”

Clause 1510 Specialized Formwork
(Modification)
Replace the words “slip formwork” by “climbing formwork” in the first sentence of this clause.
Second paragraph of this Clause shall be deleted.

SECTION 2700 WEARING COAT AND APPURTENANCES

Clause 2706 Weep Holes

This Clause shall be read as under:

"Weep holes shall be provided in solid plain concrete/reinforced concrete, brick or stone masonry abutments, wing walls, return walls as shown on the drawings or as directed by the Employer’s representative, to drive moisture from the back filling. Weep holes shall be provided with 100 mm diameter AC pipe and shall extend through the full width of concrete with slope of about 1 vertical: 20 horizontal towards the draining face.
The spacing of weep holes shall generally be 1 m in either direction or as shown on the drawing with the lowest at about 150 mm above the low water level or ground level whichever is higher or as directed by the Employer’s representative."

Specifications For Granular Sub-Base (Gsbc)
Preparation of granular sub-base by providing close graded material, conforming to specifications mixing in a mechanical mix plant at OMC, carriage of mixed material by mechanical transport to work site, for all leads and lifts, spreading in uniform layers of specified thickness with mechanical means including neatly leveling & dressing on prepared surface and compacting with vibratory power roller to achieve the desired density, complete and as per direction of Engineer-in-charge.

Construction Operations
a) Spreading and compacting

The sub base material of grading specified in the Contract and water shall be mixed mechanically by a suitable mixture equipped with provision for controlled addition of water and mechanical mixing so as to ensure homogeneous and uniform mix. The required water content shall be determined in accordance with IS: 2720 (Part-8). The mix shall be spread on the prepared sub grade with mechanical means of adequate capacity its blade having hydraulic controls suitable for initial adjustment and for maintaining the required slope and grade during the operation or other means as approved by the Engineer-in-charge.

The moisture content of mix shall be checked in accordance with IS:2720 (Part-2) and suitably adjusted so that at the time of compaction it is from 1-2% below the optimum moisture content.

Manual mixing shall be permitted only where the width of laying is not adequate for mechanical operations, as in small-sized jobs. The equipment used for mix-in place construction shall be a rotavator or similar approved equipment capable of mixing the material to the desired degree. If so desired by the Engineer-in-charge, trial runs with the equipment shall be carried out to establish its suitability for the work.
Immediately after spreading the mix, rolling shall be done by an approved roller. If the thickness of the compacted layer does not exceed 100mm, a smooth wheeled roller of 80 to 100 KN weight may be used. For a compacted single layer up to 200mm, the compaction shall be done with the help of a vibratory roller of minimum 80 to 100 KN static weight capable of achieving the required compaction. Rolling shall commence at the lower edge and proceed towards the upper edge longitudinally for portions having unidirectional crossfall or on super elevation. For pavement having crossfall on both sides rolling shall commence at the edges and progress towards crown.

Each pass of the roller shall uniformly overlap not less than one third of the track made in the preceding pass. During rolling, the grade and crossfall (camber) shall be checked and any high spots or depressions, which become apparent, corrected by removing or adding fresh material. The speed of the roller shall not exceed 5 Km per hour.

Rolling shall be continued till the density achieved is at least 98% of the maximum dry density for the material determined as per IS: 2720 (Part 8). The surface of any layer of material on completion of compaction shall be well closed, free from movement under compaction equipment and from compaction planes, ridges, cracks or loose material. All loose, segregated or otherwise defective areas shall be made good to the full thickness of layer and re-compacted.

Surface Finish and Quality Control of Work

a. General

All works performed shall conform to the lines, grades, cross-sections and dimensions shown on the drawings or as directed by the Engineer-in-Charge, subject to the permitted tolerances described herein-after.

b. Horizontal Alignment:

Horizontal alignment shall be reckoned with respect to the centre line of the carriageway as shown on the drawings. The edges of the carriageway as constructed shall be correct within a tolerance of ±10 mm therefrom. The corresponding tolerance for edges of the pavement and lower layers of pavement shall be ±25 mm.

Surface levels:

The top level of the granular sub-base shall not vary from those calculated with reference to the longitudinal & cross profile of the pavement shown in the Drawings or as directed by Engineer-in-Charge, beyond the tolerances mentioned as follow:

<table>
<thead>
<tr>
<th>S.</th>
<th>Sub-base</th>
<th>Tolerances</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Flexible pavement</td>
<td>±10 mm</td>
</tr>
<tr>
<td>2</td>
<td>Concrete pavement</td>
<td>±6 mm</td>
</tr>
</tbody>
</table>

Surface Regularity:

The maximum allowable difference between pavement surface and underside of a 3 m straightedge when placed parallel with or at right angles to the centre line of pavement at points decided by the Engineer-in-charge shall not exceed 8 mm.

Rectification:
Where the surface regularity fall outside the specified tolerances, the Contractor shall be liable to rectify the same upto the satisfaction of Engineer-in-Charge. Where the surface is high, it shall be trimmed and suitably compacted. Where the same is low, the deficiency shall be corrected to scarifying the lower layer and adding fresh material and recompacting to the required density.

Quality Control:

The following quality control tests shall be carried out at frequencies specified against each for Granular Sub-base:

<table>
<thead>
<tr>
<th>S.N.</th>
<th>Test</th>
<th>Test Method</th>
<th>Frequency (min.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Gradation</td>
<td>IS: 2720 (Part –VI)</td>
<td>One test per 200 m³</td>
</tr>
<tr>
<td>2</td>
<td>Atterberg limits</td>
<td>IS: 2720 (Part-V)</td>
<td>One test per 200 m³</td>
</tr>
<tr>
<td>3</td>
<td>Moisture Content prior to compaction</td>
<td>IS: 2720 (Part-II)</td>
<td>One test per 250 m²</td>
</tr>
<tr>
<td>4</td>
<td>Density of compacted layer</td>
<td>IS: 2720 (Part-XXVIII)</td>
<td>One test per 500 m²</td>
</tr>
<tr>
<td>5</td>
<td>Deleterious constituents</td>
<td>IS: 2720 (Part-XXVII)</td>
<td>As required</td>
</tr>
<tr>
<td>6</td>
<td>C.B.R. (On set of 3 specimens)</td>
<td>IS: 2720 (Part-XVI)</td>
<td>As required</td>
</tr>
<tr>
<td>7</td>
<td>Control of Grade, camber thickness and surface finish</td>
<td>-</td>
<td>Regularly</td>
</tr>
</tbody>
</table>

No vehicular traffic of any kind shall be allowed on the finished granular sub-base surface till it has dried and the next course laid. In exceptional cases, construction traffic may be allowed with approval of the Engineer-in-Charge for short durations once the course is completely dry provided vehicles move over the full width avoiding any rutting or uneven compaction. The Contractor will take all precautionary measures to prevent any damage to the finished surface till next layer is laid over it.

Specifications for Dry Rolled Lean Concrete (Drlc)

Providing and laying dry lean cement concrete with coarse and fine aggregate conforming to IS:383, the size of coarse aggregate not exceeding 26.5 mm, aggregate cement ratio not exceed 15:1, aggregate gradation after blending to be as per specification, cement content not to be less than 150 kg/cum, optimum moisture content to be determined during trial length construction, concrete strength not to be less than 10 MPa at 7 days, mixed in a batching plant as per mix design, transported to site, laid with a paver with electronic sensor, compacting with 8-10 tonne vibratory roller, finishing and curing etc complete as per specification and direction of the Engineer-in-Charge.

Construction

General

The pace and programme of the dry lean concrete sub-base construction shall be matching suitably with the programme of construction of the cement concrete pavement over it. The dry lean concrete sub-base shall be overlaid with concrete pavement only after 7 days after sub-base construction.
Batching and Mixing

A system approach should be adopted for construction of pavement, and the method statement for carrying out the work, detailing all the activities including indication of time cycle, equipment, personnel etc. shall be got approved from the Engineer-in-Charge before the commencement of work. The above shall include the type, capacity and make of batching and mixing plant beside the hauling arrangement and paving equipment. The capacity of paving equipment, batching plant as well as all the ancillary equipment shall be adequate for a paving requirement for day’s work.

Batching and mixing of the concrete shall be done at a central batching and mixing plant of capacity not less than 30 Cum/hr with automatic controls, located at suitable place which takes into account sufficient space for stock piling of cement, aggregate and stationary water tanks. This shall be however, situated at an approved distance, duly considering the properties of the mix and transport arrangements available with the contractor.

Proportioning of a material shall be done in the batching plant by weight, each type of material being weighed separately. The cement from the bulk stock may be weighed separately from the aggregates and water shall be measured by volume. Wherever properly graded aggregate of uniform quality can not be maintained as envisaged in the mix design the grading of aggregates shall be controlled by appropriate blending techniques. The capacity of batching and mixing plant shall be at-least 25% higher than the proposed capacity for the laying/paving equipment.

The batching plant shall include preferably four bins, weighing hoppers, and scales for the fine aggregate and for each size of coarse aggregate. If cement is used in bulk (after opening bags on platform) a separate scale for cement shall be included. The weighing hoppers shall be properly sealed and vented to preclude dust during operation. Approved safety devices shall be provided and maintained for the protection of all personnel engaged in plant operation, inspection and testing. The batch plant shall be equipped with a suitable non resettable batch counter which will correctly indicate the number of batches proportioned.

Bins preferably with four adequate separate compartments shall be provided in the batching plant.

Batching plant shall be equipped to proportion aggregates and bulk cement by means of automatic weighing devices using load cells. The weighing device shall have an accuracy within + 1% in respect of quantity of cement and water and + 2% in respect of aggregates and accuracy shall be checked at least once a month.

Mixers shall be pan type, reversible type with single or twin shaft or any other mixer capable of combing the aggregates, cement and water into a thoroughly mixed and uniform mass within the specified mixing period and of discharging the mix without segregation. Each stationary mixer shall be equipped with an approved timing device which will automatically lock the discharge lever when the drum has been charged and release it at the end of the mixing period. The device shall be equipped with a bell or other suitable warning device adjusted to give a clearly audible signal each time the lock is released. In case of failure of the timing device the mixer may be used for the balance of the day while it is being repaired provided that each batch is mixed for 90 seconds or as per the manufacturer’s recommendation. The mixer shall be equipped with a suitable non resettable batch counter which shall correctly indicate the number of batches mixed.

The mixer shall be cleaned at suitable intervals. The pickup and throw over blades in the drum or drums shall be repaired or replaced when they are worn down 20mm or more. The
contractor shall have available at the job site a copy of the manufacturers design, showing dimensions and arrangements of blades in reference to original height and depth or provide permanent marks on blade to show points of 20mm wear from new conditions. Drilled holes of 5mm diameter near each end and at mid point of each blade are recommended. Batching plant shall be calibrated for the each ingredients up to its maximum quantity being used in the mix at site in the beginning and thereafter at suitable interval not exceeding one month.

a. Air-conditioned centralized computer control cabin shall be provided for automatic operation of the equipment.

b. The design feature of the batching plant should be such that it can be shifted quickly.

Transporting

Plant mix lean concrete shall be discharged immediately from the mixer, transported directly to the point where it is to be laid and protected from the weather by covering with tarpaulin during transit. The concrete shall be transported by tipping trucks, sufficient in number to ensure a continuous supply of material to feed the laying equipment to work at a uniform speed and in an uninterrupted manner. The lead of the batching plant to the paving site shall be such that the travel time available from mixing to paving as specified in Para 4.5.2 will be adhered to. Tipping truck shall not have old concrete sticking to it. Each tipping truck shall be washed with water jet before next loading as and when required after inspection.

Placing

Lean concrete shall be laid by a paver with electronic sensor on the sub base layer or as specified. The equipment shall be capable of laying the material in one layer in an even manner without segregation, so that after compaction the total thickness is as specified. The paving machine shall have high amplitude tamping bars to give good initial compaction to the sub-base. One day before placing of the dry lean cement concrete sub-base the surface of the granular sub-base/drainage layer shall be given a fine spray of water and rolled with a smooth wheeled roller.

The Dry Lean Concrete shall be laid in such a way that it is at least 750mm wider on each side than the proposed width including paved shoulders of the concrete pavement. The extra widening beyond 750 mm width on either side shall be decided based on the specification of the paver, such that the crawler moves on the Dry Lean Concrete and the cost of extra width beyond 750 mm on either side, if any, shall be borne by the Contractor. For small works, the laying of PQC is done by manual method, the extra 750 mm width Dry Lean Concrete on either side for crawler movement is not required.

Compaction

The compaction shall be carried out immediately after the material is laid and levelled. In order to ensure thorough compaction, rolling shall be continued on the full width till there is no further visible movement under the roller and the surface is well closed. The minimum dry density obtained shall be 98 per cent of that achieved during trial length construction in accordance with clause 6. The densities achieved at the edges i.e. 0.5 m from the edge shall not be less than 96 per cent of that achieved during trial construction.

The spreading, compacting and finishing of the lean concrete shall be carried out as rapidly as possible and the operation shall be so arranged as to ensure that the time between mixing of the first batch of concrete in any transverse section of the layer and the final finishing of the same shall not exceed 90 minutes when the concrete temperature is between 25 and 30 degree Celsius and 120 minutes if less than 25 degree Celsius. The period may be reviewed by
Engineer-in-Charge in the light of the results of the trial run but in no case shall it exceed 2 hours. Work shall not proceed when the temperature of the concrete exceeds 30 degree Celsius. If necessary, chilled water or addition of ice may be resorted to for bringing down the temperature. It is desirable to stop concreting when the ambient temperature is above 35 degree Celsius. After compaction has been completed, roller shall not stand on the compacted surface for the duration of the curing period except during commencement of next day’s work near the location where work was terminated the previous day.

Double drum smooth-wheeled vibratory rollers of minimum 80 to 100 KN static weight are suitable for rolling dry lean concrete. In case any other roller is proposed, the same shall be got approved from Engineer-in-Charge, after demonstrating its performance. The number of passes required to obtain maximum compaction depends on the thickness of the dry lean concrete, the compatibility of the mix, and the weight and type of the roller and the same as well as the total requirement of rollers for the job shall be determined during trial run by measuring the in-situ density and the scale of the work to be undertaken.

A preliminary pass without vibration to bed the Dry Lean Concrete down shall be given followed by the required number of passes to achieve the desired density and, a final pass without vibration to remove roller with vibration marks and to smoothen the surface.

Special care and attention shall be exercised during compaction near joints, kerbs, channels, side forms and around gullies and manholes. In case adequate compaction is not achieved by the roller at these points, use of plate vibrator shall be made, if so directed by the Engineer-in-Charge.

The final lean concrete surface on completion of compaction shall be well closed, free from movement under roller and free from ridges, low spots cracks, loose material, pot holes, ruts or other defects. The final surface shall be inspected immediately on completion and all loose, segregated or defective areas shall be corrected by using fresh lean concrete material laid and compacted. For repairing honeycombed/hungry surface, concrete with aggregate of size 10 mm and below shall be spread and compacted as per specification. It is necessary to check the level of the rolled surface for compliance. Any level/thickness deficiency shall be corrected after applying concrete with aggregate of size 10 mm and below after roughening the surface. Strength test shall be carried out, and if deficiency in strength is noticed, at least three (evenly spread) cores of minimum 100 mm dia. per 5000 sqm shall be cut to check deficiency in strength. The holes resulting from cores shall be restored by filling with concrete of the specified strength and compacted by adequate rodding.

Segregation of concrete in the tipping truck shall be controlled by moving the dumper back and forth while discharging the mix into the same or by any appropriate means. Paving operation shall be such that the mix does not segregate.

Joints
Construction and longitudinal joints shall be provided as per the drawings. Transverse butt type joint shall be provided at the end of the construction in a day. Longitudinal construction joint shall be provided only when full width paving is not possible. Transverse joints in Dry Lean concrete shall be staggered from the construction butt type joint in concrete pavement by 800-1000 mm.
Longitudinal joint in Dry Lean Concrete shall be staggered by 300-400 mm from the longitudinal joint of concrete pavement.
At longitudinal or transverse construction joints, unless vertical forms are used, the edge of compacted material shall be cut back to a vertical plane where the correct thickness of the properly compacted material has been obtained.

Curing

After two to three hours i.e. when concrete has started setting /hardening, the exposed surfaces shall be kept damp with moist gunny bags, sand or any other material approved by the Engineer-in-Charge or by sprinkling water. 24 hours after compaction, the exposed surface shall be kept continuously in damp or wet condition by ponding or by covering with a layer of sacking, canvas, hessian or similar materials and kept constantly wet for at least 7 days from the date of laying where Ordinary Portland Cement is used.

Tolerance for Surface Regularity, Level, Thickness, Density and Strength

**Surface Regularity:** The maximum allowable difference between pavement surface and underside of a 3 m straightedge when placed parallel with or at right angles to the centre line of pavement at points decided by the Engineer-in-Charge shall not be more exceed 10 mm for dry lean concrete.

Surface level: The tolerance in surface level for dry lean concrete shall not vary ±6 mm with reference to the longitudinal and cross-profile of the pavement shown on the drawing or as directed by Engineer-in-Charge.

Thickness, density and strength shall be as per Appendix ‘A’.

Quality control test on the materials and the work and minimum frequencies shall be as under:

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Test</th>
<th>Test Method</th>
<th>Minimum desirable frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Quality of cement</td>
<td>IS:269/455/1489</td>
<td>As required</td>
</tr>
<tr>
<td>2.</td>
<td>Los Angeles Abrasion Value/ Aggregate Impact value</td>
<td>IS:2386(Part IV)</td>
<td>One test per 200m³</td>
</tr>
<tr>
<td>3.</td>
<td>Aggregate gradation</td>
<td>IS: 2386(Part I)</td>
<td>One test per 100m³</td>
</tr>
<tr>
<td>4.</td>
<td>Aggregate moisture content/ Water absorption</td>
<td>IS: 2386(Part III)</td>
<td>As required</td>
</tr>
<tr>
<td>5.</td>
<td>Wet analysis of mix</td>
<td>IS:1119</td>
<td>As required</td>
</tr>
<tr>
<td>6.</td>
<td>Control of grade, camber thickness and surface finish</td>
<td>-</td>
<td>Regularly</td>
</tr>
<tr>
<td>7.</td>
<td>Cube strength of material mixed at site (3 samples)</td>
<td>IS:516</td>
<td>One test per 1000 Sqm or part thereof</td>
</tr>
</tbody>
</table>

Rectification:

The defective length of the Dry Lean Concrete course shall be removed to full depth and replaced with material conforming to the specification. Before relaying the course, the disturbed subgrade or layer below shall be corrected by levelling, watering and compacting.

Traffic

No heavy vehicles shall be permitted on the lean concrete sub-base after its construction. Light vehicles if unavoidable may, however, be allowed after 7 days of its construction with prior approval of the Engineer-in-Charge.
Appendix ‘A’

Dry Lean Concrete

A.1 Sampling and Testing of Cubes

Samples of dry lean concrete for making cubes shall be taken from the uncompacted material from different locations immediately before compaction at the rate of 3 samples for each 1000 Sqm or part thereof laid each day. The sampling of mix shall be done from the paving site.

Test cubes of 150mm size shall be made immediately from each mix sample.

Cubes shall be made in accordance with the methods described in IS:516 except that the cubes shall be compacted by means of a vibratory hammer with the moulds placed on a level and rigid base. The vibrating hammer shall be electric or pneumatic type fitted with a square or rectangular foot having an area of between 7500 to 14000 Sqmm. The compaction shall be uniformly applied for 60 ± 5 seconds with a downward force of between 300 N and 400 N on to each of the three layers of the lean concrete material placed into the mould. The surface of each compacted layer shall be scarified before the next layer is added to give key for the next layer. The final layer shall be finished flush with the top of the cube mould.

The dry lean concrete shall be cured in accordance with IS:516.

A.2 In-Situ Density

The dry density of the laid material shall be determined from three density holes at locations equally spaced along a diagonal that bisects each 2000 sqm or part thereof laid each day and shall comply with the requirements as per Clause 4.5.1. This rate of testing may be increased at the discretion of the Engineer in case of doubt or to determine the extent of defective area in the event of non-compliance. Density holes at random may be made to check the density at edges.

A.3 Thickness

The average thickness of the subbase layer as computed by the level data of sub-base and subgrade or lower sub-base shall be as per the thickness specified in the contract drawings. The thickness at any single location shall not be 8mm less than the specified thickness. Such areas shall be corrected as stated in Clause 4.5.5. Areas which cannot be repaired should be replaced over full width. The extent of deficient area should be decided based on cores.

Specifications For Wet Mix Macadam (Wmm)

Providing, laying, spreading and compacting graded stone aggregate (size range 53 mm to 0.075 mm) to wet mix macadam (WMM) specification including premixing the material with water at OMC in mechanical mix plant, carriage of mixed material by mechanical transport to site, for all leads & lifts, laying in uniform layers with mechanical paver finisher in sub-base /base course on well prepared surface and compacting with vibratory roller of 8 to 10 tonne capacity to achieve the desired density, complete as per specifications and directions of Engineer-in-Charge.
Construction operations

Preparation of Base:

The surface of the sub grade/sub-base/base to receive the wet mix macadam course shall be prepared to the specified grade and camber and clean of dust, dirt and other extraneous material. Any ruts or soft yielding places shall be corrected in an approved manner and rolled until firm surface is obtained if necessary by sprinkling water.

As far as possible, laying wet mix macadam course over existing bituminous layer may be avoided since it will cause problems of internal drainage of the pavement at the interface of two course. It is desirable to completely pick out the existing thin bituminous wearing course where wet mix macadam is proposed to be laid over it.

 Provision of lateral confinement of aggregates:

While constructing wet mix macadam, arrangement shall be made for the lateral confinement of wet mix. This shall be done by laying materials in adjoining shoulders along with that of wet mix macadam layer and following the sequence of operations as follows:

The sequence of operations shall be such that the construction of paved shoulder is done in layers each matching the thickness of adjoining pavement layer. Only after a layer of pavement and corresponding layers in paved and earth shoulder portion have been laid and compacted, the construction of next layer of pavement and shoulder shall be taken up.

Where the materials in adjacent layers are different, these shall be laid together and the pavement layer shall be compacted first. The corresponding layer in paved shoulder portion shall be compacted thereafter, which shall be followed by compaction of earth shoulder layer. The adjacent layers having same material shall be laid and compacted together.

Preparation of mix:

Wet Mix Macadam shall be prepared in an approved mixing plant of suitable capacity having provision for controlled addition of water and forced/positive mixing arrangement like pug mill or pan type mixer of concrete batching plant.

The plant shall have the following features:

For feeding aggregates – three/four bin feeders with variable speed motor.

Vibrating screens for removal of oversized aggregates.

Conveyor belt

Control system for addition of water

Forced/positive mixing arrangement like pug mill or pan type mixture.

Centralised control panel for sequential operation of various devices and precise process control.
Safety devices.

Optimum moisture for mixing shall be determined in accordance with IS: 2720 (Part 8) after replacing the aggregate fraction retained on 22.4 mm sieve with material of 4.75 mm to 22.4 mm size. While adding water, due allowance shall be made for evaporation losses. However, at the time of compaction, water in the wet mix shall not vary from the optimum value by more than agreed limits. The mixed material should be uniformly wet and no segregation shall be permitted. For small quantity of WMM work or inaccessible/remote location and in situation of where use of machinery is not feasible, the Engineer-in-Charge may permit the mixing to be done in concrete mixers/manual mixing.

Spreading of mix:

Immediately after mixing, the aggregates shall be spread uniformly and evenly upon the prepared sub grade/sub-base/base in required quantities. In no case shall these be dumped in heaps directly on the area where these are to be laid nor shall their hauling over a partly completed stretch be permitted.

The mix shall be spread by a paver finisher. The paver finisher shall be self-propelled of adequate capacity with following features:

- Loading hoppers and suitable distribution system so as to provide a smooth uninterrupted material flow for different layer thicknesses from the tipper to the screed.
- Hydraulically operated telescopic screed for paving width up to 8.5 m and fixed screed beyond this. The screed shall have tamping and vibrating arrangement for initial compaction of layer.
- Automatic leveling control system with electronic sensitive device to maintain mat thickness and cross-slope of mat during laying procedure.
- In exceptional cases where it is not possible for the paver to be utilized, suitable mechanical means may be used with the prior approval of Engineer-in-Charge.

The surface of the aggregate shall be carefully checked with templates and all high or low spots remedied by removing or adding aggregate as may be required. The layer shall be tested by depth blocks during construction. No segregation of larger and fine particles shall be allowed. The aggregates as spread shall be of uniform gradation with no pockets of fine materials.

Compaction:

After the mix has been laid to the required thickness, grade and cross-fall / camber, the same shall be uniformly compacted, to the full depth with suitable roller. If the thickness of single compacted layer does not exceed 100 mm, a smooth wheel roller of 80 to 100 KN weight shall be used. For a compacted single layer up to 150 mm, the compaction shall be done with the help of vibratory roller of minimum static weight of 80 to 100 KN with an arrangement for adjusting the frequency and amplitude. An appropriate frequency and amplitude may be selected. The speed of the roller shall not exceed 5 Km/hr.

In portions having unidirectional cross-fall / super elevation, rolling shall commence from the lower edge and progress gradually towards the upper edge. Thereafter, roller shall progress parallel to the centre line of the road, uniformly over-lapping each preceding track by at least one-third width until the entire surface has been rolled. Alternate trips of the roller shall be terminated in stops at least 1 m away from any preceding stop.
In portions in camber, rolling shall begin at the edge with the roller running forward and backward until the edges have been firmly compacted. The roller shall then progress gradually towards the centre parallel to the centre line of the road uniformly overlapping each of the preceding track by at least one-third width until the entire surface has been rolled.

Any displacement occurring as a result of reversing of the direction of a roller or from any other cause shall be corrected at once as specified and/or removed and made good.

Along forms, kerbs, walls or other places not accessible to the roller, the mixture shall be thoroughly compacted with mechanical tampers or a plate compactor or any other suitable method decided by the Engineer-in-Charge. Skin patching of an area without scarifying the surface to permit proper bonding of the added material shall not be permitted.

Rolling shall not be done when the sub-grade is soft or yielding or when it causes a wave-like motion in the sub-base/base course or sub-grade. If irregularities develop during rolling which exceed 12 mm when tested with a 3m straight edge, the surface shall be loosened and premixed material added or removed as required before rolling again so as to achieve a uniform surface conforming to the desired grade and cross-fall. In no case the use of unmixed material shall be permitted to make up the depressions.

Rolling shall be continued till the density achieved is at least 98 per cent of the maximum dry density for the material as determined by the method outlined in IS: 2720 (Part - 8).

After completion, the surface of any finished layer shall be well closed, free from movement under compaction equipment or any compaction planes, ridges, cracks and loose material. All loose, segregated or otherwise defective area shall be made good to the full thickness of the layer and re-compacted.

Setting and drying:

After final compaction of wet mix macadam course, the pavement shall be allowed to dry for 24 hours.

Opening to Traffic

No vehicular traffic of any kind shall be allowed on the finished wet mix macadam surface till it has dried and the course laid. In exceptional cases, construction traffic may be allowed with approval of the Engineer-in-Charge for short durations once the course is completely dry provided vehicles move over the full width avoiding any rutting or uneven compaction. The Contractor will take all precautionary measures to prevent any damage to the finished surface till next layer is laid over it.

Surface Finish and Quality Control of Work

**Surface Regularity:** The maximum allowable difference between pavement surface and underside of a 3m straightedge when placed parallel with or at right angles to the centre line of pavement at points decided by the Engineer-in-Charge shall not be more exceed 8 mm.

**Surface level:** The tolerance in surface level for wet mix macadam shall not vary ±10 mm for machine laid and ±15 mm for manually laid with reference to the longitudinal and cross-profile of the pavement shown on the drawing or as directed by Engineer-in-Charge.

Quality Control:
The following quality control tests shall be carried out at frequencies specified against each for Wet Mix Macadam.

<table>
<thead>
<tr>
<th>S. No.</th>
<th>TEST</th>
<th>Test Method</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>i)</td>
<td>Los Angeles Abrasion Value/ Aggregate Impact Value</td>
<td>IS:2386 (Part IV)</td>
<td>One test per 200 cum. of aggregate.</td>
</tr>
<tr>
<td>ii)</td>
<td>Grading of mixed aggregate</td>
<td>IS:2386 (Part I)</td>
<td>One test per 100 cum. of aggregate.</td>
</tr>
<tr>
<td>iii)</td>
<td>Flakiness Index</td>
<td>IS:2386 (Part I)</td>
<td>One test per 200 cum. of aggregate.</td>
</tr>
<tr>
<td>iv)</td>
<td>Plasticity Index</td>
<td>IS:2720 (Part V)</td>
<td>One test per 200 cum. of aggregate.</td>
</tr>
<tr>
<td>v)</td>
<td>Moisture content prior to compaction</td>
<td>IS:2720(Part-28)</td>
<td>One test per 200 cum. of aggregate.</td>
</tr>
<tr>
<td>vi)</td>
<td>Density of compacted layer</td>
<td></td>
<td>One test per 500 kum.</td>
</tr>
</tbody>
</table>

The materials supplied and the works carried out by the Contractor shall conform to the relevant technical specifications and as approved by the Engineer-in-Charge.

For ensuring the requisite quality of construction, the materials and works shall be subjected to quality control tests, as described above. The testing frequencies set forth are the desirable minimum and the Engineer-in-Charge shall have the full authority to carry out tests as frequently as he may deem necessary to satisfy himself that the materials and works comply with the appropriate specifications.

Test procedures for the various quality control tests are indicated in the respective Section of these Specifications or for certain tests within this Section. Where no specific testing procedure is mentioned, the tests shall be carried out as per the prevalent accepted engineering practice to the directions of the Engineer-in-Charge.

**Rectification of Surface Irregularity**

Where the surface irregularity of the wet mix macadam course exceeds the permissible tolerances or where the course is otherwise defective due to sub grade soil getting mixed with the aggregates, the full thickness of the layer shall be scarified over the affected area, reshaped with added premixed material or removed and replaced with fresh premixed material as applicable and re-compacted in accordance with Clause 3 above. The area treated in the aforesaid manner shall not be less than 5m long and 2m wide. In no case, the depressions shall be filled up with unmixed and un-graded material or fines.

**Pavement Quality Concrete (PQC)**

Providing and laying Pavement Quality Concrete (PQC) produced in a batching plant having a Characteristic flexural strength i.e. minimum flexural strength of 4.1 MPa at 28 days using 350 Kg of ordinary Portland cement of 43 grade, fine aggregate, graded stone aggregates of 40 mm nominal size in appropriate proportion as per specification and job mix formula, laid in panels as per drawings/design as approved by the Engineer-In-Charge using Slip form paver/Manual method(Note: Areas inaccessible to paving equipment shall be constructed by manual method. Areas in which manual methods of construction become indispensable shall be got approved by the Engineer-in-Charge in writing in advance) including providing antifriction layer including 6mm sand layer over DRLC/sub base ,expansion, construction
and dummy joint, curing, etc. complete as per direction of Engineer-in-Charge and technical specifications.

Handling and Storage Of Materials

Cement
The Contractor shall provide adequate storage facilities to prevent deterioration of cement during storage due to climate and other causes. Wherever bulk storage containers are used, their capacity should be sufficient to cater to the requirement at site. The containers shall be cleaned at least once every 3 months. Cement remaining in stores for more than one and half month from the date of manufacture must be retested before use and to be rejected, if it fails to conform to any of the requirements of the specifications.

Cement produced by the major manufacture's shall be used on work should conform to one of the following I.S. standards:

Note:

A) Slip Form Paver:
   a) Ordinary Portland Cement 43 Grade conforming to IS: 269-2015.

The job mix design shall be assigned to IIT I CRRI I NIT. Following extra precautions shall be taken:

(i) Proper mix design may be done to account for shrinkage/micro cracking due to higher heat of hydration.

(ii) The temperature of aggregate, water and cement should be maintained at the lowest practical levels, so that temperature of concrete is below 30° C at the time of placement.

(iii) Aggressive curing of concrete to avoid cracking shall be done keeping surface continuously wet by providing wet hessian cloth etc. before continuous curing i.e. after 24 hours of laying.

(iv) Use of 53 grades OPC shall be avoided in case of hot weather concreting.

B) Fixed Form Paver/Manual method:

In addition to the cements as specified in para A above, the following cements can also be used:

a) Factory Produced Portland Pozzolana Cement (Fiyash based) conforming to IS: 1489 (Part-I)-2015 (Fiyash content should not be less than 15 percent and not more than 35 percent by mass of Portland pozzolana cement).

b) Portland Slag Cement conforming to IS:455-2015 (The granulated slag constituent shall not be less than 25 percent and not more than 70 percent by mass of Portland slag cement).
c) Sulphate Resisting Portland cement conforming to IS: 12330 (If soluble salt like sulphate in subgrade is more than 0.5%).

i) High alumina cement is not permitted to be used.

ii) Agency should submit copies of purchase voucher to the Engineer-in-Charge and original to be produced for verification.

iii) The cement as per the agreement is for OPC 43 grade cement. The cost adjustment shall be as per actually followed at site by deducting the market rate difference of OPC 43 grade cement and cement actually used at site. In case contractor uses cement other than OPC 43, joint measurement of PQC shall be done and certified by Engineer-In-Charge and deduction shall be made based on actual consumption of cement or theoretical consumption whichever is higher.

Aggregates

a) Stock piles shall be made immediately on receipt of aggregates at site of work. Aggregates shall be stacked separately according to the nominal sizes of coarse aggregates. For fine aggregates, separate stacks shall be made.

b) Aggregates shall be stacked on a hard surface so as to exclude the possibility of soil or grass being mixed up. When stacked in close proximity, the stock piles shall be separated by bulk heads to prevent the different sizes of aggregates from mixing together. Special care shall be taken to clean and wash the last layer of aggregates in contact with ground surface before use.

c) Before batching, the aggregates shall have been stock piled for at least 24 hours to allow for draining of water, if any. The Contractor shall make adequate provision for stock piling aggregates to the extent sufficient to meet the needs of the work taking into account the availability of supplies and rates of delivery etc. and nothing extra shall be paid for necessary double handling and transport of materials from stock piles to mixing plant etc.

d) Grading of coarse and fine aggregate shall be checked as per clause 16.1 under quality control to ensure that the suppliers are maintaining the uniform grading as approved for samples used in the mix design.

Batching And Mixing Of Concrete

A system approach should be adopted for construction of pavement, and the method statement for carrying out the work, detailing all the activities including indication of time cycle, equipment, personnel etc. shall be got approved from the Engineer-in-Charge before the commencement of work. The above shall include the type, capacity and make of batching and mixing plant beside the hauling arrangement and paving equipment. The capacity of paving equipment, batching plant as well as all the ancillary equipment shall be adequate for a paving requirement for day’s work.

Batching and mixing of the concrete shall be done at a central batching and mixing plant of capacity but not less than 30Cum/hr with automatic controls, located at suitable place which takes into account sufficient space for stock piling of cement, aggregate and stationary water tanks. This shall be however, situated at an approved distance, duly considering the properties of the mix and transport arrangements available with the contractor.
Proportioning of a material shall be done in the batching plant by weight, each type of material being weighed separately. The cement from the bulk stock may be weighed separately from the aggregates and water shall be measured by volume. Wherever properly graded aggregate of uniform quality can not be maintained as envisaged in the mix design the grading of aggregates shall be controlled by appropriate blending techniques. The capacity of batching and mixing plant shall be at-least 25% higher than the proposed capacity for the laying/paving equipment.

The batching plant shall include preferably four bins, weighing hoppers, and scales for the fine aggregate and for each size of coarse aggregate. If cement is used in bulk (after opening bags on platform) a separate scale for cement shall be included. The weighing hoppers shall be properly sealed and vented to preclude dust during operation. Approved safety devices shall be provided and maintained for the protection of all personnel engaged in plant operation, inspection and testing. The batch plant shall be equipped with a suitable non resettable batch counter which will correctly indicate the number of batches proportioned.

Bins preferably with four adequate separate compartments shall be provided in the batching plant.

Batching plant shall be equipped to proportion aggregates and bulk cement by means of automatic weighing devices using load cells. The weighing device shall have an accuracy within + 1% in respect of quantity of cement and water and + 2% in respect of aggregates and accuracy shall be checked at least once a month.

Mixers shall be pan type, reversible type with single or twin shaft or any other mixer capable of combing the aggregates, cement and water into a thoroughly mixed and uniform mass within the specified mixing period and of discharging the mix without segregation. Each stationary mixer shall be equipped with an approved timing device which will automatically lock the discharge lever when the drum has been charged and release it at the end of the mixing period. The device shall be equipped with a bell or other suitable warning device adjusted to give a clearly audible signal each time the lock is released. In case of failure of the timing device the mixer may be used for the balance of the day while it is being repaired provided that each batch is mixed for 90 seconds or as per the manufacturer’s recommendation. The mixer shall be equipped with a suitable non resettable batch counter which shall correctly indicate the number of batches mixed.

The mixer shall be cleaned at suitable intervals. The pickup and throw over blades in the drum or drums shall be repaired or replaced when they are worn down 20mm or more. The contractor shall have available at the job site a copy of the manufacturers design, showing dimensions and arrangements of blades in reference to original height and depth or provide permanent marks on blade to show points of 20mm wear from new conditions. Drilled holes of 5mm diameter near each end and at mid point of each blade are recommended. Batching plant shall be calibrated for the each ingredients upto its maximum quantity being used in the mix at site in the beginning and thereafter at suitable interval not exceeding one month.

Air-conditioned centralized computer control cabin shall be provided for automatic operation of the equipment.

The design feature of the batching plant should be such that it can be shifted quickly. Concrete mixed as above is not to be modified by the addition of water or otherwise in order to facilitate handling or for any other purpose.
Paving Equipment

The concrete shall be placed with Slip Form Paver or Manual method as per the item/as approved by Engineer-in-Charge. Slip form paver, the paver shall be equipped with electronic controls to control the line and grade from either one side or both sides of the machine. Vibrators shall operate at a frequency and spacing recommended by the manufacturer. The variable vibration setting shall be provided in the machine.

The contractor shall provide adequate no. of concrete saws with sufficient no. of diamond edge saw blades. The saw machine shall be either electric or petrol/diesel driven type. A water tank with flexible hose and pump shall be made available for this activity on priority basis. The contractor shall have at least one standby saw in good working condition. The concreting work shall not commence if the saws are not in working condition.

(a) Guidewires for Slip form Paver

Guide wire shall be provided along both sides of the slab. Each guide wire shall be at a constant height above and parallel to the required edge of the slab as described in the contract/drawing within a vertical tolerance of + 2 mm. Additionally, one of the wires shall be kept at a constant horizontal distance from the required edge of the pavement as indicated in the contract/drawing with a lateral tolerance of +/- 10mm.

The guide wires shall be supported on stakes 5-6 meters apart by connectors capable of fine horizontal and vertical adjustment. The guide wire shall be tensioned on the stakes so that a 500 grams weight shall produce a deflection or not more than 20mm when suspended at the midpoint between any pair of stakes. The ends of guide wire shall be anchored to fixing point or winch and not on the stakes.

The stakes shall be positioned and the connectors maintained at their correct height and alignment 12 hrs. on the day before concreting takes place until 12 hrs. after finishing of the concrete. The guide wires shall be checked and tensioned on the connectors at any section at least 2 hrs. before concreting that section.

The contractor shall submit to the Engineer-in-Charge for his approval of line and level, the stakes and connectors which are ready for use in the length of pavement to be constructed next day. Such approval shall be obtained at least 12 hrs. before commencement of paving operation. Any deficiencies noted by the Engineer-in-Charge shall be rectified by the contractor who shall then reapply for approval of the affected stakes. Work shall not proceed until the Engineer-in-Charge has given his approval. It shall be ensured the stakes and guide wires are not affected by the construction equipment when concreting is in progress.

(b) Side Forms and Rails for Fixed form paver

All side forms shall be of mild steel channels of depth equal to the thickness of pavement or slightly less to accommodate the surface irregularity of the subbase. The forms can be placed in series of steel packing plates or shims to take care of irregularity of subbase. They shall be sufficiently robust and rigid to support the weight and pressure caused by a paving equipment.

Side forms for use with wheeled paving machines shall incorporate metal rails firmly fixed at a constant height below the top of the forms. The forms and rail shall be firmly secured in position by not less than 3 stakes/pins for every 3 meter length so as to prevent movement in any direction. Forms and rails shall be straight within a tolerance of 3 mm in 3 meter and when in place shall not settle in excess of 1.5 mm in 3 meter

while paving is being done. Forms shall be cleaned and oiled immediately before each use.
The forms shall be bedded on a continuous bed of low moisture content lean cement mortar or concrete and set to the line and levels shown on the drawings within tolerances of +10 mm and +2 mm respectively. The bedding shall not extend under the slab and there shall be no vertical step between adjacent forms of more than 2 mm. The forms shall be got inspected by the Engineer-in-Charge for his approval 12 hrs. before construction of the slab and shall not be removed until at least 12 hrs. Afterwards. No concreting shall commence till form work has been approved by the Engineer-in-Charge.

At all times sufficient forms shall be used and set to the required alignment for required length of pavement immediately in advance of the paving operations, or the anticipated length of pavement to be laid within the next 24 hrs. Forms shall be fixed in advance as per specifications. Before any paving is done the site shall be shown to the Engineer-in-Charge in order to verify the arrangement for paving as per the relevant clauses of this specification. The mixing and placing of concrete shall progress only at such a rate as to permit proper finishing, protecting and curing of the pavement.

Steel Forms for Manual Method

All side forms shall be of mild steel. The steel forms shall be of mild steel sturdy channels sections and their depth shall be equal to the thickness of the pavement. The side forms shall have a length of at least 3.0 meters except on curves of less than 45 meters radius where shorter length may be used. When set to grade and stacked in place the maximum deviation of the top surface of any section from a straight line shall not exceed 2 mm in the vertical plane and 5 mm in the horizontal plane. The method of connection between sections shall be such that the joint formed shall be free from difference in level, play or movement in any direction. The use of bent, twisted or worn out forms will not be permitted. At least three stake pickets for each 3.0 m of form and the bracing and support must be ample to prevent springing of the forms under the pressure of concrete or the weight or thrust of machinery operating on the forms.

The supply of forms shall be sufficient to permit their remaining in place for 12 hrs. after the concrete has been placed or longer, if in the opinion of the Engineer-in-Charge, it is necessary.

The top line of the forms is not to vary from the correct level or alignment and the levels and alignment of the forms are to be checked and corrected as necessary immediately prior to the placing of concrete. The top edges and faces of the forms are to be carefully cleaned and maintained in clean condition.

While removing the steel forms, care shall be taken to withdraw them gradually. Any damages to the bull nosed edges shall be made good while the concrete is still green, as directed by the Engineer-in-Charge.

Setting of forms shall be according to the slab plan subject to the approval of the Engineer-in-Charge and concreting shall not commence until the setting of forms is approved.

Forms shall be set at least 50 meters length in advance of the point where the concrete is being laid and shall not be removed until at least 12 hrs. of the placing of concrete or longer if in the opinion of Engineer-in-Charge, it is necessary. After setting, the working faces shall be thoroughly oiled using approved oil but before concrete is placed against them.

Sufficient rigidity shall be obtained to support the forms in such a position during the entire operation of compaction and finishing that they will not at any time deviate more than 3 mm from a straight edge 3 meters in length. Forms which show a variation from the required rigidity or the alignment and levels shown on the plans, shall be reset or removed, as directed.
The length and number of pins or stakes shall be such as to maintain the forms at the correct line and grade. All forms shall be cleaned and oiled each time before they are used.

Hauling And Placing Of Concrete

Anti-friction layer of polyethylene sheet (white in colour) of thickness 400 micron confirming to IS: 2508 shall be provided between the concrete slab and the DRLC surface or any other base course. Before placing the anti-friction layer, the top of base layer shall be swept clean of all the extraneous materials and a layer of 6mm sand shall be laid. On sand layer polythene sheet shall be laid. Wherever overlap of polyethylene sheets is necessary in any direction, the same shall be at least 300mm. Any damaged sheeting shall be replaced at the contractors expenses. The anti-friction layer shall be nailed to the lower layer with concrete nails.

Freshly mixed concrete from the central batching and mixing plant shall be transported to the paver site by means of tippers/transit mixers of sufficient capacity and approved design in sufficient numbers to ensure a constant supply of concrete. Cover shall be used for protection of concrete against the weather. While loading the concrete, truck shall be moved back and forth under the discharge chute to prevent segregation. The tipping trucks shall be capable of maintaining the mixed concrete in a homogeneous state and discharging the same without segregation and loss of cement slurry. The feeding to the paver is to be regulated in such a way that paving is done in an uninterrupted manner with a uniform speed throughout the days work. Tipping truck shall be washed at a regular frequency as prescribed by the Engineer-in-Charge to ensure that no leftover mix of previous loading remains stuck.

Concrete mixed in central mixing plant shall be transported to the site without delay and the concrete which in the opinion of Engineer-in-Charge, has been mixed too long before laying will be rejected and shall be removed from the site. The total time taken from the addition of water to the mix until the completion of surface finishing and texturing shall not exceed 120 minutes when concrete temperature is less than 25\(^\circ\)C and 90 minutes when concrete temperature is between 25\(^\circ\)C to 30\(^\circ\)C. Tippers/transit mixers delivering concrete shall not run directly on plastic sheet nor shall they run on completed slabs until after 28 days of placing of concrete. In all cases the temperature of the concrete shall be measured at the point of discharge from the delivery vehicle.

The addition of water to the surface of the concrete to facilitate the finishing operations will not be permitted except with the approval of the Engineer-in-Charge when it shall be applied as a mist by means of approved equipment.

If considered necessary by the Engineer-in-Charge, the paving equipment shall be provided with approved covers to protect the surface of the slab under construction from direct sunlight and rain or hot wind.

As soon as the side forms are removed, edges of the slabs shall be corrected wherever irregularities have occurred by using fine concrete composed of 1:1:2, cement: sand: coarse aggregate (10 mm down) with water cement ratio not more than 0.4 under the supervision of Engineer-in-Charge.

If the requirement for surface regularity fails to be achieved on two consecutive working days then normal working shall cease until the cause of the excessive irregularity has been identified and remedied.

Construction by Slip Form Paver:

The slip form paving train shall consist of power machines which spreads compacts and finishes the concrete in a continuous operation.

The slip form paving machine shall compact the concrete by internal vibration and shape it between the side forms with either a conforming plate or by vibrating and oscillating finishing beams. The concrete shall be deposited without segregation in front of slip form paver across
the whole width and to a height which at all times in excess of the required surcharge. The deposited concrete shall be struck off to the necessary average and differential surcharge by means of the strike off plate or a screw auger device extending across the whole width of the slab. The equipment for striking-off the concrete shall be capable of being rapidly adjusted for changes of the average and differential surcharge necessitated by change in slab thickness or cross fall.

The level of conforming plate and finishing beam shall be controlled automatically for the guide wires installed by sensors attached at the four corners of the slip form paving machine. The alignment of paver shall be controlled automatically from the guide wire by at least one set of sensors attached to the paver. The alignment and level of ancillary machines for finishing, texturing and curing of the concrete shall be automatically controlled relative to the guide wire or to the surface and edge of an adjoining hardened slab.

Slip form paving machines shall have vibrators of variable output with a maximum energy output of not less than 2.5 kW per meter width of slab per 300 mm depth of slab for a laying speed upto 1.5 m per minute or pro-rata for higher speeds. The machine shall be of sufficient mass to provide adequate reaction during spreading and paving operations on the traction units to maintain forward movements during the placing of concrete in all situations.

If the edges of the slip formed slab slump to the extent that the surface of the top edge of the slab does not comply with the requirements, then special measures approved by the Engineer-in-Charge shall be taken to support the edges to the required levels and work shall be stopped until such time as the contractor can demonstrate his ability to slip form the edges to the required levels. The slumped edge shall have to be corrected by adding fresh concreter after roughening the surface.

Upon the instructions of the Engineer-in-Charge, contractor shall scrape the concrete surface when in plastic state with a 3.0 m long tube float fixed with a long and stable handle before texturing. Tube float shall be of an alloy steel tube of 50-60 mm diameter with a long and stable handle. The length of the tube float shall preferably be longer than half the length of slab i.e., half the distance between two transverse contraction joints. This operation shall be done to minimize surface irregularity caused due to varied causes like frequent stoppage of work, surface deformation due to plastic flow etc. The tube float shall be placed at the centre of the slab parallel to longitudinal joint and pulled slowly and uniformly towards the edges. After the use of the float tube, it shall be frequently cleaned before further use. The slurry removed shall be discarded. This activity shall be advanced laterally by providing an overlap of half the length of two float. The removal of the cement slurry from the surface shall be sufficient enough such that the texture is formed on a firm surface and is more durable. This operation however, shall be carried out after removing bleeding water.

In the case of construction by slip form paver, areas inaccessible to paving equipment shall be constructed by manual/hand guided method. Areas in which manual/hand guided methods of construction become indispensable shall be got approved by the Engineer-in-Charge in writing in advance. Work shall be carried out by skilled personnel as per methods approved by the Engineer-in-Charge. For construction by hand guided method in the limited area, no cost adjustment will be made.

Surface Texture

After the final floating and finishing of the slab and before the application of the curing membrane, the surface of concrete slab shall be brush-textured in a direction at right angles to the longitudinal axis of the carriageway.
The brushed surface texture shall be applied evenly across the slab in one direction by the use of a wire brush not less than 450mm wide. The brush shall be made of 32 gauge tape wires grouped together in tufts spaced at 10 mm centers. The tufts shall contain an average of 14 wires and initially be 100mm long. The brush shall have rows of tufts. The rows shall be 20mm apart and the tufts in one row shall be opposite the centre of the gap between tufts in the other row. The brush shall be replaced when the shortest tuft wears down to 90mm length.

The texture depth shall be determined by the Stand Patch Test as described below. This test shall be performed at least once for each day’s paving and wherever the Engineer-in-Charge consider it necessary at times after construction as under:

Five individual measurement of the texture depth shall be taken at least 2m apart anywhere along a diagonal line across a lane completed between points 50m apart along the pavement.

No measurement shall be taken within 300mm of the longitudinal edges of a concrete slab constructed in one pass.

Measurement of Texture Depth – Sand Patch Method

a) The following apparatus shall be used:

i) A cylindrical container of 5 ml internal capacity.

ii) A flat wooden disc 64mm diameter with a hard rubber disc, 1.5mm thick, stuck to one face, the reverse face being provided with a handle.

iii) Dry natural sand with a rounded particle shape passing a 300micron IS sieve and retained on a 150 micron IS sieve.

b) Method:

The surface to be measured shall be dry, any extraneous mortar and loose material removed and the surface swept clean using a wire brush both at right angles and parallel to the carriageway. The cylindrical container shall be filled with the sand, tapping the base 3 times to ensure compaction, and striking off the sand level with the top of cylinder. The sand shall be poured into a heap on the surface to be treated. The sand shall be spread over to surface, working the disc with its face kept flat in a circular motion so that the sand is spread into a circular patch with the surface depressions filled with sand to the level of peaks. The diameter of the patch shall be measured to the nearest 5mm. The texture depth of concrete surface shall be calculated from $31000/(D \times D)$ mm where D is the diameter of patch in mm.

Texture depth shall not be less than a minimum required when measurement are taken as given in table nor greater than a maximum average of 1.25 mm.

**TABLE : TEXTURE DEPTH**

<table>
<thead>
<tr>
<th>S No.</th>
<th>Time Test</th>
<th>Number of measurements</th>
<th>Required Texture Depth (mm)</th>
<th>Specified value</th>
<th>Tolerance</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Between 24 Hrs. and 7 days after the construction of the slab or until the slab is first used by vehicles.</td>
<td>An average of 5 Measurements</td>
<td>1.00</td>
<td>±0.25</td>
<td></td>
</tr>
</tbody>
</table>
2. Not later than 6 weeks before the road is opened to public traffic. 

| Measurements | 1.00 | ±0.25 |

After the application of the brushed texture, the surface of the slab shall have a Uniform appearance.

Where the texture depth requirements are found to be deficient, the Contractor shall make good the texture across the full lane width over length directed by the Engineer-in-Charge, by texturing the hardened concrete surface in all approved manner.

Construction by Manual/Hand guided method:

The pavement shall be constructed using side forms. The acceptance criteria regarding level, thickness, surface regularity, texture, finish strength of concrete and all other quality control measures shall be the same as in the case of machine laid down.

Placing of Concrete:

Concrete shall be deposited between the forms. Where a certain amount of redistribution is necessary, it shall be done with shovels and not with rakes. The concrete shall be compacted with the needle vibrator and vibrating screeds. Use of vibrator near site forms is essential to eliminate honey combing. To effect adequate compaction, the concrete shall be placed with appropriate surcharge over the final slab thickness. The amount of surcharge will depend upon the mode of placement of concrete and shall be determined by trial. In general, the required surcharge is about 20% of the required slab thickness.

The concrete is to be deposited and spread to such a depth that when compacted and finished, the slab thickness indicated will be obtained at all points and the surface will not at any point be below the level specified for the finished surface.

Compaction of Concrete:

Compaction shall be carried out by electrically operated needle and screed vibrators as stipulated hereafter. Needle vibrators should be used all over the area for obtaining initial compaction of concrete. These should be of diameter not less than 4.5 cm and if the vibrators are pneumatic, the pressure must not be below 4 kg/sq.cm. If electrically operated, they should have a minimum frequency of 3500 impulses per minute.

Minimum number of petrol driven vibrators as specified by the Engineer-in-Charge with minimum frequency of 3500 impulses per minute shall be provided at each work head as a standby arrangement. The screed and internal vibrator shall conform to I.S.: 2505 and I.S.: 2506 respectively.

There should be at least three needle vibrators working in one bay. A vibrating screed consisting of a steel or timber section weighing not less than 15 kg per meter with a tamping edge of not less than 7 cm width and having a vibrator mounted thereon shall follow needle vibrators to obtain full compaction. The face of the wooden tamping edge of the screed shall be lined with M.S. plate rigidly fixed by means of counter sunk screws. Where screed vibrators are used for compaction, a standby unit shall always be maintained ready for use, should the other one go out of order. Where electrically driven vibrators are employed, a stand by pneumatic unit shall be kept ready for use in case of power failure. At the discretion of the Engineer-in-Charge, for compaction at edges and joints, vibrators may be supplemented by hand tamping.
and rodding for securing satisfactory results. Under no circumstances, honey combing of concrete at joints or elsewhere shall be permitted.

When using screed vibrator for compaction, it should not be dragged over the concrete. During the initial passes, it shall be lifted to the adjacent forward position in the steps. Subsequently, it shall be slowly slid over the surface with its axis slightly tilted away from the direction of sliding and the operation repeated until a close, dense surface is obtained. Work men shall not be allowed to walk on freshly laid concrete. All operations shall be carried out from suitable wooden bridges spanning the lane-width.

Important Precaution

The vibration process shall be restricted just upto the stage of appearance of water/ cement slurry on the surface. After reaching this point vibration should be discontinued. It should be ensured that no over-vibration is resorted; as it leads to formation of thin cement slurry layer over the top surface which tends to peel off with passage of time by movement of traffic.

Finishing of Concrete

Immediately after compacting of concrete and the construction of joints but before the concrete has hardened and while the concrete is still in a plastic state, the pavement surface shall be inspected for irregularities with a profile checking template and minor irregularities and score marks shall be eliminated by removing surplus material or by adding and working in freshly mixed concrete if necessary by means of long handled floats and scraping straight edges followed by further compaction and finishing. The long handled floats may be used to smoothen and fill in open textured area in the pavement surface, but the final finishing is to be done with scraping straight edges.

The scraping straight edges are to be 3 metres long with flexible handles long enough to reach the other side of the slab when operated from one side of the pavement. They are to be placed parallel to the forms at the side of the pavements and worked backwards and forwards uniformly across the width of the slab. After this operation has been completed and the surface has been brought to the required finish, the straight edge is to be moved forward but not more than half its length and the process repeated.

The straight edge testing and refloating is to continue until the entire surface:

a) is free from observable departure from the straight edge.
b) conforms to the required levels and cross-section.
c) conforms to the specified surface finish when the concrete has hardened.

The foregoing work is to be carried out while the concrete is still plastic and workable and in such time sequence so as to ensure the removal of water and laitance from the surface.

Beling

Just before the concrete becomes non-plastic, the surface shall be belted with two ply canvas belt not less than 20 cm wide and at least 1 meter longer than the width of the slab. Hand belts shall have suitable handles to permit controlled uniform manipulation. The belt shall be operated with short strokes transverse to the centre line of pavement and with a rapid advance parallel to the concrete line.

Brooming

After belting and as soon as surplus water, if any, has risen to the surface, the pavement shall be given a broom finish with an approved steel or fiber broom not less than 45 cm wide. The broom shall be pulled gently over the surface of the pavement from edge to edge. Adjacent strokes shall be slightly overlapped. Brooming shall be perpendicular to the centre line of the
pavement and so executed that the corrugations formed will be uniform in character and width and not more than 1.5 mm deep.

Brooming shall be completed before the concrete reaches such a stage that the surface is likely to be torn or unduly roughened by the operation. The broomed surface shall be free from porous or rough spots, irregularities, depressions and small pockets such as may be caused by accidental disturbing of particle of coarse aggregates embodied near the surface. The rate of the contractor for the item of quality controlled concrete pavement includes the provision for belting and brooming operations and nothing extra shall be paid on this account.

Edging

After belting/brooming has been completed but before the initial setting of concrete, the edges of the slab shall be carefully finished with an edging tool of 6 mm radius, and the pavement edges shall be left smooth and true to line.

Honey Combing

As soon as the side forms are removed, any minor honey combed areas shall be filled with mortar composed of one part of cement and two parts of fine aggregate. Major honey combed areas or segregated concrete or other defective work or areas damaged by removal of the forms or concrete damaged by rain or due to any other reason whatsoever shall be considered as defective work and shall be removed and replaced by the contractor at his own expense. The total area of honey combed surface not exceeding 2.5 sq.cm. each, shall not exceed 4% of the area of the slab side. Engineer in charge’s decision as to whether the concrete is defective or not shall be final and binding.

Surface Accuracy

After the concrete has sufficiently hardened after about 12 hours and not later than 24 hours, the surface shall be tested again for high spots. All high spots shall be marked and those exceeding 3 mm shall be ground down immediately as directed by the Engineer-in-Charge after obtaining his written permission. Care shall be taken to see that the grinding does not in any way damage the concrete surface.

The final surface finish is to be such that when tested with a profilograph/roughness indicator/or a 3 meter long straight edge or an equivalent mechanical unevenness indicator placed anywhere within the same or adjoining slab in any direction on the surface, there shall be no variation greater than 3mm.

If the surface irregularities exceeding 3 mm still remains despite grinding if permitted, as per para 10.1 the concrete shall be removed to its full depth and replaced. The area of concrete to be removed shall be complete slab between the nearest joints.

Where the defective slab is less than 4.5 meter from the construction joint, the whole area upto the construction joint shall be removed to the full depth. The concrete so removed shall not be reused in the work.

Fresh concrete shall be laid in the manner already described in these specifications and shall again be subjected to test for surface accuracy and other quality control measures. Nothing extra shall be paid for all these operations.

Every slab shall bear an impression not exceeding 3 mm in depth comprising the number allotted to the slab and the date on which it is laid. This impression shall be formed by the Contractor when the concrete is green so as to leave permanent mark on setting.

Curing Of Concrete

Initial curing shall be done by application of curing compound or by manual method as given below. However, nothing extra shall be paid for curing by application of curing compound.

Initial Curing by application of Curing Compound:

Immediately after the surface texturing, the surface and sides of the slab shall be cured by the application of approved resin-based aluminized reflective curing compound or white pigmented
curing compound which hardens into an impervious film or membrane with the help of a mechanical sprayer.

Curing compounds shall contain sufficient flake aluminium in finely divided dispersion to produce a complete coverage of the sprayed surface with a metallic finish. The compound shall become stable and impervious to evaporation of water from the surface of the concrete within 60 minutes of application and shall be of approved type. The curing compounds shall have a water retention efficiency index not less than 90 percent in accordance with BS Specifications No.7542 or as per ASTM C-309-81 Type 2.

The curing compound shall not react chemically with the concrete and the film or membrane shall not crack, peel or disintegrate within three weeks after application. Immediately prior to use, the curing compound shall be thoroughly agitated in its containers. The rate of spread shall be in accordance with the manufacturer’s instructions checked during the construction of the trial length and subsequently whenever required by the Engineer-in-Charge. The mechanical sprayer shall incorporate an efficient mechanical device for continuous agitation and mixing of the compound during spraying. Arrangements should be made to spray the curing compound on the sides of the slab. The curing compound shall be sprayed in two applications to ensure uniform spread. In addition to spraying of the curing compound, the fresh concrete surface shall be protected for at least 3 hours by covering the finished concrete pavements with tents supported on mobile truss during adverse weather conditions as directed by the Engineer-in-Charge.

Initial Curing by Manual Method

Immediately after completion of the finishing operations, the surface of the pavement shall be entirely covered with wetted burlap, cotton or jute mats. The mats used shall be of such length (or width) that as laid they cover the extra surface and extend at least 450mm beyond the edges of the slab. The mats shall be so placed and weighed down so as to make them to remain in close contact with the surface covered, and the covering shall be maintained fully wetted and in position for 24 hours after the concrete has been placed or until the concrete is sufficiently hard to be walked on without suffering damage. Water shall be gently sprayed so as to avoid damage to the fresh concrete. If it becomes necessary to remove a mat for any reason, the concrete slab shall not be exposed for a period more than half an hour.

Worn burlap or burlap with holes will not be permitted. Burlap reclaimed from previous use other than curing concrete shall be thoroughly washed prior to use for curing purposes. If burlap is obtained in strips, shall be laid to overlap at least 150mm.

Burlap shall be placed from suitable bridges. Walking on freshly laid concrete to facilitate placing burlap will not be permitted.

Final Curing

Final curing shall be done either by spreading of wet hessian and moisturising it regularly or by ponding method as given below. However, nothing extra shall be paid for curing by spreading wet hessian method. All joints shall be filled in with temporary filler like sand etc. in order to prevent the edges of joints from being damaged and entry of clay materials into the joints during final curing.

Final curing by spreading of wet hessian method

After two or three hours after application of curing compound, the pavement shall be covered including sides by moist hessian (minimum of two layers) and the same shall then be kept damp for a minimum period of 14 days after which time the hessian may be removed. During the
curing period, the hessian shall be kept continuously moist. All damaged/torn hessian shall be removed and replaced by new hessian on a regular basis.

Final curing by ponding method

After two to three hours after application of curing compound or upon removal of the burlap as the case may be, the slab shall be thoroughly wetted and cured by ponding as follows:

Exposed edges of the slab shall be banked with a substantial berm of earth. Upon the slab shall then be laid a system of transverse and longitudinal height of clay about 50 mm high immediately covered with a blanket of sandy soil free from stones to prevent the drying up and cracking of clay. The rest of slab within these boundaries shall then be covered with sufficient sandy soil so as to produce blanket of earth not less than 40mm deep after wetting. The earth covering shall be thoroughly wetted while it is being placed on the surface and against the sides of the slab and kept thoroughly saturated with water for 21 days and thoroughly wetted down during the morning of the 22nd day and shall thereafter remain in place until the concrete has attained the required strength and permission is given by the Engineer-in-Charge. Thereafter the covering shall be removed and the pavement cleaned and swept. If the earth covering becomes displaced during the curing period, it shall be replaced to the original depth and restarted.

The contractor shall be liable at his cost to replace any concrete damaged as a result of incomplete curing or cracked on a line other than that of a joint as per procedure in IRC:SP-83.

The Contractor shall employ his own security personnel to prevent workmen, cattle straying etc., on the pavement concrete.

Concrete shall not be subjected to any load or weight of any plant until at least 28 days after laying, except for cutting the joints as directed by the Engineer-in-Charge.

Contraction/Dummy Joints

The spacing of transverse and longitudinal joints shall be 4.5 to 5 meter or as shown in the drawing. It shall be 10 mm wide and shall extend vertically from the surface of the slab to a depth equal to one-third depth of slab. The joint shall be formed by cutting with a joint cutting machine. The initial cut or slot of not less than 3mm wide is to be formed by sawing the concrete with a joint cutting machine of approved design as soon as the concrete hardens. Normally, in summer when ambient temperature is more than 30°C, initial cutting may be carried after 4-8 hrs. of laying and in winter when ambient temperature is less than 30°C, initial cut may be done at 8-12 hrs. of laying. Top 25mm of this joint groove shall be subsequently widened to 10mm, after 14-16 days of casting concrete pavements. The details of Contraction/dummy joint shall be as given in Appendix ‘A’.

Before cutting the dummy joints, all necessary precautions shall be taken to ensure that the joint alignment is marked straight and true as per the drawings. The joint cutting machine will be handled only by an experienced person thoroughly familiar with this type of work. The joint should be cut along this alignment only. Any error in the joint cutting alignment shall be rectified by the Contractor at his own expense as directed by the Engineer-in-Charge, preferably using epoxy concrete as approved.

The groove shall be inserted with 12mm dia closed-cell Polyethylene foam back-up rod, 13mm below from the surface of the concrete and filling with Polysulphide Sealant conforming to grade B.S.: 5212-1990 or IS:11433-1995. Prior to filling with Polysulphide, the joints shall be
cleaned by compressed air up to full depth and primed properly with appropriate Polysulphide primer up to back-up rod and masking tape shall be applied along the edges of joint to prevent spillage of sealant on top surface to give neat finish to sealant. The masking tape shall be removed after the sealant has been applied and tooled.

All joints shall be sealed as soon as practicable after 28 days of placing of slabs. Joints shall be sealed flush with the adjacent pavement surface. The pavement shall be opened to traffic only after joint sealing over the entire pavement has been completed. To prevent tackiness or pick up under traffic, the exposed surfaces of the sealing compound shall be dusted with hydrated lime, if directed by Engineer-in-Charge, for which nothing extra shall be paid to the Contractor.

Each lot Polysulphide sealant shall be supported with manufacturers test certificate. However, one sample per 1000 kg. of polysulphide received at site or part thereof shall be collected by the Engineer-in-Charge in charge or his authorized representative and sent for testing to any Government/AAI approved Laboratory. Testing charges for the same shall be borne by the contractor.

The contractor shall note that as testing charges of polysulphide sealant seem to be high, they shall confirm the testing charges and quote their rates accordingly. Nothing extra over and above the quoted rates is payable on this account and no plea on what so ever ground will be entertained later on.

In case of sudden rain or storm, the work can be concluded at the dummy joints but these will then be formed as construction joints.

Before sealing of joints, it may be ensured that the transverse joints on each side of the longitudinal joint shall be in line with each other and of the same type and width. Any concrete or other foreign matter must be removed from the groove before sealing.

Construction Joints

Construction joints shall be provided as shown in the drawing and also at places whenever day’s operations start and stops or where concreting is stopped due to unforeseen circumstances. The joints shall be straight and vertical through the full depth of the slab.

At all construction joints, bulk head shall be used to retain the concrete and care shall be taken in striking off and finishing the surface to the top face of the bulkhead. When work is resumed, the surface of concrete laid subsequently, shall conform to the grade and cross section of previously laid pavement.

Where semi-mechanized method of construction is used, the concrete along the face of all joints shall be compacted with an internal vibrator inserted in the concrete and worked along the joint to ensure a concrete free from honeycombing. In case of mechanized construction, working and vibration/RPM of all the fixed vibrators shall be checked. There shall be two additional needle vibrators to compact the concrete near bulk head.

The Sealing of joints shall be done in the same manner as for contraction joints, by cutting a groove of 10mm wide and 25mm deep as shown in Appendix 'A'.

Expansion Joints

Expansion joints are essential where cement concrete pavement is designed to abut with structures like bridges, culverts, etc. and at junction of building and pavement. Expansion joint shall also be provided at the intersection of runway, taxiway and Apron. The spacing of expansion joint shall be decided at the design stage/technical sanction stage. The expansion joint shall be straight, extend through the full depth of the slab and shall be of the shape and dimensions shown on the drawing. The slab edges adjacent to the joint shall be formed truly vertical.

Where semi-mechanized method of construction is used, the concrete along the face of all joints shall be compacted with an internal vibrator inserted in the concrete and worked along the joint to ensure a concrete free from honeycombing. In case of mechanized construction,
working and vibration/RPM of all the fixed vibrators shall be checked. There shall be two
additional needle vibrators to compact the concrete near bulk head.

Synthetic expansion joint filler board as per specification shall be used to fill the gap between
adjacent slabs at expansion joint. The joint groove shall be filled with Polysulphide conforming
to grade B.S.: 5212-1990 or IS: 11433-1995. Prior to filling with Polysulphide, the joints shall be
cleaned by compressed air up to full depth and primed properly with appropriate Polysulphide
primer up to back-up rod and masking tape shall be applied along the edges of joint to prevent
spillage of sealant on top surface to give neat finish to sealant. The masking tape shall be
removed after the sealant has been applied and tooled. The details of expansion joint shall be
as given in Appendix ‘A’.

Application of Polysulphide Joint Sealing Compound

a. **Sealant**: It shall be cold Polysulphide sealant of approved make conforming to BS: 5212-1990 or

b. **Back-up Rod**: Type of material shall be Expanded closed cell Polyethylene foam and shall
   conform to ASTM-C5249-95 or ASTM D 3575.

c. **Primer**: It shall be applied on the concrete faces of the joints. It shall be single component
   primer suitable for use with Polysulphide joint sealant, as approved by the Engineer-in-Charge.

d. **Joint Filler Board**: The joint filler shall be Synthetic joint filler board of approved make. It shall
   be 25mm thick within a tolerance of ±1.5mm and of a firm compressible material and complying
   with the requirements of IS:1838 (Part 3):2011 with a compressibility more than 25%. It shall be
   provided to the full width between the side forms. If two pieces are joined to make up full
   width, the joint shall be taped such that no slurry escapes to the joint. The physical requirement
   of filler shall be as per the table given below:

<table>
<thead>
<tr>
<th>S.No</th>
<th>Characteristics</th>
<th>Requirement</th>
<th>Method of test, Ref. to IS</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Resistance to handling</td>
<td>Filler strips shall not be deformed or broken by twisting, bending or other</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td></td>
<td>types of ordinary handling when exposed to atmospheric condition (see note)</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Recovery</td>
<td>90% min.</td>
<td>10566</td>
</tr>
<tr>
<td>3</td>
<td>Compression</td>
<td>a) Load required to compress the specimen to 50% of its original thickness</td>
<td>-do-</td>
</tr>
<tr>
<td></td>
<td></td>
<td>before the test shall be (i) 7 kgf/cm², min.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>(ii) 53 kgf/cm², max.</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Extrusion</td>
<td>Amount of extrusion of the free edge shall not exceed 6mm</td>
<td>-do-</td>
</tr>
<tr>
<td>5</td>
<td>Water Absorption</td>
<td>1%, max.</td>
<td>-do-</td>
</tr>
<tr>
<td>6</td>
<td>Density</td>
<td>100 ± 10 kg/m³, min.</td>
<td>-do-</td>
</tr>
<tr>
<td>7</td>
<td>Weathering</td>
<td>a) shall show no sign of disintegration, delamination or separation after</td>
<td>-do-</td>
</tr>
<tr>
<td></td>
<td></td>
<td>the test</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>b) shall satisfy the requirement of recovery, compression and extrusion</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>after the test</td>
<td></td>
</tr>
</tbody>
</table>
Note: Pieces of joint filler that have been damaged shall be rejected.

In order to ensure that sides of the PQC pavement in the portion of above expansion joint filler board do not get dirty and this space does not accumulate pieces of aggregates and other foreign materials, precaution is required to be taken as indicated in note 1 given below.

1) Expansion joint filler board should be provided upto the top of finished pavement surface. At the time of filling the joint with sealant material and backing polyethylene rod, the required depth of joint filler board from the top upto the bottom of polyethylene backing rod should be cut & removed. For easy removal of top filler board and to avoid damage to the filler board, a pre-cut in the expansion joint filler board shall be provided at a suitable depth so that back-up rod & sealant could be filled after removal of the top cut portion of the filler board. Nothing extra shall be paid for the filler board from top upto the bottom of polyethylene backing rod.

2) As the period for the test will be around three weeks, advance planning is required to avoid any delay on this account.

Procedure

**Preparation of Surface**: All the joint surfaces to which the sealant is to be applied should be clean, dry and free from any loose material, dirt, dust, scale, protective lacquer, grease.

Expansion joint filler material must be checked to ensure that it is tightly packed and no gaps or voids exist at the base of the joint slot.

Sealant should be prepared as per manufacturer’s specifications.

Before sealant is applied, primer shall be applied to secure better adhesion between sealant and the concrete surface. The surface shall be allowed to dry for at least 30 minutes but no longer than 3 hours before the sealant is applied.

To prevent accidental spillage of sealant on the top surface and to give a neat finish, masking tape should be applied along the edge of joint before the sealant material is filled.

Immediately after filling the joints, the sealant should be tooled either with a stainless steel or wooden spatula of the size of the joint to give a smooth surface. While tooling, the spatula should be wetted with a wetting agent like soap water. Masking tape shall be removed immediately after the sealant has been tooled. By tooling, the sealant is compressed with the result that air bubbles if any, are broken up and the sealant becomes free of voids and there is a proper adhesion of the sealant to the sides of the joints.

Sealant of approved make shall be filled only after complete curing of concrete i.e., after 28 days. Sealant shall be applied slightly to a lower level than the slab with a tolerance of $3\pm 1\text{mm}$ as shown in Appendix –‘A’.

Sealant of approved make shall be filled up for a depth as specified in item. The rate of application of sealant may be calculated on the basis of the following formula:

Number of 1 Kilogram tins required = $0.0015 \times L \times W \times D$ where

$L$ =Length of joint in meters

$W$ =Width of joint in mm.

$D$ =Depth of joint in mm.
Manufacturer’s certificate shall be produced for establishing that the sealant is not more than six months old or the shelf-life of the sealant. For storage, preparation of sealant, health and safety precautions etc., manufacturer’s specifications shall be applicable.

A typical sketch showing details of filling of joints is enclosed as Appendix-‘A’.

Quality Control

The following quality control tests shall be carried out at frequencies specified against each, as per the table given below:

<table>
<thead>
<tr>
<th>Test</th>
<th>Test Method</th>
<th>Frequency</th>
<th>Acceptance Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>I Cement</td>
<td>Physical and chemical tests</td>
<td>IS:4031, IS:4032</td>
<td>Once for each source of supply and occasionally when called for in case of long/improper storage as directed by Engineer-in-charge. Besides, the Contractor also will submit daily test report on cement released by the manufacturer.</td>
</tr>
<tr>
<td>II Coarse aggregate</td>
<td>a) Flakiness Index</td>
<td>IS:2386 (Part-I)</td>
<td>Before approval of the quarry and at every subsequent change in the source of supply and one test for every 100 cum of aggregate</td>
</tr>
<tr>
<td></td>
<td>c) Impact value</td>
<td>IS:2386 (Part-IV)</td>
<td>- do-</td>
</tr>
<tr>
<td></td>
<td>c) Los Angeles abrasion value</td>
<td>IS:2386 (Part IV)</td>
<td>- do-</td>
</tr>
<tr>
<td></td>
<td>d) Deleterious materials</td>
<td>IS:2386 (Part II)</td>
<td>Before approval of the quarry and at every subsequent change in the source of supply.</td>
</tr>
<tr>
<td></td>
<td>e) Moisture content</td>
<td>IS:2386 (Part III)</td>
<td>Regularly as required subject to a minimum of one test per day</td>
</tr>
<tr>
<td></td>
<td>f) Water absorption</td>
<td>IS:2386 (Part-III)</td>
<td>Before approval of the quarry and at every subsequent change in the source of supply and one test for every 100 cum of aggregate and part thereof</td>
</tr>
<tr>
<td></td>
<td>g) Grading</td>
<td>IS: 2386 (Part– I)</td>
<td>Two tests per day on each size of aggregates</td>
</tr>
</tbody>
</table>
### Test Table

<table>
<thead>
<tr>
<th>Test</th>
<th>Test Method</th>
<th>Frequency</th>
<th>Acceptance Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>III Fine Aggregates</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>a) Silt Content</td>
<td>CPWD Specification 2009 Vol. I, Page 78, Appendix –C</td>
<td>One test per 50 cum and part thereof</td>
<td>Not more than 8%</td>
</tr>
<tr>
<td>b) Grading</td>
<td>IS : 2386 (Part- I)</td>
<td>- do-</td>
<td>Fineness modulus between 2.5 to 3.9</td>
</tr>
<tr>
<td>c) Deleterious materials</td>
<td>IS: 2386 (Part- II)</td>
<td>Before approval of the quarry and at every subsequent change in the source of supply.</td>
<td>As per table 1 of IS 383</td>
</tr>
<tr>
<td>d) Moisture content</td>
<td>IS:2386  (Part-III)</td>
<td>Regularly as required subject to a minimum of two test per day.</td>
<td>-</td>
</tr>
<tr>
<td>e) Water absorption</td>
<td>IS:2386  (Part-III)</td>
<td>Regularly as required subject to a minimum of two test per day.</td>
<td>Not more than 3%</td>
</tr>
<tr>
<td><strong>IV Combined Grading of Aggregates</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>a) Grading</td>
<td>IS : 2386 (Part-i)</td>
<td>1 test per 150 cum. and part thereof</td>
<td>As per Para 1.5</td>
</tr>
<tr>
<td><strong>V Concrete</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>a) Slump test of concrete</td>
<td>IS : 1199</td>
<td>At least once in 50 batches at each mixer or more frequently if directed by the EIC.</td>
<td>As per Para 3.1</td>
</tr>
<tr>
<td>b) Compaction factor test</td>
<td>-do-</td>
<td>-do-</td>
<td>-do-</td>
</tr>
<tr>
<td>c) Flexural strength</td>
<td>IS : 516</td>
<td>One test consisting of six beam specimens. Three specimens shall be tested after 7 days and another three shall be tested after 28 days for every 100 Cum of Concrete and part thereof.</td>
<td>As per Para 16.4</td>
</tr>
</tbody>
</table>
Equipment as per list at Appendix–’B’ shall be provided by the Contractor in the field testing laboratory. Nothing extra shall be paid to him on this account. Records as required shall be maintained at site.

All test details in support of mix design shall be maintained as part of records of the contract and shall be signed both by the contractor and the Engineer-in-Charge or their authorized representatives. The contractor shall provide all labour, materials and equipment required for all tests to be carried out, at his own cost.

The Engineer-in-Charge reserves the right to test any concrete laid regarding quality, soundness, compaction, thickness strength and finish of the concrete at any time before the expiry of the "Defects Liability period" notwithstanding that necessary tests had been carried out and found satisfactory at the time of execution.

Quality Control And Standard Of Acceptance Of Strength Of Concrete

Samples of concrete shall be collected at the point of discharge on the pavement and beams cast as controlled specimens and tested in accordance with IS: 516 and IS: 1199. The concrete will be said to comply with the specified flexural strength, when the following conditions are met with.

The mean strength determined from any group of four consecutive samples (each sample containing 3 beam specimen i.e. 4 x 3 = 12 beam specimens) at 28 days should exceed the specified characteristic flexural strength by at least 0.3 MPa i.e., 4.4 MPa.

The strength of any specimen is not less than the specified characteristic flexural strength minus 0.3 MPa i.e., 3.8 MPa.

Should the concrete fail to pass the specification for strength as described above, the contractor may, all at his own expense elect to cut cores (diameter of the core not less than 150mm) as per the direction of Engineer-in-Charge where the requirements are not met with. The points from where cores are to be taken and the number of cores required shall be at the discretion of the Engineer-in-Charge and shall be representative of the whole of concrete concerned. In no case, however, shall fewer than 3 cores be tested.

Cores shall be prepared and tested as described in IS 516. Concrete in the member represented by a core test shall be considered acceptable if the average of the results of crushing strength tests of the cores shall not be less than 0.8x0.85 times the corresponding Characteristic compressive strength of cubes and no individual core has a strength less than 0.8x0.75 times the corresponding Characteristic compressive strength of cubes where height to diameter ratio of the core is 2. Where height to diameter ratio of the core is not 2 necessary corrections shall be made in calculating crushing strength of cubes as per clause 12.21.1 of IRC:15-2011

Sample calculation for required core strength is placed below for core cut up to 90days and height to diameter ratio of core is 2:
MPa Flexural strength \( f_{cr} \) = 0.7 \( f_{ck} \) = 4.1 \( f_{ck} \) = 4.31MPa

Average core strength required = 0.8x0.85x\( f_{ck} \)
= 0.8x0.85x34.31
= 23.32MPa say 23.3 MPa

Individual core strength required = 0.8x0.75x34.31
= 20.58MPa say 20.6MPa

With regard to age factor, if the cores are cut within 90 days of casting of slab, no allowance for age factor is required, the strength of the core may be considered as at 28 days. However if the core are cut after 90 days, an age factor of 115 percent as compared to 28 days compressive strength of may be applied.

If however, the tests on cores also confirm that the concrete is not satisfying the strength requirements, then the concrete corresponding to the area from which the cores were cut should be replaced, i.e., over an area extending between two transverse joints where the defects could be isolated or over larger area as decided by the Engineer-in-Charge.

All defective and sub-standard work which includes concrete slab of sub-standard strength as established in above para shall be liable to rejection and shall be replaced by the contractor at his expense. When due to operational or any other reason, such replacement does not become possible (decision of Engineer-in-charge in this respect being final and binding on the contractor), the cost of removal and replacement of such rejected work shall be recovered from the contractor whether such rejected work is subsequently replaced by the Deptt. or not.

Weather Limitations

**Concreting during rains:** To prevent damage to freshly laid concrete during monsoon, or sudden rains, the Contractor shall provide an adequate supply of tarpaulins or other waterproof material. Any concrete damaged by rain shall be removed and replaced by the Contractor at his own cost as directed by the Engineer-in-Charge. If need be, necessary provisions shall be made to support the waterproof material clear of the newly-laid concrete surface to prevent smoothening or any damage due to the contact with tarpaulin. The whole unit should be weighted down appropriately to prevent from blown off by winds. The rate quoted shall include all these.

**Concreting in hot weather:** No concreting shall be done when the concrete temperature is above 30\( ^{0} \)C. Besides, in adverse conditions like high temperature, low relative humidity, excessive wind velocity, imminence of rains etc. if so desired by the Engineer-in-charge, tents on mobile trusses may be provided over the freshly laid concrete for a minimum period of 3 hours as directed by the Engineer-in-Charge. The temperature of the concrete mix on reaching the paving site shall not be more the 30\( ^{0} \)C. To bring down the temperature, if necessary, chilled water or ice flakes should be made use of. No extra payment shall be made for this arrangement.

Concreting in cold weather: No concreting shall be done when the concrete temperature is below 5\( ^{0} \)C.

Measurements of concrete slabs shall be recorded jointly by the Engineer-in-Charge or his authorized subordinate and the Contractor or his authorized agent.
APPENDIX-B

LIST OF MINIMUM EQUIPMENT TO BE PROVIDED IN THE FIELD TESTING LABORATORY BY THE CONTRACTOR AT HIS OWN COST

CONCRETE SECTION:

1. Sieve analysis for combined grading of aggregates
   Sets of I.S. Sieves of sizes 63mm, 45mm, 22.4mm, 11.2mm, 5.6mm, 2.8 mm, 1.4 mm, 710 micron, 355 micron and 180 micron.
2. Sieve analysis for coarse aggregates
   Sets of I.S. Sieves of sizes 63mm, 40mm, 20mm, 12.5mm, 10mm, 4.75 mm, 2.36 mm
3. Sieve analysis of fine aggregate
   Sets of I.S. Sieves of sizes 10mm, 4.75mm, 2.36mm, 1.18mm, 600micron, 300 micron and 150 micron.
4. Silt content of sand
   Graduated glass cylinders 500 C.C. capacity.
5. Bulkage of sand
   a) Graduated glass cylinders 250 C.C. capacity
   b) Graduated glass cylinders 500 C.C. capacity.
6. Slump test/ Compacting Factor Test
   a) Slump cones
   b) Slump rods 3/8" dia. 24" long bullet pointed.
   c) Steel plates 24" x 24"
   d) Steel scales
   e) Compacting Factor Apparatus
6. For making beam specimens for flexural strength
   a) Beam moulds size 70x15x15cm
   b) Tamping rods.
7. Testing flexural strength of concrete:
   100 ton capacity compressive strength testing i/c hand operated in two numbers with flexure test attachment.
8. Other miscellaneous items
   a) Physical balance with set of weights
   b) PAN balances
   c) Spring balances
   d) Glass measuring jar
   e) Beakers, Towels, glass plates etc.
   f) Apparatus for testing flakiness index, Impact value and Los Angeles Abrasion value of coarse aggregates.
TS - 02

PHE SYSTEM
1.0 SANITARY & PLUMBING WORK

1.1 BASIS OF DESIGN

The Plumbing, Sanitary & Drainage System for the project is designed keeping in view the following:

Requirement of adequate and equal pressure availability of cold water lines in Toilets and kitchen.

Adequate storage of water in underground domestic water tanks in necessary areas.

Levels of roads / pavements and other services in the area of project.

The execution of works and materials used shall be as per the latest relevant I.S. specifications. Wherever reference has been made to Indian Standard, CPWD specifications or any other specifications, the same shall mean to refer to the latest specification irrespective of any particular edition of such specification being mentioned in the specifications below or Schedule of Quantities.

1.2 CONCEPT OF THE SYSTEM

The following services are envisaged for the project:

The potable water source for the project is the rain water stored in ponds. The water stored in the new pond will be treated in the proposed Water Treatment Plant (WTP) and the treated water is transferred to the proposed UG sump. The non-potable water source for the buildings is the treated water from the Sewage Treatment Plant (STP).

The UG sump will have different tanks (partitioned) for storage of water for various purposes like potable water, non-potable water, firefighting, HVAC make up water etc.

The domestic water supply, through a Hydro-pneumatic pumping system located at the pump room in the Utility building for making water available at the residual pressure of 1-1.5 bar, is provided for the proposed Terminal. The non-potable water shall be distributed through separate piping network. Also the water supply to potable water terrace tank shall be provided from potable water ring Mains through Fire Terrace tank. A separate Terrace tank has also been provided for non-potable water. Gravity distribution of water from Terrace tanks towards user points are also provided.

Irrigation system shall comprise of pumps and piping network using treated water from STP/ponds. The landscaping areas will be having provisions for water connections through the irrigation piping network from the STP treated water tank. The irrigation pumps are located at Utility pump room.

Sewage and Sullage collection system is based on IS: 1742 and applicable standards for domestic drainage. The sanitary system inside buildings shall be two pipe systems as per National Building Code, in which the soil and waste pipes shall be distinct with common vent. All waste lines shall be connected to the sewer manhole through gully trap. All Sanitary drainage shall be connected to the main sewer line which will be conveyed by gravity up to the holding tanks. Sewage shall be pumped from holding tank to STP. Submersible sewage pumps with necessary valves, automation system, level monitoring system, alarm system etc shall be provided in the sewage pumping system.

The rain water from building roof shall be collected through gutter with appropriate slope and suitable size down pipe provided at the edge of the roof. Overflow arrangement for rain water gutter has been provided with 2 Nos. of inlet gratings for each rain water down pipe. The rainwater down pipes of building shall be connected to main rain water line through inspection chamber leading towards the rain water storage at the UG sump. The overflow from the rain water harvesting sump to drainage network shall be provided with proper valve mechanisms. Mechanical gate system shall be provided for bypass arrangement. Bypass arrangement to drain off the first rain water is provided at two locations. The rain water
water collected in rain water harvesting tank shall be treated to potable water standard through the water treatment plant located at Utility pump room.

The Water Treatment Plant (WTP) shall comprise of filter feed pumps, pressure sand filter, Activated Carbon filter, hypochlorite dosing, Softener feed pump, Softener and necessary piping works. The outlet water from the WTP will be meeting the domestic water quality requirement with chemical parameters in acceptable limits as per SP: 35 (S&T) 1987 which is considered safe for human consumption.

At the North West side of the Terminal, a provision for rectangular RCC drain with cover slab with perforations has been made. The roof top water from airside of the terminal will be collected in this drain to facilitate the quick disposal of storm water. This intern will be connected to the proposed drain of Apron.

In city side, road side drains with gratings are proposed to facilitate the quick disposal of storm water. This intern will be connected to the existing canal located at the east side of the site boundary.

1.3 WATER SUPPLY SYSTEM

1.3.1 POTABLE WATER SYSTEM

The potable water source for the proposed buildings is considered as the treated water from Pond. The roof top water collected in the rain water harvesting tank/pond shall be treated to potable water standard through the water treatment plant located at Utility pump room. Alternate source of Potable water is tanker Water supply.

The required potable water storage tank (Two day capacity) is proposed to be provided below utility building. All tanks are separated with partition wall and connected with valves for easy operation and maintenance. The roof top rain water from terminal building will be collected through rain water down pipes in Rain water sump (capacity of Rain water sump shall be designed for 30minutes storage for peak rainfall). The rain water collected in sump shall be treated to potable water standard through the water treatment plant located at Utility pump room. This treated water will be stored in the potable water sump itself.

WTP (8 hrs working to meet the daily potable water demand) shall comprise of filter feed pumps, Disc filter, Activated carbon filter, softner feed pumps, softner and hypochlorite dosing and necessary piping works. Components of WTP shall be finalized after the physical, chemical and biological analysis of the existing pond or well water in the premise. The outlet water from the Water Treatment Plant shall meet the domestic water quality requirement with chemical parameters in acceptable limits as per SP: 35 (S&T) 1987 which is considered safe for human consumption. Inlets to WTP is taken from rain water harvesting tank and outlet from WTP is connected to Potable water compartments.

Potable water supply for the Terminal shall be through Hydro pneumatic pumping system for making water available at the residual pressure of 1-1.5bar for the toilets, kitchen and other end users. Hydro pneumatic system for Potable water shall be located at Utility pump room which will feed the potable water outlets at Terminal building. Also the water supply to Potable water OH tank shall be provided from potable water ring Mains through Fire OH tank. Gravity distribution of Potable water from OH tank towards Terminal building shall also be provided. Terrace tanks shall be provided for ATC and Service building which will be feed by separate pumps located at pump room in utility building. Potable water distribution by gravity for ATC and service building user points shall be provided. The Hazen and William formula and the charts based on the same shall be used in computing the size of the water supply pipe lines. Hazen and William's formula is applicable to flow of water under pressure and its velocities normally used for plumbing pipes. The quantity of water required to be supplied to every plumbing fixture shall be represented by the fixture units as NBC clause 4.7.3.1
1.3.3 NON POTABLE WATER SYSTEM

The non-potable water source for the buildings is treated water from STP. The outlet water from the Sewage Treatment Plant shall meet the potable water quality requirement with chemical parameters in acceptable limits as per SP: 35 (S&T) 1987 and IS 10500 which is considered safe for flushing, irrigation and HVAC makeup water requirements.

The non-potable water storage tank (Two day capacity) is proposed to be provided in UG sump below utility building. UG sump shall be separated with partition wall and connected with valves for easy operation and maintenance. From STP treated water storage tank, treated water shall be transferred and stored in UG sumps. Non Potable water supply through Hydro pneumatic pumping system for making water available at the residual pressure of 1-1.5 bar for the Terminal toilets, kitchen and other end users is provided. Hydro pneumatic system for Non-potable water shall be located at the pump room in utility building which will meet the flushing requirements at Terminal Building. For irrigation purpose, hydropneumatic pumps shall provide which may locate in the pump room near utility building. Softener is provided to convert the treated water from STP as per ASHRAE/ OEM standard for using it for make up water for HVAC. Terrace tanks shall be provided for ATC and Service building which will be feed by separate pumps located at pump room in utility building. Non-potable water distribution by gravity for ATC and service building user points shall be provided. The Hazen and William formula and the charts based on the same shall be used in computing the size of the water supply pipe lines. Hazen and William's formula is applicable to flow of water under pressure and its velocities normally used for plumbing pipes. The quantity of water required to be supplied to every plumbing fixture shall be represented by the fixture units as NBC clause 4.7.3.1

1.3.4 IRRIGATION SYSTEM

The proposed landscaping area within the boundary is approximately 68000m$^2$. STP treated water/pond water will be utilizing for irrigation requirements. The pumps are located at the pump room in Utility area. Sub-Surface Dripline Tubing shall be provided in Lotus and shrubs areas. For lawn areas, pop up sprinklers of required radius shall be provided. Quick coupling valves are provided throughout the irrigation areas for arranging easy tapping stations. Irrigation system shall comprise of hydro pneumatic pumps, filter, flow sensor, moisture sensor, rain sensor, solenoid valves, air releasing valves, piping networks and necessary control valves. The pumps are located at the pump room in utility area.

2.0 APPURTEMENT

Following components are included in the water supply system for efficient functioning:

- Hydropneumatic system
- Centrifugal monoblock pumps
- Water treatment plant (WTP)
- Control valves
- Nonreturn valves
- Foot Valves
- Flow meter.
- Pressure Gauge.
- Anchor block / thrust block.
- Air release Valves
- Pressure reducing Valves
- Strainers
- Level switch
- Irrigation system- pop up sprinklers
- Drip irrigation
- Valves- Quick coupling valves, air releasing valves and Control valves
3.0 SCOPE OF WATER SUPPLY SYSTEM

The scope of this section comprises the supply, installation, testing and commissioning of piping network for water supply for internal & external services as follows:

a. External Water supply- This section covers the storage facilities like UG Sump, OH tank and distribution of Domestic water. This distribution network make available the water at each individual UG sumps or Individual OH tank for each building which may change according to the ground level and height of building. This section also covers the distribution network from other sources like treated water from STP for Flushing, irrigation and HVAC make up water distribution.

b. Internal Water Supply- This section covers the Potable water distribution from the individual Sump or OH tank for each building. It also covers the Non potable water distribution from the individual Sump for each building. (Treated water from STP shall be supplied). The sanitary and plumbing fittings inside the buildings also come under this section.

The Contractor shall make all necessary application and arrangements for his work to be inspected by the Local Authorities.

The Contractor shall be solely responsible for obtaining the Authorities approval of his works prior to the handing over of the complete water supply / distribution installation to the Department.

3.1 PIPING MATERIALS

The water supply piping system shall consist of DI k9 100 to 200mm for piping under ground/ Trenches, GI C class pipe 25 to 200mm inside pump room and CPVC piping from 20 mm to 100 mm in shafts/ inside buildings for cold water as per CPWD Specifications.

For Potable water supply distribution works, the CPVC pipes and fittings shall be embedded in the wall chase or run on the floor/ceiling or run in shafts/ trenches unless otherwise specified. No unsightly exposed runs shall be permitted.

For Non potable water supply distribution works, the CPVC pipes and fittings shall be embedded in the wall chase or run on the floor/ ceiling or run in shafts/ trenches unless otherwise specified. No unsightly exposed runs shall be permitted.

Application:
- DI k9 pipes are for Potable and Non potable water supply for below ground /trenches applications
- GI C class pipes are for Potable and Non potable water supply inside pump room applications
- CPVC pipes are for Potable and Non potable water supply for above ground applications
- HDPE PE 100 PN 10 pipes and PVC 10 kg/cm2 for irrigation pipes on the external areas of the building
3.1.1 Ductile Iron Pipes

Centrifugally cast ductile iron pipes are latest development in cast iron pipes. Molten metal treated with magnesium is used for producing these pipes. Adding magnesium based alloy to the molten metal gives a uniform distribution of nodular carbon graphites in casting, which improves the properties of the pipe to a great extent. Ductile iron pipes have got high mechanical strength and good impact resistance when compared to cast iron pipes. These pipes have high wear and tear resistance and smooth internal surface. These pipes are approximately 30 percent lighter than conventional CI pipes because of their reduced thickness due to high mechanical properties. The requirements for ductile iron pipes are covered in IS 8329 :1990. The requirements for ductile iron fittings for pressure pipes for water gas and sewage are covered in IS 9523: 1980. These pipes are suitable for hydraulic working pressures up to 4 MPa (40 kgf/cm²) depending on diameter. These pipes can be used where high stress concentrations are anticipated.

For the purpose of surface protection, these pipes are required to be coated during manufacturing stage. Except when otherwise agreed to between the purchaser and the manufacturer, all pipes shall be coated externally and internally with the same material, the pipes being preheated prior to total immersion in a bath containing a uniformly heated composition having a tar or other suitable base. The coating material shall set rapidly with good adherence and shall not scale off when the pipes are to be used for conveying potable water, the inside coating shall not contain any constituent soluble in such water or any ingredient which could impart any taste or odour whatsoever to the potable water after sterilization and suitable washing of the mains.

TRANSPORTATION, HANDLING, STORAGE AND INSPECTION

Transportation
Pipes should be loaded in such a way that they are secured and that no movement should take place on the vehicle during transit. The pipes should be loaded on vehicles in pyramid or straight sided formation. In case of pyramid loading the pipes in the bottom layer should be restrained by the use of broad wooden wedges secured to the vehicle being loaded. The pyramid is to be formed by resting pipes between the pairs of pieces in the preceding layer with the sockets in layers reversed. Straight sided loading may be used with supports along the sides of the vehicles. The use of straight sided loading is advantageous for utilizing full capacity of the vehicle.

Off-Loading
a) **Ductile Iron Pipes** - Cranes should be preferred for off-loading. However, for pipes up to 400 mm nominal bore, skid timber and ropes may be used.

When using mechanical handling equipment, it is necessary to employ sufficient personnel to carry out the operation efficiently with safety. The pipes should be lifted smoothly without any jerking motion and pipe movement should be controlled by the use of guide ropes in order to prevent damage caused by pipes bumping together or against surrounding objects.

Where the crane operator does not have a clear view, he should be guided by the personnel supervising the operation. When cranes are used, the whole sequence of operation should be carried out smoothly and without snap. Properly designed ‘hooks and adequate stead ropes are essential. The hooks should be of suitable shape to ensure positive engagement when entered into the ends of the pipes and then should pass over any protective packing fitted around the pipe ends.

The use of slings passed around bundles of pipes is not recommended because bundles become unstable as the sling is drawn tight or released. However, when it is necessary to use the central slinging method for lifting single pipe, a broad webbing sling is recommended which minimizes the risk of the pipe slipping. Chain slings may slip and are dangerous.

Stacking
Pipes being taken to a stock ground for storage and held pending for further distribution should be arranged into stacks. The first layer of pipes should be laid on a firm foundation consisting of solid timber set level on the ground. Subsequent layers should be placed according to the method of stacking.
Methods adopted for stacking of CI & ductile iron pipes are described in the following paragraphs:

a) **Square stacking** - In square stacking methods, second and subsequent layers are set at right angles to the previous layers with spigots and sockets alternating in each layer and sockets project beyond spigot end. The pipes rest directly upon those beneath it and care is needed in placing to prevent damage.

b) **Parallel stacking with timbers** - All the pipes are parallel with the sockets of successive layers reversed end-to-end with sockets projecting beyond spigot end. Timber battens, placed about 600 mm from each end at right angles to the pipes, are used to separate the successive layers. Wedges at both ends of each batten prevent pipe movement.

c) **Nested stacking (pyramid stacking)** – Nested stacking consists of placing each pipe between the two pipes underneath it, with the sockets being all at one end of each layer and being reversed in successive layers. The bottom layer should be firmly anchored to prevent stack collapse.

d) **Special precautions for bitumen-sheathed pipes** – Bitumen-sheathed pipes should be handled with care to avoid any damage to the sheathing. They should not be stacked but laid in a single layer supported on timbers placed under the uncoated portions of the spigots and sockets. Sheathed pipes should be lifted by means of properly designed hooks fitting into the spigot or socket, or by specially designed slings which will not damage the sheathing. Wire rope, chains or hemp slings should not be used.

**Inspection**

**Inspection of Ductile Iron Pipes**

The pipes and fittings shall be inspected for defects and be rung with a light hammer preferably while suspended to detect cracks. Smearing the outer side with chalk dust helps the location of cracks. If doubt persists further confirmation may be obtained by pouring a little kerosene on the inside of the pipe at the suspected spot; if a crack is present the kerosene seeps through and shows on the outer surface. If a pipe is mishandled either accidentally or due to carelessness during unloading or lowering operation it should be thoroughly inspected before laying and shall be rejected if found unsuitable by the authority.

**LAYING AND JOINTING OF DUCTILE IRON PIPES**

**Laying Underground**

Pipes should be lowered into the trench with tackle suitable for the weight of pipes. For smaller sizes, up to 250 mm nominal bore, the pipe may be lowered by the use of ropes but for heavier pipes, either a well designed set of shear legs or mobile crane should be used. When lifting gear is used, the positioning of the sling to ensure a proper balance, should be checked when the pipe is just clear of the ground. If sheathed pipes are being laid, suitable wide slings or scissor dogs should be used.

All construction debris should be cleared from the inside of the pipe either before or just after a joint is made. This is done by passing a pull-through in the pipe, or by hand, depending on the size of the pipe. When laying is not in progress, a temporary end closure should be securely fitted to the open end of the pipe-line. This may make the pipe buoyant in the event of the trench becoming flooded, in which case the pipes should be held down either by partial refilling of the trench or by temporary strutting. All persons should vacate any section of trench into which the pipe is being lowered.

On gradients of 1: 15 or steeper, precautions should be taken to ensure that the spigot of the pipe being laid does not move into or out of the socket of the laid pipe during the jointing operations. As soon as the joint assembly has been completed, the pipe should be held firmly in position while the trench is backfilled over the barrel of the pipe. The backfill should be well compacted.
Laying Above Ground
The ground should be dressed to match the curvature of the pipe shell for an arch length subtending an angle of 120° at the centre of the pipes. Alternatively, the pipe-line should be laid either on saddle, roller or rocker supports as specified by authority. The pipes may be allowed to rest on ground if the soil is non-aggressive.

Supporting Pipes above Ground
The following recommendations assume that no additional bending moments above those due to the self weight of the pipe and its contents are present.

With Spigot and Socket Pipes
It is recommended that above ground installation of spigot and socket pipes be provided with one support per pipe, the supports being positioned behind the socket of each pipe.

Pipes should be fixed to the supports with mild steel straps so that axial movement due to expansion or contraction resulting from temperature fluctuation is taken up at individual joints in the pipe-line. In addition, joints should be assembled with the spigot end withdrawn 5 to 10 mm from the bottom of the socket to accommodate these thermal movements. Pipes supported in this way are capable of free deflection and axial movement at the joints which accommodate small movements of the pipe supports.

The designed anchorage shall be provided to resist the thrusts developed by internal pressure at bends, tees, etc. Where a pipe-line crosses a watercourse, the design and method of construction should take into account the characteristics of the watercourse. Early consultation with river authorities will assist in evaluating the effect of river characteristics (for example, nature of bed, scour levels, maximum velocities, high flood levels, seasonal variations, etc), on design and construction. If necessary, unsupported spans between 4 and 6 m may be obtained by positioning the pipe supports.

With Flanged Pipes
The recommended maximum unsupported span is 8 m. The supports shall be located at the centre of every second pipe.

The supports of all flanged pipe work spans should be stable and unyielding due to movements in the pipeline.

The straps should prevent any lateral movement or lifting of the pipe-lines but not restrict expansions and contractions caused by temperature fluctuations.

Cutting of Pipes
The cutting of pipe for inserting valves, fittings, etc, shall be done in a neat and workmanlike manner without damage to the pipe or lining so as to leave a smooth end at right angles to the axis of the pipe.

Methods of cutting ductile iron pipes are given in 3.4.1 to 3.4.3.

By Hacksaw
Hand or power operated hacksaw should be used with blades having teeth at a pitch of 1 mm.

By Manually Operated Wheel Cutter
The type of cutting wheel used for cast iron pipes is not suitable for ductile iron pipe. Special wheels, as used for cutting steel pipes, shall be used and cut ends are trimmed with a file.

By Pipe Cutting Machine
Machines with cutter heads or abrasive wheels shall be used. Cutter head should have a front rake angle of 7° as used for steel pipes.
End Preparation of Cut Pipes for Jointing

The burr left after cutting should be trimmed off by light grinding or by filing.

Wrapping

When ductile iron pipes are to be laid in aggressive soils, the pipes should be wrapped externally with protective coatings, such as bitumen or coal tar sheathing protective tapes or by loose polyethylene sleeving, or in certain circumstances, concrete before laying. At joints, bends and valves, precautions should be taken to provide sufficient overlap of the wrapping sleeve so that no pipe-line is exposed to the aggressive soil.

Pipe-line Markers

Distinctive markers should be erected at all roads, railways, river and canal crossings, and elsewhere as required to identify the pipe-line and to indicate its position. Markers should be placed at field boundaries, preferably in such a way that they are not obscured by vegetation. At all valve installations, plates should be provided to give the same information as on the markers. Markers should not be treated with any substance likely to be harmful to livestock.

Pipe-line Anchorage

All pipe-lines having unanchored flexible joints require anchorage at changes of direction and at dead ends to resist the static thrust developed by internal pressure. Dynamic thrusts caused by flowing water act in the same direction as static thrusts. This thrust is of sufficient magnitude at high velocities to warrant safety consideration.

Anchorage to resist the thrust should be designed taking into account the maximum pressure the main is to carry in service or on test, and the safe bearing pressure of the surrounding soil.

Where possible, concrete anchor blocks should be of such a shape as to allow sufficient space for the remaking of the joints.

Pipe-line should be securely anchored at dead ends, tees, bends, tapers and valves to resist thrust arising from internal pressure. Anchors and thrust blocks should be designed in accordance with IS 5330 : 1984. Steeply inclined pipe-lines should be secured by transverse anchors spaced as shown below:

<table>
<thead>
<tr>
<th>Gradient</th>
<th>Spacing</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 in 2 and steeper</td>
<td>5.5</td>
</tr>
<tr>
<td>Below 1 in 2 to 1 in 4</td>
<td>11.0</td>
</tr>
<tr>
<td>Below 1 in 4 to 1 in 5</td>
<td>16.5</td>
</tr>
<tr>
<td>Below 1 in 5 to 1 in 6</td>
<td>22.0</td>
</tr>
<tr>
<td>Flatter than 1 in 6</td>
<td>Not usually required</td>
</tr>
</tbody>
</table>

Joints and Jointing of Ductile Iron Pipes

Two main types of joints are used with ductile iron pipes and fittings:

a) Socket and spigot flexible joints:

1) Push on joints; and
2) Mechanical joints.

b) Rigid flanged joint.
Flexible Joint

The spigot and socket flexible joint should be designed to permit angular deflection in direction and axial movement to compensate for ground movement and thermal expansion and contraction. They incorporate gasket of elastomeric materials and the joints may be of the simple push-on-type or the type where the seal is effected by the compression of a rubber gasket between a seating on the inside of the socket and the external surface of spigot. Joints of the latter type are referred to as mechanical joints. Both push-in and mechanical joints are flexible joints. Flexible joints require to be externally anchored at all changes in direction such as at bends, etc., and at blank end to resist the thrust created by internal pressure and to prevent the withdrawal of spigots.

Flanged Joint

Flanged joints are made on pipes having a machined flange at each end of the pipe. The seal is usually effected by means of a flat rubber gasket compressed between two flanges by means of bolts which also serve to connect the pipe rigidly. Gaskets of other materials, both metallic and non-metallic, are used for special applications.

Jointing Procedure

Procedure for jointing will vary according to the type of joint being used. Basic requirements for all types are:

a) Cleanliness of all parts,

b) Correct location of components,

c) Centralization of spigot within socket, and

d) Strict compliance with manufacturer’s jointing instructions.

The inside of sockets and the outside of spigots should be cleaned and wire brushed for a distance of 150 to 225 mm. Glands and gaskets should be wiped clean and inspected for damage. When lifting, gear is used to place the pipe in the trench, it should also be used to assist in centralizing the spigot in the socket.

Where the pipe-line is likely to be subjected to movement due to subsidence or temperature variations, the use of flexible joints is recommended. A gap should be left between the end of the spigot and the back of the socket to accommodate such movement.

TESTING OF DUCTILE IRON PIPE-LINE

After a new pipe-line is laid and jointed, testing shall be done for:

a) Mechanical soundness and leak tightness of pipes and fittings;

b) Leak tightness of joints; and

c) Soundness of any construction work, in particular that of the anchorages.

Hydrostatic Testing

The completed pipe-line may be tested either in one length or in sections; the length of section depending upon:

a) Availability of sufficient water,

b) Number of joints to be inspected, and

c) Difference in elevation between one part of the pipe-line and another.

Where the joints are left uncovered until after testing, sufficient material should be back-filled over the centre of each pipe to prevent movement under the test pressure. It is prudent to begin testing in comparatively short length of test section. Progressively as experience is gained, lengths of about 1.5 km
or more, are tested in one section, subject to consideration of length of trench which can be left open in particular circumstances. Each section should be properly sealed-off, preferably with special stop ends secured by adequate temporary anchors. The thrust on the stop ends should be calculated and the anchors designed to resist it. All permanent anchors should be in position and, if of concrete, should have developed adequate strength before testing begins. The section under test should be filled with water, taking care that all the air is displaced either through vents at the high points or by using a pig or a sphere.

The test pressure to be applied should be not less than any of the following:

   a) The maximum sustained operating pressure,
   b) The maximum static pressure plus 5 MPa (50 kgf/cm²), and
   c) The sum of the maximum sustained operating pressure (or the maximum static pressure) and the maximum calculated surge pressure.

After filling, the pipe-line should be pressurized to the specified operating pressure and left for a period of time to achieve stable conditions. The length of this period of time depends on many factors such as slight movement of the pipe-line under pressure whether air is trapped in the pipe-line or whether the pipe-line has a concrete lining which absorbs water.

The pipe-line is then pressurized up to the full test pressure and the section under test completely closed off. The test pressure should be maintained for a period of not less than 10 minutes to reveal any defects in the pipes, joints or anchorages.

The test pressure should be measured at the lowest point of the section under test or alternatively, an allowance should be made for the static head between the lowest point and the point of measurement, to ensure that the required test pressure is not exceeded at the lowest point.

In case of extreme temperature conditions, there may be a tendency of hydraulic pressure building up inside the pipe-line because of expansion of water during the day time. This should normally not be of any major concern as the joints and the pipes are manufactured to resist a much higher pressure. However, sufficient care should be taken to prevent floating or bulging of the pipe-line because of building up of such high pressure during the temperature rise.

If the test is not satisfactory, the fault should be found and rectified. Where there is difficulty in locating a fault, the section under test should be subdivided and each part tested separately.

Methods employed for finding leaks include:

   a) Visual inspection of each joint, if not covered by the backfill;
   b) Use of a bar probe to detect signs of water in the vicinity of joints, if back-filled;
   c) Aural inspection using a stethoscope or listening stick in contact with the pipeline;
   d) Use of electronic listening device which detects and amplifies the sound or vibrations due to escaping of water, actual contact between the probe and the pipe is not essential;
   e) Injection of a dye into the test water-particularly suitable in waterlogged ground; and
   f) Introduction of nitrous oxide in solution into the test water and using an infra-red gas concentration indicator to detect the presence of any nitrous oxide that has escaped through the leak.

After all sections have been joined together on completion of section testing; a test on the complete pipe-line should be carried out. This test should be carried out at a pressure not less than the maximum
sustained operating pressure or the maximum static pressure of the pipe-line and, during the test, inspection made of all works which have not been subjected to section tests. During the test, the pressure at the lowest point in the pipe-line should not exceed the maximum given in Table 1.

### Table 1 Maximum Field Hydrostatic Test Pressure for Ductile Iron Pipe-Lines with Flexible Joints (Clause 2.5)

<table>
<thead>
<tr>
<th>Nominal bore (Mm)</th>
<th>Max field hydrostatic test pressure (Mpa (kgf/cm²))</th>
</tr>
</thead>
<tbody>
<tr>
<td>Up to 300</td>
<td>4.5 (45)</td>
</tr>
<tr>
<td>350 to 600</td>
<td>3.0 (30)</td>
</tr>
<tr>
<td>700 to 1200</td>
<td>2.1 (21)</td>
</tr>
</tbody>
</table>

### NOTES

1. The above pressures are 0.5MPa (5 kgf/cm²) higher than the pressure ratings for ductile iron pipes and fittings with flexible joints. It is not considered necessary to field test ductile iron pipelines to 1.5 times the design operating pressure as is often the practice with cast iron pipelines.

2. The field test pressures is applied to ductile iron pipe-lines only when the pipe-line and its fittings are properly anchored.

It is important to ensure that proper arrangements are made for the disposal of water from the pipe-line after completion of hydrostatic testing and that all consents which may be required from authorities have been obtained. In some cases, for example, for heavily chlorinated water, some treatment may be necessary before final disposal.

Reference: SP 57 Handbooks on pipes and fittings for Drinking water supply

3.1.2 G.I Piping

A. Transportation and Stacking

The transportation of materials to the work site and stacking shall be done in a manner to cause minimum inconvenience to the traffic and other construction works. Pipes shall be protected during handling against impact, shocks and free fall, to avoid cracks and damage.

B. Lowering

The pipes shall be lowered cautiously to prevent disturbance of the bed and sides of the trench. The heavy pipes shall be lowered by means of proper shear legs, chain pulley or as directed by Engineer-in-Charge.

C. Laying and Fixing

Screwed G.I pipes shall be jointed with screwed sockets, joints, using screwed fittings. Care shall be taken to remove any burn from the ends of the pipes. After screwing, white lead with a few stands of fine hemp shall be applied while tightening.

Compounds containing red lead shall not be used. All pipes above ground shall be fixed with G.I holder bat clamps clear of the walls. If the pipes are fixed in chasses or embedded in wall, they shall be secured properly in position by grounding and pipe inside chase will be painted thickly with bituminous paint.

All underground pipes shall have a minimum cover of 1 metre or as directed by Engineer-in-Charge.
D. Testing

Before any pipes are painted or covered up they shall be tested to required hydrostatic pressure.

In addition to the sectional testing of water supply piping, the contractor shall test entire installation on completion of the job to the satisfaction of the Engineer-in-Charge.

3.1.3 CPVC PIPES

All CPVC pipes and fittings for water supply shall be according to requirements of ASTM D 2846 or ASTM F 441/442 (SDR11) and rated at a continuous working pressure of 7 kg/cm² at 180°F (82°C). The solvent cement used for CPVC pipes and fittings shall conform to ASTM F 493.

CPVC fittings shall conform to ASTM F 438 for SCH 40 pipes and ASTM F 439 for SCH 80 pipes. The terminal fittings for jointing fixtures shall be brass threaded Male/Female type as per ASTM F 437.

LAYING AND JOINTING

The pipes may be cut to the required lengths using circular tubing cutters, Ratchet type cutters or chop saws. The cuts shall be square. Burrs and filings shall be removed from outside and inside of the pipes using a chamfering tool.

For jointing CPVC pipes special solvent cement is required. The cement may be applied by a paint brush to the end surfaces to be jointed. The surfaces are to be dry before solvent cement is applied. A heavy even coat of solvent cement may be applied. Excess solvent cement shall not be allowed to puddle in the fitting and pipe assembly. The pipe may then be rotated to one quarter to half turn while inserting into the fitting socket. When the pipe end is seated it may be held in place for ten seconds to allow the joint to set. Teflon tape may be used as thread sealant.

TESTING

Water testing to a pressure of 10 kg/cm² may be carried out for CPVC SDR 11 piping system. Air testing shall not be done. Other gases shall also not be used for testing.

Hydrostatic pressure testing should commence only after all set and cure times for solvent cemented joints have been satisfied.

The system should be pressure tested in accordance with local code requirements following industry accepted practices for thermoplastic systems.

Under slab installations that contain joints must be pressure tested before pouring the slab.

CPVC Solvent Cemented Hot and Cold Water Distribution Systems,” requires a test at 150 psi (10 kg/cm²) for 2 hours.

In freezing temperatures the system should be adequately purged of water after testing to avoid damage from freezing.

3.2 VALVES

All valves shall be of the particular duty and design as specified. Valves shall either be of screwed type or flanged type, as specified, with suitable flanges and non-corrosive bolts and gaskets. Tail pieces as required shall be supplied along with valves.
All valves shall be suitable for the working pressure involved.

a. Sluice / Gate Valves

Sluice Valves above 50 mm (inside screw and non-raising screw type) shall be of Cast Iron body and Gunmetal seat with double flanged ends and valve wheel. They shall conform totype PN 1.6 of IS:780. Sluice valves upto 50mm (outside screw raising spindle type) shall be of Gunmetal Full way Valve with wheel tested to 20 Kg./cm² class-II as per I.S. 778 with female screwed ends. Valve wheels shall be of right hand type and have an arrow head engraved or cast there on showing the direction for turning open and close. Wherever necessary, suitable chamber of required depth shall be provided, and in case of deep location of sluice valve, necessary key/level/extension rod shall be provided for operation.

3.2.2 Butterfly Valves

The Butterfly Valve shall be suitable for wastewater / waterworks. The Valves conforming to IS: 13095 shall be provided. All valves shall be suitable to withstand the pressure in the system and rating shall be PN 1.6. All valves shall be right handed (i.e. handle or key shall be rotated clock wise to close the valve). The direction of opening and closing shall be marked and an open / shut indicator fitted. The material of valves shall be as under:

- Body - Cast iron
- Style of disk- Wafer end type
- Disc - Ductile Iron
- Seat - EPDM / nitrile rubber
- Shaft - Stainless Steel

The Valve shall be fitted between two flanges on either side of pipe flanges. The Valve edge rubber shall be projected outside such that they are wedged within the pipe flanges to prevent leakages.

3.2.3 Non-Return Valve

Non-return valves shall be of Cast Iron body ball type and Stainless Steel seat for Sewage water handling up to clarified water tank. They shall conform to API-594 and have companion flanges. They shall be Stainless steel Dual Plate Type for Clear water suitable for both horizontal and vertical installation. An arrow mark in the direction of flow shall be marked on the body of the valve.

3.2.4 Ball Valve

The Ball Valve of size below 50 mm dia shall be made from forged brass and tested to 20 Kg/ cm² pressure. The valve shall be internally threaded to receive pipe connections. The Ball shall be made from brass and machined to perfect round shape and subsequently chrome plated. The seat of the valve body bonnet gasket and gland packing shall be of Teflon. The handle shall be of chrome plated steel with PVC jacket. The handle shall also indicate the direction of ‘open’ and ‘closed’ situations. The gap between the ball and the Teflon packing shall be sealed to prevent water seeping upto 14 Kg / cm² pressure. The handle shall also be provided with a lug to keep the movement of the ball valve within 90 degree.

Strainers shall be of the approved type with SS body with SS304 Strainer Basket designed to the test pressure of 10 Kg/ cm². Strainers shall be fabricated with minimum 1.2mm thick stainless steel sheet with 3 mm dia. perforation holes. Strainers shall be provided with flanges or threaded sockets as required. They shall be designed so as to enable blowing out accumulated dirt and facilitate removal and replacement of screen without disconnection of the main pipe.

3.2.5 Pressure Gauges

Pressure gauges shall be of 150mm dia. dial and of 0 to 10 Kgs / Sq. cm. and be complete with shut off gauge valve etc. duly calibrated before installation. Diaphragm seal type Pressure Gauges shall be provided with proper isolation valves. Flow meters shall also be provided with isolation valves and bypass arrangement to enable of maintenance of the flow meter as and when required Care shall be taken to protect pressure gauges during pressure testing.
3.3 CONNECTIONS TO VARIOUS MECHANICAL EQUIPMENT SUPPLIED BY OTHER AGENCIES

All inlets, outlets, valves, piping and other incidental work connected with installation of mechanical equipment supplied by other agencies shall be carried out by the contractor in accordance with the drawings, requirements for proper performance of equipment and the directions of the Engineer In-Charge. The equipments to be supplied by the other agencies consist of mainly pumps, water treatment filters, water meters etc. All these mechanical equipments installations shall be carried out in the presence of personnel from respective manufacturer and satisfactory installation certificate from manufacturer to be submitted before commissioning. The work of connections to the various equipments shall be effected through proper unions and isolating valves. The work of effecting connections shall be executed in consultation with and according to the requirement of equipment suppliers, under the directions of the Engineer In-Charge. The various aspects of connection work shall be executed in a similar way to the work of respective trade mentioned elsewhere in these specifications.

4.0 SEWAGE, SULLAGE AND STORM WATER

4.1 CONCEPT OF THE SYSTEM.

Sewage and Sullage collection system is based on IS: 1742 and applicable standards for domestic drainage. The sanitary system inside buildings shall be two pipe systems as per National Building Code, in which the soil and waste pipes shall be distinct with common vent. The disposal from water closets shall be connected to the soil stack and local manholes directly and the waste pipes through a Gully trap. From the gully trap it is connected to the soil manholes. All traps of water closets and the urinals shall be completely vented in the system. Provision for cleaning eyes shall be made at suitable locations to facilitate system maintenance.

Sewage and Sullage collection system is based on IS: 1742 and applicable standards for domestic drainage. The sanitary system inside buildings shall be two pipe systems as per National Building Code, in which the soil and waste pipes shall be distinct with common vent. All waste lines shall be connected to the sewer manhole through gully trap. All Sanitary drainage shall be connected to the main sewer line which will be conveyed by gravity up to the holding tanks. Screen chambers shall be provided in sewage line before connection in to holding tank. Holding tanks (Minimum 2 hour storage of daily peak sewage flow) with sewage pumping stations shall be located at suitable locations. The freeboard shall limit to 2 to 3 metres so that maintenance is easy. Sewage shall be pumped from holding tank to STP. The self cleansing velocity of sewage inside pumping line shall be strictly maintained. Standby pumping line of same size shall be installed parallel to the main sewer pumping line in case of an emergency. Submersible sewage pumps with necessary valves, automation system, level monitoring system, alarm system etc shall be provided in the sewage pumping system.

The sewage lines are designed as per Mannings formula as per CPHEEO manual.

4.2 DESIGN PARAMETER

Velocity in pipes – 0.6 to 3 m/sec as per National Building Code of India 2016 & as per Hand Book on Water Supply and Drainage, BIS: SP: 35 (S &T) 1987

Manholes shall be provided at intersection of soil/waste collection pipe, junction between different size/gradient of pipe and location where the soil/waste collection pipe changes direction wherever applicable.

Manholes may be rectangular or circular type. The minimum internal size of the manholes, chambers shall be as follows:

a) Rectangular Manholes:
   1) For depths upto 0.60m - 600mm x 600mm
   2) For depths less than 0.90m - 900mm x800mm
   3) For depths from 0.90m and upto 2.50m - 1200mm x900mm
b) Circular Manholes:
1) For depths above 0.90m and upto 1.65m - 900mm diameter
2) For depths above 1.65m and upto 2.30m - 1200mm diameter

4.3 DESIGN LIMITATIONS

The system is designed considering the following:

a. Termination of vent cowl at terrace level.
b. Provision of adequate slope for horizontal header pipes for achieving self-cleaning velocity in the pipes.
c. Provision of cleanout plug in necessary areas.

4.4 WORKMANSHIP

The workmanship shall be best of its kind and shall conform to the CPWD specifications and Indian Standard Specifications in every respect or latest trade practices and shall be subject to approval of the Engineer In-Charge. All materials and/or Workmanship which in the opinion of the Engineer In-Charge is defective or unsuitable shall be removed immediately from the site and shall be substituted with proper materials and/or workmanship forthwith.

4.5 MATERIALS

All materials shall be best of their kind and shall conform to the latest Indian Standards. All materials shall be of approved quality as per samples and approved by the Engineer In-Charge.

As and when required by the Engineer In-Charge, the contractor shall arrange to test the materials and/or portions of works at his own cost to prove their soundness and efficiency. If after tests any materials, work or portions or work are found defective or unsound by the Engineer In-Charge the contractor shall remove the defective material from the site, pull down and re-execute the works at his own cost to the satisfaction of the Engineer In-Charge. To prove that the materials used are as specified the contractor shall furnish the Engineer In-Charge with original vouchers on demand.

4.6 INTERNAL DRAINAGE (SOIL, WASTE, VENT & RAIN WATER PIPES)

SCOPE

The scope of this section comprises the supply, installation, testing and commissioning of internal drainage services.

Work under this section shall consist of furnishing all labour, materials, equipments and appliances necessary and required to completely install all soil, waste, vent and rainwater pipes and fittings as required by the drawings.

4.7 BASIC PIPING SYSTEM

Soil, waste and vent pipes in shafts, and in concealed areas i.e. false ceilings etc. shall consist of PP pipes / PVC Pipes 10 kg/cm² / PVC Pipes 4 kg/cm² & fittings as called for. The rain water down taking system shall also consist PVC 10 kg/cm² pipes as per IS 4985 and CPWD Specifications for all diameters.

The soil pipes shall be circular with a minimum diameter of 100mm. Pipes shall be fixed by means of stout GI clamps in two sections, bolted together, built into the walls, wedged and neatly jointed as directed and approved by the Engineer In-Charge. All bends, branches, swan necks and other parts shall conform to the requirement and standards as described for the pipes. Pipes shall be rested against the walls on suitable wooden cradles. Local authority regulations applicable to the installations shall be strictly followed.
Where indicated, the soil pipes shall be continued upwards without any diminution in its diameter, without any bend or angle to the height shown in the drawings. Joints throughout shall be made with molten lead as described under jointing of cast iron pipes. Soil pipes shall be painted as provided under 'painting'. The soil pipes shall be covered on top with cast iron terminal outlets as directed and approved by Engineer in charge. All vertical soil pipes shall be firmly fixed to the walls with properly fixed clamps, and shall as far as possible be kept 50mm clear of wall. Waste pipes and fittings shall be of pvc pipes. Pipes shall be fixed, jointed and painted as described in installation of soil, waste & vent pipes.

Every waste pipe shall discharge above the grating of properly trapped gully. The contractor will ensure that this requirement is adequately met with. Wherever floor traps are provided, it shall be ensured that at least one wash is connected to such floor traps to avoid drying of water seal in the trap. Ventilating pipes shall be of pvc pipes, conforming to the requirements laid down earlier. All traps on branch soil and waste pipes shall also be ventilated at a point not less than 75mm or more than 300mm from their highest part and on the side nearest to the soil pipe or waste pipes.

Access doors for fittings and clean outs shall be so located that they are easily accessible for repair and maintenance. Any access panel required in the civil structure, false ceiling or marble cladding etc. shall be clearly reported to the Department in the form of shop drawings so that other agencies are instructed to provide the same.

All the fittings used for connections between soil, waste and ventilation pipes and branch pipes shall be made by using pipe fittings with inspection doors for cleaning. The doors shall be provided with 3mm thick rubber insertion packing and when closed and bolted shall be air and water tight.

Where soil, waste and ventilating pipes are accommodated in shafts, adequate access to cleaning eyes shall be provided.

Head (starting point) of drains and sewage / waste water sumps (as and where applicable) having a length of greater than 4 m up to its connection to the main drain or manhole shall be provided with a 80 / 100 mm vent pipe.

5.0 PROPOSED RAIN WATER HARVESTING SYSTEM

Rain water harvesting system consists of collecting, storing, filtering and putting to use the roof top rain water collected from Terminal building. Roof top rain water harvesting & conserving systems both small and large are comprised of six basic components as described below:

- Catchment Area/ Roof: Surface up on which rain falls.
- Gutters and downspouts: transport channels from catchment surface to storage.
- Leaf screens and roof washers: systems that remove contamination and debris.
- Cisterns or storage tanks: where collected rain water is stored.
- Conveying the delivery system for treatment either by gravity or pump.
- Water treatment: filters and equipment and additives to settle, filter and disinfect.

The quantity of rain water which can be harvested depends up on the annual rainfall and the catchment area. The rooftop area of the terminal building has been considered as the catchment area for Rainwater Harvesting purpose. By using the most common rational equation to determine the peak discharge from the roof top area. Minimum 30 minutes storage capacity for rain water shall be provided in underground sump.

The roofs of a building shall be so constructed or framed as to permit effectual drainage of the rain water by means of a sufficient number of rain water pipes of adequate size so arranged, jointed and fixed as to ensure that the rain water is carried away from the building without causing dampness in any part of the walls or foundations of the building or those of an adjacent building.

Catchment area of the rain water harvesting system is the rooftop area of the terminal building. The rain fall on the roof area is collected through the gutters with appropriate slope and suitable size down pipe
provided at the edge of the roof provided each side of the building. The vertical down take rain water pipes are having a bell mouth inlet on the roof surface with effective cross sectional area of grating 1.5 to 2 times the rain water pipe area. Here, each rain water down pipes shall be provided with minimum 2 Nos. of inlet gratings for effective drainage of the roof. The rain water down pipes shall be designed as per NBC clause 4.5.11.6.8. Also intensity of rainfall and time of concentration selected for rain water down pipe are the factors that decide the quantity of rain water entering into the pipes. The rational method is a universally accepted empirical formulae to determine the peak discharge from the tributary area relating rainfall to run-off and is applicable to small catchment areas not exceeding 200 sq.km. Self cleansing velocity shall be maintained in rain water pipes below ground.

Manholes shall be provided at intersection of rain water pipe, junction between different size/gradient of pipe and location where the rainwater pipe changes direction wherever applicable.

5.1 Rain Water Harvesting Ponds

Rain water collecting ponds is considered as the main source of water in the premise. Since the water table is at high level, the depth of pond shall be thoroughly verified with High Flood Level. The collected rain water in the pond will be pumped to the Rainwater harvesting tank at the utility building which in turn will be treated in the proposed WTP. The pond shall be of minimum 20000m$^3$ capacity. The system shall comprise of pumps, control valves, automation, monitoring and necessary piping networks.

6.0 PROPOSED DRAINAGE SYSTEM

Storm runoff is that portion of the precipitation which drains over the ground surface. The estimation of such runoff reaching the storm drain therefore dependent on intensity and duration of precipitation characteristics of the tributary area and the time required for such flow to reach the drain.

The area within the boundary of the project other than the roof top area will be the tributary area of the periphery drain. The proposed drain will collect the storm runoff and convey it to the existing drainage network.

The rational method is a universally accepted empirical formulae to determine the peak discharge from the tributary area relating rainfall to run-off and is applicable to small catchment areas not exceeding 200 sq.km.

The primary component in designing storm drains is the design storm value of specified duration and return period. As the extent of drainage system is small, even intense rainfall of short durations may cause heavy outflows. Extreme values of various short durations are, therefore required in designing drainage systems.

The storm water drain shall be designed for an intensity of rain for minimum 5 year return period. For this value, rainwater intensity duration curves for different return periods shall be prepared from the IMD rainfall datas. The storm duration chosen for design purposes is equal to time of concentration and is based on the assumption that the maximum discharge at any point in a drainage system occurs when the entire catchment is contributing to the flow.

At the North West side of the Terminal, a provision for rectangular RCC drain with cover slab with perforations has been made. The roof top water from airside of the terminal will be collected in this drain to facilitate the quick disposal of storm water. This intern will be connected to the proposed drain of Apron.

In city side, road side drains with gratings are proposed to facilitate the quick disposal of storm water. This intern will be connected to the existing canal located at the east side of the site boundary.
Application:

- PVC 10 kg/cm² pipes are for concealed sewage works inside building
- PP pipes and HDPE PE 80, PN 10 are for external sewage works inside shafts/trenches and below ground applications.
- PVC 4 kg/cm² pipes are for vent piping works.
- HDPE PE 80, PN 10 pipes are for sewage pumping Lines for below ground applications
- PVC 10 kg/cm² pipes (100mm dia to 200mm dia) for rain water pipes located within the core of the building
- HDPE PE 80 PN 10 pipes for rain water pipes on the external areas of the building up to 300mm diameter.
- RCC NP3 Hume pipes for rain water pipes on the external areas of the building above 300mm diameter
- HDPE PE 100 PN 10 pipes and PVC 10 kg/cm² for irrigation pipes on the external areas of the building

7.0 PIPING MATERIAL

7.1. UPVC PIPES - JOINTING

Solvent Cement

Consists essentially of a solution of vinyl chloride polymer or copolymer dissolved in a suitable volatile mixture of organic solvents. The solvent constituents soften the mating surfaces, which diffuse into one another to form a ‘cold weld’.

Specification

Solvent cement shall conform to all the requirements of IS 14182.

Selection

Solvent cement is available in three grades of viscosity as given below to cover a range of pipe sizes from 20 mm to 630 mm. Sufficient solvent cement shall be applied so that a wet-film thickness adequate enough to fill a gap in a pipe joint is formed. Selection is also dependent on the climatic conditions prevalent at the site.

Pipes upto 50 mm dia regular bodied and between 63mm to 160 mm dia medium bodied and above 200 mm dia heavy bodied solvent cement shall be used.

TESTING

Pressure tests should never be carried out using compressed air or gasses.

Preparation

a. Pipe systems should be hydraulically tested in lengths appropriate to the diameters and site conditions. Pipelines longer than 800 m may require testing in sections. Preferably, the length selected for test is between 300 m and 500 m.

b. Preferably, the test should be carried out between blank flanges. Testing against closed valves is not recommended, unless there is no alternative.
c. Do not support the end pieces of the test section against the already laid pipes of the proceeding section.

d. Testing should not take place until any concrete used for anchoring has fully cured (normally 72 h) and attained its required strength. Solvent cemented joints must be allowed to harden for a minimum of 24 h before being subjected to test conditions.

e. It is important to provide sufficient backfill over the main barrel of the pipe, to prevent displacement and to maintain stable temperature conditions. Leave joints free for inspection.

f. The test position should be located at the lowest point of the pipeline profile to encourage expulsion of air as the pipe is being filled with water. Adequate air release mechanisms should be located at all high points along the line.

g. Test-ends should be designed to enable the measured filling and subsequent emptying of the pipe line. Air bleed should also be incorporated at each end.

h. Pressurizing equipment should be adequately sized. Check all seals and non-return valves prior to the test. Pressure gauges should have an accuracy of ± 0.2 bar. Automatic pressure recording equipment is recommended.

i. Before filling the pipeline, all line valves and air venting systems should be checked open. All air must be removed from the system.

j. Fill the system slowly. Water velocity must not exceed 0.6 m/s. Potable water pipelines should be tested with potable water only. After charging, close all air valves and check proper action of automatic valves.

k. During filling, a number of movements will be seen in the pipeline. Allow the pipeline to stabilize under a nominal pressure for a minimum of 2 h.

**Test Pressures**

The test should conform to the following conditions:

a) Be carried out at ambient temperature;

b) Be applied for at least 1 h, but not more than 24 h; and

c) Not exceed 1.5 times the maximum rated pressure of the lowest rated component.

**Applying the Test**

a. Allow the system to stabilize for 2 h after filling. Apply pressure steadily. Observe pressure gauges throughout and record the rates of pressure increase recorded.

b. The pressure should be increased till the specified pressure is reached at the lowest part of the section. Maintain test pressure at this level, by additional pumping if necessary, for a period of 1 h.

c. Close all valves and disconnect the pressurizing unit. No further water should be allowed to enter the system for a further period of 1 h.

d. During the test period, carry out a visual examination of all joints and exposed connections.
Interpretation of the Results

a. There should be no leakage in any part of the section.

b. If there has been a decrease in pressure during this period other than due to leakage, the original pressure is re-established by injecting a measured quantity of water into the section.

c. The test is considered to be satisfactory if;
   i) There is no decrease in pressure (a slight rise in pressure is also, possible due to changes in ambient temperatures),
   ii) The measured quantity of water required to reinstate the pressure to the original test pressure is less than the 'permissible maximum' Q, where \( Q = 4.5 \text{ litres per 1.6 km per 25 mm of nominal bore per 30 m head of test pressure per 24 h} \).

The recommended selection of test pressure is either the nominal pressure \( PN \) of the piping system (lowest \( PN \) of any component), or 1.5 times the actual operating pressure, whichever is greater.

The volume of water added is an allowance made to compensate for the natural expansion/movement of the pipe and flexible joints under pressure and for the inevitable entrapment of small amounts of air within the test length. In bubble form, this air compresses and may pass in and out of solution at test pressures.

c. On completion of any test, the residual pressure should be released slowly and in a carefully controlled manner.

   WARNING: The rapid decompression of any entrained air may cause surge conditions which are potentially dangerous both to the pipeline and to personnel.

d. All defects revealed in the test should be rectified and the procedure repeated until a satisfactory result is obtained.

7.2 POLYPROPYLENE PIPES

Polypropylene pipes (PP) Pipe is sound-absorbing, hot water resistant pipe that is suitable for all pressure less sewage pipes according to DIN EN 12056 and DIN 1986-100. The pipes and molded parts are made of PP-M (mineral reinforced Polypropylene), so that general sound protection is guaranteed from the extraction positions to the manifold. Although it is conceived as a sound-absorbing residential sewage pipe, the pipe is also permitted as main pipe up to the house connection duct. PP can be delivered in the DN 50 to DN 200 dimensions with the density of 1.9 gm/cm³. It is corrosion-resistant and resistant to aggressive effluents. No crust formation takes place due to the smooth surface. The lesser weight in comparison with metallic pipes and the quick, safe plugin fittings of the system make it easy to lay.

7.3 HDPE PIPES

JOINTING TECHNIQUES

General
Polyethylene pipes are made by continuous extrusion process and are generally available in factory cut lengths and in form of coils. PE pipes conforming to IS 4984, as they are UV protected (due to carbon black content in the pipe), may be stored either in open or covered.

THE COMMONLY USED JOINTS ARE AS FOLLOWS:

1) FUSION WELDING
   i) Butt fusion welding,
   ii) Socket fusion welding, and
iii) Electro fusion welding

2) INSERT TYPE JOINTS
3) COMPRESSION FITTINGS / PUSH FIT JOINTS
4) FLANGED JOINTS AND
5) SPIGOT AND SOCKET JOINTS

1) FUSION WELDED JOINTS

The principle of fusion welding is to heat the two pipe surfaces to a designated temperature and then fuse them together by application of sufficient force. This force causes the melted materials to flow and mix, thereby resulting in fusion.

Fusion welding of PE Pipes must be carried out with welding equipment having temperature and pressure (where applicable) display arrangements. PE Pipes and PE fittings, to be joined by face-to-face (butt fusion) welding must be of the same wall thickness and the ends must be cut square. However, in some cases of fusion, where face-to-face contact is not involved the jointing pipes'/fittings’ wall thicknesses need not be same. The integrity of the fusion joint is dependent on the cleanliness, temperature control and designated equipment that has been properly maintained. The pipe ends shall be dry and free of dust. Mating surfaces shall be planned/scraped before fusion to remove surface material as polyethylene (PE) oxidizes on exposure to air. These prepared (scraped) surfaces should not be touched, as there is a risk of contamination of the surface, which may affect the weld efficiency. The site conditions must be protected against bad weather influences such as moisture and temperatures below 5°C.

The fusion welding procedure described here is suitable for welding polyethylene pipes and fittings falling in melt flow rate (MFR) range of 0.1 – 1.2 g/10 min.

i) BUTT FUSION WELDING

a) Butt fusion equipment

Basic welding machine shall be self-supporting such as guides and clamps to suit the stability of the basic machine and with sleeves as per the size requirement along with the following accessories.

a) Non-stick coated with Poly Tetra Flouro Ethylene (PTFE) heating plate with thermostat and temperature indicator.
b) Chamfering (Planning) Tool – electrical /manual as appropriate and
c) Electro-hydraulic power pack (For sizes >125 mm) unit with pressure indicator, by-pass arrangement and accumulator

The butt fusion equipment shall incorporate a facility for supporting the heating plate and planning tool (necessary to square cut the pipe end) when in use. The machine shall be robust enough to withstand normal field use. Butt welding machines can be manual (for diameters up to 125 mm), hydraulic or pneumatic. However, a locking system to hold the fusion force is to be ensured in all the systems, and the equipment shall be protected against exerting overpressure on the pipe. It shall be able to maintain the required interface force on the pipe or fittings end as long as necessary.

b) Butt welding procedure

- Clamp the pipes/fitting in the butt fusion machine.
- Where practicable keep the brand-marking in line,
• Wipe the ends to be welded, inside and out, with a clean cloth to remove water, dirt, mud etc.

• Welding ends should be squared. In case of pipe, plane both ends by a planner (mechanical/electrical for pipe diameters >160mm) until they are perfectly square. Fittings’ ends can be re-cut square where necessary.

• Remove the plastic shavings from the vicinity of the ends without touching the prepared surface as any contamination will be detrimental to the welding process. Re-clean the surface with proper solvent.

• Bring together the two ends and ensure they are aligned.

• Check the hot plate (mirror) temperature (range 200-230 oC) and make certain the plate surfaces are clean. It is good practice to make ‘dummy’ welds daily, prior to welding sessions as a means of cleaning the mirror. That is, the weld procedure should be taken to the heat soak stage, when the process can be aborted. The hot plate surface must not be touched with hand, metal implements or tools. A damaged or dirty hot plate will result in a poor joint. Heating mirror is nothing but a metallic plate heated up to the required temperature by electrical coil embedded inside. The word ‘mirror’ has come into vogue because the heating plate radiates heat.

• Prior to heating, leveling of the pipes/fitting is essential to ensure square plane face over the heat surface (see 3.2.1.2.d).

• Move the pipe/fitting ends into contact with hot plate and a steady pressure of 0.15 ± 0.1MPa shall be applied while a uniform bead forms around the circumference of the both ends. This procedure is to ensure that the entire face of the weld-able portion heats uniformly through the surface contact with the mirror.

• When satisfactory bead height is formed, relieve the pressure but maintain contact pressure between the plate and the ends of the heated surfaces until the recommended time (heat soak time) has elapsed.

• Push back the pipe/fitting ends away from the mirror after the above operation. When removing the mirror, make sure it is not brushed across the molten pipe ends.

• Bring the molten ends together and follow the recommended pressure as per the requirement of the pipe/fitting wall thickness (see Table 1). This pressure should be applied by building up gradually to avoid squeezing out too much of the melt. Do not disturb the joint during the required cooling time.

• Relax the pressure and carefully remove the clamps only after ensuring cooling time has elapsed.

• Inside or outside bead removal after the weld joint cools, shall have no affect on the weld performance.

c) **Caution**

It is essential to ensure the pressure-temp chart and the corresponding timing table is followed.

While jointing, the pressure should be maintained until the joint is lukewarm and after the pressure is relieved, the joint is allowed to cool completely. Under no circumstance the weld should be forcibly cooled (no quenching).

ii) **SOCKET FUSION**

This technique consists of simultaneously heating the external surface of the pipe and the internal surface of the socket fitting until the material reaches fusion temperature; inspecting the melt pattern; inserting the pipe end into the socket; and holding it in place until the joints cools.
a) Socket fusion procedure

a) Cut pipe square,

b) Chamfer pipe end. Remove burrs and chips inside pipe ends.

c) Utilize proper depth gauge to ensure correct insertion depth and pipe roundness,

d) Clean pipe and fitting with cloth to remove all the contaminants,

e) Verify proper heater plate temperature. Temperature should be 200-230 °C,

f) Force fitting and pipe onto a heater surface. Be sure to insert pipe completely into female socket and the fitting completely onto the male socket

g) Apply heat for the time listed as per equipment manufacturer’s recommendation,

h) Remove pipe and fitting from heater plate being careful not to torque or twist the pipe or fitting,

j) Allow joint to cool for proper cooling time. Be sure to maintain pressure while cooling.

k) Allow joint to cool to room temperature before moving the joint, and

l) Inspect joint for weld integrity.

iii) ELECTRO FUSION

Electro fusion is a heat fusion process where a coupling or fitting containing an integral heating source (resistance wire) is used to join the pipes and fittings. The jointing areas, that meets the pipe surface and the inside the fittings are overlapped and the resistance wires inside the fitting are heated by electric current. During heating, fitting and pipe materials melt, expand and fuse together. Heating and cooling cycles are automatically controlled by the bar code arrangement on the fittings and machinery used. The welding equipment or its accessory shall be able to supply the required voltage for the electro-fusion joint. The device must switch off as soon as the necessary heat has been fed to the welding zone. The welding machine must be calibrated and timing adjusted to the electro fusion fitting’s bar code data (the fitting and machinery manufacturer recommendations shall be followed).

Electro fusion is the only heat fusion procedure that does not require longitudinal movement of the joinable surfaces. It is frequently used where both pipes are constrained, such as for repairs or tie-in joints in the trench. Joints between dissimilar polyethylene grades and different wall thicknesses can also be made using electro fusion, as the procedure readily accommodates polyethylene grades with different melt flow rates and is independent of the pipe wall thickness.
a) **Electro Fusion Welding Procedure**

   a) Prepare the pipe – Cut at right angles and trim,
   
   b) Remove the outer film of pipes using scraper,
   
   c) Clean pipe surfaces with cleaner (as recommended by the Electro Fusion fittings supplier),
   
   d) Mark the insertion depth on the pipe,
   
   e) Remove the fittings from the packaging without touching the fusion surface,
   
   f) Firmly push-in the pipe until the center stop or marking,
   
   g) Mount and fix assembly attachment,
   
   h) Slide in the second pipe up into the fitting to center stop or marking,
   
   i) Firmly fasten the integrated clamp to ensure no movement while welding,
   
   j) Follow operating instructions of the machine and fitting manufacturer or read the bar code.
   
   k) Check the fusion indicator on the fittings and then remove cable. And
   
   l) Wait for cooling to remove the assembly (follow the fusion guidelines of the fusion fittings supplier or what is given in the bar code data).

**INSERT TYPE JOINT**

These insert type of fittings are available in both plastic and metal for use with PE pipes. These are commonly used for threaded connections and for the delivery pipe connections of bore/tube well pumps. In corrosive locations plastic/stainless steel insert fittings are preferred. In less corrosion conditions gunmetal fittings may be used and in normal or slightly corrosive environments, brass fittings may be employed. The insert moulding plastic fittings with metallic inserts are also available. The outer serrations of PE/metal insert type fittings - slightly over sized - lock into the pipes to prevent their coming out under sudden pressure surge. The pipe bore is expanded by immersion in oil bath (130°C) where the heat of the oil bath would soften the pipe to enable insertion of fitting. The insertion of these fittings into the bore of the pipe is done with hand pressure only. A worm driven type clip while the surface of the pipe is relatively warm should be tightened over the pipe to ensure the grip. Bolting or riveting the inserted fitting onto the pipe wall is also recommended for carrying heavy weight such as a submersible pump.

This type of jointing is used normally for diameter pipes up to 110 mm and internal pressure below 0.4 MPa. Load carrying capacity of this assembly depends on the pull force applied by the weight of the total assembly including the weight of the hung item (say a submersible pump) and media weight inside the pipe. The pipe manufacturers’ recommendations are to be followed for allowable total pull force on a given pipe with this insert type connection. The elongation of PE pipe is very high – over 600% - hence these recommendations attain significance. More so, if the load on to the assembly is very high such as in the case of submersible pump lowered with PE pipe as a delivery pipe with this type of connection.

**COMPRESSION FITTINGS**

Compression fittings are detachable joints and are made of metal or plastics polypropylene (PP) or a combination of both.
Compression fittings form a tight seal by applying a compressive force to the pipe and pipe fitting. The fitting is compressed against the pipe with a force sufficient to eliminate all space remaining in the joint, thus preventing the fluid from leaking. It is critically important to the integrity of the fitting that excessive force is avoided in tightening the nut. If the fitting is over tightened, the gripper (clip ring) will deform and cause leaks. Over tightening is the most common cause of leaks in compression fittings. As a general rule, a compression fitting should be ‘finger tight’ and then tightened 1 turn with a wrench. The fitting should then be tested, and if slight weeping is observed, the fitting should be slowly tightened a bit more until the weeping stops. Compression fittings are also available as metal fitting such as the type of fitting commonly used for copper tubes. In this type of joint the dimensions of the pipe are generally not altered. The joint is affected by an internal liner and a compression ring or sleeve which shrinks and therefore compresses the pipe wall on the liner, thus gripping to the wall of the pipe. The liner and compression sleeve may also be an integral unit. Compression fittings with collar /pipe ends and flat gaskets – Aluminum alloy or brass fitting with male and female coupling parts may also be used for jointing with metallic fittings. The male and female ends of the coupling are weld face to face on two ends with hot plate or electric coil. The two collars are brought together and the female end of the coupling is tightened on the male end. A water tight seal is made between the flanges. This is the detachable type of jointing and is practicableup to 50 mm diameter pipes.

Compression fittings are popular because they do not require fusion, so they are comparatively quick and easy to use. They work at higher pressures and even with toxic media. Compression fittings are especially useful in installations that may require occasional disassembly or partial removal for maintenance etc, since these joints can be detached and re-joined without affecting the integrity of the joint. They are also used in situations where a heat source, in particular a heating plate, is prohibited and instead bead formation by fusion is not preferred. For coiled polyethylene pipes, of small diameters (<110mm) where the working pressure do not exceed 1.6 MPa, jointing by polypropylene (PP) compression fittings is generally recommended over fusion jointing. Various varieties of PP compression fittings such as couplers, bends, tees, reducers and threaded/flanged adapters to connect to valves /tanks/ non-PE pipes are available.

PP compression fittings are easy to fit requiring no special skills have no possibility of infiltration (seepage) from outside or leaks from inside and therefore, are most ideal for domestic service connections enabling easy threaded connections to the Ductile/Cast Iron/PVC-U/PE Pipe ferrules/saddles of the main lines.

**FLANGED JOINTS**

These are used for jointing the PE Pipes particularly of larger size to valves and vessels and large size metal pipes, and where non-PE pipes are to be joined with PE pipes. It contains slip-on metallic/polyethylene flanges with collar/stub ends. The Collar/stub-end is welded (by butt, socket or electro fusion - as per procedures to the pipe. In case polyethylene flanges are used a suitable metallic backing plates shall be used to support the polyethylene flanges to enable the bolt force does not deform the plastic flange. Injection moulded polyethylene flanges without backing flanges conforming to IS 8008 (Part 7) may also be used. Sealing is improved by incorporating a natural or synthetic rubber gasket between flanges.

**NOTE** - Dimensions and bolt tightening torque shall be as per manufacturers’ recommendations.

**SPIGOT AND SOCKET JOINT**

Any joint that permits sliding of the free end (spigot end) inside the socket with a rubber or suitable gasket, without leakage is called a Spigot and Socket joint.

The socket (bell) could be an integral part of the pipe at one end or a special coupler, into which the free ends (spigot ends) of the pipes are pushed to achieve a water tight joint. Various types of ‘O’ rings are available in the market and the user may check with the manufacturer about the suitability of the same as per site conditions.
These joints are normally weak in longitudinal pull and hence need anchoring where ever such a tendency of longitudinal pull is likely in the pipe line. The supports of the side connection should ensure that excessive lateral bending does not occur. In small diameter, the coupler itself could be modified to have a split, threaded, grip type gasket of hard materials in addition to O’ ring to prevent loosening because of longitudinal pull. Special type of rubber gasket (for water tightness) to prevent any slipping out of the free end of the pipe shall be used.

This type of joints is best used for non-pressure applications – such as gravity lines and for encasing cables or smaller diameter pipes.

**All HDPE pipe joints using electro fusion method is envisaged in the proposed terminal and Allied works.**

**PIPE LAYING**

The pipe line may be laid along side of the trench and jointed there. There after the jointed pipeline shall be lowered into the trench carefully without causing undue bending. The pipeline shall be laid inside the trench with a slack of about 1.0 m per 100 meter of pipe line.

PE Pipes conforming to IS 4984, being black in colour, when subjected to direct sunlight or warm ambient temperature may become warmer than the ground temperature. When placed inside the trench, the pipe will contract in length as it cools to the surrounding soil temperature. If the pipe is connected to sub-surface structures (such as preset valve etc) before it is cooled sufficiently, excessive pull forces could develop. Allow the pipe to cool to ambient temperature prior to making a connection to an anchored joint.

PE pressure piping systems jointed by butt welding, electro fusion and flanges do not require external joint restraints or thrust block joint anchors.

PE Pipes are non-metallic, so once buried, metal detector type locators are ineffective. To facilitate locating a buried PE pipe, metallic locating tapes or copper wires can be placed alongside the pipe. Locating tapes/wires are placed slightly above the crown of the above before the final back fill.

Because of high integrity of properly made fusion joints, PE pipes can be used with special installation techniques such as horizontal directional drilling, pipe bursting, micro tunneling methods of trench less technologies.

**EARTH WORK AND PIPE SUPPORT (TRENCHING)**

A) Trench width and depth shall be as per the Fig 12 and Table 3.

**Table 3 Trench Dimensions**

All dimensions in millimetres

<table>
<thead>
<tr>
<th>SL No.</th>
<th>Size of Pipe(mm)</th>
<th>Width</th>
<th>Initial Back Fill</th>
<th>Range of Depth of cover</th>
</tr>
</thead>
<tbody>
<tr>
<td>i)</td>
<td>20-110</td>
<td>300</td>
<td>150</td>
<td>900-1100</td>
</tr>
<tr>
<td>ii)</td>
<td>125</td>
<td>425</td>
<td>150</td>
<td>900-1100</td>
</tr>
<tr>
<td>iii)</td>
<td>140</td>
<td>440</td>
<td>150</td>
<td>900-1100</td>
</tr>
<tr>
<td>iv)</td>
<td>160</td>
<td>460</td>
<td>150</td>
<td>900-1100</td>
</tr>
<tr>
<td>v)</td>
<td>180</td>
<td>480</td>
<td>150</td>
<td>900-1100</td>
</tr>
<tr>
<td>vi)</td>
<td>200</td>
<td>500</td>
<td>50</td>
<td>900-1100</td>
</tr>
<tr>
<td>vii)</td>
<td>225</td>
<td>525</td>
<td>150</td>
<td>900-1100</td>
</tr>
<tr>
<td>viii)</td>
<td>250</td>
<td>550</td>
<td>150</td>
<td>900-1100</td>
</tr>
<tr>
<td>ix)</td>
<td>315</td>
<td>615</td>
<td>150</td>
<td>900-1100</td>
</tr>
<tr>
<td>x)</td>
<td>355</td>
<td>655</td>
<td>150</td>
<td>900-1100</td>
</tr>
<tr>
<td>xi)</td>
<td>400</td>
<td>700</td>
<td>150</td>
<td>900-1100</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td></td>
</tr>
</tbody>
</table>
xii) 450  750  150  900-1100
xiii) 500  800  150  900-1100
xiv) 560  860  150  900-1100
xv) 630  930  150  900-1100
xvi) 710 1010  150  900-1100
xvii) 800 1100  150  900-1100
xviii) 900 1200  150  900-1100
xix) 1000 1300  150  900-1100

Notes –

1. Width may be increased where jointing inside the trench becomes necessary because of site conditions.
2. Under National/State Highways, a concrete/Hume pipe shall be covered over the pipe.
3. Depth is to be measured over the crown of the pipe.
4. In case of mole-plough technique of pushing the coils of diameters 20-100mm in a narrow trench the width of 300mm is not mandatory.
5. Initial back fill material shall be as per this standard.
6. For gravity lines SDR more than 22, manufacturers should be consulted for allowable deformation calculations under dynamic traffic load.

B) Flexibility

For rigid pipes such as concrete etc, the pipe alone has to take the main vertical forces acting on the pipe, while flexible PE pipe makes use of the horizontally acting soil support accumulating as a result of the deflection of the pipe. This aspect improves the load bearing capacity of PE pipe especially useful property in gravity pipe design where there is no internal pressure to ensure the pipe circularity.

C) Trench Bedding

PE pipe requires no special bed preparation for laying the pipe underground, except that there shall be no sharp objects around the pipe. However, while laying in rocky areas suitable sand bedding should be provided around the pipe and compacted.

D) Trench Depth

The trench depth shall be as per Table 3. The initial back fill up to 150 mm above the crown of the pipe should compacted with screened excavated material free of sharp stones or objects or with fine sand where no such material is available. The excavated soil from the trenches should be placed such that it shall not interfere with stringing and jointing of the pipes. In all cases, 150 mm above the top of the crown of the pipe is to be compacted either by mechanical or manual means. Where ever road crossing with heavy traffic is likely to be encountered – a concrete pipe encasing is recommended. PE pipes can be jointed inside or outside the trench, as per site conditions. However, in case of jointing inside the trench, the width of the trench may be suitably increased to ensure work space.

E) Water in the Trench

The pipe shall be laid on a stable foundation. Where water is present or where the trench bottom is unstable, excess water should be removed before laying the pipe. In case there is a chance of floatation because of likely flood, the pipe shall be encased with concrete weights as per the buoyancy calculations.

F) Under Water Installations

PE pipes are frequently used for carrying potable water across rivers/canals/lakes. Even water-filled PE pipe is lighter than water. Thus the pipe can be aligned along the recommended route over the water.
surface and then submerged with suitable weights. Submerged installations require permanent concrete ballast rings attached around the pipe to ensure submergence and stable system once it is submerged. Concrete block design depends on type of installation, tidal flows and wave actions.

G) Service Connection

New service connections can be made on PE pipes with mechanical saddles or electro fusion saddles. Mechanical saddles are similar to those available for PVC-U and ductile iron.

Installation of mechanical saddle is similar to techniques used to install saddles on other piping materials; however, care has to be taken as excessive tightening of the side bolts may make the pipe oval. Mechanical saddles should have wide straps to distribute compressive forces and must be installed as per manufacturer’s recommendations.

Mechanical saddles can also be used for PE to metal connection as a transition tapping.

H) Pipe through Concrete Structures

PE pipe when required to pass through concrete wall, such as valve chambers etc. the joint between the pipe surface and the concrete wall will not be a leak proof one, as PE pipe surface being smooth does not bond with concrete. The gap could be a potential source of seepage, both from inside and outside of the concrete wall and the pipe surface. To prevent the same a puddle flange – normally made of PE or Rubber – can be used as shown in the Fig. 16 to increase the path of resistance to media flow.

INSTALLATION

A) Lowering

When jointed outside of the trench the jointed pipeline shall be lowered into the trench (for underground installations) carefully (preferably with mechanical handling equipment for sizes > 160mm) without causing undue bending that can cause kinking. The pipeline shall be laid inside the trench with a slack of about 1.0 m per 100m of the pipeline (pipe line to be laid in a sinuous alignment). Bending of pipe inside the trench involves excavating the trench to the desired bend radius. Exposed black PE pipe to ambient temperatures greater than 30°C will have very high surface temperature that makes it difficult to handle. Proper precautions shall be taken to ensure safety at work site.

B) Thermal Expansion

For exposed PE pipes, provisions shall be made for the effects of thermal movement. The support anchors for exposed PE pipes should not grip or distort the pipe, but should allow free movement of the pipe due to temperature variation. Plastics pipe clamps may be used to support the pipe. Standard pipe clips may also be used but care shall be taken not to over tighten and cause the clips to bite into the pipe. Pipe clips should be correctly aligned and should provide a smooth flat surface for contact with pipe. Sharp edged supports should be avoided.

C) Painting

Plastics pipes in general need not be painted. Painting may disguise its character. Hazard might occur by mistaking this pipe for metal one in using it for load bearing support, or for electrical grounding.

Precaution - PE pipes shall not be installed near hot water pipes or near any other heat sources.

D) Valve anchoring

All types of manual controls and valves in particular should be anchored firmly so as to avoid the turning torque imparted by the operation of the hand wheel of the valve onto the pipe. In short the valve should not be ‘hung’ on the pipe, as is normally done for metallic pipes.
E) Support Spacing

Supports for horizontal over ground run of PE pipe with pipe clamps/brackets should be used at approximately at the support distance as per Table 5. IS 7634 part II. Table 5 is meant for water at 27ºC. For temperature above 27ºC closer supports are required. At >40ºC, continuous support is recommended, if the pipe is carrying heavier liquids.

F) Effect of Temperature

i) Expansion and Contraction

The co-efficient of expansion is about fourteen times than that for expansion experienced with metal pipes. This also holds good for contraction due to fall in temperature.

ii) In underground pipe the normal changes in the direction of the pipe provide an adequate means of accommodating expansion/contraction.

iii) In the continuous straight runs of exposed pipe it is necessary to insert units to absorb the expansion. Expansion loops, bellows or sliding gland expansion joints may be used.

iv) Care should be taken to account for the high increase in surface temperatures of these pipes in cases of exposed laying or laying in the close proximity of artificial heat sources.

G) PE Fittings

PE pipe fittings conforming to IS 8008 (Part 1 to 9) and IS 8360 (Part 1 to 3) may be used for connecting the pipes and other system appurtenances. These fittings can also be used for connecting to metallic valves ( sluice, scour and air), tanks, pipes and other mechanical equipment (pumps etc). However, where there is a likely hood of vibrations and turning torques in such connections, the fitting wall thickness shall be minimum one rating higher than the corresponding pipe.

H) Concrete Encasement

PE Pipes may be encased in concrete wherever necessary. Compressible padding material at least 3 mm thick and at approximately 150 mm from the face of concrete shall be provided around pipes at the entry and exit points to eliminate any potential sharp edges from rubbing against the pipe wall. Pipeline shall not be filled with water until the concrete has developed sufficient strength.

LAYING THE PIPE IN TRENCHES

Trench filling

On completion of the pipe laying operations up to a length of about 1000 metres while further laying work is still in progress, refilling of trenches of this stretch shall be carried out up to 300 mm above pipe line. Pipe laying shall follow closely the progress of trench excavation. Only soft earth and gravel of good quality free from boulders, roots vegetable matter etc. shall be used first. If sufficient quantity of suitable (sharp edge stone free) excavated earth is not available, the trench shall be filled by borrowed gravel or material up to 300 mm above top of the pipe.

Care shall be taken when back filling, not to damage the pipe or joints. Filling has to be carried out simultaneously on the both the sides of the pipes so that unequal pressure does not occur. Load on the buried pipeline shall not be permitted unless the trench has been filled to the height of at least 300 mm over the top of the pipe. Filling shall be done in layers of 150 mm, with the first layer watered and compacted by stamping or by mechanical means. The trench shall be refilled so as to build up the original ground level, keeping due allowance for subsequent settlement likely to take place.

FIELD TESTING OF PIPE LINE
The pipeline to be tested shall be filled with water slowly allowing for splurging the entrapped air. Air valves at high points should be open to allow air to escape while water is being filled. Before pressure is applied, the pipeline section under test shall be restrained against movement. The following procedure is recommended for PE pipe Testing.

a) Polyethylene pipelines must not be pressure tested unless the wall temperature is kept below 30°C. Pipe exposed to hot summer weather should not be tested unless the ambient temperature comes to 30°C. After filling, the pipe line shall be left to stabilize at its temperature for a minimum period of 1 hour.

b) Fusion joints may be covered during testing. Flanged or other threaded type joints shall be kept open for visual inspection. The pipe line shall be filled and pressure tested from the lowest point.

c) During the test period, make-up water is continuously added to maintain the pressure.

d) The test pressure shall be 1.5 times the rated pressure of pipes or of the proposed maximum design pressure of the section. Apply the pressure by continuously pumping at a constant rate.

e) Under no circumstance, air is to be used instead of water for testing.

f) Tests should be performed on reasonable lengths of pipelines. Long lengths more than 2000mtrs may make leak detection more difficult.

g) Acceptance Criteria - If the pressure remains steady (within 5% of the target value) for one and half hour, leakage is not indicated. Flanged and other threaded connections shall be visually inspected.

h) If the test is not complete because of leakage or equipment failures, the test section shall be depressurized and allowed to ‘relax’ for at least eight hours, before starting the next testing sequence.

j) Testing outside the trench is to be avoided, as pipe rupture may involve safety issues.

REPAIR AND MAINTENANCE

A perfectly welded fusion jointed PE pipes is totally leak proof. A good compression fitting also ensures total integrity of the system. However, there may be external conditions that necessitate repairs and maintenance of the system. Various methods may be employed for repairing leakages or damage to sections of PE pipes. In general, the best way is to cut the damaged portion and to replace it by a new pipe or prefabricated flanged replacement section. The connections of new pipe to either ends of the old pipe may also be done by insert type of fittings (subject to their pressure limitations) and by electro fusion fittings. Butt fusion inside the trench for repairs is not recommended as the movement of the pipe for attaining the required facial pressure for good weld integrity may not be possible. When failure or damage occurs in a welded joint, the original weld shall be removed entirely before re-welding. No patch work recommended.

GENERAL GUIDANCE

A) Freezing

Freezing of water inside the PE pipes does not fracture it, as the pipe expands to allow the extra volume. However, direct application of intense heat, such as a torch or open flames should not be used to de-freeze.

B) Pressure Check
In any application where polyethylene pipe is attached to a pressure source, which is greater than the pressure rating of the polyethylene pipe being installed, adequate pressure reduction devices shall be installed. Whenever such devices are installed a regular check of such devices should be made to ensure their continued proper functioning as a protection to the PE pipe.

C) Surge Pressure

PE pipes, by their visco-elastic nature and creep properties, can withstand much higher short term loads, that is, 2.3 times the working pressures. This property enables PE pipe to be able to withstand repetitive water hammer surges of pumping mains, without any need for any extra correction factor. However, for velocities higher than 1.5m/sec a surge check is necessary.

D) Slack in laying

When PE pipes are laid inside the trench, up to 3% slack for coiled pipes (20-110 mm) and up to 2% for straight length pipe (>110 mm) is naturally expected as the pipe is significantly flexible.

SUPPLY, PACKAGING, HANDLING, STORAGE & TRANSPORTATION

A) Supply

The polyethylene pipes shall be supplied in straight lengths either independent or bundle together, or as self supporting coils as agreed to between supplier and purchaser.

Their ends shall be clearly cut square and protected against shocks. Coils shall be protected for the ingress of foreign bodies by appropriate end caps.

B) Packing

Generally, PE pipes are tough and do not require any special packing. However, where necessary (during long distance transportation) the pipes shall be bundled to eliminate scratches. Coils may be wrapped in jute cloth.

C) Handling

Polyethylene is a tough resilient material which may be handled easily. However, because it is softer than metals, it is prone to damage by abrasion and by objects with a cutting edge. Such practices as dragging pipes over rough ground should therefore be avoided. If handling equipment is not used, choose techniques, which are not likely to damage the pipe.

i) Coils

Individual coils must not be rolled off the edge off the loading platforms or trailers. These coils should be slung individually when off-loading with a crane. Uncoiling the pipe at site requires trained personnel. The manufacturer need to be consulted, as unloading of the coils may involve safety concerns of the workmen involved. If, due to satisfactory storage or handling, a pipe is damaged or ‘kinked’ the damaged portion should be cut out completely.

ii) Straight Pipe

Handling and storage of straight polyethylene pipes should be to avoid penetration by sharp objects. When loading, unloading or handling of large dia (>160mm), it is preferable to use mechanical equipment. Safety precautions should be followed while unloading the pipes at site. Unloading of the large dia pipes from trucks and trailers shall be with the help of properly set-up platforms and the same shall be rolled smoothly and not dumped from a high ground.
D) Transportation

i) When transporting straight polyethylene pipes, use flat bedded vehicles. The bed shall be free from nails and other projections. The polyethylene pipes shall rest uniformly in the vehicle over their long length.

ii) The vehicle shall have side supports approximately spaced 2 m apart, and the pipes shall be secured effectively during the transportation. All posts shall be flat with no sharp edges. Strapping the pipe bundles during transit may be required to avoid excessive movement in the truck.

iii) PE pipes shall not be transported with other metallic items in the same vehicle.

iv) Coiled pipe with OD<63mm may be supplied on pallets. The coils should be firmly strapped to the pallets, which in turn be firmly secured to the vehicle. Coiled pipe with OD≥63 mm should be supplied individually.

v) There should be facilities to ensure each coil is securely fastened throughout transit and the unloading process.

vi) To save on transport cost nesting of coils/straight length can be considered if agreed between the purchaser and the supplier.

E) Storing

i) Polyethylene pipe conforming to IS 4984 may be stored either under cover or in the open as the pipes are suitably protected from ageing due to sun light by the addition of the appropriate quantity and the type of carbon black. Other non black polyethylene pipes, however, should be stored under cover and protected from direct sunlight.

ii) PE Pipe shall be stored in the manner to prevent damage from elevated temperature, contact with harmful chemicals (such as solvents). Prolonged exposure to direct sunlight shall not alter the pipe performance, but the pipe may bend because of the heat during summer months. Precautions are to be taken accordingly.

iii) Non-ventilated covering of the polyethylene may sometimes create excessive heat, which may be cumbersome for Pipe handling.

iv) Storage of pipes in hot areas should be avoided. While storing the pipes at temperatures above 45oC continuous support

v) The polyethylene pipes shall be stacked on a reasonably flat surface, free from sharp objects, stones or projections likely to deform or damage them.
7.4 **RCC PIPES**

Pipes shall be true and straight with uniform bore throughout. Cracked, warped pipes shall not be used on the work. All pipes shall be tested by the Contractor and shall produce, prior to use on site, a certificate to that effect from the manufacturer.

The pipes shall be with or without reinforcement as required and of the class as specified. These shall conform to IS: 458-1971. All pipes shall be true to shape, straight, perfectly sound and free from cracks and flaws. The external and internal surface of the pipes shall be smooth and hard. The pipes shall be free from defects resulting from imperfect grading of the aggregate mixing or moulding.

**Application:**

RCC NP3 Hume pipes for rain water pipes on the external areas of the building above 300mm diameter.

8.0 **TRAPS**

**FLOOR TRAPS**

Floor traps where specified shall be siphon type full before P or S type Cast Iron having a minimum 50 mm deep seal. The trap and waste pipes when buried below ground shall be set and encased in cement concrete blocks firmly supported on firm ground or when installed on a sunken RCC structural slab. The blocks shall be in 1:2:4 mix (1 cement: 2 coarse sand : 4 stone aggregate 20 mm nominal size). Contractor shall provide all necessary shuttering and centering for the blocks. Size of the block shall be 30 x 30 cms of the required depth.

**FLOOR TRAP INLET /HOPPER**

The water from the floor shall directly enter to the trap and flowing water shall not come in direct contact with the floor materials below the floor such as bed mortar, bed concrete etc. Toilet traps and connection shall ensure free and silent flow of discharging water. Where specified, contractor shall provide a special type of floor inlet fitting fabricated from GI pipe, with one, two or three inlet sockets welded on side to connect the waste pipe. All joint between waste hopper and CI inlet socket shall be lead caulked. Inlet shall be connected to a CI “P” trap. Floor trap inlet and the traps shall be set in cement concrete blocks where buried in floors without extra charge. Floor trap for the shower cubicle shall suit site and as per the approval of Engineer In-Charge.

**FLOOR TRAP GRATING**

Floor and urinal traps shall be provided with 100 – 150 mm square or round stainless steel gratings, with frame and rim of approved design and shape or as specified in the schedule of quantities and as approved by the Engineer In-Charge.

**CLEANOUT PLUGS**

**Floor Clean Out Plug**

Clean out plug for soil, waste or rain water pipes laid under floors shall be provided near pipe junctions bends, tees, “Y” and on straight runs at such intervals as required as per site conditions. Cleanout plugs shall terminate flush with the floor level. They shall be threaded and provided with key holes for opening. Cleanout plugs shall be cast brass suitable for the pipe dia. With screwed to a GI socket. The socket shall be lead caulked to the drain pipes.

**Cleanout on Drainage Pipes**

Cleanout plugs shall be provided on head of each drain and in between at locations indicated on plans or directed by Engineer In-Charge. Cleanout plugs shall be of size matching the full bore of the pipe but no exceeding 150 mm dia. CO plugs on drains of greater diameters shall be 150 mm dia. Fixed with a suitable reducing adapter. Floor cleanout plugs shall be cast brass.
Cleancouts provided at ceiling level pipe shall be fixed to a CI flanged tail piece. The cleancout doors shall be specially fabricated from light weight galvanized sheets and angles with hinged type doors with fly nuts, gasket etc. as per drawing.

PART B - Electrical

1.0 WATER SUPPLY PUMPS, EQUIPMENTS, WATER TREATMENT PLANT

1.1 CONCEPT OF THE SYSTEM

The potable water source for the project is the rain water stored in ponds. The water stored in the new pond will be treated in the proposed Water Treatment Plant (WTP) and the treated water is transferred to the proposed UG sump. The non-potable water source for the buildings is the treated water from the Sewage Treatment Plant (STP).

The UG sump will have different tanks (partitioned) for storage of water for various purposes like potable water, non-potable water, firefighting, HVAC make up water etc.

The domestic water supply, through a Hydro-pneumatic pumping system located at the pump room in the Utility building for making water available at the residual pressure of 1-1.5 bar, is provided for the proposed Terminal. The potable water and non-potable water shall be distributed through separate piping network. Also the water supply to potable water terrace tank shall be provided from potable water ring Mains through Fire Terrace tank. A separate Terrace tank has also been provided for non-potable water. Gravity distribution of water from Terrace tanks towards user points are also provided.

Irrigation system shall comprise of pumps and piping network using treated water from STP/ponds. The landscaping areas will be having provisions for water connections through the irrigation piping network from the STP treated water tank. The irrigation pumps are located at Utility pump room.

Sewage and Sullage collection system is based on IS: 1742 and applicable standards for domestic drainage. The sanitary system inside buildings shall be two pipe systems as per National Building Code, in which the soil and waste pipes shall be distinct with common vent. All waste lines shall be connected to the sewer manhole through gully trap. All Sanitary drainage shall be connected to the main sewer line which will be conveyed by gravity up to the holding tanks. Sewage shall be pumped from holding tank to STP. Submersible sewage pumps with necessary valves, automation system, level monitoring system, alarm system etc shall be provided in the sewage pumping system.

The rain water from building roof shall be collected through gutter with appropriate slope and suitable size down pipe provided at the edge of the roof. Overflow arrangement for rain water gutter has been provided with 2 Nos. of inlet gratings for each rain water down pipe. The rainwater down pipes of building shall be connected to main rain water line through inspection chamber leading towards the rain water storage at the UG sump. The overflow from the rain water harvesting sump to drainage network shall be provided with proper valve mechanisms. Mechanical gate system shall be provided for bypass arrangement. Bypass arrangement to drain off the first rain water is provided at two locations. The rain water collected in rain water harvesting tank shall be treated to potable water standard through the water treatment plant located at Utility pump room.

The Water Treatment Plant (WTP) shall comprise of filter feed pumps, pressure sand filter, Activated Carbon filter, hypochlorite dosing, Softener feed pump, Softener and necessary piping works. The outlet water from the WTP will be meeting the domestic water quality requirement with chemical parameters in acceptable limits as per SP: 35 (S&T) 1987 which is considered safe for human consumption.
At the North West side of the Terminal, a provision for rectangular RCC drain with cover slab with perforations has been made. The roof top water from airside of the terminal will be collected in this drain to facilitate the quick disposal of storm water. This intern will be connected to the proposed drain of Apron.

In city side, road side drains with gratings are proposed to facilitate the quick disposal of storm water. This intern will be connected to the existing canal located at the east side of the site boundary.

2. WATER SUPPLY SYSTEM

2.1 POTABLE WATER SYSTEM

The potable water source for the proposed buildings is considered as the treated water from Pond. The roof top water collected in the rain water harvesting tank/pond shall be treated to potable water standard through the water treatment plant located at Utility pump room. Alternate source of Potable water is tanker Water supply.

The required potable water storage tank (Two day capacity) is proposed to be provided below utility building. All tanks are separated with partition wall and connected with valves for easy operation and maintenance. The roof top rain water from terminal building will be collected through rain water down pipes in Rain water sump (capacity of Rain water sump shall be designed for 30minutes storage for peak rainfall). The rain water collected in sump shall be treated to potable water standard through the water treatment plant located at Utility pump room. This treated water will be stored in the potable water sump itself.

WTP (8 hrs working to meet the daily potable water demand) shall comprise of filter feed pumps, Disc filter, Activated carbon filter, softner feed pumps, softner and hypochlorite dosing and necessary piping works. Components of WTP shall be finalized after the physical, chemical and biological analysis of the existing pond or well water in the premise. The outlet water from the Water Treatment Plant shall meet the domestic water quality requirement with chemical parameters in acceptable limits as per SP: 35 (S&T) 1987 which is considered safe for human consumption. Inlets to WTP is taken from rain water harvesting tank and outlet from WTP is connected to Potable water compartments.

Potable water supply for the Terminal shall be through Hydro pneumatic pumping system for making water available at the residual pressure of 1-1.5bar for the toilets, kitchen and other end users. Hydro pneumatic system for Potable water shall be located at Utility pump room which will feed the potable water outlets at Terminal building. Also the water supply to Potable water OH tank shall be provided from potable water ring Mains through Fire OH tank. Gravity distribution of Potable water from OH tank towards Terminal building shall also be provided. Terrace tanks shall be provided for ATC and Service building which will be feed by separate pumps located at pump room in utility building. Potable water distribution by gravity for ATC and service building user points shall be provided. The Hazen and William's formula and the charts based on the same shall be used in computing the size of the water supply pipe lines. Hazen and William's formula is applicable to flow of water under pressure and its velocities normally used for plumbing pipes. The quantity of water required to be supplied to every plumbing fixture shall be represented by the fixture units as NBC clause 4.7.3.1

2.2 NON POTABLE WATER SYSTEM

The non-potable water source for the buildings is treated water from STP. The outlet water from the Sewage Treatment Plant shall meet the potable water quality requirement with
chemical parameters in acceptable limits as per SP: 35 (S&T) 1987 and IS 10500 which is considered safe for flushing, irrigation and HVAC makeup water requirements.

The Non potable water storage tank (Two day capacity) is proposed to be provided in UG sump below utility building. UG sump shall be separated with partition wall and connected with valves for easy operation and maintenance. From STP treated water storage tank, treated water shall be transferred and stored in UG sumps. Non Potable water supply through Hydropneumatic pumping system for making water available at the residual pressure of 1-1.5bar for the Terminal toilets, kitchen and other end users is provided. Hydro pneumatic system for Non-potable water shall be located at the pump room in utility building which will meet the flushing requirements at Terminal Building. For irrigation purpose, hydropneumatic pumps shall provide which may locate in the pump room near utility building. Softner is provided to convert the treated water from STP as per ASHRAE/ OEM standard for using it for make up water for HVAC. Terrace tanks shall be provided for ATC and Service building which will be feed by separate pumps located at pump room in utility building. Non-potable water distribution by gravity for ATC and service building user points shall be provided. The Hazen and William formula and the charts based on the same shall be used in computing the size of the water supply pipe lines. Hazen and William's formula is applicable to flow of water under pressure and its velocities normally used for plumbing pipes. The quantity of water required to be supplied to every plumbing fixture shall be represented by the fixture units as NBC clause 4.7.3.1

2.3 IRRIGATION SYSTEM

The proposed landscaping area within the boundary is approximately 68000m². STP treated water/pond water will be utilizing for irrigation requirements. The pumps are located at the pump room in Utility area. Sub-Surface Dripline Tubing shall be provided in Lotus and shrubs areas. For lawn areas, pop up sprinklers of required radius shall be provided. Quick coupling valves are provided through out the irrigation areas for arranging easy tapping stations. Irrigation system shall comprise of hydro pneumatic pumps, filter, flow sensor, moisture sensor, rain sensor, solenoid valves, air releasing valves, piping networks and necessary control valves. The pumps are located at the pump room in utility area.

2.4 Standards and Codes to be followed.

Entire Water supply, sanitary, rain water harvesting and drainage system has been designed as per NBC standards.

Following standard & guidelines is adopted while designing the PHE system:-

- National Building Code of India (NBC) 2016
- SP 35 - Handbook on water supply and Drainage
- Manual on Water supply and treatment
- Manual on sewerage and sewage treatment
- National Fire Codes 2000

Following Relevant Bureau of Indian Standards:

- General
- IS: 782 Specification for caulking load.
- IS: 1172 Code of Basic requirements for water supply drainage and sanitation.
- IS: 2064 Selection, installation and maintenance of sanitary appliance code of practice.
- IS: 2104 Specification for water meter for boxes (domestic type)
- IS: 2373 Specification for water meter (bulk type)
- IS: 5329 Code of practice for sanitary pipe work above ground for buildings.
- IS: 8419 (Part 1) Requirements for water filtration equipment: Part 1 Filtration medium sand and gravel.
- IS: 8419 (Part 2) Requirements for water filtration equipment: Part 2 under drainage system.
- IS: 10500 Water Quality.
- IS: 5572 Code of practice for sanitary pipe work.
- BS: 6700 Specification for design, installation, testing and maintenance of services supplying water for domestic use within buildings and their cartilages.
- BS4504 Circular Flanges for Pipes, Valves and Fittings.
- IS: 778 Specification for copper alloy gage, globe and check valves for water works purposes
- IS: 5312 (Part 1) Specification for swing check type reflux (non-return) valves: Part 2, Multi door pattern
- IS: 13095 Butterfly valves for general purposes
- IS: 2082-1965 Storage type automatic electric water heaters (revised)
- IS: 458 Specifications for precast concrete pipes (with or without reinforcement) Pumps & Vessels
- IS: 1520 Specification for horizontal centrifugal pumps for clear cold fresh water.
- IS: 5600 Specification for sewage and drainage pumps
- IS: 8034 Specification for submersible pump sets for clear, cold, fresh water.
- IS: 8418 Specification for horizontal centrifugal self-priming pump

### 3.0 SCOPE OF WORK

#### 3.1 Pumps and Water Treatment Equipment

Work under this sub-head consists of furnishing all labour, with appropriate T&P scaffolding & staging as required to install pumping system completely for various water supply services and water treatment system in all respect.

Without restricting to the generality of the foregoing, the work of pumps and water treatment equipment shall include the followings:

**Details of Pumps in PHE System**

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Description</th>
<th>Pump Operation Arrangement</th>
</tr>
</thead>
<tbody>
<tr>
<td>i</td>
<td>Hydro pneumatic pump Multi VFD: Potable water for Terminal building</td>
<td>2W + 1S + 1 Jockey</td>
</tr>
<tr>
<td>ii</td>
<td>Hydro pneumatic pump Multi VFD: Non Potable water for ATC</td>
<td>2W + 1S + 1 Jockey</td>
</tr>
<tr>
<td>iii</td>
<td>Filter Feed Pump (Centrifugal Monobloc) for Filtration plant</td>
<td>1W + 1S</td>
</tr>
<tr>
<td>iv</td>
<td>Softner Feed Pump (Centrifugal Monobloc) for soft water for HVAC</td>
<td>1W + 1S</td>
</tr>
<tr>
<td>V</td>
<td>Potable water to ATC Terrace Tank: Centrifugal Monobloc pump</td>
<td>1W + 1S</td>
</tr>
<tr>
<td>Vi</td>
<td>Non Potable water to ATC Terrace Tank: Centrifugal Monobloc pump</td>
<td>1W + 1S</td>
</tr>
<tr>
<td>Vii</td>
<td>HVAC Terrace tank Filling Centrifugal Monobloc pump</td>
<td>1W + 1S</td>
</tr>
<tr>
<td>Viii</td>
<td>Potable water to Terminal Terrace Tank: Centrifugal Monobloc pump</td>
<td>1W + 1S</td>
</tr>
<tr>
<td>lx</td>
<td>Non Potable water to Terminal Terrace Tank: Centrifugal Monobloc pump</td>
<td>1W + 1S</td>
</tr>
<tr>
<td>x</td>
<td>Drainage pumps: Submersible in Pump room and BHS Tunnel</td>
<td>(1W+1S) &amp; (1W+1S)</td>
</tr>
<tr>
<td>Sl. No.</td>
<td>Description</td>
<td>Pump Operation Arrangement</td>
</tr>
<tr>
<td>--------</td>
<td>------------------------------------------------------------------------------</td>
<td>-----------------------------</td>
</tr>
<tr>
<td>Xi</td>
<td>Holding tank 1 To STP: Submersible pumps</td>
<td>2W + 2S</td>
</tr>
<tr>
<td>Xii</td>
<td>Holding tank 2 To Holding tank1: Submersible pumps</td>
<td>1W + 1 S</td>
</tr>
<tr>
<td>Xiii</td>
<td>Irrigation Pumps: Hydro pneumatic Pump Multi VFD</td>
<td>3W + 1S + 1 Jockey</td>
</tr>
<tr>
<td>Xiv</td>
<td>Pond to Rainwater harvesting Tank (utility building) Centrifugal Monobloc</td>
<td>1W + 1S</td>
</tr>
<tr>
<td>Xv</td>
<td>Dual media Filter</td>
<td>1 Set</td>
</tr>
<tr>
<td>Xvi</td>
<td>Activated Carbon Filter</td>
<td>1 Set</td>
</tr>
<tr>
<td>Xvi</td>
<td>Softner</td>
<td>1 Set</td>
</tr>
<tr>
<td>Xvii</td>
<td>Chlorine dosing System</td>
<td>1 Set</td>
</tr>
<tr>
<td>Xviii</td>
<td>Bore well</td>
<td>1W + 1S</td>
</tr>
<tr>
<td>Xviii</td>
<td>Hydro-pneumatic pumping system (small capacity) for portable water – from lower floor tank to 6th Floor of ATC toilet block.</td>
<td>1W + 1S</td>
</tr>
</tbody>
</table>

### 3.2 Others Equipment

Without restricting to the generality of the foregoing, equipment shall include the followings:

1. Double Bubbler type water dispenser with chiller, RO and UV with Necessary housing of SS-304 as specified. Water dispenser with UV for normal, cold and hot water with SS-304 base stand of minimum height of 300mm for Terminal building, Water coolers with inbuilt RO, UV for normal, cold and hot water for ATC, Service building and Substation.

2. Additional Sump pumps for disposal of Drainage from Basements as per site condition.

3. Sump pumps for disposal of Sewage from Basements as per site condition.

4. Complete Water treatment unit consisting of dual media Filters, Pressure Sand Filters, Softening Plant, dosing pumps and related equipment and accessories etc.


6. Motor control panels (with two incomers), power and control cabling and allied electrical works.

7. Pipes, valves, accessories, hangers, supports, delivery and suction feeders and connection to proposed pipe work.

8. EPC Contractor shall submit water test quality report before designing the WTP and shall design and install the system accordingly.

9. Motor control panels (with two incomers), power and control cabling and allied electrical works at Pump room. All necessary cabling, switchgears, earthing for all above pumps are included in the scope of EPC contractor.

10. Required foundation for all pumps, etc. as per OEM recommendations.
11. Bore well Pumps along with control, connection, piping, valves, complete
12. Hydro-pneumatic pumping system (small capacity) for portable water – from lower floor tank to 6th Floor of ATC toilet block. Inlet Water connection shall be extended from overhead tanks provided with the required piping, valve, etc. Power supply shall be extended from nearest switch.

3.3 Clear water pump

- Water supply pumps shall be suitable for clean water. Pumps shall be multistage, Inline vertical, centrifugal pumps with SS/CI casing, stainless steel impeller, stainless steel shaft, CI base with CED coating and directly coupled with TEFC induction motor of class "F" insulation& efficiency class IE-3, 2900 RPM, IP 55 enclosure, suitable for operation on 415 volts ±10%, 3 phase, 50 Hz, A.C. supply. Each pump should operate at specific duty point of max. efficiency. Tenderers shall select their drivers within 10% to 15% in excess of the maximum B.H.P of the pump plus transmission losses if any.
- Pump and motor shall be mounted on a common M.S. structural or C.I. base plate or as required as per site conditions.
- Each pumping set shall be provided with a 150mm dia or of suitable size gunmetal “Burden” type pressure gauge with gunmetal isolation cock and connecting piping.
- Provide vibration-eliminating pads appropriate for each pump.
- Provide vibration eliminators/expansion joints on suction and Discharge side of the Pump and wherever required.
- Provide rate of flow measuring meter with bypass arrangement with every set of pumps as shown on the drawings.
- All water supply pumps shall be provided with mechanical seals of required specifications.

3.4 HYDRO-PNEUMATIC SYSTEMS

3.4.1 Hydro pneumatic systems (With Variable Frequency Drive)

The scope of this section covers supply, installation, testing and commissioning of compact packaged type skid mounted, self-contained variable frequency drive hydro pneumatic system. The skid mounted, factory assembled hydro-pneumatic system shall be provided with pressure transmitters, frequency convertor for noiseless operation of the pump at varying duty point. The convertor shall be provided with short circuit safety, earthing, over current, under voltage protection. The pump shall be complete with suction and delivery pipe. The system shall comprise of multiple pumps working and one stand-by to meet the system discharge requirements.

It shall conform to the following specifications:

(i) Pumps shall be vertical, inline multistage centrifugal and fulfills all specifications as specified in the Clear water pump section.

(ii) Pressure vessel shall be of non-corrosive FRP composite construction lined with NSF and/or FDA listed material, like high density polyethylene with fully replaceable polyurethane. Air cell burst pressure of minimum of five times the vessel operating pressure and cycle tested for 80,000 cycles with charging connections to discharge pipe line with necessary flanges, gaskets, isolating valve, nuts/ bolts etc. with suitable foundation bolts & other accessories, complete. Capacity provided shall be as per manufacture specifications.

(iii) Panel mounted microprocessor multi pump controller with large graphical display and variable frequency drive (VFD) mounted inside a panel complete with pressure sensor transmitter. The graphical display is capable to show number of pumps running & also communicate with other controllers following with open protocol through RS485 port. System should be capable to compensate for frictional losses at lower flows. All alarms should be displayed in the controller. The panel should also have provision for manual/automatic alternate (cyclic) operation of pumps, ON/OFF switch, dry run protection, interconnecting power and control cabling etc complete.

3.4.2 CONTROL PANEL (FOR HYDRO-PNEUMATIC SYSTEMS)
The control panel shall have terminals for:
• Remote monitoring.
• Pump fault.
• Analog output signal for frequency converctor
  (In case of VFD operated Hydro-pneumatic systems).
• Pressure sensor / Pressure switches as per system requirement.

3.4.3 GENERAL REQUIREMENT FOR HYDRO-PNEUMATIC SYSTEMS

The hydro pneumatic system shall be capable of maintaining a constant pressure at varied consumption. The hydro pneumatic system shall be complete with pressure sensor and microprocessor based controller for flow control by means of frequency variation (in case of VFD operated system). The controller should have time control switch to adapt pump operation to actual requirement in peak load situation. The control panel should also have manual operation.

The pumping system shall perform the following functions:
• Shut off the pump at zero demand.
• Shut off the pump at zero suction (Dry Run protection)
• Protect the pump from overvoltage, under voltage, overload & earth fault.
• Vary the time of pump speed acceleration and deceleration
  (For VFD operated Hydro pneumatic system).
• Compensate for higher friction losses at high flow rates.
• Send out a signal for remote monitoring of flow as well as pressure.
• Conduct automatic test run of pumps at set times.
• Keep track of run time for pumps.
• Perform run time equalization of all pumps in system.

3.4.4 INSTALLATION

Hydro pneumatic systems shall be mounted on a common base frame & installed as per manufacturer's recommendations. Pump sets shall be mounted on machinery isolation cork or any other equivalent vibration isolation fitting. The vibration isolation pads, foundation bolts etc. shall be supplied by the Contractor. Contractor shall ensure that the foundation bolts are correctly embedded. Pump-sets shall be factory aligned, wherever necessary, site alignment shall be done by competent persons. The entire system along with pumps & control panel must be sourced from single manufacturer only for unit responsibility.

3.5 Pressure sand Filters

Water filter shall be of dual media pressure filter (comprising of minimum 300mm bed depth of Anthracite and support media and minimum Height on Straight 1500mm) of downward or upward flow type suitable for desired rate of filtration as per design criteria.

Op. Pressure: 3.5 Kg/cm²

Filter shall be vertical type of required diameter. The shell shall be fabricated from M.S. plate suitable to withstand a working pressure of 3 Kg/cm². The minimum thickness of shell will be 5 mm and disc thickness shall be 6 mm. The quality of Steel shall be as per IS:2062 Grade B, thickness as per ASME Section 8. The filter shall have at least one pressure tight manhole cover.

Accessories
Each filter shall be provided with following accessories:-
1. Air release valve with connecting piping.
2. 150mm dia dial burden type gunmetal pressure gauges with gunmetal isolation cock and connecting piping on inlet and outlet.
3. SS Sampling cocks on raw water inlet and filtered water outlet.
4. Individual drain connection with gunmetal full way valve should be piped through a properly sized G.I. pipe to nearest drain point.

3.6 Activated carbon filter
- Water filter shall be of dual media pressure filter (comprising of minimum 300mm bed depth of graded washed Pebbles, Silex and Activated Carbon (IV450) and minimum Height on Straight 1500mm) of downward or upward flow type suitable for desired rate of filtration as per design criteria.
  
  Op.Pressure : 3.5 Kg/cm²
  
  Filter comprising of:
  - Vertical, welded MS pressure vessel complete with dished ends. Internally & externally painted with Anticorrosive Paint
  - Internals for the above comprising of raw water distributor and filter water collecting system.
  - FrONTAL pipe work of MS construction & Suitable Butterfly valve complete with vent piping.
  - Initial charge of filter media comprising of graded washed Pebbles, Silex and Activated Carbon (IV450)
  - Inlet and outlet pressure gauges.
  - Inlet and outlet sample valves.

3.7 Chlorine dosing system
- Pump capacity 0-6 LPH
- Pump type Eletronic metering type
- Dosing tank size 100 ltr HDPE

10.1.6 Online Rotameter
- Capacity range 1000LPH- 30000 LPH

3.8 Water Softener
- Softener shall be designed to give zero commercial hardness. Softener shall be with “cation” ION exchange resins.

1. Softener vessel shall be of mild steel plate with dished ends and self supporting arrangement. Vessel shall be suitable for a minimum working pressure of 3 Kg/ Sq. cm. The vessel shall be tested at 1.5 times the working pressure. The shell shall be designed to allow a minimum free board space at 50% of the mineral bed depth for adequate expansion during back washing. The shell shall have a minimum thickness of 8 mm and dished ends 10 mm. The quality of Steel shall be as per IS:2062 Grade B, thickness as per ASME Section 8. All internal parts of the softener shall be rubber lined as per approved specifications rubber lined and externally with one coat of red oxide and two or more coats of synthetic enamel paint of approved shade.

2. The vessel shall have an internal collecting and distribution system of manufacturer’s design.

3. The softener shall have a set of interconnecting face piping consisting of inlet, outlet and brine injection system with valves and accessories complete as per requirement. Piping shall be G.I heavy duty, as per I.S: 1239 and valves shall be cast iron double flanged sluice valves with C.I. body and Neoprene rubber diaphragm. Individual drain connection with gunmetal full way valve should be piped through a properly sized G.I. pipe to nearest drain point.

4. The brine injection system consist of hydraulic ejector with control valve, brine delivery pipes with adjustable indicator.

5. Measuring tank (Brine Tank) having a capacity of minimum one regenerations.
6. Orifice board for indicating wash and rinse rate to be fitted in drain sump.

7. Initial charge of supporting gravel, sand and “cation” ION exchange resin in requisite quantity.

8. Water testing kit with instructions for testing water samples.

9. Rotameter to indicate flow rate.

10. Inlet & outlet pressure gauges.

i. **Plant room drainage and BHS tunnel Sump Pumps**

   - Sump pump set shall be compact, mono-block, submersible type with class “F” insulation of suitable capacity & RPM operating on 415volt ± 10%, 3 phase, 50Hz AC supply, with non-clog free flow open CI impellers, CI casing (Pump & Motor) and having solid handling capacity of required size for lifting domestic sewage or muddy water/drainage.
   
   - Pump shall inclusive of all necessary accessories like valves, piping, Control Panel and Cabling, Level Controllers, Test and/or air vent cocks, gland drain etc. as required within the quoted cost. The Contractor has to ensure for smooth and trouble free operation after the commissioning of the entire system. Nothing shall be paid extra on this account. Below are the functions of panel

   (a) All the working and standby pumps shall start/stop automatically and alternatively.
   
   (b) Each pump shall start/stop automatically at pre-set levels and work alternatively in cyclic operation.
   
   (c) In case of pump getting overloaded, indication shall come on the panel and hooter will give sound for non-operation of pump.
   
   (d) In case of emergency due to high volume flow of incoming sewer all pumps shall start operating simultaneously.

ii. **Chlorinator**

   Chemical dosing should consist of electronic / electro mechanical metering pump with suction and delivery flexible connections and fittings. The pump shall be mounted on FRP tank of 200 litre capacity. The system should be completed with electrically operated single phase motor driven stirrer having stainless steel shaft. This should be suitable for working against a pressure of 1.5 kg/Sq.cm and should be capable of ejecting Sodium Hypo-chloride solution / suitable alternate chemicals with a dose of 1 ppm.

<table>
<thead>
<tr>
<th>PARTS</th>
<th>MATERIAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Head</td>
<td>CF8M</td>
</tr>
<tr>
<td>Suction &amp; Discharge Valve Plug</td>
<td>SS-316</td>
</tr>
<tr>
<td>Ball</td>
<td>Ceramic</td>
</tr>
<tr>
<td>Ring Seal</td>
<td>PTFE</td>
</tr>
<tr>
<td>Diaphragm</td>
<td>Teflon Faced Hypalon</td>
</tr>
<tr>
<td>Pressure Relief Valve</td>
<td>SS-316</td>
</tr>
<tr>
<td>Anti-syphon Valve</td>
<td>SS-316</td>
</tr>
</tbody>
</table>
3.9 Salt saturator assembly

- Tanks shall be in High density Polyethylene (HDPE) construction of required capacity. The assembly shall be suitable for holding and supplying salt for softener with inlet & outlet piping with valves and accessories complete as per requirement.
- The assembly shall be provided with an automatic agitator. The automatic agitator shall be motorized (motor of suitable rating operating on single phase, 50 Hz, AC supply) having Stainless steel shaft with fan blade, coupled with suitable gear box duly mounted MS Frame with Epoxy Coating.
- The transfer Pump for supplying salt solution to softener shall be of multistage, Inline vertical, centrifugal pumps with cast iron/cast steel body, SS316L stage casing, SS316L impeller, stainless steel shaft, and directly coupled with TEFC induction motor of class "F" insulation & efficiency class EFF-1, 2900 RPM, IP 55 enclosure, suitable for operation on 415 volts ±10%, 3 phase, 50 Hz, A.C. supply.
- The contractor has to ensure that the effective capacity of the system shall be of minimum 10% greater than actual salt required for approx. 3 Days with complete structural arrangement including suitable foundation bolts & other accessories etc.

<table>
<thead>
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</tr>
<tr>
<td>Anti-syphon Valve</td>
<td>SS-316</td>
</tr>
<tr>
<td>Suction Strainer</td>
<td>CF8M Y-Type</td>
</tr>
</tbody>
</table>

3.10 Water dispenser with inbuilt RO + UV filters

3.10.1 Double Bubbler type water dispenser and one bottle filling station with chiller, Filter & UV - Terminal Building.
Area: Near to all toilet block inside the Terminal building

i. Equipment Specifications & Requirements -

The fountain type drinking water system and bottle filling station shall comply with the following requirements & specifications-

ii. WATER FOUNTAIN WITH BUBBLER & BOTTLE FILLING STATION

a) Components:
   - Pressure Boosting device / Pressure reducing valve
   - (as required to meet the desired water pressure at fountain)
   - On line Chiller
   - Sediment filter, carbon filter & UV sterilizer
   - Barrier Free drinking water fountain with two bubblers.
   - Single Bottle filling station

b) Line Diagram:
c) **Drinking water fountain:**

- **Type:** Wall Mounted barrier free with bubbler & Bottle filling station.
- **Material of construction:** Satin Finished 14 Gauge Stainless steel.
- **Bubbler:** Polished Chrome plated brass bubbler head with integral laminar flow preventing splashing and provides a superior flow pattern. Should be vandal resistant.
- **Bowl:** inbuilt swirl design made from Satin finished min. 22 Gauge stainless steel.
- **Water Ways:** Should be lead free meeting the requirements of NSF 61. Built in strainer of 100 microns.
- **No. of Bubbler:** 2 Nos.
- **No. of Bottle filling station:** 1No.
- **Mounting Frame:** should be of heavy duty galvanized steel frame providing sturdy hidden support to the front panel housing the bubbler and bowls.
- **Method of operation for bubbler:** push button. Push button shall facilitate the adjustment of water stream.
- **Method of operation for bottle filling station:** Push button or suitable mechanical arrangement.
- **Should be disabled friendly meeting ADA requirements.**
- **Should be listed by UL**
- **Drinking water fountain and bottle filling station shall be similar to model no. M8WRSBF-Oasis make.**
- **Necessary housing of SS-304 matching with the finishes of area shall be provided as per the approval of Engineer-in-charge.**
- **Provision of necessary plumbing (inlet line, outlet line) and electrical connection including connection from nearest point, complete.**

3.10.2 **WATER DISPENSER FOR NORMAL, COLD AND HOT WATER WITH SEDIMENT FILTER, CARBON FILTER & UV STERILIZER:**

Area: VIP rooms, CIP rooms, Near all toilet blocks of ATC, Medical Inspection room in terminal building, Utility Building and near public toilet outside terminal building.

i. **Equipment Specifications & Requirements –**

The Water dispenser for normal, cold and hot water with sediment filter, carbon filter & UV sterilizer shall comply with the following requirements & specifications-
a) Components:

(i) Tap for water having normal, cold and hot water dispensing facility
(ii) Chiller unit – 1 No.
(iii) Heater unit – 1 No.
(iv) Sediment filter, carbon filter & UV sterilizer – 1 No.
(v) Separate water Tank for hot water, cold water – 1 Set.
(vi) Inline Normal water

- **Type:** Floor Mounted Water dispenser of total storage capacity of 14 litre (min.) for normal, cold and hot water with sediment filter, carbon filter & UV sterilizer.
- **Material of construction:** ABS (Acrylonitrile Butadiene Styrene) / MS powder coated body and stainless steel tanks
- **Water dispenser for normal, cold and hot water with sediment filter, carbon filter & UV sterilizer shall be similar to model no. AQUABAR II -Oasis make or VENZA Pure R.O.
- **Provision of necessary plumbing (inlet line, outlet line) and electrical connection including connection from nearest point, complete.
- **Provision of all safety features, valves

3.10.3 Pipes & jointing

Pipes for suction and delivery shall be galvanized steel pipes (heavy duty) confirming to I.S:1239 upto 150mm dia and as per I.S:3589 for dia 200mm and above.

3.10.4 Automation: Plumbing

- All electrical panels for plumbing pumps shall be designed for automatic operation via Starters – DOL or Star Delta according to the rating of the pumps.
- Each feeders are provided with START STOP Buttons and ON OFF TRIP Indication Lamps.
- If necessary, additional Contactors need to be incorporated in the panel. All modifications of the panel shall be executed by the panel manufacturer itself to retain the warranty of the panel.
- Necessary control wiring shall be done.
- Provision for connection to BMS shall be provided.
- Wireless or wired automation with level sensor in the tank shall be provided for all pumping systems. Pump operation shall be automatic based on level sensor.

**Level sensors for PHE system**

<table>
<thead>
<tr>
<th>S. No</th>
<th>Description</th>
<th>LEVEL SENSORS &amp; MOTORISED BUTTERFLY VALVES AT SUMP</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Inlet to Fire+ Potable sump</td>
<td>For all Fire and Potable water compartments</td>
<td>Pump room (Utility building)</td>
</tr>
<tr>
<td>2</td>
<td>Inlet to HVAC sump</td>
<td>For HVAC water compartments</td>
<td>Pump room (Utility building)</td>
</tr>
<tr>
<td>3</td>
<td>Inlet to Non Potable water sump</td>
<td>For Non Potable water compartments</td>
<td>Pump room (Utility building)</td>
</tr>
<tr>
<td>4</td>
<td>Bore well Inlet to Rain water sump</td>
<td>For Rain water compartments</td>
<td>Pump room (Utility building)</td>
</tr>
<tr>
<td>5</td>
<td>STP Treated water inlet to STP Treated water Sump</td>
<td>For Treated water sump at STP</td>
<td>Pump room (in STP)</td>
</tr>
<tr>
<td>6</td>
<td>STP Treated water inlet to Non Potable water Sump</td>
<td>For Treated water from STP in Non-potable water sump</td>
<td>Pump room (Utility building)</td>
</tr>
</tbody>
</table>
4.0 STANDARDS

The design, manufacture, identification of material and testing of the equipment covered in this specification shall comply with the latest editions of the appropriate standard of the following. Unless otherwise specified, Indian Standards are preferred.

- IS: 1520 Centrifugal pumps for clean water
- IS: 5600 for drainage and sewage
- IS: 325 Three phase Induction Motors
- IS: 210 Gray Iron Castings

Unless mentioned otherwise, all applicable codes and standards in their latest editions as published by the Bureau of Indian Standards and all such other as may be published by them during the tenure of the contract shall govern in respect of design, workmanship and properties of materials and methods of testing. In cases where suitable Indian Standards are not available, generally accepted codes and practices shall be adopted.

All the pumps shall be installed in presence of manufacturer representative for satisfactory commissioning.

5.0 DESIGN AND CONSTRUCTION

- a. The pumps shall be designed to handle the liquid at the pressures and temperature indicated in the specifications. The pumping shall be free from turbulence.

- b. The pumps shall be designed and constructed for continuous operation of two years minimum at full or any part of full load down to shut off without overloading the motors and shall be capable of starting and shutting down, without causing surge, detrimental vibration or objectionable noise.

- c. The Head-Discharge characteristic at shut off head shall be stable.

- d. All parts requiring periodic maintenance ie. bearings, glands, wear rings, shaft sleeves, etc. shall be accessible without disassembling the suction or discharge pipe.
e. All openings shall be identified with metal tags giving their or service.

f. The pumps shall run smoothly free of vibration and noise. The magnitude of any vibration, encountered at the manufacturers’ shop test shall be limited to 1 mil.

measured at the bearing housings.

g. All pressure continuing components of the pump shall be designed in accordance with the ASME Boiler and pressure vessel code, section VIII Div. I Latest Edition.

h. The manufacture shall conform to their respective material specification mentioned in specification for pumps and shall be free from flaws and objectionable imperfections, machined true and confirming to the highest quality of workmanship.

i. Workmanship shall be in accordance with high grade commercial practice adequate to ensure satisfactory operation and service life in accordance with the provision of this specification.

6.0 DRAWINGS

General arrangement drawings indicating frame size mounting details, foundations, terminal box drawings etc. shall be forwarded to purchaser for approval prior to manufacture.

7.0 PAINTING & SHIPMENT

All external surfaces of centrifugal pumps and electric motors shall be cleaned of loose substance and foreign material, e.g. dirt, rust, scale, oil, grease, etc. so that the prime coat adheres to the original metal surface. The work shall be carried out generally in accordance with IS: 1477 (Part I). The surface shall be cleaned either by blast cleaning using graded sand to ‘commercial’ level or by acid pickling using dilute sulphuric or hydrochloric acid followed by thorough rinsing with fresh water. The prime coat shall be applied as soon as possible after the surface preparation.

8.0 SHOP DRAWINGS

Contractor shall submit three (3) sets of Shop drawings containing the following within 30 days of issue of work order for approval of AAI.

i. Block Diagram showing all PHE systems area wise/ building wise.

ii. Detailed Water supply, Sanitary, Drainage and Rain water harvesting, Water Treatment Plant drawings for all proposed buildings.

iii. The Contractor shall submit Technical submittal of all products and also submit compliance to contract condition/specifications para wise for approval from AAI before procurement.

9.0 GENERAL REQUIREMENTS

i. Commissioning of WTP and stabilizing the system as per the instructions given by Engineer-in-Charge to ensure that the treated effluent characteristics as per the treated water parameters as per IS 10500 or parameters stipulated by State Pollution Control Board or parameters required for irrigation, flushing and cooling tower whichever stringent.

Supply of all chemicals/nutrients such as coagulant, lime etc. and labour & supervision for the commissioning of the plant shall be in the scope of the Contractor. Any minor modification/changes of the system required during commissioning for achieving the output parameters shall be in the scope of the Contractor.

ii. Trial run/operation of the system for one month after commissioning including training of Client’s personnel

iii. All equipments and panels shall be rugged in design. It shall be reliable in design and should have long service life.
iv. Pumps/Equipments shall be designed to operate continuously on a maximum ambient temperature of 45oC and the temperature rise shall be within the allowable limit.

v. The internal circuits shall be so designed that due to failure of any part/component or malfunction it should not give any false fire alarm signals at any time. It should instead may give rise to fault alarm signals only.

vi. There shall be no easily accessible normal controls, e.g. switches off – main/standby power supply etc to the unauthorized person.

vii. All manual controls, indicators, switches etc shall be clearly labeled to indicate their proper function/services. All manual controls shall be robust in construction positive in action and so located that no accidental operation can take place.

viii. All equipments and components shall be designed, manufactured and selected to work satisfactorily against deterioration due to temperature, humidity, corrosion etc. resulting from the atmospheric condition existing in the vicinity. The equipments and components shall be of first class good quality materials for its reliability. Protective painting shall be provided after installation of the panels and equipments wherever required.

ix. The selection of the power supply unit and the cables shall be such that no appreciable voltage drop takes place. There shall be provision of protection against over load.

x. All the electrical/electronic components covered under this specification, shall conform to the following:

i) Components shall conform to the ISI specification or to BS specification where no IS specification exist.

ii) Alarm indication lamps may have signals or double filaments to suit the requirement and it should be having longer life. The intensity of the indications shall be clearly visible from a distance at 10 meters in normal condition. LED may be used wherever it suits to have low power consumption.

iii) Double lamps should be used to avoid confusion/inattention in case of one lamp blows off.

iv) All frictional contact surfaces should be plated/flashed with double metals or equipments.

10.0 Technical Documents

i. Contractor shall submit detailed design basis report along with supporting calculations for the entire PHE system.

ii. Drawings shall include Plumbing layouts for Toilets, AHU rooms, Kitchen/ F&B, detailed plumbing drawings in ducts/Trenches/below ground/ above ceiling etc showing exact location of supports, flanges, bends, tee connections, reducers, , distribution grids, , collars for Terminal, ATC, Service buildings, External areas like sewage pumping stations, Irrigation systems etc..

iii. These drawings shall contain all information required to complete the Design and Execute the Works and shall contain details of construction, size, arrangement, operating clearances, performance characteristics and capacity of all items of equipment, also the details of all related items of work.

iv. Each item of equipment/material proposed shall be a standard catalogue product of an established manufacturer from the list of approved makes.

v. Manufacturer’s drawings, catalogues, pamphlets and other documents shall be maintained in the Records Office. Each item in each set shall be properly labelled, indicating the specific services for which material or equipment is to be used, giving reference to the governing section and clause number and clearly identifying the items and the operating characteristics.

vi. Samples of all materials like sanitary and plumbing fittings, valves, pipes etc. shall be maintained at site in a dedicated samples room provided by the Contractor and
submitted for approval to Engineer in charge.

vii. All PHE drawings shall be coordinated with all other services drawings any impact or change due to co-ordination will be absorbed by contractor.

viii. Final handover documents shall include O&M manual along with as built drawing.

18.0 ELECTRICAL CONTROL PANEL

18.1 Motor Control System
The main switchboard shall be fabricated and provided as described in LT Panel sections. Control panel shall contain starters and safety protection for different types of pump motors & various feeders along with its controls. It shall also house the switchgears for incoming as well for outgoing supply. Provision of volt meter (for incomer) & ammeter for incomer as well as for other feeders with selector switch, a set of LED indicating light for incoming phases as well as status indication of each equipment. The volt meter & indication lamps shall be protected by MCBs. The feeders for all those motors having more than 7.5 HP capacity shall be provided with fully automatic Star Delta starters with motor duty MCCBs for short circuit protection only (ICS = 100% ICU) & Overload Relays with contactors of suitable range & ratings, for overload protection, while less than or equal to 7.5 HP motor shall have Motor protection circuit breaker (MPCB) with suitable rating contactor. Single phase preventer shall be provided for all 3 phase motors. Single phase preventer shall be in conformity with relevant ISI standards. Single phase preventer shall act when the supply voltage drops down to 90% of the rated voltage or failure of one or more phases. Single phase preventer shall be voltage operated and of approved make.

Other feeders of the panel which don't require starter shall be housed with:

i. MCCB with Thermal magnetic release & should provide adjustable setting for overload and short circuit protection with ICS = 100% ICU.

ii. MCB used for controlling shall be with tripping characteristics of C curve. The miniature circuit breakers shall be 1/2/3/4 pole as per requirement. The breaking capacity of MCBs shall have minimum 10KA.

ON-OFF switches for each motor / equipment should not be provided on the cover of the control panel. Interlocking shall be provided between switch and the door in such a way that the door of the panel cannot be opened when the supply is ON.

All dosing tanks and process tanks/sumps shall be provided with level indicators/switches for low and high level alarm as well as for dry run protection, indications of which shall be provided in the main Electrical Control Panel.

18.2 PUMP MOTOR CONTROLLER CUM WATER LEVEL INDICATING PANEL

The Pressure Transducers shall be used for water level measurement, and it shall be convenient to mount on the water tanks. Hydrostatic pressure level sensors shall be submersible or externally mounted pressure sensors suitable for measuring the level of liquids in deep tanks or water in reservoirs. Level measurement shall be based on the pressure measurement principal, also referred to as hydrostatic tank gauging (HTG). It shall work on the principle that the difference between the two pressures (d/p) is equal to the height of the liquid (h, in inches) multiplied by the specific gravity (SG) of the fluid.

\[ \text{d/p} = h \times \text{SG} \]

Therefore, the Transducers reading will represent the tank level. These sensors sense increasing pressure with depth and because depth is proportional to Volume for a regular tank, the Volume of Water can be easily calculated using a PLC.

The Centralized PLC control panel shall be front operated, cubicle construction, wall mounted
type, fabricated out of 1.6 mm thick CRCA Sheet, with hinged lockable doors, dust and vermin proof, powder coated of approved shade, inter-connections, having, internal wiring, earth terminals, Top / Bottom control cable entry, numberings etc. comprises of touch-screen display board (Minimum Diagonal size 8") along with all accessories for complete Programmable logical controls & indications, having necessary interlocks, Inputs/Outputs, required number of repeater amplifiers, all audio-visual alarms as per the requirements listed below i/c emergency stop push button on the panel etc. The panel shall have BMS compatible with open protocol.

Water level indicators and controllers: The hydrostatic pressure sensor (Water level indicator) is working on hydrostatic pressure measurement principle made of Stainless Steel for installation in storage tanks, and capable of providing 4 to 20 mA analog signal compatible with PLC signal inputs and all control outputs to MCC panel (Plumbing/Water supply), for various water tanks.

18.3 Power / Control Cabling

Contractor shall provide all power /control cables from the motor control centre to various motors, level controllers and other control devices.

Cables and wires in conduits shall be laid on the metallic trays.

18.4 Earthing

All three phase motors / equipment shall be earthed with two independent earth conductors as per the requirement of Indian Electricity Rules and Regulation - 1956.

18.5 Commissioning

After successful testing of the different items in parts, the Contractor shall provide all facilities including necessary piping, labour, tools and equipment etc. for carrying out final commissioning of the entire water treatment plant complete as per requirement in the presence of Engineer-In-charge or his representative whenever and as may be required. Generally, the following test/inspection has to be carried out:

19.0 Manufacturer’s Guarantees

The manufacturer’s guarantee for design, workmanship and performance for all bought out items shall be made available to AAI airport and shall be valid atleast for the entire defects liability period.

20.0 Performance Guarantee

Any defects found in the workmanship, materials or performance of the plant and effluent / emission quality shall be made good by the contractor at his own expense within the two years defect liability period after successful commissioning and one month trial run period.

The contractor at his own expense shall commission the WTP and prove that it is giving satisfactory service and desired characteristics of the treated water/emissions. The Contractor shall also have to supply all chemicals/ nutrients/ consumables and all manpower in three shifts required for the commissioning and one month trial run period of the system and to guarantee the quality of the treated final water to meet the specifications or latest standards prescribed by the State Pollution Control Board, whichever is more stringent.

In case the contractor fails to achieve any of the aforesaid guarantees he will be penalized. For this purpose any money due to the contractor shall be forfeited and adjusted against such penalty.
TS – 03
SEWAGE TREATMENT PLANT
1. **Introduction:**

This specification covers the technical requirements for manufacture, inspection, packing, forwarding, delivery, erection, testing and commissioning of various equipment in Modular type above ground Sewage Treatment Plant.

Compact activated sludge system working on the principle of MBBR based technology. Modular type sewage treatment plant shall be designed with required capacity. Process flow of the system has been mentioned in Design basis report for the reference of bidders. The STP work shall be executed in compliance with the technical specifications and requirements contained in the contract and Manual on Sewerage and Sewage Treatment as published by the Central Public Health and Environment Engineering Organization (CPHEEO) as applicable

1.2 **Standards & Codes to be followed for Designing:**

Below mentioned list is not exhaustive and the Contractor shall be responsible to follow the appropriate standards.

  - Environment (Protection) Act, 1986
  - Environment (Protection) Rules, 1986
- Manufacturer, use import and storage and Hazardous Micro-Organizers, Genetically Engineered organizations or Cell Rules, 1989.
- Manual of sewage and sewage treatment CPHEEO.
- All Standards as laid down by Central Pollution Control board and any other relevant statutory Authority.
- 100% recycle of waste water and removed sludge with no water to be discharged outside the premises.
- CPWD Specifications 2009 volume I and II with latest correction slips for Civil Works
- Energy Conservation and Building Code(ECBC)
- Indian Electricity Rules and Regulations 1956
- CPWD Specifications 2013 with latest correction slips for Electrical Works
- CPWD General Specifications
  - Part I Internal 2005
  - Part II External 1994
The proposed work consists of the complete Design, Supply, Installation, Testing & Commissioning, Handing over, and Operation & Maintenance for a period of 5 years after defect liability period of 2 years. The period of five years shall be reckoned from the date of successful commissioning of the whole plant which shall be inclusive of 2 years defect liability period. For O & M – after DLP is covered under SOW.
2. **Scope of work under this contract:**

1.1 The proposed modular STP unit shall be placed above ground with raised PCC/RCC platform.

1.2 The STP will receive sludge input from sludge holding tank as proposed in PHE system package. However, the operation of the pumps shall be controlled from STP control panel.

1.3 Screen process will be at STP unit level.

1.4 Modular STP unit shall be in two parts (identical capacity) to be selected & designed so that, it can work independently after screening chamber. Therefore necessary valves, piping, control panel etc. shall be designed & planned.

1.5 STP unit shall be modular in construction and all its motors, control valves, panel etc. shall be within STP module suitable for outdoor applications.

1.6 Control panel specifications shall be followed as desired in LT panel section.

1.7 Output of STP water shall be collected in underground treated water tank located near modular STP. Treat water tank shall be underground of RCC and shall be provided by EPC contractor. Further treated water shall be transferred and stored at main UG tank (utility building) transfer pump (submersible type (1W+1S) with control panel, level indicator, etc.

1.8 Treated water shall achieve parameter as per Govt. norms/standard.

1.9 If any room(s), foundation etc. are required as per design of OEM of STP unit, shall be provided by the EPC contractor within his scope.

   a) The contractor shall be fully responsible for the final quality of treated effluent and getting final certifications from the Engineer-in-Charge & all the relevant Government & Environmental Authorities as applicable.

   b) Generally, but not limited to the following, the main activities that are expected from the Contractor are listed below in a sequential manner:

   It should be brought to the notice that complete design and drawings shall be made available along with tender document.

3. **Design Criteria**

   i) Duration of flow to STP : 24 hours

   ii) Annual mean Max. : Max. 43 deg C

   iii) pH : 6.5 to 7.5

   iv) Colour : Mild

   v) Total suspended solids : 250 to 400 mg/l

   vi) BOD : 300 to 400 mg/l

   vii) COD : 450 to 650 mg/l

   viii) Oil & Grease : < 50 mg/l.

**Desired Effluent Characteristics after Tertiary Treatment**

   i) pH : 6.0 to 8.5

   ii) Total suspended solids : < 20 mg/l

   iii) BOD : < 5 mg/l

   iv) COD : < 30 mg/l

   v) Oil & Grease : < 1 mg/l

4. **MAIN ELECTRO-MECHANICAL COMPONENTS OF THE PLANT**

Without restricting to the generality of the fore-going, the scope of work shall consist of design, supply, erection, testing, commissioning and satisfactory handing over of all Electro-mechanical equipments and works for the satisfactory performance of the plant, generally comprising of –

   i) Bar Screen (coarse & Fine) with frame.

   ii) Belt Oil Skimmer

   iii) Air Blowers with motor and related accessories

   iv) Air diffusers.

   v) Bio media for MBBR & secondary settling tank/ Lamella clarifier.
vi) Submersible type Raw Sewage Relift pumps  
vii) Sludge Return / Relift pumps  
viii) Filter feed pump  
ix) Sludge Loading pump  
x) Treated water transfer pumps (1W+1S)  
x) Dual Media filter, Activated Carbon Filter  
xii) PH dosing system.  
xiii) Centrifuge / Sludge handling Mechanism.  
xiv) UV for supply for treated water line.  
xv) All pipelines with necessary accessories and valves  
xvi) Motor control centre complete with all internal wiring and accessories, Electrical cables from M.C.C panel to all electric motors and units, level indicators/switches for low and high level alarm for all tanks, sumps as well as for dry run protection of pumps.  
xvii) Instrumentation Equipments and Laboratory apparatus.  
xviii) Centrifuge / Sludge handling Mechanism.

5. TECHNICAL SPECIFICATIONS SEWERAGE TREATMENT PLANT

i) Manual Bar Screen:
Bar Screen (Course Screening): The raw sewage is let through Manual bar screen with manual rack cleaning arrangement, which is installed before Equalization Tank (ET). Screen provided will remove all floating and big size matter such as plastic bottles, polythene bags, glasses, stones, etc., which may otherwise choke the pipeline and pumps.

ii) Belt Oil Skimmer
Mechanical belt type oil skimmer basin MS housing with HDPE tank with suitable flow rate capacity complete in all respect.

iii) AIR BLOWERS
The treatment plant shall be provided with rotary positive displacement roots type blowers with a common base TEF C electric motors, necessary valves including a pressure release valve and suitable filter and silencing. All piping and related accessories necessary to connect the blowers to the plant air header shall be provided. Flexible reinforced rubber connecting sleeves shall be provided wherever required. There shall be standby arrangements for blowers to enable cyclic operations.

The Air blower shall have min. requirements as mentioned below:

<table>
<thead>
<tr>
<th>Casing</th>
<th>CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fluid Handled</td>
<td>Air</td>
</tr>
<tr>
<td>Installation</td>
<td>Indoor</td>
</tr>
<tr>
<td>Sealing</td>
<td>Lip Seal</td>
</tr>
<tr>
<td>Recommended Motor</td>
<td>Suitable H.P. Motor &amp; RPM of efficiency class IE-3, operated on 415 Volts ±10%, 3 phase, 50 Hz A.C. supply.</td>
</tr>
<tr>
<td>Drive</td>
<td>Direct coupled</td>
</tr>
<tr>
<td>Shafts</td>
<td>As per EN18 /19 (BS970:1955)/SG Iron</td>
</tr>
</tbody>
</table>

iv) AIR DIFFUSERS
Each diffuser shall be non-clog type diffuser. Supply pipes shall be of sufficient size to keep pressure loss through the drop-pipe assembly to a minimum. The air diffusion devices shall be designed to distribute air to cover the entire length of the tanks and to have efficiency such that an adequate supply of oxygen is maintained in the tanks to treat the effluent load for which the
plant is designed. The aeration grid is provided in the tanks to mix the content of sewer to avoid any septic condition in the tank.

6. **SPECIFICATION OF BIO-MEDIA FOR MBBR AND SECONDARY SETTLING TANK**

i) The Bio-Media shall be in PVC/PP/ suitable plastic media, having shape and design such that there is uniform and continuous distribution of air and water throughout with self-supporting shape.

ii) The surface area shall be for effective attached growth of bacteria & shall increases the contact time of waste water within media, providing high efficiency with minimum recirculation.

iii) The media shall have low resistance to air flow to provide better aeration & shall have excellent wetting so that there should be zero fly nuisance.

**Specifications for MBBR tank Media:**

<table>
<thead>
<tr>
<th>Type</th>
<th>Semi clog</th>
</tr>
</thead>
<tbody>
<tr>
<td>Void ratio</td>
<td>78.43</td>
</tr>
<tr>
<td>Material</td>
<td>Polypropylene</td>
</tr>
<tr>
<td>Surface area</td>
<td>400 - 450 m2/m3 (0.00648 m2 per piece)</td>
</tr>
<tr>
<td>Media fill range, % fill of V</td>
<td>15-40%</td>
</tr>
<tr>
<td>Specific gravity</td>
<td>0.92 to 0.945</td>
</tr>
<tr>
<td>Membrane forming time</td>
<td>7-15 days</td>
</tr>
</tbody>
</table>

**Specifications for Secondary settling tank Media / Tube settler media:**

<table>
<thead>
<tr>
<th>Distance b/w adjacent tubes</th>
<th>Horizontal 120mm, vertical 44 mm</th>
</tr>
</thead>
<tbody>
<tr>
<td>MOC of media</td>
<td>UV stabilized rigid PVC material</td>
</tr>
<tr>
<td>Shape of tube</td>
<td>Hexagonal chevron</td>
</tr>
<tr>
<td>Tube fitting</td>
<td>Tongue and groove</td>
</tr>
<tr>
<td>Thickness</td>
<td>1.1 mm</td>
</tr>
<tr>
<td>Maximum continuous working</td>
<td>55 deg Celsius</td>
</tr>
<tr>
<td>Temperature</td>
<td></td>
</tr>
<tr>
<td>Color</td>
<td>Black</td>
</tr>
<tr>
<td>Height of media</td>
<td>750</td>
</tr>
</tbody>
</table>

7. **SUMP PUMPS (RAW SEWAGE RELIFT PUMP FOR EQUALIZATION TANK, DRAINAGE SUMP)**

i) Sump pump set shall be dry motor submersible type with SS304 Guide Rail, & SS304 Chain with level float switches &suitable for auto / manual operation with class “F” insulation of suitable capacity & RPM operating on 415volt ± 10%, 3 phase, 50Hz AC supply, with non-clog free flow open CI impellers, CI casing (Pump &Motor) and having solid handling capacity of required size for lifting domestic sewage or muddy water/drainage.

ii) Pump shall inclusive of all necessary accessories like valves, piping, and Cabling, Test and/or air vent etc. as required. The Contractor has to ensure for smooth and trouble free operation after the commissioning of the entire system.

iii) The pump having dry run protection & high level alarm and shall automatically operate with high water level and stop at low water level in the sump, with necessary control cabling upto control panel. The pump shall have the facility to cycle through the total number of pumps provided and in case of High Level shall be capable of cumulative operation.

iv) The pumps shall be complete in all respect and shall be installed as per manufacturer’s recommendations. All accessories shall be In-Built as per manufacturer’s specification.

8. **SLUDGE RETURN**
i) Sludge return pumps shall be horizontal non-clog centrifugal pumps for the required discharge and head of required specifications. Pump shall be directly connected to an electric motor by means of a flexible coupling and mounted on a common C.I. or G.I. base plate.

ii) Each sludge return pump shall have a capacity suitable for re-circulating 100% sludge. The second pump shall be a standby in cyclic operation.

iii) The sludge return pumps shall have CI Impeller, Cast Steel Shaft, CI delivery casing, bronze sleeve & Mechanical Seal fitted coupled with suitable motor of efficiency class IE-3 with required HP & RPM operated on 415 Volts ±10%, 3 phase, 50 Hz A.C. supply.

9. SLUDGE LOADING / DISPOSAL PUMP

i) Sludge loading/disposal pumps shall be horizontal non-clog screw type pumps for the required discharge and head and of required specifications.

ii) The pump shall have following operating parameters:

- Pump Type: Screw Pump
- Pumping Fluid: Sludge
- Suction Head: Flooded
- Motor: Suitable Motor of required HP & RPM operated on 415 Volts ±10%, 3 Phasc, 50 Hz A.C. supply.
- Flow: Suction on Gland
- Suction / Delivery Position: Top / End
- Type of drive: O/H Drive, V-Belt Driven
- Mounting: M.S. Fabricated Common Base Plate

10. CLEAR WATER PUMP

i) Water supply pumps shall be suitable for clean water. Pumps shall be multistage, Inline vertical, centrifugal pumps with SS casing, stainless steel impeller, stainless steel shaft, CI base with CED coating and directly coupled with TEFC induction motor of class "F" insulation & efficiency class IE-3, suitable RPM, IP 55 enclosure, suitable for operation on 415 volts ±10%, 3 phase, 50 Hz, A.C. supply. Each pump should operate at maximum efficiency duty point at specified head. Bidders shall select their drives within 10% to 15% in excess of the maximum B.H.P of the pump plus transmission losses, if any.

ii) Pump and motor shall be mounted on a common G.I. structural base frame.

iii) Each pumping set shall be provided with a 150mm dia or of suitable size gunmetal “Bourdon type pressure gauge with gunmetal isolation cock and connecting piping.

11. DUAL MEDIA FILTERS & ACTIVATED CARBON FILTERS

i) Water filter shall be of dual media pressure filter (comprising of minimum 300mm bed depth of Anthracite and support media and minimum Height on Straight 1500mm) of downward or upward flow type suitable for a rate of filtration of 15 m/hr. (Surface velocity).

ii) Filter shall be vertical type of required diameter. The shell shall be fabricated from M.S. plate suitable to withstand a working pressure of 4 Kg/cm². The minimum thickness of shell shall be 6mm and dished ends shall be of 8mm thick. The quality of Steel shall be as per IS:2062 Grade B, thickness as per ASME Section 8. The filter shall have at least one pressure tight manhole cover. Filter shall be provided with screwed or flanged
connections for inlet, outlet, individual drain connections and all other connections necessary as required. Filter shall be painted inside with two or more coats of coal tar epoxy paint or internally FRP Lined, one coat of zinc chromate yellow primer outside with two or more coats of synthetic enamel paint of approved shade. The Filter media shall comprise of 0.5 to 1.00 mm fine filtering silica sand for removal of turbidity and suspended matter. The initial charge of filter media as specified in above para’s shall be the responsibility of contractor. The pressure filter shall be complete with cleaning cycle controller adjustable to meet application requirement, actuating control valves in required sequence for back wash.

12. PH DOSING SYSTEM

i) Chemical dosing should consist of electronic / electromechanical metering pump with suction and delivery flexible connections and fittings. The pump shall be mounted on HDPE tank of 100 ltr capacity. The system should be completed with electrically operated single-phase motor driven stirrer having stainless steel shaft. This should be suitable for working against a pressure of 1.5 kg/Sq.cm and should be capable of ejecting Sodium Hypo-chloride solution with a dose of 1-3 ppm.

<table>
<thead>
<tr>
<th>PARTS</th>
<th>MATERIAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Suction &amp; Discharge Valve Plug</td>
<td>SS-316</td>
</tr>
<tr>
<td>Ball</td>
<td>Ceramic</td>
</tr>
<tr>
<td>Ring Seal</td>
<td>PTFE</td>
</tr>
<tr>
<td>Pressure Relief Valve</td>
<td>SS-316</td>
</tr>
<tr>
<td>Anti-syphon Valve</td>
<td>SS-316</td>
</tr>
<tr>
<td>Suction Strainer</td>
<td>Y-Type</td>
</tr>
</tbody>
</table>

13. Filter Press System (SLUDGE HOLDING MECHANISM)

Supplying, installing, testing and commissioning of Hydraulic Closing type. filter press including all accessories as under for sludge handling system suitable for STP designed capacity. The operation of the filter press system will be of 1-2 shift operation. The specifications shall be as follows:

<table>
<thead>
<tr>
<th>Structure</th>
<th>Cast Iron / Mild Steel</th>
</tr>
</thead>
<tbody>
<tr>
<td>Size &amp; Number of Plate</td>
<td>To be recommended by manufacture/ vendor</td>
</tr>
<tr>
<td>Nozzles</td>
<td>P.P./SS-304</td>
</tr>
<tr>
<td>Filter Element (MOC)</td>
<td>P.P.</td>
</tr>
<tr>
<td>Filter Element</td>
<td>Plate &amp; Frame</td>
</tr>
<tr>
<td>Drainage surface</td>
<td>P.P. - Piped</td>
</tr>
<tr>
<td>Delivery</td>
<td>Open</td>
</tr>
<tr>
<td>Operating Pressure</td>
<td>3.5 bar (max.)</td>
</tr>
<tr>
<td>Working temperature</td>
<td>Ambient</td>
</tr>
<tr>
<td>Filter Media</td>
<td>P.P./Polyester</td>
</tr>
</tbody>
</table>

14. UNDER DRAIN SYSTEM

Filter shall be provided with an efficient under drain system comprising of collecting pipes, gun
metal / polypropylene nozzles of manufacturer’s design. The entire under drain system shall be provided on adequate cement concrete/structural supports.

15. FACE PIPING
Filter shall be provided with interconnecting face piping comprising of inlet, outlet, and backwash pipe complete with pipes, valves and accessories, as per requirement. Piping shall be G.I. piping, heavy duty, as per I.S. 1239 and valves shall be cast iron butterfly valve with C.i Body and EPDM Seat. or UPVC PN 40 Piping with multiport valve.

16. ACCESSORIES
Each filter shall be provided with following accessories:-

i) Air release valve with connecting piping.

ii) 150mm dia dial burden type gunmetal pressure gauges with gunmetal isolation cock and connecting piping on inlet and outlet.

iii) SS Sampling cocks on raw water inlet and filtered water outlet.

iv) Individual drain connection with gunmetal full way valve should be piped through a properly sized G.I. pipe to nearest drain point.

Activated carbon filters shall have minimum Height on straight 1500mm comprising of minimum 450mm bed depth of Activated carbon (900IV), support media as required, consisting of downward or upward flow type as suitable.

17. BACKWASH SYSTEM FOR FILTERS
Water Stream shall be pushed up through the filter material causing the Filter Bed to expand and carrying away the particles in suspension.

i) One initial charge of supporting gravel, sand and “cation” ION exchange resin in requisite quantity.

ii) One water testing kit with instructions for testing water samples.

iii) One rota meter to indicate flow rate.

iv) Inlet & outlet pressure gauges.

18. PIPING
i) G.I. Pipes confirming to I.S.1239 up to 150mm nominal bore and as per I.S:3589 for 200mm nominal bore and above to be used in the STP. Galvanizing shall conform to IS 4736 and IS 2629. Pipes and fittings shall be jointed with screwed/flanged joints, flanges shall be either screwed or welded complete and jointed with 3mm thick rubber gasket as per requirements complete with nuts, bolts and washers etc. All Fittings shall be new and from approved manufacturers, Fittings shall be of malleable iron galvanized of pressure ratings suitable for the piping system. Fitting for G.I. pipes shall include couplings, bends, tees, reducers, nipples, unions, bushes etc.

ii) uPVC pipes being used for the air distribution lines shall be un-plasticized Polyvinyl chloride pipe, confirming to IS:4985.

iii) All metal pipes should have high corrosion resistance and should be immune to chemical, electrolytic and galvanic action. These pipes should be long lasting as it would be corrosion prone.

iv) Pipes should be kept on an even surface while storing. They should be properly supported and should not be stacked for heights more than 1.5 meters for longer duration.

v) For the connection of PVC pipe to metal pipes, a piece of special thick wall PVC connecting tube threaded at one end shall be used. The other end shall be connected to the normal PVC pipe by means of glued spigot and socket joint.
vi) All piping shall be tested to hydrostatic test pressure of minimum 10 kg/cm² or 1.5 times the design pressure whichever is higher for a period of not less than 24 hours. All leaks and defects in joints revealed during the testing shall be rectified to the satisfaction of the Engineer-in-charge.

vii) The direction of flow of all fluids in the pipes shall be visibly marked in white arrows or as directed by the Engineer-in-charge.

19. VALVES
i) Sluice / Gate Valves
Sluice Valves above 50 mm (inside screw and non-raising screw type) shall be of Cast Iron body and Gunmetal seat with double flanged ends and valve wheel. They shall conform to type PN 1.6 of IS:14846. Sluice valves up to 50mm (outside screw raising spindle type) shall be of Gunmetal Full way Valve with wheel tested to 20 Kg. /cm² class-II as per I.S: 778 with female screwed ends. Valve wheels shall be of right hand type and have an arrow head engraVed or cast thereon showing the direction for turning open and close. Wherever necessary, suitable chamber of required depth shall be provided, and in case of deep location of sluice valve, necessary key/level/extension rod shall be provided for operation.

ii) Butterfly Valves
a) The Butterfly Valve shall be suitable for waste water / water works. The Valves conforming to IS: 13095 shall be provided. All valves shall be suitable to withstand the pressure in the system and rating shall be PN 1.6. All valves shall be right handed (i.e. handle or key shall be rotated clockwise to close the valve).

b) The direction of opening and closing shall be marked and an open / shut indicator fitted.

c) The material of valves shall be as under:

<table>
<thead>
<tr>
<th>Body</th>
<th>Cast iron</th>
</tr>
</thead>
<tbody>
<tr>
<td>Style of disk</td>
<td>Wafer end type</td>
</tr>
<tr>
<td>Disc</td>
<td>Ductile Iron</td>
</tr>
<tr>
<td>Seat</td>
<td>EPDM / nitrile rubber</td>
</tr>
<tr>
<td>Shaft</td>
<td>Stainless Steel</td>
</tr>
</tbody>
</table>

d) The Valve shall be fitted between two flanges on either side of pipe flanges. The Valve edge rubber shall be projected outside such that they are wedged within the pipe flanges to prevent leakages.

iii) Non-Return Valve
Non-return valves shall be of Cast Iron body ball type and Stainless Steel seat for Sewage water handling up to clarified water tank. They shall conform to IS 3512 and have companion flanges. They shall be Stainless steel Dual Plate Type for Clear water suitable for both horizontal and vertical installation. An arrow mark in the direction of flow shall be marked on the body of the valve.

iv) Ball Valve
a) The Ball Valve of size below 50 mm dia shall be made from forged brass and tested to 16Kg/ cm² pressure. The valve shall be internally threaded to receive pipe connections.

b) The Ball shall be made from brass and machined to perfect round shape and subsequently chrome plated. The seat of the valve body bonnet gasket and gland packing shall be of Teflon.

c) The handle shall be of chrome plated steel with PVC jacket. The handle shall also indicate the direction of ‘open’ and ‘closed’ situations. The gap between the ball and the Teflon packing shall be sealed to prevent water seeping up to 14 Kg / cm² pressure.

d) The handle shall also be provided with a lug to keep the movement of the ball valve within 90 degree.
v) **Strainer**
Strainers shall be of the approved type with SS body with SS304 Strainer Basket designed to the test pressure of 16 Kg/cm². Strainers shall be fabricated with minimum 1.2mm thick stainless-steel sheet with 3 mm dia. perforation holes. Strainers shall be provided with flanges or threaded sockets as required. They shall be designed so as to enable blowing out accumulated dirt and facilitate removal and replacement of screen without disconnection of the main pipe.

vi) **Pressure Gauges**
Pressure gauges shall be of 150mm dia. dial and of 0 to 15 Kgs / Sq. cm. and be complete with shut off gauge valve etc. duly calibrated before installation. Diaphragm seal type Pressure Gauges shall be provided with proper isolation valves. Flow meters shall also be provided with isolation valves and by-pass arrangement to enable maintenance of the flow meter as and when required. Care shall be taken to protect pressure gauges during pressure testing.

vii) **Flexible Connection for Pumps**
All suction and delivery lines shall be provided with double flanged reinforced neoprene flexible pipe connectors. Connectors should be suitable for a working pressure 0 to 10Kgs/ Sq. cm. of each pump. Length of the connector shall be as per manufacturer’s details and site requirement.

20. **INSTALLATION**
i) Pump shall be installed as per manufacturer's recommendations. Pump sets shall be mounted on machinery isolation cork or any other equivalent vibration isolation fitting. The vibration isolation pads, foundation bolts etc. shall be supplied by the Contractor. Contractor shall ensure that the foundation bolts are correctly embedded and providing 1:2:4 cement concrete foundation.

ii) Pump-sets shall preferably be factory aligned, wherever necessary, site alignment shall be done by competent persons.

21. **TESTING**
The contractor shall submit the performance curves of the pumps supplied by them. They shall also check the capacity and total head requirements of each pump to match his own piping and equipment layout. On completion of the entire installation, pumps shall be tested, wherever possible, for their discharge, head, flow rate, B.H.P. Where it is not possible at least the discharge, head and B.H.P. (as measured on the input side) shall be field tested. Test results shall correspond to the performance curves.

22. **PAINTING**
After complete installation and testing, pumps accessories and fittings shall be given two coats, 75 microns each of approved color synthetic enamel paint.

23. **GENERAL**
i) Contractor shall provide, install and commission instrumentation system / equipments for the proper and efficient functioning of the Sewage Treatment Plant.

ii) Contractor shall be fully responsible for design, sizing and selection of the proper instruments for the system.

iii) All equipments supplied shall be approved both with respect to design and materials. No prototype instrument or instrument of an experimental nature shall be offered or supplied.

iv) No instrument requiring special maintenance or operating facilities shall be offered or supplied as far as possible.

v) Contractor shall prepare and submit a P & I (Process & Instrumentation) Diagram for the system within the scope of his supply, showing all the instruments and interlock/trip operations. Each instrument shall be given individual tag numbers from blocks of numbers allotted by the purchaser.

vi) All instrument design shall be intrinsically safe wherever applicable.
vii) All instruments and equipment shall be suitable for use in a hot, humid and tropical industrial climate (in which corrosive gases and/or chemicals may be present).

viii) All the panel-mounted instruments i.e. indicators, recorders, controllers etc shall be provided as per approved technical data sheets to be submitted by the Contractor.

ix) All the controllers shall be single loop dedicated controllers. All the recorders shall be 3-pin type.

x) The contractor shall submit to the Engineer-in-Charge the Technical Specifications for all instruments supplied giving manufacturers name, model number etc. Instrument specification must include process data, minimum/normal/maximum values or variable and all information required to define instrument specification and application.

xi) Electronic instruments shall generally operate on 220v, 50 Hz and shall have transmission and output signal generally of 4 to 20 mA DC. Transmitters shall be two wire and shall be capable of delivering rated current into external load of at least 600 ohms when powered with 24vDC.

xii) All electronic instruments shall be immune to Radio-interference.

24. MECHANICAL DESIGN BASIS

<table>
<thead>
<tr>
<th>1.</th>
<th>Pressure Vessels / Horizontal tanks</th>
<th>Thickness shall be designed based on ASME SEC VIII DIV I / IS 2825 (latest edition). The material shall be IS 2062 / equivalent</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.</td>
<td>Small Atm. Tanks &amp; Housing for Cartridge filter</td>
<td>Good Engineering Practice</td>
</tr>
<tr>
<td>3.</td>
<td>Vertical tanks</td>
<td>These shall be designed to IS 803. MS tank Thickness 5 mm with internal Epoxy painting</td>
</tr>
<tr>
<td>4.</td>
<td>Corrosion allowance</td>
<td>For unlined vessels 1.5 mm corrosion allowance has been considered. And for lined vessels atmospheric tanks and piping no corrosion allowance has been considered</td>
</tr>
<tr>
<td>5.</td>
<td>Pumps</td>
<td>IS 5120 or pump manufacturers standards</td>
</tr>
<tr>
<td>6.</td>
<td>Motors</td>
<td>IE3 manufacturers standard Motors for safe zone</td>
</tr>
<tr>
<td>7.</td>
<td>Fittings</td>
<td>UPVC or fabricated from the parent pipes</td>
</tr>
<tr>
<td>8.</td>
<td>Flanges</td>
<td>UPVC or These shall be plate type made from is 2062 / IS 226 plates drilled to ANSI B 16.5 Class 150 S off</td>
</tr>
<tr>
<td>9.</td>
<td>Fasteners</td>
<td>These shall be as per IS 1367</td>
</tr>
<tr>
<td>10.</td>
<td>Piping</td>
<td>Low pressure piping for MS - These shall be as per IS 1239 Part I B class ERW up to 150 NB and IS 3589 ERW for 200 NB and above - Low pressure piping UPVC - Sch 40 - Chemical dosing piping UPVC –Sch 40</td>
</tr>
<tr>
<td>11.</td>
<td>UPVC Valves</td>
<td>NRV wafer type swing check valve. (For 25NB to 65 NB) -Body &amp;Ball : Polypropylene (PP) -Seat Ring : Neoprene -Rating : 150 # / PN 10</td>
</tr>
<tr>
<td></td>
<td>Ball Valve (For 15NB to 80 NB)</td>
<td>-Body, Ball &amp; Handle: Polypropylene (PP) -Seat : PTFE -Rating: 150 # / PN 10 -End Connection: long neck stub end</td>
</tr>
<tr>
<td></td>
<td>Metallic Valves</td>
<td>NRV wafer type swing check valve (For 25NB to 600 NB)</td>
</tr>
<tr>
<td><strong>Item</strong></td>
<td><strong>Details</strong></td>
<td></td>
</tr>
<tr>
<td>----------</td>
<td>-------------</td>
<td></td>
</tr>
<tr>
<td>- <strong>Body &amp; Disc:</strong></td>
<td>SGI/WCB/CF8/CF8M</td>
<td></td>
</tr>
<tr>
<td>- <strong>Seat:</strong></td>
<td>EPDM/Viton/Nitrile/Neoprene/PTFE</td>
<td></td>
</tr>
<tr>
<td>- <strong>Rating:</strong></td>
<td>150 # / PN 10</td>
<td></td>
</tr>
<tr>
<td><strong>Ball Valve (For 15NB to 80 NB)</strong></td>
<td><strong>Ball Valve (For 15NB to 80 NB)</strong></td>
<td></td>
</tr>
<tr>
<td>- <strong>Body:</strong></td>
<td>CI</td>
<td></td>
</tr>
<tr>
<td>- <strong>Seat:</strong></td>
<td>PTFE, Ball – SS 304</td>
<td></td>
</tr>
<tr>
<td>- <strong>Rating:</strong></td>
<td>150 # / PN 10</td>
<td></td>
</tr>
<tr>
<td>- <strong>End Connection:</strong></td>
<td>long neck stub end</td>
<td></td>
</tr>
<tr>
<td><strong>Butterfly Valve</strong></td>
<td><strong>Butterfly Valve</strong></td>
<td></td>
</tr>
<tr>
<td>- <strong>Body:</strong></td>
<td>CI</td>
<td></td>
</tr>
<tr>
<td>- <strong>Disc:</strong></td>
<td>SG Iron Nylon Coated</td>
<td></td>
</tr>
<tr>
<td>- <strong>Seat:</strong></td>
<td>EPDM &amp; Shaft: SS410/SS316</td>
<td></td>
</tr>
<tr>
<td>- <strong>Operation:</strong></td>
<td>Lever type up to 200 NB &amp; Geared type above 200 NB</td>
<td></td>
</tr>
<tr>
<td>- <strong>Rating:</strong></td>
<td>150 # / PN 10</td>
<td></td>
</tr>
<tr>
<td>- <strong>End Connection:</strong></td>
<td>Wafer type up to 200 NB &amp; Lug type above 200 NB</td>
<td></td>
</tr>
</tbody>
</table>

12. **External Painting**: 2 coats of red oxide primer or as per equipment manufacturer standard

13. **Inspection and testing**: As per standard Quality Plan

25. **TESTING & MONITORING SYSTEM**
   i) The scope of work includes establishing fully equipped in-house Testing Laboratory at the STP so as to perform regular testing and monitoring of the quality of the incoming raw effluent, as well as the treated effluent from the various main components/stages of the sewage treatment plants. The monitoring system shall ensure that a strict vigilance may be kept on the functioning of the plant and to enable smooth operation & maintenance of the plant.

   ii) Parameters to be Monitored
      - **Physical**:
        a) pH
        b) Color Odor
        c) Turbidity
        d) Total Suspended Solids

   iii) Operating parameters:
        a) Chemical Oxygen Demand
        b) MLSS
        c) MLVSS
        d) F/M Ratio

   iv) Biological:
        a) Biochemical Oxygen Demand

   v) Microbiological:
        a) Coli form
        b) E. Coli
        c) Total Plate Count
        d) Fecal Coli forms

26. **EQUIPMENT GUARANTEE / DEFECTS LIABILITY PERIOD**
   i) All equipment supplied and installed by the contractor under this tender (whether manufactured by him or not) shall be guaranteed for a defect liability period (DLP) of 24 months from the date of successful commissioning of the respective Sewage Treatment Plants, and the DLP shall be applicable for all components of the plant against defective
materials, workmanship and installation.

ii) The DLP shall include warrantee to cover replacement of all defective parts with new ones. Replaced parts shall also be covered by a similar warrantee.

iii) The replaced parts shall be of approved make as per approval by the Engineer-In-charge.

27. COMMISSIONING OF THE SEWAGE TREATMENT PLANTS

i) After successful testing of the different items in parts, the Contractor shall provide all facilities including necessary piping, labour, tools and equipment’s etc. for carrying out testing and commissioning of the entire treatment plant complete as per requirement in the presence of Engineer-In-charge or his representative whenever and as may be required. Contractor shall carry out the Operation & Maintenance of Sewage Treatment Plant during trial run/ start-up/ stabilization up to complete stabilization of the plant indicating satisfactory performance of the plant for a continuous period of two weeks as per approved work-wise schedule based on which successful commissioning of the system shall be considered. Supply of as-built drawings (3 sets) after completion, O&M Manual, Catalogues, Guarantee & Warrantee Cards etc., shall also be prepared and submitted by the contractor as a part of successful commissioning.

ii) Sewage Treatment Plant shall be handed over as per the approved schedules of completion.

28. MAINTENANCE

i) The formal maintenance period shall commence from the date of certification of successful commissioning of the systems. During this maintenance period, the contractor shall provide round-the-clock, all technical/ supervisory/ unskilled staff. The personnel for maintenance like foreman, operator, sewer-man and helper etc. shall be provided by STP contractor at his own cost. The contractor shall also train any operational personnel as deputed by the Engineer-in-Charge, about the method of operation and maintenance of the plant, its functioning, control and internal laboratory testing operations, if required, during and after successful handing over of the STP. The Contractor shall also train about handling the Consumables and Chemicals etc. purchased and it’s use for the operation of plants. Contractor shall perform regular testing of the required parameters of the influent and effluent quality, for BOD, COD, TDS, hardness etc., as specified. The scope of work shall include but not be limited to the following:

ii) Supply of equipment drawings, Technical specification/Catalogue.

iii) Supply of Operation & Maintenance manual Three (3 sets) including manufacturer manual of the equipment supplied.

iv) Testing and monitoring of the required parameters on a daily basis, as specified in documents, and periodical maintenance records with all relevant information.

v) Consumable items like chemicals, rubber bush, graphite packing, rubber sheet, nut-bolts, material required for cleaning and housekeeping etc. are to be provided by the Contractor within his quoted cost.

vi) Maintenance of STP shall be done as per O&M manual approved by EIC. Contractor has to maintain all the parameters of effluent within stipulated limit or else he will be penalized for not maintaining the parameters specified by Client. All expenditure incurred by client on account of default to meet the standards like suite fee, court fee, case fee, or the penalty as decided by EIC and penalty charged by Client will be at the risk and cost of the contractor and deducted from his bills, Security Deposit etc. . The decision of EIC on such issues shall be final and binding on the Contractor.

vii) Contractor shall have to test the effluent / influent at his own cost at the plant lab on daily basis. The same shall be verified by and checked by client whenever required. The Contractor shall also have to test the effluent / influent at Client lab or any other approved lab as approved by the EIC for various parameters at regular intervals specified at his own cost.

viii) No equipment shall remain idle or un-attended or damaged for the period of 5 days. If any equipment is not repaired, rectified and or replaced within 5 days, the Contractor shall be
penalized on per day delay basis per each individual equipment of the plant. This should not, in any way, affect the successful functioning of the STP.

ix) Contractor will have to maintain required Power Factor as per rules and regulations. In case penalty is levied by Power authorities for not maintaining the Power Factor the same shall be at the risk and cost of the contractor and deducted from his bills, Security Deposit, etc.

x) The Contractor during the O&M period will have to follow all the guidelines set by the Client for Operation & Maintenance of STP.

xi) Operation and maintenance of all General facilities and utility services including all other component softwork done under this contract shall be within the scope of this contract.

xii) Operation and maintenance of Electrical panel and all instruments installed in the STP. All repairs, replacements towards the entire instrumentation works during the O&M period shall be within the scope of Contract.

xiii) The contractor shall provide any other services required for smooth running of the system without any additional charge to client.

xiv) The Contractor shall dispose off the surplus sludge, screenings, grit and any other material, at regular intervals as directed by Engineer-in-Charge to an approved dumping area beyond campus premises by mechanical transportation at his own cost.

xv) At the end of every year of operation & maintenance period, an assessment of the condition of the plant has to be done by the Contractor through third party inspection at his own cost and based on that assessment the Contractor shall, at no extra cost to client, repair and re-condition all the electro-mechanical equipments in the concluding year of the O&M contract with regular preventive and recommended maintenance as per manufacturer's recommendations or as per CPHEEO manual to ensure they are in good running condition. The third party for conducting the inspection shall be as approved by EIC.

xvi) On completion of the O&M period, the Contractor shall have to hand over the STP to client in full working condition, as it was on the date of commissioning of the STP. The contractor shall handover the plants with all relevant documents such as registers, physical & operational condition of the assets, rights on proprietary technologies, software, systems, O&M manual, periodical reports along with one soft and hard copies to client.

29. LIST OF SPARES
The list of spares shall be prepared by the contractor and submitted for approval.

30. OUTPUT & OPERATIONAL GUARANTEES
The Contractor is fully responsible for treating all the Sewage reaching at the Receiving chamber. The performance of the Contractor shall be treated as unsatisfactory if he fails to treat the complete sewage or does not maintain the guarantees listed in this clause.

31. TREATED SLUDGE DISPOSAL
The Contractor shall operate the Sewage Treatment Plant such that the sludge produced is of a spade-able consistency and the volume of sludge produced after necessary process, is minimum. The sludge shall be deposited at approved location till disposal of the same from STP premises. The sludge generated from the STP shall be made available free of charge for utilizing for horticulture within the campus site and the surplus sludge, if any shall be disposed off by mechanical means to approved dumping yard at contractor’s own cost.
TS – 04
ELECTRICAL WORKS
I – GENERAL (Internal & External Electrical Installations)

The electrical Installation work shall be carried out in accordance with Indian Standard Code of Practice. It shall also be in conformity with the current Indian Electricity rules and regulations and requirements of the Local Electricity Supply Authority and Fire Insurance regulations, so far as these become applicable to the installation. Electrical work in general shall be carried out as per following CPWD Specifications amended upto date.

General Specifications for Electrical Works.
- Part -I : Internal Work - 2013
- Part -II : External Work - 1994

Wherever this specifications calls for a higher standard of material and or workmanship than those required by any of the above mentioned regulations and specification then the specification here under shall take precedence over the said regulations and standards.

1.0 GENERAL INSTRUCTIONS

1.1 The Contractor shall include whole of the new material in accordance with the Particular Specifications for supply & fixing accessories for the complete installation. This shall also includes any materials, appliances, equipment not specifically mentioned herein or noted on the drawings as being furnished or installed but which are necessary and customary to make the installation complete in all respects. In general the work to be performed under this contract shall comprise supply and installation of the following as per scope of work of EPC.

- All conduit work shall include for junction boxes, outlet boxes, swapping and drawing fish wires etc. as required and directed.
- Light control switches, plug sockets, cover plates, metal boxes etc. shall include under the wiring accessories. Back boxes required for the control switches shall also form part of the scope of work.
- LT Cables for power to equipments, sub-main panel boards and final distribution boards (DB’s).
- Lighting Fixtures, ceiling / exhaust fans, etc
- DB type panel, feeder pillar etc
- External Lighting with High masts & street poles, complete.
- Earthing & loop earthing
- Any other items, which are required for successful completion & put into operation of the EI system.

1.2 The Scope of work covered in this tender is for proposed Airport as per layout plan enclosed. The contractor has to coordinate with the other agencies/ sub-agencies for proper co-ordination and execution of the work at site.

2.0 QUALITY OF WORK

The work shall be carried out to the satisfaction of the Engineer Incharge. The supply, installation testing and commissioning shall comply with the latest requirements of Bureau of India Standard and code of practice as amended upto date. All equipment and material being
supplied shall meet the requirements of IS, Indian Electricity Rules, Local Electrical Inspectorate and other governmental statutory bodies.

3.0 FEES, PERMITS AND TESTS

The Contractor shall obtain and pay for any and all fees and permits required for the installation of this work. Fee paid / deposited with local Authorities will be reimbursed on production of cash receipt in original. On completion of the work the contractor shall obtain and deliver to the owner certificates of final inspection and approval by the local electricity authority.

4.0 DRAWINGS & SPECIFICATIONS

4.1 Specifications

As described in subsequent paras

4.2 Shop drawings

The Contractor shall prepare and submit shop drawings scale not less than 1:100 to the Engineer in charge for approval. The detailed shop drawing shall include all Schematics, Load distribution and balancing, Cable routing and Schedule, all lighting, UPS, signages, network/telephone and power layout, conduit layout, Control wiring/logics, SLD of distribution boards(DBs), switch boards, special pull boxes, raceway & junction boxes layout, earthing and any other items provided by the contractor.

4.3 Completion drawings & Deliverables

On the completion of the work and before issuance of certificate of virtual completion, the Contractor shall submit a soft copy of as built drawings in a CD with soft media after incorporating changes done during execution. These drawings should necessarily show the following details:

- A Complete conduiting and wiring diagram including control circuits as installed from starting point i.e. power supply panel / telephone / network panel to last receiving end i.e. power / light / telephone/ network point and schematic drawings showing all connections, control logic (wherever applicable), Junction box, DBs, Raceway, Electrical switch gears, accessories etc. in the complete electrical system.
- Location of all earthing stations, routes and size of all earthing conductors, manholes etc.
- Layout and particulars of all cables.
- Instruction, maintenance and operation manuals if any for the equipment.
- Data Sheets / Equipment name plate details.
- Details of Inventory
- Detailed system specification.
- Test Certificates (Factory Tests, site Test)
- Guarantee / Warranty Certificates (where applicable)
- Keys, operating handles, tools etc as applicable.
5.0 COMPLETION

On completion of the Electrical Installation the Contractor shall furnish a certificate signed by the licensed supervisor and Contractor’s Engineer, under whose direct supervision the installation was carried out. This certificate shall be in the prescribed form as required by the local Power Supply Distribution Authorities concerned.

6. MATERIALS AND EQUIPMENT

All materials and equipments shall be of the one of the approved make listed in Appendix-I enclosed with this document and design. Unless otherwise called for only the best quality materials and equipments shall be used. The materials and equipments shall conform to relevant IS as listed under the sub-head ‘Regulations and Standards’. The contractor shall be responsible for the safe custody of all materials. The materials shall be insured against theft or damage in handling or storage etc. All changes and substitutions shall be requested in writing and approvals obtained in writing from the Engineer In-charge shall be maintained. For common electrical items used in different packages, approved makes for detailed under electrical package shall be applicable for other packages also.

7. TOOLS AND TACKLES

The contractor shall provide and install all necessary hoists, ladders, scaffolding, tools, tackles, plants, transport for labour and materials and plant necessary for the proper execution and completion of the work to the satisfaction of the Engineer In-charge.

8. SAFETY PROCEDURES

The policy is to clearly define responsibilities and then to obtain the commitment of all contractors to maintain a high safety standards compatible with the policy. Safe methods of working shall be the main consideration in all operations. Contractors shall provide the Engineer In-charge with details of their methods statement of work, highlighting the safety aspects and they shall update this information as necessary. It is the responsibility of all persons employed on this project to act responsibly to prevent accidents to themselves and others. The contract shall be governed by the Latest National Safety Rules and Regulations as stipulated from time to time and the contractor shall provide as mentioned herein, wherever required for the safety of working manpower:

- Providing safe plant, tools, equipment etc. wherever required and working conditions
- Ensure and establish safe working procedures.
- Provide suitable protective equipment, clothing, gloves, ear muffs, goggles, safety belts, Helmets, Aluminium ladders, Steel scaffolding etc.
- Provide adequate job training.
- Provide fire extinguishers and First aid box with adequate medical supplies.
- SOP with emergency contact details etc. for clarity towards action to be taken by various persons, in case of accident / mis-happening.
- Report accidents and dangerous occurrences if any, to the Engineer In-charge with copies of relevant documents.
- Ensure that hazardous materials, if necessary on site, will be stored and used in the safe manner.
- The Contractor shall co-operate with AAI in creating and maintaining a high standard of safety, health and welfare.
No claim from the contractor for loss of or damage to equipment, materials, crew of the works during the course of the work due to natural causes like cyclones, gales, floods, rains or other cause or combination of causes will be entertained by AAI. The contractor shall be fully liable to compensate AAI for any loss or damage to works till the time of taking over of the work by AAI. A Safety Officer is mandatory for the execution of this project.

9.0 TESTING

9.1 On the completion of the work, the entire installation shall be subject to the following tests in the presence of the Engineer In charge:

- Wiring continuity test
- Insulation resistance test
- Earth continuity test
- Earth resistively test
- Test as per Appendix 'E' of IS: 732-1989
- Tests as per relevant CPWD specifications.

9.2 Besides the above and any other test specified by the Local Authority/Supply Company shall also be carried out. Approved testing laboratories shall calibrate all testing instruments and the Contractor shall produce the test certificates thus obtained on demand to Engineer-in-Charge for his inspection and record.

9.3 For any tests as directed by the Engineer-in-Charge, that have to be carried out at an outside laboratory, the cost of such tests, materials transport etc., shall be borne by the Contractor.

10.0 DEMONSTRATION TO AAI

On completion of the Installation, devices subject to manual operation shall be operated at least in presence of Engineer In-Charge or his representative to demonstrate the satisfactory operation of the complete system.

At the time of checkout and testing, the owner’s representative shall be thoroughly trained in the proper operation of the system. The contractor shall train the owner’s representatives in the operation of the system.

11.0 MANUFACTURER’S INSTRUCTION

Where manufacturers have furnished specific instructions relating to the material used in the job and points that are not specifically mentioned in this document, manufacturer’s instruction shall be followed.

****
II - POINTS & SUBMAINS WIRING / CABLELING

1.0 **SCOPE**
This section covers the general technical requirements and scope of works of the various components in Internal Electrical Installation Works.

2.0 **TERMINOLOGY**
The definition of terms shall be accordance with IS 732: 1989 (Indian Standard Code of Practice for Electrical Wiring and CPWD Specifications of Internal EI – 2013 with up to-date amendments.

3.0 **POINT WIRING**

3.1 **Definition:**
A point (other than socket outlet point) shall include all works necessary in complete wiring to the following outlets from the controlling switch or MCB. The scope of wiring for a point shall, however, includes the wiring work necessary in tapping from another point in the same distribution circuit:

a) Ceiling rose or connector (in the case of points for ceiling/ exhaust fan points, pre-wired light fittings and call bells)
b) Ceiling rose (in case of pendants except stiff pendants)
c) Back plate (in the case of stiff pendants)

3.2 In the case of call bell points, the words “from the controlling switch or MCB” shall be read as “from the ceiling rose meant for connection to bell push”.

3.3 **Scope**

i) Following shall be deemed to be included in point wiring:

a) Conduit, accessories for the conduit and wiring cables between the switch box and point outlet, loop protective earthing of each fan/light fixture i/c loose wire in switch board & points for connection.
b) All fixing accessories such as clips, nails, screws, Phil plug, rawl plug etc. as required.
c) Metal GI switch boxes for control switches, regulators, sockets etc. recessed or surface type and outer & inner cover plates of modular type switches. Boxes, plates and switch/socket shall be of same make.
d) Outlet boxes, junction boxes, pull-through boxes etc. but excluding metal boxes if any, provided with switchboards for loose wires/conduit terminations.
e) Control switch as required.
f) Ceiling rose or connector as required/ flexible conduit for connecting the wires to fitting.
g) Connections to ceiling rose, connector, lamp holder, switch etc.
h) Interconnection wiring between points on the same circuit, in the same switch box or from another.
i) Bushed conduit or porcelain tubing where wiring cables pass through wall including repairing etc.
Note: In areas where false ceiling is provided, termination of wires should be at the fittings. Flexible conduits from ceiling junction box to the fittings shall be provided duly coupled at both ends. This shall be included within the scope of point wiring.

ii) Following shall be deemed to be included in group control point wiring:

Conduit, accessories for the conduit and wiring cables between the Switchboard/ MCBDB to the first point or wiring cable between points forming a group including loop protective earthing of each fan/ light fixture.

All fixing accessories such as clips, nails, screws, Phil plug, rawl plug etc. as required.

Junction boxes, pull-through boxes etc. for loose wires/ conduit terminations.

Connector as required.

Connections to connector & Switch/ MCB etc.

Bushed conduit or porcelain tubing where wiring cables pass through wall etc.

4.0 CIRCUIT AND SUBMAIN WIRING

4.1 Circuit Wiring

Circuit wiring shall mean the wiring from the distribution board to the first tapping point inside the switchbox, from where point wiring starts.

4.2 Submain Wiring

Submain wiring shall mean the wiring from one Main/Distribution switchboard to another.

5.0 SYSTEM OF DISTRIBUTION AND WIRING

o Each main distribution board and branch distribution board shall be controlled or provided with miniature circuit breaker (MCB) of specified rating on the phase or live conductor or combined phase and neutral control gear for incoming and outgoing as per system design required.

o Generally, no switchboard will have more than one source of incoming supply.

o Distribution of submain and circuits.- As per system design required for light, power and UPS load of light & power. DB should be separate for light, power and UPS.

5.1 Balancing of Circuits

The balancing of circuits in three wire or poly phase installations shall be done before handing over to the satisfaction of the Engineer-In-Charge.

5.2 Wiring System

i) Unless and otherwise specified in the tender documents, wiring shall be done only by the “Looping System”. Phase of live conductors shall be looped at the switch boxes and neutral conductors at the point outlets.

ii) Power wiring shall be kept separate & distinct from light wiring, from the level of circuits, i.e., beyond the branch distribution board. Conduit for light/ power wiring shall be separate.

iii) The wiring throughout the installation shall be such that there is no break in the neutral wire except in the form of linked switchgear.

iv) All DB’s should have 20% spare outgoing MCB’s
v) Mains/Inverter or UPS distribution each will have a completely independent & separate distribution system starting from the main switch board up to final wiring for each system. As for example, conduit carrying main supply wiring shall not have inverter/UPS wiring. Wiring for inverter supply will have their own conduit system. No mixing of wiring is allowed.

vi) Generally, no switchboard will have more than one source of incoming supply. More than one incomer supply will be allowed only at LT panel with proper safety & interlocking so that one source can be switched on at a time.

vii) Light, fans and call bells shall be wired in the ‘lighting’ circuits. 15A / 16A socket outlets and other power outlets shall be wired in the ‘power’ circuits. 5A / 6A socket outlets shall also be wired in the ‘power’ circuit both in residential as well as non-residential buildings.

.viii) Ferrules of suitable size indicating circuit & DB numbers are to be provided at both the ends.

5.3 Run of Wiring

The type of wiring shall be carried out as per system design required.

Surface wiring shall run, as far as possible, along the walls and ceiling so as to be easily accessible for inspection.

In no case, the open wiring shall be run above the false ceiling without the approval of Engineer-In-Charge.

In all types of wiring, due consideration shall be given for neatness, good appearance and safety.

5.4 Passing through walls or floors

When wiring cables are to pass through a wall, these shall be taken through a protection (Steel) pipe of suitable size such that they pass through in a straight line without twist or cross in them on either end of such holes. The ends of metallic pipe shall be neatly bushed with approved material.

Where a wall pipe passes outside a building so as to be exposed to weather, the outer end shall be bell mouthed and turned downwards and properly bushed on the open end.

All floor openings for carrying any wiring shall be suitably sealed after installation.

5.5 Joints in Wiring

i) No bare conductor in phase and/or neutral or twisted joints in phase, neutral, and/or protective conductors in wiring shall be permitted.

ii) There shall be no joints in the through runs of cables. If the length of final circuit or submain is more than the length of a standard coil, thus necessitating a through joint, such joints shall be made by means of approved mechanical connectors in suitable junction boxes.

iii) Termination of multi-stranded conductors shall be done using suitable crimping type thimbles.

6.0 Interchangeability

Similar parts of all switches, lamp holders, distribution boards, switchgears, ceiling roses, brackets, fans and all other fittings of the same type shall be interchangeable in each installation.
7.0 **Wiring Cables**
   
i) Copper conductor cable only will be used for submain/circuit/point wiring.

   ii) Minimum size of wiring:
       - Point wiring: 1.5 Sq.mm
       - Circuit wiring: 2.5 sq.mm
       - Power wiring: 4 sq.mm
       - Power circuit rated: more than 1 kW, size as per calculation.

   iii) Insulation: Copper conductor cable shall be PVC insulated, FRLSH type conforming to BIS specification.

   iv) Multistranded: cables are allowed to be used.

8.0 **Flexible Cables**
   
i) Conductor of flexible cables shall be of copper and FRLSH type conforming to BIS specification. The minimum cross sectional area of conductor for flexible cable shall be as per design.

   ii) Only 3 core flexible cables shall be used for connecting single-phase appliances.

   iii) Unless flexible cables are mechanically protected by armour, or tough rubber, or PVC sheath, these shall not be used in workshops and other places where they are liable to mechanical damage.

   iv) Flexible cable connection to bell push from ceiling rose shall be taken through steel conduit/metallic casing and capping.

9.0 **WIRING ACCESSORIES**

9.1 **Control Switches For Points**
   
i) Control switch (single pole switch) carrying not more than 16 A shall be modular type. The switch shall be on when the knob is down.

   ii) For A.C. points, 25 Amp 3 Pin socket outlet controlled by 25 A Modular SP MCB housed in suitable G.I. box will be used.

   iii) Control switch shall be placed only in the live conductor of the circuit. No single pole switch or fuse shall be inserted in the protective (earth) conductor, or earthed neutral conductor of the circuit.

   b) Switch box (Back Box)
      
      Switch box shall be hot dip galvanized, factory fabricated, suitable in size for surface/recess mounting and suitable in size for accommodating the required number of switches and accessories.

9.2 **Socket Outlets**

   Combined switch cum socket shall not be permitted.

9.3 **Switch box covers**
Modular type switches/sockets suitable outer and inner cover plates as specified shall be provided over the standard box as recommended by the manufacturers of modular type switch/sockets and no separate sheet cover is required to be provided.

NOTE: The make & model of switch, socket, etc. shall be selected equivalent to Legrand make of minimum Myrius range. The colour of switch, socket, etc. should match with the architecture features of surroundings or as per the Architect decision. The contractor shall take prior approval of the same from Engineer-in-charge.

9.4 Ceiling Rose

i) A ceiling rose shall not be used on circuit the voltage of which normally exceeds 250 Volts.

ii) Only one flexible cord shall be connected to ceiling rose. Specially designed ceiling roses shall be used for multiple pendants.

iii) A ceiling rose shall not embody fuse terminal as an integral part of it.
III - METALIC CONDUIT & ACCESSORIES

1.0 **SCOPE**
   This section covers the detailed requirements for wiring work in metallic conduits both surface and recessed types of works.

2.0 **APPLICATIONS**
   Conduit system used shall be Rigid.

3.0 **MATERIALS**

3.1 **Conduits** :
   i) All rigid conduit pipes shall be of steel and be ISI marked. The wall thickness shall be 1.6mm (16 SWG) for conduits upto 32mm dia. and 2mm (14 SWG) for conduits above 32mm dia and as per IS. These shall be solid drawn or reamed by welding, and finished with galvanized or stove enameled surface.
   ii) The maximum number of PVC insulated cables conforming to IS: 694-1990 that can be drawn in one conduit is given size wise in Table I., and the number of cables per conduit shall not be exceeded. Conduit sizes shall be selected accordingly in each run.
   iii) No steel conduits less than 20mm in diameter shall be used.

3.2 **Conduits Accessories** :
   i) The conduit wiring system shall be complete in all respects, including their accessories.
   ii) All conduit accessories shall be of threaded type, and under no circumstances pin grip type or clamp grip accessories shall be used.
   iii) Bends, couplers etc. shall be solid type in recessed type of works and may be solid or inspection type as required, in surface type of works.
   iv) a) Saddles for surface conduit work on wall shall not be less than 0.55mm (24 gauge) for conduits upto 25mm dia and not less than 0.9mm (20 gauge) for larger diameter. The corresponding widths shall be 19mm and 25mm.
      b) The minimum width and the thickness of girder clips used for fixing conduits to steel joints, and clamps shall be as per Table-II.

3.3 **Outlets** :
   i) a) Outlet boxes for light/ power sockets shall be of standard size of manufacturer to accommodate required number of modular switches, socket outlet.
      b) Where a large number of control switches and/ or fan regulators are required to be installed at one place, these shall be installed in more than one outlet box adjacent to each other for ease of maintenance.
   ii) An earth terminal with stud and metal washers shall be provided in each DB/MS box for termination of protective conductor and for connection to socket outlet/ metallic body of fan regulator etc.
4.0 INSTALLATION

4.1 Common aspects for recessed and surface conduit works.

i) Conduit Joints
   a) The conduit work in each circuit or section shall be completed before the cables are
drawn in.
   b) Conduit pipes shall be joined by means of screwed couplers and screwed accessories
   only. Threads on conduit pipes in all cases shall be between 13mm to 19mm long,
sufficient to accommodate pipes to full threaded portion of couplers or accessories.
   c) Cut ends of conduit pipes shall have no sharp edges, nor any burrs left to avoid
damage to the insulation of the conductors while pulling them through such pipes.
   d) The Engineer-In-Charge, with a view to ensuring that the above provision has been
carried out, may require that the separate lengths of conduit etc. after they have
been prepared shall be submitted for inspection before being fixed.
   e) No bare threaded portion of conduit pipe shall be allowed, unless such bare threaded
portion is treated with anticorrosive preservative or covered with approved plastic
compound.

ii) Bends in Conduit
   a) All necessary bends in the system, including diversion, shall be done either by neatly
bending the pipes without cracking with bending radius of not less than 7.5 cm., or
alternatively, by inserting suitable solid or inspection type normal bends, elbows or
similar fittings, or by fixing cast iron inspection boxes, whichever is most suitable.
   b) No length of conduit shall have more than the equivalent of four quarter bends from
outlet to outlet.
   c) Conduit fittings shall be avoided as far as possible on conduit system exposed to
weather. Where necessary, solid type fittings shall be used.

iii) Outlets
   a) All outlets such as switches, wall sockets etc. may be either flush mounting type, or of
surface mounting type.

iv) Painting after erection
   After installation, all accessible surface of conduit pipes, fittings, switch and regulator boxes
etc. shall be painted in compliance with the clauses under the painting specification.

4.2 Additional requirements for surface conduit works

i) Painting before erection

   The outer surface of conduit including all bends, unions, tees, junction boxes, etc. forming
part of the conduit system, shall be adequately protected against rust, by painting with 2
coats of red oxide paint applied before they are fixed.

ii) Fixing Conduit On Surface

   Conduit pipes shall be fixed by saddles, secured to suitable approved plugs with screws in
an approved manner at an interval of not more than one meter, but on either side of the
couplers or bends or similar fittings, saddles shall be fixed at a distance of 30 cm from the
centre of such fittings.
Where conduit pipes are to be laid along the trusses, steel joists etc. the same shall be secured by means of saddles or girder clips or clamps as required by the Engineer-In-Charge.

In long distance straight run of conduit, inspected type couplers at reasonable intervals shall be provided, or running threads with couplers and jam nuts shall be provided.

iii) Fixing Outlet Boxes

Only a portion of the switch box shall be sunk in the wall, the other portion being projected out for suitable entry of conduit pipes into the box.

4.3 Additional requirements for recessed conduit works

i) Making Chase

a) The chase in the wall shall be neatly made, and of ample dimensions to permit the conduit to be fixed in the manner desired.

b) In the case of building under construction, the conduits shall be buried in the wall before plastering, and shall be finished and plastered neatly with wire mesh after erection of conduit.

c) In chase of exposed brick/ rubber masonry work, special care shall be taken to fix the conduit and accessories in position along with the building work.

ii) Fixing Conduits in Chase

a) The conduit pipe shall be fixed by means of staples, J-hooks, or by means of saddles, not more than 60 cm apart, or by any other approved means of fixing.

b) All threaded joints of conduit pipes shall be treated with some approved preservative compound to secure protection against rust.

iii) Fixing Conduits in RCC work

a) The conduit pipes shall be laid in position and fixed to the steel reinforcement bars by steel binding wires before the concreting is done. The conduit pipes shall be fixed firmly to the steel reinforcement bars to avoid their dislocation during pouring of cement concrete and subsequent tamping of the same.

b) Fixing of standard bends or elbows shall be avoided as far as practicable, and all curves shall be maintained by bending the conduit pipe itself with all long radius, which all permit easy drawing in of conductors.

iv) Fixing Inspection Boxes

Suitable inspection boxes to the minimum requirement shall be provided to permit inspection, and to facilitate replacement of wires, if necessary. The distance between inspection/ junction boxes shall not exceed 12.5 mts in straight run.

Location of inspection/ junction boxes in RCC work should be identified by suitable means to avoid unnecessary chipping of the RCC slab subsequently to locate these boxes.

These shall be mounted flush with the wall or ceiling concrete. Minimum 65mm depth junction boxes shall be used in roof slabs and the depth of the boxes in other places shall be as per IS : 2667-1977.

Suitable phenolic laminated sheet cover shall be provided on the inspection box.

Suitable ventilating holes shall be provided in the inspection box covers.
v) **Fixing Switch Boxes and Accessories**
Switch boxes shall be mounted flush with the wall. All outlets such as switches, socket outlets etc. shall be flush mounting type, unless otherwise specified.

vi) **Fish wire**
To facilitate subsequent drawing of wires in the conduit, GI fish wire of 1.6mm / 1.2mm (16/ 18 SWG) shall be provided along with the laying of the recessed conduit.

vii) **Bunching of Cables**
   a) Cables carrying direct current may, if desired, be bunched whatever their polarity, but cables carrying alternating current, if installed in metal conduit shall always be bunched so that the outgoing and return cables are drawn into the same conduit.
   b) Where the distribution is for single phase loads only, conductors for these phases shall be drawn in one conduit.
   c) In case of three phase loads, separate conduits shall be run from the distribution boards to the load points or outlets as the case may be.

4.4 **Earthing Requirements**

i) The entire system of metallic conduit work, including the outlet boxes and other metallic accessories, shall be mechanically and electrically continuous by proper screwed joints, or by double check nuts at termination. The conduit shall be continuous when passing through wall or floors.

ii) Protective (loop earthing) conductor(s) shall be laid inside the conduit between the metallic switch boxes and the distribution boards/switchboards and terminated into proper earth lugs/terminals. Only PVC insulated copper conductor cable of specified size, green-yellow in color shall be allowed. Such conductor will not run external to the conduit.

iii) The protective conductors shall be terminated properly using earth studs, earth terminal block etc. as the case may be.

iv) Gas or water pipe shall not be used as protective conductor (earth medium).

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**TABLE – I**

| IMPHAL AIRPORT | C-nil | I-nil | O-nil | 781 |
Maximum number of PVC insulated 650/1100 V grade aluminium/copper conductor cable conforming to IS : 694 - 1990

<table>
<thead>
<tr>
<th>Nominal Cross-Sectional area of Conductor in sq.mm</th>
<th>20mm</th>
<th>25mm</th>
<th>32mm</th>
<th>38mm</th>
<th>51mm</th>
<th>64mm</th>
</tr>
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<td>42</td>
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</tbody>
</table>

**NOTE:**

1. The above table shows the maximum capacity of conduits for a simultaneous drawing in of cables.
2. The columns headed 'S' apply to runs of conduits which have distance not exceeding 4.25m between draw in boxes and which do not deflect from the straight by an angle of more than 15 degrees. The columns headed 'B' apply to runs of conduit which deflect from the straight by an angle of more than 15 degrees.
3. Conduit sizes are the nominal external diameters.

**TABLE - II**

Girder clips or clamps
5.0 PAINTING

5.1 SCOPE
This section covers the requirements of painting work in internal electrical installations, carried out manually by brush. This does not cover spray painting work of factory-made items.

5.2 PAINTING WORK IN GENERAL

5.2.1 PAINTS
Paints, oils, varnishes etc. of approved make, in original tin to the satisfaction of the Engineer-In-Charge, shall only be used.

5.2.2 PREPARATION OF THE SURFACE
The surface shall be thoroughly cleaned and made free from dust or foreign matter before painting is started. The proposed surface may be inspected by the Engineer-In-Charge before the paint is applied.

5.2.3 APPLICATION:

i) Paint shall be applied with brush. The paint shall be spread as smooth and even as possible. Particular care shall be paid to rivets, nuts, bolts and overlapping. Before drawing out in small containers, it shall be continuously stirred with a smooth stick, while painting work is taken up.

ii) Primary coat of anti-corrosive paint shall be given in the case of steel work, after preparation the surface. In all cases of painting work, finishing shall be with 2 coats of paint in approved shade.

iii) Each coat shall be allowed to dry out sufficiently before a subsequent coat is applied.

5.2.4 PRECAUTIONS
All furniture, fixture, glazing, floors etc. shall be protected by suitable covering. All stains, smears splashing, dropping etc. shall be removed. While painting of wiring etc., it shall be ensured that the painting of wall and ceiling etc. is not spoiled in any way.

****

<table>
<thead>
<tr>
<th>Size of Conduit</th>
<th>Width</th>
<th>Thickness</th>
</tr>
</thead>
<tbody>
<tr>
<td>i) 20 mm</td>
<td>19 mm</td>
<td>0.9mm (20 SWG)</td>
</tr>
<tr>
<td>ii) 25 mm</td>
<td>19 mm</td>
<td>0.9mm (20 SWG)</td>
</tr>
<tr>
<td>iii) 32 mm &amp; above</td>
<td>25 mm</td>
<td>1.2mm (18 SWG)</td>
</tr>
</tbody>
</table>
IV. TESTING OF INSTALLATION

1.0 Scope

This section describes the details of test to be conducted in the completed internal electrical installation, before commissioning.

1.1 General:

1.1.1 Tests

On completion of installation, the following tests shall be carried out:

i) Insulation resistance test.

ii) Polarity test of switch.

iii) Continuity test

iv) Earth continuity test.

v) Earth electrode resistance test.

1.1.2 Witnessing of Tests

Testing shall be carried out for the completed installations, in the presence of and to the satisfaction of the Engineer-In-Charge by the Contractor. All test results shall be recorded and submitted to the Department (AAI).

2.0 Insulation Resistance

The tests described below shall be made before the installation is permanently connected to the supply. For these tests large installations may be divided into groups of outlets, each containing not less than 50 outlets. For the purposes of this code the term ‘outlet’ includes every point and every switch except that a socket outlet, appliance or luminaire incorporating a switch is regarded as one outlet. The test voltage for insulation resistance measurement shall be 500 V.

When measured with all fuse links in place, all switches (including, if practicable, the main switch) closed and, all poles or phases of the wiring electrically connected together, the insulation resistance to earth shall be not less than 1 mega ohm.

When measured between all the conductors connected to any one phase or pole of the supply and, in turn, all conductors connected to each other phase or pole the insulation resistance shall be not less than 1 mega ohm. Wherever practicable, so that all parts of the wiring may be tested, all lamps shall be removed and all current-using equipment shall be disconnected and all local switches controlling such lamps or other equipment shall be closed. Where the removal of lamps and/or the disconnection of current-using equipment is impracticable, the local switches controlling such lamps and/or equipment shall be open. Particular attention shall be given to the presence of electronic devices connected in the installation and such devices shall be isolated so that the test voltage does not damage them.

Where equipment is disconnected for the tests prescribed above, and the equipment has exposed conductive parts required by these clauses to be connected to protective conductors, the insulation resistance between the exposed conductive parts and all live parts of the equipment shall be measured separately and shall comply with requirements of the appropriate Indian Standard and the insulation resistance shall not less than 0.5 mega ohm.
3.0 **POLARITY TEST OF SWITCH**

In a two wire installation, a test shall be made to verify that all the switches in every circuit have been fitted in the same conductor, throughout, and such conductor, shall be labeled or marked for connection to the phase conductor, or to the non-earthed conductors of the supply.

In a three wire or a four wire installation, a test shall be made to verify that every non-linked single pole switch is fitted in a conductor which is labeled, or marked for connection to one of the phase conductors of the supply.

The installation shall be connected to the supply for testing. The terminals of all switches shall be tested by a test lamp, one lead of which is connected to earth. Glowing of test lamp to its full brilliance, when the switch is in ‘ON’ position irrespective of appliance in position or not, shall indicate that the switch is connected to the right polarity.

4.0 **TESTING OF EARTH CONTINUITY PATH**

The earth continuity conductor, including metal conduits and metallic envelopes of cables in all cases, shall be tested for electric continuity. The electrical resistance of the same alongwith the earthing lead, but excluding any added resistance, or earth leakage circuit breaker, measured from the connection with the earth electrode to any point in the earth continuity conductor in the completed installation shall not exceed one ohm.

5.0 **MEASUREMENT OF EARTH ELECTRODE RESISTANCE** – As described in earthing section.

6.0 **TEST CERTIFICATE**

On completion of an electrical installation or an extension to an installation, a certificate shall be furnished by the Contractor, countersigned by the certificate supervisor under whose direct supervision the installation was carried out. The certificate shall be in the prescribed form in addition to test certificate required by the local Electricity supply authorities.

****
**5 - OUTDOOR AREA LIGHTING**

(Street lighting & high mast)

1.0 GENERAL

This section cover detailed requirement of provision of –

a) Approach road lighting from Airport entry gate up-to terminal building, inter-connected service roads, car park etc with LED street light fixtures with single / twin arm(s) octagonal poles to achieve desired lux level.

b) Apron / carpark area illumination with LED flood light fixtures to achieve desired lux level with high mast of required height.

c) The architectural layout plan showing the proposed roads, carpark, apron areas etc is enclosed for reference.

d) Successful bidder shall obtain required NOC for high mast height etc from the department.

2.0 STANDARD & CODE:

<table>
<thead>
<tr>
<th>Code No</th>
<th>Description</th>
</tr>
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<tbody>
<tr>
<td>IS 875 (Part –III) -1987</td>
<td>Code and practice for design loads for structures</td>
</tr>
<tr>
<td>BS-EN 10025/ DIN 17100</td>
<td>Material of construction/Grade of MS Plate</td>
</tr>
<tr>
<td>IS1461/IS4759/IS-2629/BS 729</td>
<td>Galvanising / hot dip Galvanizing standard</td>
</tr>
<tr>
<td>IS 10322 (All Parts)</td>
<td>Specification for Luminaires</td>
</tr>
<tr>
<td>LM80</td>
<td>Measuring Lumen Maintenance of LED Light Sources</td>
</tr>
<tr>
<td>SP 72 : 2010</td>
<td>National Lighting Code</td>
</tr>
<tr>
<td>16103(Part 1)</td>
<td>2012 Led Modules for General Lighting- Safety Requirements</td>
</tr>
<tr>
<td>16103(Part 2)</td>
<td>2012 LED Modules For General Lighting Part 2 Performance Requirement.</td>
</tr>
<tr>
<td>IS 16107 (Part 1)</td>
<td>Luminaire performance Part 1 General Requirement</td>
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<tr>
<td>IS 16107 (Part 2)</td>
<td>Luminaire performance Part 2 Particular Requirements Section 1 LED Luminaires.</td>
</tr>
<tr>
<td>IS 16104</td>
<td>2012 - d.c. or a.c. Supplied Electronic Control Gear for LED Modules - Performance Requirements</td>
</tr>
<tr>
<td>EN 61547</td>
<td>Immunity to interference</td>
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<tr>
<td>EN 60928 / IEC 928 / IS 13021 (Part I)</td>
<td>Safety</td>
</tr>
<tr>
<td>EN 60929 / IEC 929 / IS 13021 (Part II)</td>
<td>Performance</td>
</tr>
<tr>
<td>IEC 68-2-6 FC / IEC 9001</td>
<td>Vibrations &amp; Bump tests</td>
</tr>
<tr>
<td>ISO 14001</td>
<td>Environmental Standard</td>
</tr>
<tr>
<td>EN 55015 &amp; EN 55022</td>
<td>RFI Compliance</td>
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<tr>
<td>EN 6 1000-3-2</td>
<td>Harmonics</td>
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<tr>
<td>CISPR-15</td>
<td>EMI Compliance</td>
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<tr>
<td>EN 61000-3-2</td>
<td>Current waveform</td>
</tr>
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</table>
2.0 SCOPE OF WORK

2.1 The scope of works broadly covered as under:-

i) Design, supply, installation, testing & commissioning (DSITC) of G.I. octagonal poles with single/ double arm decorative bracket, foundations, and LED street light fixtures.

ii) DSITC of high mast including provision of feeder pillar as control panel for high mast, foundation, LED flood light fixtures, lantern carriage, LED Aviation obstruction lights, etc.

iii) DSITC of feeder pillars, earth pit, cabling, earthing etc. as may be required to extend power to street light, carpark, high mast control panel, etc.

iv) Supply and laying of HDPE pipe along with the progress of other work in WBM/ excavated soil, etc. as per site conditions. Cable laying in ground can be done to comply specifications for laying of cables.

v) Supply and making end terminations with double compression gland etc.

vi) If high mast light to use only for security, 50% light can only be put ON. Therefore, circuitry shall be made accordingly w.r.t. its control panel.

vii) NOC for high mast of selected height to be obtained by the EPC contractor. All required assistance will be provided by AAI.

2.2 Lux level requirement:

a) **Main approach upto terminal building & carpark** - to be designed to achieve average 40 lux (Av) and for service / internal roads areas to achieve 20 lux average.

b) **Apron lighting** is the necessary part of modern airports lighting. The good apron lighting considerably facilitates the apron manoeuvrings for aircraft pilots. It also increased safety and speed of manoeuvrings, the quality of maintenance by comfortable vision conditions for attending personnel. All of these are the important factors for fail-safety and reliable flight service. The primary functions of apron lighting are:

• to assist the pilot to taxi his aircraft into and out of the final parking position;
• to provide lighting suitable for embarkation and debarkation of passengers, loading and unloading cargo, refuelling and performing other apron service function;
• maintain airport security.

The pilot mainly relies on apron lighting when taxiing on the apron. Uniform luminance of the pavement within the aircraft stand area (parking place) and glare restriction are the major requirements. It is necessary to obtain the following ICAO recommendations:

• An average horizontal illumination should be not less than 20 lx for aircraft stands. The uniformity ratio (average illuminance to minimum) should be not more than 1:4.

  Average vertical luminance at a height of 2 meters should be not less than 20 lx in relevant directions;

• in order to maintain acceptable visibility conditions the average horizontal illumination on the apron, except where service functions are taking place, should not be less than 50 % of the average horizontal illuminance of the aircraft stands, within a uniformity ratio of 1:4 (average to minimum). The area between the aircraft stands and the apron limit (service equipment, parking area, service roads) should be illuminated to an average horizontal illumination of 10 lx.
A STREET LIGHTING WORK
3.0 STREET LIGHT POLES & BRACKETS

3.1 CONSTRUCTION

The octagonal pole shall be supplied with single/double bracket of required height to achieve lux level as per system design.

The pole supplier/ manufacturing & galvanizing unit shall be ISO 9001:2000 certified & preparedly ISO 14001 certified to ensure consistent quality & environmental protection.

The octagonal pole shall be designed to withstand the max. wind speed not less than 47m/sec. The max stress at wind speed of 47 m/sec. shall not exceed 80% of the strength of steel. The details of top loading – i.e. weight and area of luminaries are to be worked out based on this consideration. Maximum deflection of the pole shall meet the requirement of BS 5649: Part 6 1982 with up to date amendments.

The pole shaft shall have octagonal cross section and shall continuously taper with aesthetically pleasing appearance. The poles shall be manufactured in single piece construction (except for spigot) from 3mm thick high tensile steel sheet. The top and bottom dia (A/F) shall be minimum of 70mm & 130 mm respectively. The pole shaft shall be continuously tapered with single longitudinal welding. There shall not be any circumferential welding.

The steel used in the manufacturing of the pole shaft, base flange etc. shall be suitable for such type of poles.

The pole shall be hot dip galvanized after fabrication, internally and externally in accordance with IS-2629/BS-729 or equivalent standards. The average coating thickness of galvanization shall not less than 65 micron. Hot dip galvanizing shall be done in single dip operation.

A rigid flange plate of suitable thickness with provision for fixing 4 nos. of foundation bolts shall be provided. The base plate shall be fillet welded to the pole shaft at two locations i.e. from inside and outside.

The octagonal pole shall be provided with a door flush with the pole surface without any projection with special locking arrangement. Door opening shall be approx. 300 to 500 mm long for the smooth termination of incoming and outgoing cables. There shall be provision inside the pole to accommodate a Bakelite terminal plate. Required door reinforcement shall be provided to compensate for loss in section. Required door reinforcement shall be provided to compensate for loss in section. There shall be provision inside the pole to accommodate a Bakelite terminal plate. The terminal plate shall have provision for 4 way, 40 A terminal studs with insulated cap (suitable for loop in loop out connections to a minimum three armored cables of size up to 4 core 16 sq.mm) and 1 no. 6-10 Amp DP MCB for ON/OFF operation of the each luminarie. Suitable earth stud(s) shall be provided for earthing the poles.

Two sets of tool kit shall be supplied within the quoted cost of octagonal poles. The tool kit set shall consist of Ellenkey-6 nos., spanner suitable for foundation bolt-2 nos., screw driver-2 nos. and any other tool recommended by the manufacturer.

Octagonal Pole shall be of flanged type to be fixed on the Foundation Bolts. Material of steel foundation bolts shall confirm to Gr. 6.8 as per IS 1367. Exposed portion of foundation bolts shall be hot dip galvanized.

3.2 POLE BRACKETS (for octagonal pole)

The bracket shall be decorative and suitable for installation of LED light fixture(s). The design of the decorative bracket(s) shall be submitted and got approved by Engineer In Charge. The brackets shall have a suitable tilt angle and shall be galvanized internally and externally by hot dip galvanizing process.
The octagonal poles and brackets should be from same manufacturer to ensure proper matching and alignment of the pole and bracket.

4.0 INSTALLATION OF STREET LIGHT POLES

4.1 Foundation

a) Design & Approval:

The foundation shall be designed to withstand the wind velocity (not less than 47m/ sec) and maintaining the maximum deflection of the pole as specified with bracket & fixtures within limits of specified standard. The successful tenderer has to submit the design calculation & foundation drawing duly vetted / certified by recognized Govt. engineering college viz. IIT/NIT etc or by approved structural consultant of Department for approval of Engineer-in-charge before casting the foundation.

b) Casting of Foundation:

Reinforced cement concrete (RCC) foundation of M 25 grade shall be casted as per design and approved drawing. The curing shall be done for two weeks before loading the pole. The foundation shall project above ground by 200mm which shall be neatly finished with sand cement plaster.

c) Cable Guard pipe:

50mm (OD) ISI marked HDPE pipe as required shall be laid for of loop-in loop-out cables in concrete foundation for easy laying & relaying of cable without any change to the RCC foundation work. The end of the pipe shall be sealed after cable is laid & tested. Only one pipe will used for laying of a single cable.

4.2 Installation of Pole

- The octagonal poles shall be installed in a workman like manner so that it is levelled, properly aligned and oriented.
- Care shall be taken in handling the octagonal pole to avoid any distortion to the supporting structure or damage to the delicate instruments & electrical parts.
- After erection of pole, bracket and all accessories, the pole should be numbered as per the direction of Engineer-in-charge and the exposed portion of concrete foundation shall be painted. The cost of the same is deemed to be included within the quoted cost.

5.0 WIRING TO LIGHT FIXTURES

Each street light fixture shall be wired from DP MCB provided on loop-in-loop-out box of pole by means of a separate flexible unarmored 3core,2.5 sq mm, copper conductor, PVC insulated cable.

B APRON & CAR PARK LIGHTING WORK

6.0 SPECIFICATION FOR HIGHMAST

6.1 The design of the high mast and its foundation shall take into account seismic activity at proposed Airport site and also the Basic wind speed of 47 mtr/sec as per clause 5.2 of IS:875 (Part-3) 1987 with up to date amendment. The following or their corresponding equivalent reference standards for the loading of high mast shall be applicable:

<table>
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<tbody>
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<tr>
<td>BS-EN 10025/ DIN 17100</td>
<td>Material of construction/Grade of MS Plate</td>
</tr>
<tr>
<td>IS 1461 / IS 4759 / IS-2629 / BS 729</td>
<td>Galvanising / hot dip Galvanizing standard</td>
</tr>
</tbody>
</table>
6.2 Illumination requirement

A general illumination level of 20 lux in the car park area is desired. The contractor shall submit his drawing showing the luminaire fixing arrangement, tilt angle etc. on the high mast and illumination level achieved with such arrangement and obtain approval of Engineer-in-Charge before proceeding with the luminaire fixing work. The flood lightings are to be designed with an overall maintenance factor of 0.85 and after taking into account all the factors and obstructions in the area.

6.3 Obstruction lights

Flood light high mast tower shall be provided with two numbers of LED aviation obstructions light fitting and it shall meet the test specification as per ICAO Aerodrome Manual, Anexxure-14, chapter 6, Table 6.3 for low intensity Type B along with the all mounting accessories for installation of fixture on TOP of Flood light high mast tower.

6.4 Flood lighting Mast

The mast shall be designed for 25 years long life. The tenderer should design the flood lighting system considering location of mast only.

6.5 Mast structure

The mast shall be continuously tapered and of polygonal cross section with a raising / lowering luminaries' carriage on top presenting good visual appearance. Provision shall be made for lightning arrester. The structure shall be suitable for wind loadings as per IS 875 part-3 1987.

6.6 Dynamic Loading

Mast shall be designed for maximum reaction arising as a result of dynamic analysis as per relevant IS codes. The design shall be such that wind excited oscillation shall be damped as much as possible and an adequate allowance shall be made to resist stresses due to these oscillations. The tenderer shall indicate the method of dampening. On award of work, the tenderer shall furnish full calculations of the forces involved for approval. In case design is done with the help of computer, all input data, design assumptions, forces inducted in each member shall be submitted including the results.

6.7 Mast Construction

The High mast manufacturing & galvanizing unit shall be ISO 9001:2000 certified & preferably ISO 14001 certified to ensure consistent quality & environmental protection.

The mast shall be continuously tapered, constructed from steel plates/ sheets, cut and folded for polygonal section and telescopically jointed and fillet welded except the site joints which are to be push fit type. The steel used in construction of the masts shall comply with BS: 4360-50C/43C, IS 226-1975/ IS: 2062-80 of appropriate grade. Welding shall be in accordance with BS: 3135/5135/IS: 9595-80.

The mast shall be delivered in two / three sections (maximum) in respect of 20M / 25 M high mast as per design and to be assembled at site by slip stress fit method. The top and bottom dia of the mast shall be not less than 150mm & 450mm A/F respectively (or as per design calculations for service life of 25 years). There shall not be any site welding or bolted joint in the mast. The entire mast shall be hot dip galvanized internally and externally having uniform thickness of galvanization thickness of minimum 65 microns. Prior to the dispatch each joint shall be tested in work shop.

To enable clear access to the winch and other electrical equipment, inside the high mast, a vandal resistant weather proof door opening has to be provided in the mast base, with a
secured heavy duty lock. The lock should not be easily accessible and special arrangements are to be made to open the door for undertaking break down/ maintenance. This opening has to be adequately reinforced with welded steel section, thereby restoring the section modules and preventing trickle.

The distance between the flange of mast and the bottom of the door is to be kept twice the width of the door. Mounting plate or brackets shall be installed within the mast to support the winch and the mast electrical equipment.

A 12mm dia. stainless steel stud should be attached to the main body of the mast structure, at a readily accessible position in the base compartment to provide lightning and cable earth points, with adequate hardware for separate connections to the earthing strip from the lightning conductor to the nearest earth station.

6.8 Lantern Carriages
A fabricated Lantern Carriage shall be provided for fixing and holding the flood light fittings and control gear boxes with stainless steel nuts, bolts & spring washers. The Lantern Carriage shall be of special design and shall be of steel tube construction, the tubes acting as conduits for wires, with holes fully protected by grummets as per IS 4923. The Lantern Carriage shall be so designed and fabricated to hold the required number of flood light fittings and the control gear boxes, and also have a perfect self balance. The lantern carriage shall be fabricated in two halves and joined by bolted flanges with SS bolts and nylock type SS nuts to enable easy removal from the erected mast for replacement/ maintenance purpose. The carriage shall be supported by two wire ropes from winch for better stability thereby minimising the joints to enable smooth operation. The lantern carriage assembly shall not touch the lower surface of the Mast. The carriage design and fabrication shall be such that the lantern carriage will suit the lanterns and their control gear boxes to be used in the work. The inner lining of the carriage shall be provided with protective PVC arrangement, so that no damage is caused to the surface of the mast during the raising and lowering operation of the carriage. The complete Lantern Carriage shall be hot dip galvanised after fabrication. The weather proof cast aluminium/MS junction box (IP-55) shall be provided on the Lantern Carriage assembly from which the inter - connections will be made to the designed number of floodlight fittings and lanterns on the carriage.

6.9 Foundations
Concrete foundation required for the mast shall be designed as per IS: 875 (Part-3) -1987/ IS: 456/78 / IS: 4091-79 and with due consideration to the seismic activities in the proposed airport and cost of the same shall be included in the rate for the design, manufacture, supply, installation, testing and commissioning of high mast lighting. Foundation shall be designed for safe bearing capacity of 10.0 tones per sq.mtr available at a depth of 2 m below ground level with M25 grade concrete. Footing can be taken deeper if required from structural considerations.

The foundation design of high mast structure shall be certified / vetted by a recognized Govt. Engineering College viz. IIT / NIT etc. or by a reputed structural consultant of AAI and submitted for approval. The cost for the same shall be borne by the contractor. The mast foundation column shall be 300mm above finish surface ground level. Nothing extra shall be paid on this account.

6.10 Metal Protection
All components & accessories used in mast shall be hot dipped, galvanized internally and externally in accordance with BS: 729/ IS: 4736-68 / IS: 4759- 79/ IS: 5358-69/ IS: 4848-79.

6.11 Mechanical Arrangements
The mast shall have the facility to raise or lower the lantern carriage, at the top, for the ease of installation and maintenance. A winch located at the base of the mast, along with stainless
steel wire rope(s), is used for the purpose. The steel wire rope supporting/holding the lantern carriage is in tension at all times.

The raising and lowering system is to be robust arrangements, requiring little or no maintenance at the mast head and is to absolutely safe in operation. The system should have minimum number of moving parts and, to have least chance of parts failure.

6.12 Pulley Arrangements (TOP)

The pulley shall be of large diameter appropriate to the multicore flexible cable being used. They shall be of non-corrodible material and shall run on self lubricated bearings or gun metal bearings. Arrangements shall be provided to ensure that the electric cables and steel wire ropes are separated before passing over their respective pulleys and close fittings guides shall protect the pulleys to prevent ropes and cables leaving the pulley grooves. The axles of the pulley are made out of appropriate grade of stainless steel and are of suitable diameter, retained by stainless steel split pins and washers. Separate ways are made internally for each wire rope and the cable. Externally a divider is fitted to separate ropes and cables, to avoid the possibility of over-wrapping of the same during wind conditions and the carriage in the lowered conditions. Each pulley is to be protected by four close fittings sides. The cover is to be secured by a single stainless steel captive bolt and is holed to receive the safety rope.

6.13 Winch

The winch has to perform the following duties:
- Raising and lowering the luminaries carriage.
- Supporting the luminaries carriage in the raised position.
- Raising and lowering the maintenance carriage and equipment.

The winch has to be designed for an estimate operating life of 25 years, with the due allowances for the reduction in section as a result of wear and possible corrosion during the operating life.

The termination of the winch ropes shall not involve distortion of the rope structure. Also in the case of double drum the layout of the drum is spatial (two separate independently drum for anchored ropes), thereby ensuring no inter-winding of the lifting ropes. Four turns of the rope remain on the drum with the carriage in fully lowered position.

The winch is to be self sustaining type without the need of brakes or clutches. The winch shall be provided with permanent oil bath where from the winch will be self lubricated and required no attention in service other than recharging of the lubricant at intervals. The type of Lubricant shall be of SAE 90/140 grade.

The winch is to be provided with a positive locking device which remains in ENGAGED condition to prevent rotation in the lower direction when the mast is in service. Raising and lowering arrangements shall be by inbuilt motorized system with all latest safety.

6.14 Steel wire Ropes

The mast is to be fitted with 6mm diameter flexible stranded stainless steel wire ropes (7/19 construction) with central core of grade AISI:316 with a factor of safety of more than 5-10 times the safe working load of the winch. Single wire rope without any joints to be used from lantern carriage to winch.

6.15 Lightening Finial

One number heavy duty hot dip galvanized lightening finial shall be provided for each mast. The lightening finial shall be minimum 1.2 M in length and shall be provided at the center of the head frame. It shall be bolted solidly to the head frame to get a direct conducting path to the
earth through the mast. The lightning finial shall not be provided on the lantern carriage under any circumstances in view of safety of the system.

6.16 **High mast Luminaires**
Luminaires shall be supplied in accordance with design / selection and as per detailed scope of work.
All light luminaries and the associated control gear shall be rated for operation at 230V, 50 Hz. A.C. supply unless otherwise specified in this specification.

6.17 **Trailing cable & Connections**
The mast is to be provided with suitable size tinned copper conductor EPR insulated and PCP sheathed flexible multi core trailing cable. The flexible cable is to be secured to the lantern carriage by means of clamp. The size and cores shall be selected as per load requirement. The Terminal blocks shall be suitable for 45 A at 600 Volts.
The system should have in-built facilities for testing the luminaries while in lowered position. Also, suitable provision shall be made at the base compartment of the mast to facilitate the operation of internally mounted, electrically operated power tool for raising and lowering of the lantern carriage assembly. The trailing cables of the lantern carriage rings shall be terminated by means of specially designed, metal clad, multi pin plug and socket provided in the base compartment to enable easy disconnection when required.

6.18 **Power Tool for the winch**

A suitable, high-powered, electrically driven, integral internally mounted power tool, with manual over ride, shall be supplied for the raising and lowering of the lantern carriage for maintenance purposes. The speed of the power tool shall be preferably of slow speed, of 1.5 mtr/minute to avoid vibration. The power tool shall be single speed, provided with a motor of the required rating. Push button control for the motor shall be provided. The capacity and speed of the electric motor used in the power tool shall be suitable for the lifting of the design load installed on the lantern carriage. A handle for manual operation shall also be provided. Each mast shall have its own individual power tool.

There shall be a separate torque-limiting device to protect the wire ropes from over stretching. It shall be mechanical with suitable load adjusting device. The torque limiter shall trip the load when it exceeds the adjusted limits. There shall be suitable provision for warning the operator once the load tripped off.

7.0 **LUMINAIRES & LIGHT SOURCES FOR STREET LIGHT & HIGH MAST**

LED Luminaire shall be supplied in accordance with below specifications and rated wattage as required:

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>a)</td>
<td>System efficacy</td>
<td>≥ 100 lm/W.</td>
</tr>
<tr>
<td>b)</td>
<td>Housing</td>
<td>Pressure Die Cast Aluminium, IP66.</td>
</tr>
<tr>
<td>c)</td>
<td>Optics</td>
<td>PC lenses with Toughened Glass protector with min. IK08 (impact resistance) rating.</td>
</tr>
<tr>
<td>d)</td>
<td>Operating CCT &amp; CRI shall be</td>
<td>5700K +/- 300 with CRI of ≥70.</td>
</tr>
<tr>
<td>e)</td>
<td>THD</td>
<td>≤ 10% &amp; PF ≥ 0.95</td>
</tr>
<tr>
<td>f)</td>
<td>Driver with input voltage range</td>
<td>140 to 270V,</td>
</tr>
<tr>
<td></td>
<td></td>
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<tr>
<td>---</td>
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<td></td>
</tr>
<tr>
<td><strong>g)</strong></td>
<td><strong>Life - LED Light fixtures</strong> : 50,000 Hrs with L70 Criteria. Luminaire shall Auto Cut off at Low and High Voltage and will resume normal work once voltage in 140 to 270V. Luminaire should also be capable of 440V withstand for 8 hours.</td>
<td></td>
</tr>
<tr>
<td><strong>h)</strong></td>
<td><strong>LED Type</strong> : SMD</td>
<td></td>
</tr>
<tr>
<td><strong>i)</strong></td>
<td><strong>Inbuilt surge protection with Luminaire</strong> : 4KV (min).</td>
<td></td>
</tr>
<tr>
<td><strong>j)</strong></td>
<td><strong>Company Logo</strong> : Emboss / Printed</td>
<td></td>
</tr>
<tr>
<td><strong>k)</strong></td>
<td><strong>SDCM</strong> : &lt; 5</td>
<td></td>
</tr>
<tr>
<td><strong>l)</strong></td>
<td><strong>Driver</strong> : Potted complying Class B serviceability</td>
<td></td>
</tr>
</tbody>
</table>

**NOTE** :

i) The luminaire shall be with following certifications: LM79 from NABL accredited Lab; & LM80 issued by LED manufacture along with Photo Biological Safety Standard.

ii) The luminaire shall be with BIS Registered

### 8.0 SPECIFICATION FOR FEEDER PILLAR

i) The feeder pillar shall be provided as system design requirement for street lighting control and/or for looping / extension of power supply required in the outdoor areas etc. The feeder pillar for high mast shall be provided by high mast supplier as a part of high mast light control panel scope of works for their system design requirement. **Street light as well as high mast light operation shall be provided with auto ON/OFF control with timer.**

ii) The enclosure shall be fabricated out of at least 2mm thickness CRCA sheet for all load bearing parts and rest may be 1.6mm, finished with 2 coats of red oxide primer and grey enamel paint or powder coated as approved by Engineer In charge. Feeder pillar shall be free standing type suitable for outdoor installation in dust, vermin and weather proof construction.

iii) Hinged door(s) of the same material shall be provided on the front and rear side(s) with necessary handles and inbuilt locks with double keys. Neoprene rubber gasket shall be provided for the doors.

iv) Suitable MS top cover of 2mm thick with suitable glands/overhang shall be provided for protection against rain/weather etc.

v) Detachable gland plates shall be provided at the bottom with compression type cable glands to the sizes as required. Adequate space should be provided below the same for safe bending and termination of cables.

vi) The enclosures shall be provided with ventilation louver covered with wire mesh, lifting hooks, supporting legs and double earth terminals with double washers.

vii) The feeder pillar shall be provided M S angle base frame stand fabricated out of 35 x35 x6 mm angle (legs of stand 500 mm above ground and 300mm below grouted with cement concrete mortar ( min). Feeder Pillar shall be suitable for continuous operation on 415V three phase, four wire, 50Hz, AC power supply. The type, rating etc of protection switch gear forming part of the feeder pillar assembly shall be followed as per system requirement and as described in LT panel specification section.

**Note**:
a. In the case of feeder pillars whose width may not exceed 600mm, single leafed doors may be permitted both on the front and rear side.
b. If the depth is less than 300mm, then no need of providing any door on rear sides.

9.0 Lux Level Measurement

Before taking up the work, the contractor shall furnish the typical lux level calculation sheet for the given fixtures, lamp wattage, pole height & bracket with tilt angle etc to achieve the desired lux level. The grid layout between pole to pole shall be with 10 points & 6 points of grid in longitudinal & transverse sections respectively to achieve desired lux level. Similarly for carpark & apron areas, the typical lux level calculation sheet shall be submitted with a standard grid.

On completion of work, contractor shall demonstrate & furnish the same as final lux level of typical areas and submitted for acceptance of Engineer in charge.

10.0 Pre Commissioning and Commissioning Test of Street light & High mast Lighting.

a) Check erection and alignment of poles, bracket and fixtures.
b) Incoming and outgoing cables are brought with ample clearance.
c) Terminal plate is tightly held to pole / mast etc.
d) Terminal connections of incoming and outgoing wires / cables are O.K.
e) Insulation Resistance of incoming and outgoing cable and wire going to fixtures etc.
f) Pole / mast junction box covers are water tight and lockable.
g) Foundations are firm.
h) Electrical load balancing is properly carried out and readings to be taken and submitted.
i) Taking lux level reading of typical areas & its submission.

j) Numbering of poles / masts and proper nomenclature on MV panels, feeder pillars indicating incoming and outgoing, etc.

VI - RACEWAY & PVC TRUNKING

1.0 GENERAL:

This section covers the detailed requirement of provision of Pre-Galvanized metal sheet raceways with junction boxes / cross over junction boxes etc with material specification conforming to IS 277 and provision of PVC trunking with junction boxes / cross over confirm to BS EN 50085-1:1999 & BS EN 61386-1:2004 for distributing data, power and communication cables as per site condition.

All safety standards shall be followed for separations of compartment for under raceway as well as for PVC trunking and their accessories.

2.0 SCOPE OF WORKS

The scope of works broadly covers the following:

a) Design, supply and installation of under floor raceway with junction boxes / cross over junction boxes, jointing sleeve / bracket complete. The junction boxes & raceway to be selected suitable load capacity as required. The junction boxes should have adjustable height with a minimum height of 45 mm.
b) The raceway to be laid for drawing power and control circuit wiring / cabling separately as per design requirement having compartment 1/2/3 along with progress of civil flooring.
works. The raceways shall be fabricated out of pre-galvanized sheet steel with 1.6 mm thickness

c) The raceway shall be considered in floor for – terminal building and DVOR building.

d) On award of works, contractor has to develop the raceway layout for terminal building to extend power as well as control circuit wiring / cabling with separate raceways so that wiring/ cabling can be extended easily from switch room/ equipment room power/ data source for all floor/ column and for equipments / fixtures in the terminal building areas.

e) Therefore, PVC trunking layout is to be works out for extending data, power & communication cables within the equipment room as per site conditions. PVC trunking should have pre-punched bases, inbuilt dividers with knockouts for wiring to make it more installation friendly. PVC trunking to be provided with 1/2/3 compartments as per site conditions. The required switch, socket etc shall be of same make and model to suit for installation in PVC trunking.

f) The Stainless steel grade-304 cover plate with chamfering the edges is to be provided over the raceway junction boxes in terminal building areas. In all other areas, the GI cover supplied along with the boxes shall be remaining as final cover to be finishes with floor.

3.0 MAKE: MK (Honeywell) / Legrand

4.0 Contractor shall submit the sample along with technical data sheet and test certificate suitable for load bearing capacity to withstand the site condition for approval of Engineer –in–charge before procurement.

*****
VII - LIGHT FIXTURES, FANS, DB PANEL & FEEDER PILLARS, ETC & ITS ATTACHMENTS

A) LIGHT FIXTURES

i) LED type light fittings shall be used for illumination to achieve the desired Lux level as per the below mentioned Technical Parameters.

Soft Copy of Catalogues, Polar Diagrams, Cone Diagrams, IES Files. Test Certificates - relevant LM 79 from NABL, LM80-TM21, IEC 60598, LM 80 test certificates of the luminaries submission is mandatory.

Fixtures to BIS certified with registered R number

ii) Technical Parameters of General LED Light Fixtures

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Technical Parameters</th>
<th>Recommended requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>System Efficiency (of fixture)</td>
<td>&gt;=100 lm/w for following areas with mentioned Sno under (For Terminal Building - 1,2,3,5,6,7, 8,9,11,12,13,14,17,18,19,20,21,22,25,30) (For - ATC Building 1,2,3 &amp; 4) &gt;140 lm/w for high bay fixture (For Terminal Building - 10,15 &amp; 16)</td>
</tr>
<tr>
<td>2.</td>
<td>System life @ L70</td>
<td>50,000 hours, OEM to give undertaking</td>
</tr>
<tr>
<td>3.</td>
<td>CRI</td>
<td>Min. 80 for indoor and min. 70 for outdoor application &amp; highbay</td>
</tr>
<tr>
<td>4.</td>
<td>THD</td>
<td>Less than 10%</td>
</tr>
<tr>
<td>5.</td>
<td>Type of Housing</td>
<td>Extruded aluminium/Standard alloy housing/CRCA for indoor Applications.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Pressure die cast aluminium/Standard Alloy for Double Height area fixture.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>High Pressure die cast for Street light/ Flood Light.</td>
</tr>
<tr>
<td>6.</td>
<td>IP Category</td>
<td>IP 20 for indoor &amp; IP 65 or higher for outdoor.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>IP 65 for High bay Fixture.</td>
</tr>
<tr>
<td>7.</td>
<td>Surge Protection</td>
<td>Min. 2Kv for Indoor and 4 KV for outdoor &amp; high bay fixtures. If higher rating is required, shall be workout and provided separately. In built driver : EN61000 - 4 – 5 For additional surge IEC 61643-II Class-2 &amp; EN 61643 –II Type -2).</td>
</tr>
<tr>
<td>8.</td>
<td>Labelling/Identification Mark</td>
<td>Manufactures Name / Logo engraved / Embossed on housing / body or Name / Logo on aluminium plate Labels or Name / Logo printed on housing / body.</td>
</tr>
</tbody>
</table>
9. **Warranty Period**  
5 years warranty from actual date of completion of work on complete luminaire including driver / control gear, LED, all accessories etc.

10. **Power Factor**  
Equal to 0.9 or more.

11. **Total Power Consumption**  
Not more than 110% of rated capacity of LED Light.

12. **CCT**  
5700-6500K or 4000K for indoor light fixtures as per Architect approval

13. **Mirror Ops. Or diffused**  
- PMMA Diffused / Polycarbonate / Poly Styrene
- Toughened Glass/Flat Glass for street Light & Flood Light

14. **Type of driver & its serviceability**  
Non-potted for indoor and potted for outdoor; complying serviceability class-B

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**Special Architectural Outdoor Luminaires (For Terminal Building Sl.nos: 4,23,24,26,27,28 & 29)**

Soft Copy IES Files along with Link of the official web page of Luminaries submission is mandatory.

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Technical Parameters</th>
<th>Recommended requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>System life @ L70</td>
<td>50,000 hours, OEM to give undertaking</td>
</tr>
<tr>
<td>2.</td>
<td>CRI</td>
<td>Min. 70 for outdoor application.</td>
</tr>
<tr>
<td>3.</td>
<td>THD</td>
<td>Less than 20%</td>
</tr>
</tbody>
</table>
| 4.    | Type of Housing           | - Extruded aluminium/Standard alloy housing/CRCA for indoor Applications.  
                             | - Pressure die cast aluminium/Standard Alloy for Double Height area fixture.  
                             | - High Pressure die cast for Street light/ Flood Light.               |
| 5.    | IP Category               | - IP 20 for indoor & IP 65 or higher for outdoor.  
                             | - IP 65 for High bay Fixture.                                   |
| 6.    | Surge Protection          | - 4 KV for outdoor & high bay fixtures. If higher rating is required, shall be workout and provided separately.  
                             | In built driver : EN61000 - 4 – 5  
                             | For additional surge IEC 61643-II Class-2 & EN 61643 –II Type -2). |
| 7.    | Labelling/Identification Mark | Manufactures Name / Logo engraved / Embossed on housing / body or Name / Logo on aluminium plate Labels or Name / Logo printed on housing / body. |
| 8.    | Warranty Period           | 5 years warranty from actual date of completion of work on complete luminaire including driver / control gear, LED, all accessories etc. |
| 9.    | Power Factor              | Equal to 0.9 or more.                                         |
| 10.   | CCT                       | 5700-6500K or 4000K for outdoor monocolor light fixtures.  
                             | RGB for direct view façade luminaires & RGBW for Façade floodlights as per Architect approval |
11. **Type of driver & its serviceability** | Potted for outdoor; complying serviceability class-B

**Special Architectural Indoor Luminaires** *(For Terminal Building Sl. Nos:31,32,33,34 & 35)*

Soft Copy IES Files along with Link of the official web page of Luminaries submission is mandatory.

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Technical Parameters</th>
<th>Recommended requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>System life @ L70</td>
<td>50,000 hours, OEM to give undertaking</td>
</tr>
<tr>
<td>2.</td>
<td>CRI</td>
<td>Min. 80 for Indoor application.</td>
</tr>
<tr>
<td>3.</td>
<td>THD</td>
<td>Less than 10%</td>
</tr>
<tr>
<td>4.</td>
<td>Type of Housing</td>
<td>Extruded aluminium/Standard alloy housing/CRCA for indoor Applications.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Pressure die cast aluminium/Standard Alloy for Double Height area fixture.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>High Pressure die cast for Street light/ Flood Light.</td>
</tr>
<tr>
<td>5.</td>
<td>IP Category</td>
<td>IP 20 for indoor &amp; IP 65 or higher for outdoor.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>IP 65 for High bay Fixture.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>In built driver : EN61000 - 4 – 5</td>
</tr>
<tr>
<td></td>
<td></td>
<td>For additional surge IEC 61643-II Class-2 &amp; EN 61643 –II Type -2).</td>
</tr>
<tr>
<td>7.</td>
<td>Labelling/Identification Mark</td>
<td>Manufactures Name / Logo engraved / Embossed on housing / body or Name / Logo on aluminium plate Labels or Name / Logo printed on housing / body.</td>
</tr>
<tr>
<td>8.</td>
<td>Warranty Period</td>
<td>5 years warranty from actual date of completion of work on complete luminaire including driver / control gear, LED, all accessories etc.</td>
</tr>
<tr>
<td>9.</td>
<td>Power Factor</td>
<td>Equal to 0.9 or more.</td>
</tr>
<tr>
<td>10.</td>
<td>CCT</td>
<td>3000K or 4000K as per Architect approval</td>
</tr>
<tr>
<td>11.</td>
<td>Type of driver &amp; its serviceability</td>
<td>Non-potted for indoor ; complying serviceability class-B</td>
</tr>
</tbody>
</table>
NOTE:–
Bidder shall comply the following note and submit while submission of technical submittal of fixtures for approval of the AAI:-

a) The manufacture of fixture shall submit the undertaking for use of approved make LED in their fixtures.
b) Output voltage ripple factor to be <5% as per IEEE Std. 1789-2015 to avoid stroboscopic effect wherever mentioned.
c) Luminaire shall be supplied with LM80 from source manufacture along with authorization certificate & LM79 report from third party / NABL / UL approved lab.
d) Luminaire & driver both shall be BIS certified.
e) Minimum Impact Factor (IK07) should be taken for street light & Highbay.
f) Minimum Impact Factor (IK07) should be taken for Floodlights.
g) Minimum Impact Factor (IK10) should be taken for Bollards.

iii) Area wise similar type light fixtures shall be as follows:

**ATC Building:**

<table>
<thead>
<tr>
<th>Sno</th>
<th>Location</th>
<th>Fixture Type</th>
<th>Cat no.</th>
<th>Lux &amp; Uniformity</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>ATC Building</td>
<td>Linear recessed fixture - mirror /diffused optics with UGR&lt;19 &amp; Ripple &lt;5%</td>
<td>Philips Pureline 4 feet Trilux LCL 1200 OTA Wipro Axeon</td>
<td>300 &amp; 0.4</td>
</tr>
<tr>
<td></td>
<td>Office areas - Plank ceiling</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>ATC Toilet</td>
<td>Recessed General downlighter</td>
<td>Philips Greenperform Trilux Ambiella Plus Wipro Hollis</td>
<td>200 &amp; 0.4</td>
</tr>
<tr>
<td>3</td>
<td>ATC Utility areas</td>
<td>Surface mounted batten</td>
<td>Philips WT201 Wipro Capsule LED Keselec KASML</td>
<td>200 &amp; 0.4</td>
</tr>
<tr>
<td>4</td>
<td>ATC Building</td>
<td>Surface/Suspended downlighter Ripple &lt;5%</td>
<td>Trilux ADRASTIA D/H Wipro Hollis Philips Surface</td>
<td>300 &amp; 0.4</td>
</tr>
<tr>
<td></td>
<td>Office areas - Open cell ceiling</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sno</td>
<td>Location</td>
<td>Fixture Type</td>
<td>Cat no.</td>
<td>Lux &amp; Uniformity</td>
</tr>
<tr>
<td>-----</td>
<td>-------------------------</td>
<td>---------------------------------------</td>
<td>------------------------------------------------------------------------</td>
<td>------------------</td>
</tr>
<tr>
<td>1</td>
<td>Level 1 &amp; level 2</td>
<td>Recessed General downlighter</td>
<td>Philips Greenperform, Trilux Ambiella Plus, Wipro Hollis</td>
<td>200 &amp; 0.4</td>
</tr>
<tr>
<td></td>
<td>General corridors / Toilets</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Level 1 Departure Lounge</td>
<td>Recessed Architectural downlight with UGR &lt;19</td>
<td>Philips Luxspace, Trilux SONNOS, Iguzzini Reflex/Easy, Flos Spot</td>
<td>200 &amp; 0.4</td>
</tr>
<tr>
<td></td>
<td>Arrival Lounge</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Passage / transit</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Level 2 Departure Lounge</td>
<td>Recessed Architectural downlight with UGR &lt;19</td>
<td>Philips Luxspace, Trilux SONNOS, Iguzzini Reflex/easy, Flos Spot</td>
<td>200 &amp; 0.4</td>
</tr>
<tr>
<td></td>
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<tr>
<td>4</td>
<td>Multiple Beam floodlight</td>
<td>Surface mounted architectural floodlight with spot, flood and medium beam</td>
<td>Philips EW Blast, Flos Spock, Lumenpulse projector</td>
<td>400 Lux at 5 meter with 20 degree beam</td>
</tr>
<tr>
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</tr>
<tr>
<td>5</td>
<td>Service areas</td>
<td>Surface mounted batten</td>
<td>Philips WT201, Wipro Capsule LED, Keselec KASML</td>
<td>200 &amp; 0.4</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Parking Area</td>
<td>Surface mounted batten</td>
<td>Philips WT201, Wipro Capsule LED, Keselec KASML</td>
<td>200 &amp; 0.4 Uniformity - Min/Max 0.33 Min/Avg 0.4</td>
</tr>
<tr>
<td></td>
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</tr>
<tr>
<td>7</td>
<td>Level 1 Departure Lounge</td>
<td>Suspended Boat Shaped luminaire as per architects guideline (6.7 mtrs) with UGR &lt;19</td>
<td>Philips Boat with Luxspace, Wipro Boat with LD56</td>
<td>200 &amp; 0.4</td>
</tr>
<tr>
<td></td>
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<td></td>
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</tr>
<tr>
<td>8</td>
<td>Level 2 Departure Lounge</td>
<td>Suspended Boat Shaped luminaire as per architects guideline (9 mtrs) with UGR &lt;19</td>
<td>Philips Boat with Luxspace, Wipro Boat with LD56</td>
<td>200 &amp; 0.4</td>
</tr>
<tr>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>Level 2 Departure Lounge</td>
<td>Suspended Boat Shaped luminaire as per architects guideline (14.6 mtrs) with UGR &lt;19</td>
<td>Philips Boat with Luxspace, Wipro Boat with LD56</td>
<td>200 &amp; 0.4</td>
</tr>
<tr>
<td>No.</td>
<td>Location</td>
<td>Lighting Type</td>
<td>Specifications</td>
<td>Luminaires</td>
</tr>
<tr>
<td>-----</td>
<td>------------------------</td>
<td>----------------------------------------</td>
<td>--------------------------------------------------------------------------------</td>
<td>-----------------------------------------</td>
</tr>
<tr>
<td>10</td>
<td>BMA/BBA</td>
<td>Surface/Suspended Highbay 1 Ripple</td>
<td>Philips Elite, Trilux LBL 8000 ET, Keselec KABL 60</td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>Level 1 Check In Hall</td>
<td>Linear recessed /Suspended fixture</td>
<td>Philips Pureline 4 feet, Trilux LCL 1200 OTA, Wipro Axeon</td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>Level 1 Check In Hall</td>
<td>Linear recessed /suspended fixture</td>
<td>Philips Pureline 8 feet, Trilux LCL 2400, Wipro Axeon</td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>Checkin counter</td>
<td>Recessed Architectural downlight</td>
<td>Philips Luxspace, Trilux SONNOS, Iguzzini Reflex/easy, Flos Spot</td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>VIP Area</td>
<td>Surface/Suspended Linear LED</td>
<td>Philips Pureline 8 feet, Trilux LCL 1200 OTA, Wipro Axeon</td>
<td></td>
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<tr>
<td>15</td>
<td>Entrance</td>
<td>Surface/Suspended Highbay 2 with Ripple</td>
<td>Philips Elite, Trilux LBL 23000 ET, Keselec KABL 180</td>
<td></td>
</tr>
<tr>
<td>16</td>
<td>Level 2 Circular ceiling</td>
<td>Surface/Suspended Highbay 3 with Ripple</td>
<td>Philips Pureline Ring, Wipro orbit ring,</td>
<td></td>
</tr>
<tr>
<td>17</td>
<td>Atrium in retail area</td>
<td>Suspended Ring LED as per architects guideline, 1500, 2000 &amp; 2500mm dia (5 nos each)</td>
<td>Philips Pureline Hexagon, Trilux LCL 600 52OTA -ET HX, Wipro orbit hexagon</td>
<td>Philips Pureline Hexagon, Trilux LCL 600 52OTA -ET HX, Wipro orbit hexagon</td>
</tr>
<tr>
<td>18</td>
<td>Retail domestic and international</td>
<td>Indirect suspended hexagon fixtures as per architects guideline with Ripple</td>
<td>Philips Pur...</td>
<td>Philips Pureline Hexagon, Trilux LCL 600 52OTA -ET HX, Wipro orbit hexagon</td>
</tr>
<tr>
<td>19</td>
<td>Level 2 Retail Clouds</td>
<td>Cove Lighting</td>
<td>Philips CK, Vaya freeform, Dotspot Led strip</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Description</td>
<td>Pole/Location</td>
<td>Light Model</td>
<td>Uniformity</td>
</tr>
<tr>
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<td>------------------------------------------</td>
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</tr>
<tr>
<td>20</td>
<td>Street Lights for 10mtr Road</td>
<td>Octagonal Pole mounted Streetlight</td>
<td>Philips Skyline, Wipro Skyline, Keselec HANA</td>
<td>Lux 40</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Uniformity - Min/Max 0.33 Min/Avg 0.4</td>
</tr>
<tr>
<td>21</td>
<td>Street Lights for 7 mtr road, 10 mtr median</td>
<td>Octagonal Pole mounted Streetlight</td>
<td>Philips Skyline, Wipro Skyline, Keselec HANA</td>
<td>Lux 40</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Uniformity - Min/Max 0.33 Min/Avg 0.4</td>
</tr>
<tr>
<td>22</td>
<td>Street Lights for 7 mtr road, 4 mtr median</td>
<td>Octagonal Pole mounted Streetlight</td>
<td>Philips Skyline, Wipro Skyline, Keselec HANA</td>
<td>Lux 40</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Uniformity - Min/Max 0.33 Min/Avg 0.4</td>
</tr>
<tr>
<td>23</td>
<td>Landscape Tree Uplighter</td>
<td>Surface Mounted Medium Uplight</td>
<td>Philips EW Burst, Iguzzini Palco in-out, Flos Kirk</td>
<td>Minimum Lumen 600</td>
</tr>
<tr>
<td>24</td>
<td>Landscape Tree Uplighter</td>
<td>Surface Mounted High Uplight</td>
<td>Philips CK Vaya, Iguzzini Palco in-out, Flos Spock</td>
<td>Minimum Lumen 3100</td>
</tr>
<tr>
<td>25</td>
<td>Round About Landscape</td>
<td>Linear Pole mounted Postop</td>
<td>Philips Uniurban, Trilux Publica, Neri Light112</td>
<td>Lux 5-8</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Uniformity - Min/Avg 0.25</td>
</tr>
<tr>
<td>26</td>
<td>Landscape Pathway &amp; Green Area</td>
<td>Surface Mounted Bollards</td>
<td>Philips Citycube, Neri Lars, Flos Vincenza</td>
<td>Lux 5-8</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Uniformity - Min/Avg 0.25</td>
</tr>
<tr>
<td>27</td>
<td>Façade Pillars</td>
<td>Medium Floodlight RGBW</td>
<td>Philips CK, colorblast RGBW, Lumenpulse Large color changing</td>
<td>Minimum lux level of 900lux at a height of 7.0Mtr height</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Peak intensity &gt;45000 cd</td>
</tr>
<tr>
<td>Sno</td>
<td>Location</td>
<td>Fixture Type</td>
<td>Cat No</td>
<td>Beam/Lumens</td>
</tr>
<tr>
<td>-----</td>
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</tr>
<tr>
<td>28</td>
<td>Façade Canopy</td>
<td>Long Throw Floodlight RGBW</td>
<td>Philips Color Reach, Lumenpulse LBX color changing</td>
<td>Minimum lux level of 6000 lux at 7 m Peak intensity &gt; 350000 cd minimum</td>
</tr>
<tr>
<td>29</td>
<td>Glass Façade</td>
<td>Direct View RGB</td>
<td>Philips CK direct view, Lumenpulse XT Direct View</td>
<td>minimum 60 cd per 1.2 m (4 ft) Minimum 180 lumens per feet</td>
</tr>
<tr>
<td>30</td>
<td>Terminal Building Office areas - Open cell ceiling</td>
<td>Surface/Suspended downlighter Ripple &lt;5%</td>
<td>Trilux ADRASTIA D/H, Wipro Hollis Philips surface</td>
<td>300 &amp; 0.4</td>
</tr>
</tbody>
</table>

**Terminal Building Special Architectural Indoor fixtures**

<table>
<thead>
<tr>
<th>Sno</th>
<th>Location</th>
<th>Fixture Type</th>
<th>Cat No</th>
<th>Beam/Lumens</th>
</tr>
</thead>
<tbody>
<tr>
<td>31</td>
<td>Retail domestic and international</td>
<td>Wall Mounted Up downlighter</td>
<td>Iguzzini ipro BK, Flos Leo bidirectional</td>
<td>Medium beam Narrow + Medium beam</td>
</tr>
<tr>
<td>32</td>
<td>Retail Area</td>
<td>Wall mounted Trimless Linear</td>
<td>Flos Infinity, Iguzzini I1N60</td>
<td>Minimum 2300 lumens</td>
</tr>
<tr>
<td>33</td>
<td>Retail Area</td>
<td>Track Lights Medium power</td>
<td>Iguzzini Palco/Front Light, Flos UT Spot, Philips Proair</td>
<td>Medium power minimum 2400 lumens. With Elliptical Lens, flood lens &amp; honeycomb louvre</td>
</tr>
<tr>
<td>34</td>
<td>Retail Area</td>
<td>Track Lights Low power</td>
<td>Iguzzini Palco/Front Light, Flos UT Spot, Philips Proair</td>
<td>Low power minimum 1400 lumens. With Elliptical Lens, flood lens &amp; honeycomb louvre</td>
</tr>
</tbody>
</table>
VIP Area
Asymmetric Recessed Wallwasher
Flos easy Kap, Iguzzini Reflex/Laser
Minimum 560 lumens

Accessories

<p>| | | |</p>
<table>
<thead>
<tr>
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<th></th>
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</thead>
<tbody>
<tr>
<td>36</td>
<td>Retail Area</td>
<td>Three/Single Phase Tracks as per requirement</td>
</tr>
<tr>
<td>37</td>
<td>Facade</td>
<td>Data enabler</td>
</tr>
<tr>
<td>38</td>
<td>Facade</td>
<td>i-player DMX</td>
</tr>
</tbody>
</table>

Data enabler

Data formatting device specifically designed for luminaires operates on the same technology (single-cable line voltage operation) as mentioned above with the following features:

- Power I / p - 100-240V AC, 50-60 Hz, Max connected load 20A Internal loss not to exceed 20W
- Heat dissipation should be in the order of 10W max
- Ambient temperature - Upto 50 degree Celsius
- Data I / p interface - DMX / Ethernet
- Protection rating - IP 66 (Suitable for humid / raining locations)

Work should be complete with wiring, junction boxes, provisioning of power and data cabling etc.

Body of fittings

<p>| | |</p>
<table>
<thead>
<tr>
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</thead>
<tbody>
<tr>
<td>Cast aluminum housing</td>
<td>16A</td>
</tr>
<tr>
<td>100-277V AC, 50-60 Hz</td>
<td>Not to exceed 20 W</td>
</tr>
<tr>
<td>Upto 50 degree C</td>
<td>Should be in the order of 20 W max</td>
</tr>
<tr>
<td>DMX 512 / Ethernet</td>
<td>IP 66</td>
</tr>
<tr>
<td>Double-pair, double-entry IDC connector</td>
<td>Upto 50 degree C</td>
</tr>
<tr>
<td>UL/CE certification</td>
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</tbody>
</table>

DMX iplayer

Single DMX ports control up to 340 light addresses, Works as a stand-alone or computer-driven controller, Secure Digital (SD) card drive for flexible show storage, USB 2.0 interface for downloading shows and configuring from attached PC or Mac, Simple installation and wiring is required, Flexible, adaptable mounting options are expected, Should be provided with light show authoring software, Direct line voltage power supports 100-240 VAC, Six configurable effects using light show authoring software to select from six effects, adjust effect settings, such as colour, speed, and brightness.
Number of simultaneously controllable individual LED nodes & Minimum 340 individually addressable fixtures via DMX protocol

Packaged with Light System Composer & Software allowing creation and managing dynamic light shows with fully customizable effects, multi-layer editing and unique colour palettes

Versatile Zone Usage & Configure and control multiple playback zones

Input Voltage 100-240 VAC, Auto-Switching
Power Consumption 5 W max
Network Data Protocol Via standard DMX switch
Playback Output Light Shows containing one or more visual effects

Operating Temperature Upto 35 degree C
Operating Humidity 0 - 90%, relative humidity, non-condensing

Certification UL/CE
Operating Temperature Upto 50 degree C
Mandatory Certification UL/CE certification

The fixtures proposed above area-wise are tentative. Bidder is requested to submit the fixtures selection w.r.t. area, type of mounting etc to AAI. Final selection/approval shall rest with Engineer –In-charge to meet the technical as well as operational requirement.

iv) The LED lighting fixtures / luminaire shall be in accordance with the Following standards

A. Illuminating Engineering Society of North America (IESNA).
   a. IES LM - 79 -08 with up to date corrections / amendments / addendum covering:
      • Measurement of total luminous flux (Lumen).
      • Measurement of Luminous efficacy (Lumen/watt).
      • Measurement of chromaticity, Correlated color temperature (CCT) & Color Rendering Index (CRI).
      • Measurement of Luminous intensity distribution.
      • Measurement of Electrical Power, Input voltage and current.
   b. IES LM - 80 -08 with up to date corrections / amendments / addendum covering:
      • Measurement of LED packages, Arrays and LED modules.
      • Measurement of Lumen maintenance life of LED light source.
      • Measurement of Temperature for LED packages.
   c. IES LM - 82 -12 with up to date corrections / amendments / addendum covering:
• Measurement of performance of the LED light engine and integrated lamp as a function of temperature.

d. IES TM -21 -11 with up to date corrections / amendments / addendum covering:
  • Measurement of Lumen maintenance life projection.
  • Measurement of Temperature data interpolation.

OR

B. Bureau of Indian Standards.

a. IS 16101 (2012): General Lighting-LED’s and LED Modules-Terms and definitions - Descriptive Terms Such as “Built - in LED module” and measurable terms such as “Luminance”.

b. IS 16103-1 (2012): LED modules for general lighting, Part-1: Safety requirements (This standard is based on IEC 62031: 2008 LED module for general lighting - safety specifications & document 34 A / 1416 / CDV, LED module for general lighting safety specifications issued by IEC.

c. IS 16103 - 2 (2012): LED modules for general lighting, Part - 2: Performance requirements (This standard is based on IEC 62717 & document 34 A / 11445 / NP, LED module for general lighting - Performance requirement issued by IEC.

d. IS 16104 (2012): d.c. OR a.c. supplied electronic control gear for LED modules - Performance requirements (This standard is to be read in conjunction with IS 15885 (Part -2/section 13) & is based on IEC 62384: 2006.

e. IS 16105 (2012): Method of measurement of Lumen maintenance of solid state light (LED) sources (This standard is based on IES - LM - 80 -2008).

f. IS 16106 (2012): Method of Electrical and Photometric measurements of solid state lighting (LED) products (This standard is based on IES - LM - 79 - 2008).


h. IS 16107-2 - 1 (2012): Luminaires performance, part 2: Particular requirements, section 1: LED Linaire (This standard is based on IEC / PAS 62772 - 1 (Feb 2011) “Luminaires performance – part 1: General requirements issued by IEC.

i. IS 16108 (2012): Photo biological safety of lamps & lamp systems (This standard is identical with IEC 62471: 2006 “Photo biological safety of lamps & lamps systems” issued by IEC).

j. IS 15885-2-13 (2012): Safety of lamp control gear, Part-2 particular requirements, section 13: d.c OR a.c supplied electronic gear for LED modules (This standard is based on IEC 61347 - 2-13, Ed 1 2006-05 “Lamp control gear - Part 2 - 13: Particular requirements for d.c OR a.c supplied electronic gear for LED modules” and IEC 34 C / 901 A / DC “d.c OR a.c supplied electronic control gear for LED modules” issued by IEC.
Note: - International Electro technical Commission (IEC).

OR

C. UL standard.

b. UL - 1598 - Luminaires.
c. UL -153 - Portable Electric Lamps.
d. UL - 1993 - Self - Ballasted Lamps and Lamp Adapters.
e. UL – 1838 - Low Voltage Landscape Lighting System.
f. UL - 2108 - Low Voltage Lighting System.

v) ATTACHMENT OF FITTINGS AND ACCESSORIES

Conduit Wiring System

i) All accessories like switches, socket outlets, call bell push and regulators shall be fixed in flush pattern inside the switch boxes. Accessories like ceiling roses, brackets, batten holders, stiff pendants etc. shall be fixed on metal outlet boxes.

ii) Brass screws shall be used to fix the accessories to their bases.

iii) The switch box shall normally be mounted with their bottom 1.25 m from floor level, unless otherwise directed by the Engineer-In-Charge.

Fixing on Walls and Ceiling

i) PVC sleeves / dash fasteners should normally be used for fixing to walls or ceiling.

ii) Plugging of walls or ceiling is to be done in a better way for neatness. In all such cases, an approved type of asbestos or fibre fixing plug (rawl or Phil plug) with correct size of tools shall be used and done in a workmanlike manner.

iii) Looping of fittings etc. shall be done using connectors of suitable rating.

B) FANS, REGULATORS AND CLAMPS

a) Ceiling Fans

i) Ceiling fans including their suspension shall conform to relevant Indian Standards.

ii) Any additional hardware items required for installation of ceiling fans including fan hooks/clamps shall be provided as required.

iii) All ceiling fans shall be wired to ceiling roses or to special connector boxes, and suspended from hooks or shackles, with insulators between hooks and suspension rods. There shall be no joint in the suspension rod.

iv) Recessed type fan clamp inside a metallic box shall be used. The metallic box shall suitably be covered with 3mm thick phenolic laminated sheet.

v) Canopies on top of suspension rod shall effectively hide the suspension.

vi) The leading in wire shall be of copper and nominal cross sectional area not less than 1.5 Sq.mm. and shall be protected from abrasion.
vii) All ceiling fans shall be hung at a height as directed by the Engineer-In-Charge.
viii) Extra down rod with wiring as required.

C) Exhaust Fans
i) Exhaust fans shall conform to relevant Indian Standards.
ii) Exhaust fans shall be erected at the places indicated by the Engineer-In-Charge, additional hardware items required for installation of exhaust fans including clamps etc. shall be provided as required.
iii) Louvers shall be erected with exhaust fan at the existing opening with the required hardware clamps etc. as required.

D) Distribution Boards-

MCB type DB’s shall be used on account of their superior technical features, compared to conventional DBs, which don’t allow for proper wiring space and wiring termination. Rewirable fuse type DBs shall not be used.

DBs shall have following feature:

i) Phase / neutral / earth terminal blocks for termination of incoming & outgoing wires.
ii) DIN Channel arrangement for mounting incomer / outgoing MCB/RCCB/RCBO/MCCB as required.
iii) Electrolytic Copper Bus bar & neutral link.
iv) Earthing terminals.
v) Wiring from MCB’s to phase terminal block.
vi) Interconnection between terminal block / incoming switch / bus bar/ neutral terminal block/ earth terminal connector with specified size of FRLSH pre insulated copper conductor cable duly fitted with copper lugs.

vii) Terminal blocks should be suitable for termination of conductor / cable of required size but minimum rated cross section of the terminal blocks should be 6 sq mm.

viii) Colored terminal blocks and FRLSH wires for easy identification of RYB Phases, Neutral and Earth.
ix) The DB shall have peel able poly layer on the cover for projection from cement, plaster, paints etc. during the construction period.
x) Detachable plate with Knock out holes shall be provided at the top / bottom of board. Complete board shall be factory fabricated and pre-wired in factory ready for installation at site. The box and cover shall be fabricated from min 1.0 mm sheet steel, properly pretreated with powder coated finish.
xii) It shall be of double door construction provided with hinged cover in the front.
xiii) Wiring diagram of each DB shall be fixed inside the DB clearly indicating ferrule numbers.

xiii) DB shall be sectioned in such a manner that incomer has separate row.
xiv) MCB shall comply IS/IEC 60898-1-2002.
xv) MCB used for light circuit & power circuit shall be C series.
xvi) MCB used for motor/UPS circuit shall be D series.
xvii) DB used for indoor application shall comply IP-43 & IK09.
xviii) DB used for Outdoor application shall comply EN 60439-3, IP-65, IK09
xix) DB shall have RCCB on each phase for phase separation.

Recess / Surface type loose wire box & cable End Box shall be provided as per site requirement with respect to individual DB or for group of DBs. The material of construction and shade of loose wire box & cable End Box shall be as per DB finishes.

E) Out Door Type Feeder Pillar

This specification covers the design, manufacture, shop floor tests, type and routine tests and delivery of outdoor floor mounted Feeder Pillar, voltage rating 415, 3 phase, and 4 wire systems. The switchgear must have been type tested in the same configuration that has been offered.

a. All outdoor type feeder pillar shall be floor mounted, front operated with Double door with lockable arrangements.
b. 2 mm Thickness of CRCA MS sheet shall be used for all load bearing parts and rest may be 1.6 mm with MS power coated.
c. Base frame shall be of power coated MS Angle.
d. Inside and Outside painting shall be of approved shade as per IS:55 unless otherwise specified.
e. Enclosure shall be IP 55 protected with canopy.
f. Flat Neoprene gasket shall be provided wherever required.
g. Cable entry shall be from Bottom side.
h. Double compression gland shall be used.
i. Bus bar material shall be pure annealed copper with 99.99% purity.
j. Heat shrinkable – color coded sleeve to be provided.
k. The minimum fault level should be considered as 25 KA.
l. Bus bar supports shall be Epoxy _ suitable size to be used.
m. Supply of copper cables for inter-connecting, all inter-connections with cable glands and end terminations are included in scope of works.
n. All switch gears & control gears shall be as per approved make.
o. Danger Plate and Identification Feeder Pillar No plate to be provided as required.
p. Continuous earthing provision to be provided to connect at two points. All doors and structural parts to be earthed with adequate copper braided wires.

IX - HAND DRIER

1.1 This section covers the requirement of HAND DRIERS to be provided as per the layout drawing enclosed with this NIT, specifications laid down below and as per description of the item given under scope of work.

Specification;

1. HYGIENE LEVEL: Fully hygienic hand drier, no-touch operating.
2. ON/OFF MODE: The drier shall switch ‘ON’ when hands approach, automatically, and switches off by itself after drying the hands.
3. TIMER: With solid-state time-delay feature to avoid chattering.
4. TIME RATING: Time required to dry a pair of hands upto wrists: Half a minute.
5. DUTY: Rated for continuous repeat use.
6. TEMPERATURE: Temperature of the drying air-stream shall be such that the user does not feel uncomfortable and the hands do not feel excessive heat. With SUMMER-WINTER control.
7. SOUND: Quiet operation below 70 dB.
8. ENCLOSURE: Stainless steel enclosure of 304 grade multiple grounded electrically and mechanically to avoid danger of shock.
9. MOUNT: Indoor wall mounting. With one integral bracket for firm mounting the drier on wall.
10. ARROW GUIDE: A guiding arrow to indicate the drying position of hands.
11. ELECTRICITY: Suitable for 230 volts, single-phase, 50 Hz, 15 amps AC supply.
12. CABLE: Sheathed three core copper flexible cable 1- metre length, 1-three pin 15 amps ISI marked plug top.
13. LOCK AND KEY arrangement to avoid unauthorized movement of the machine.
14. MUSIC: A musical chime plays while user is drying hands, with volume and ON/OFF control.
PART-II- (SUBSTATION WORKS)

STATION TRANSFORMER (Above 2500kVA)

1.0 GENERAL

The scope of these specifications covers the detailed requirement of Supply Installation, Testing & Commissioning of oil filled /dry type transformers suitable for BMS /SCADA system including all that reasonably inferred as necessary for the proper installation and putting the installations in operational of the extended in the following specifications and Scope of work (SOW) as specified.

The transformer shall be indoor / outdoor as specified. All transformers shall have thermal as well as dynamic ability to withstand external short circuit as per standard.

2.0 STANDARDS

The oil filled/ dry type Transformer shall comply with the following Indian standard specifications as amended up to date.

(a) IS 2026 Part – I to V - Power / Station Transformers
(b) IS 11171- 1985 & IEC 726 - Dry type power transformers
(c) IS 335-1993 - Insulating oil.
(d) IS 10028 (Part-II & III) - Installation & Maintenance of Transformers.
(e) 2099 - Bushings
(f) IS 2705 - Current Transformer
(g) IS 2071 - Method of high voltage testing technique.
(h) IS 6600 - Guide for loading of oil immersed transformer.

2.0 OIL COOLED TRANSFORMER (Indoor / outdoor)

2.1 Transformer Operation

The transformer shall be suitable for operation on 33/11KV, three phase, 50 cycle, earth system, oil immersed natural air cooled (ONAN), double winding type, connected delta on 33KV side and star on 11KV side (Dyn-11) with neutral brought out separately for earthing.

The transformer shall be suitable for continuous operation at the rated capacity under site conditions specified.

2.2 Transformer Characteristics

The no load voltage ratio of the transformer shall be 33/11KV and the percentage impedance shall be as per IS 2026 as amended up to date.

2.3 Transformer materials & its enclosure

The material used in the manufacture of the transformer shall be of the best quality of their respective kind available as per standard specifications.

The transformer shall be provided with a mild steel Tank with adequate provision for ventilation. The degree of protection for Tank shall be IP 55. Thickness of Tank shall be as per IS-2026.

After rigorous cleaning & surface treatment, the transformer shall provide primer coat, finished with two coats of weather resisting or enamel machinery paint conforming to relevant IS.
2.4 **CORE**

The magnetic iron core shall be made up of high grade, low loss grain oriented CRGO steel stamping, Hi-B grade steel or superior grades. The maximum flux density at any point in core and York shall not exceed 1.6 Tesla on normal rated voltage and frequency and 1.76 Tesla at 110% rated voltage & frequency. Each core laminations shall be insulated with material that will not deteriorate due to pressure and hot oil. Am margin of 10 to 12.5% for overfluxing may be provided for the worst combination of voltage and frequency within the range specified. The contractor shall provide saturation curve of the core material proposed to be used and calculations.

**Note:** No core of second grade / scarab materials will be acceptable. The manufacturer of the transformer shall select prime (first) grade core materials. OEM undertaking shall be submitted to authority along with technical submittal for approval/acceptance by the bidder.

2.5 **WINDING & its insulation:**

The winding shall be of copper wound. The insulation material used shall be insulation class 'A'. The conductors shall be of electrolytic grade copper. Better insulating material shall be used and compression of the windings after drying out shall be carried out at a pressure exceeding one and a half to twice the force which can occur in the transformer; to impart greater mechanical strength to the windings against heavy short circuit stresses.

2.6 **EXPLOSION VENT:**

Explosion vent or pressure relief device shall be provided of sufficient size for rapid release of any pressure that may be generated within the tank and which might result in damage to the equipment. The device shall operate at a static pressure less than the hydraulic test pressure for transformer tank. Means shall be provided to prevent the ingress of moisture and of such a design to prevent gas accumulation.

2.7 **BUCHHOLZ RELAY**

Oil and gas actuated relay equipment shall conform to IS 3637-1966 and shall be double float type having contacts which close falling oil surge or under incipient fault condition. Buchholz relay shall have contact for alarm / trip as required. The relay shall be provided with ateststock suitable for aaflexiblepipe connection for checking its operation and taking gas sample. The device shall be provided with two electrically independent ungrounded contacts, one for alarm on gas accumulation and the other for tripping on sudden rise of pressure. The contacts of relay shall be properly housed, sealed and gasketted to make the arrangements water proof.

2.8 **OIL:**

The insulating oil should have non-sludging low viscosity property and comply with the requirement of relevant IS.

2.9 **TAPINGS:**

The tapping shall be arranged on the high voltage windings only to provide for a voltage adjustment of +5% to -10% in steps of 2.5% of rated voltage at constant KVA output. Full output shall be available on all the tapings specified above. The tapping shall be brought out to the terminal block located just below the oil level. A triple pole off load hand wheel tap changing switch with position indicator and locking arrangement shall be provided for operation without removing the tank covers or lowering off the oil levels.

2.10 **TERMINALS:**
Primary terminal arrangement shall consist of 3 pole-single gland cable sealing box fitted to the underside of the connection chamber. Secondary terminal arrangement shall consist of cable(s) connections. Appropriate characters in accordance with relevant IS shall be indelibly and clearly marked upon on adjacent to terminal and sub-terminals.

2.11 RATING AND DIAGRAM PLATES
The following plates shall be fixed to transformer in a visible position.
   a) A rating plate of weather proof material bearing the data specified in the appropriate clauses 15 of IS: 2026(Part-I).
   b) A diagram plate showing the internal connection and also the voltage vector relationship of the several windings in accordance with IS: 2026-1977 and a plan view of the transformer giving the correct physical relationship of the terminals.

2.12 JOINTS AND GASKETS
All gaskets used for making oil tight joints shall be of proven material such as granulated cork bonded with synthetic rubber gaskets or synthetic rubber or such other good material.

2.13 Transformer shall be complete with first filling oil, control cable between transformer marshalling box up to HT panel including interconnection and with following fittings & accessories conforming to IS 3639- (with up to date amendment) shall be provided with each transformer:
   a) Inspection cover.
   b) External hand operated off-circuit tap changing switch with position indicating plate & locking arrangement.
   c) Oil conservator with filling hole and cap having detachable end cover.
   d) Plain / Magnetic oil level gauge with minimum oil level marking.
   e) Oil drain valve of size as per ISS with plug or cover plate.
   f) Silica-gel dehydrating breather along with breather pipe of suitable size.
   g) Rating plates and terminal marking plate of stainless steel / brass / aluminium engraved containing the information specified in relevant IS.
   h) Two earthing terminals for body earthing consisting of hexagonal bolts of size M-20 as per relevant IS.
   i) Lifting lugs/cover lifting eyes.
   j) Radiator for the cooling system (natural air cooling) by means of pressed /round tubes and fins around transformer tank.
   k) Four bi-directional flat rollers of suitable size fitted on cross channels, corresponding to weight of transformer to facilitate movement of transformer.
   l) Thermometer pocket with plug.
   m) Air release device.
   n) Explosion vent.
   o) 150mm dial type winding and oil temperature indicator with potential free electrical contact for alarm & trip, fitted with Anti-vibrating mounting with maximum reading pointer.
   p) Oil filter valve at TOP of the tank.
   q) Marshalling box to terminate the control cables of thermometer etc.
   r) 33kv side cable end box suitable for heat shrinkable termination of maximum size and type of HT cable(s) as required /specified.
   s) 11KV side cable termination arrangements suitable for rating & type as required /specified.
   t) Facility to connect Buchholz Relay.
u) Additional neutral separately brought out on a bushing for earthing for all transformers.

PRE-COMMISSIONING TESTS
After the transformer is installed, the following pre-commissioning tests and checks shall be done before putting the transformer in service.

i) IR Test
ii) DC Resistance measurement of windings
iii) Ratio test on all taps
iv) Phase relationship test (Vector grouping test)
v) Buchholz relay alarm & surge operation test
vi) Low oil level (in conservator) alarm
vii) Temperature Indicators
viii) Marshalling kiosk
ix) Protective relays
x) Magnetizing current

The following additional checks shall be made:

i) All oil valves are in correct position closed or opened as required.
ii) All air pockets are cleared.
iii) Thermometer pockets are filled with oil
iv) Oil is at correct level in conservator, diverter switch & tank etc.
v) Earthing connections are made. Colour of Silica gel is blue. CT polarity and ratio is correct.

3.0 DRY TYPE TRANSFORMER (indoor / outdoor)

3.1 Transformer operation:
The transformer shall be suitable for operation on 33/11KV, three phase, 50 cycle earth system, natural air cooled (AN), cast resin double winding type insulated HV & LT winding with class H respectively, connected delta on 33KV side and star on 11KV side (Dyn-11) with neutral brought out separately for earthing. The transformer shall be suitable for continuous operation at the rated capacity under site conditions. The dry type transformer shall comply with the regulations of IEC 726, BS: 7806 & IS: 11171 as amended up to date.

3.2 Transformer Characteristics
The no load voltage ratio of the transformer shall be 33/11KV and the percentage impedance shall be as per IS 2026 as amended up to date.

3.3 Transformer materials & its enclosure
The material used in the manufacture of the transformer shall be of the best quality of their respective kind available as per standard specifications.

The transformer shall be provided with a sheet steel enclosure with adequate provision for ventilation. The degree of protection for enclosure shall be IP 23 for indoor & IP-33 for outdoor installation. Thickness of enclosure shall be 2 mm thick mild steel CRCA sheet.

After rigorous cleaning & surface treatment, the transformer shall provide primer coat, finished with two coats of weather resisting or enamel machinery paint conforming to relevant IS.
Powder coating finish after rigorous cleaning and surface treatment.

3.4 CORE
The magnetic iron core shall be made up of high grade, low loss grain oriented CRGO steel stamping. The maximum flux density at any point in core and York shall not exceed 1.6 Tesla on normal rated voltage and frequency and 1.76 Tesla at 110% rated voltage & frequency.

**Note:** No core of second grade / scarab materials will be acceptable. The manufacturer of the transformer shall select prime (first) grade core materials. Documentary evidence shall be submitted to authority along with technical submittal for approval/acceptance.

3.5 WINDING & its insulation:
The winding shall be of copper wound completely impregnated and cast under vacuum in to moulds. The insulation material used shall be insulation class 'H'.

3.6 TERMINALS:
Primary terminal arrangement shall consist of 3 pole-single gland cable sealing box fitted to the underside of the connection chamber. Secondary terminal arrangement shall consist of cable(s) connections. Appropriate characters in accordance with relevant IS shall be indelibly and clearly marked upon adjacent to terminal and sub-terminals.

3.7 RATING AND DIAGRAM PLATES
The following plates shall be fixed to transformer in a visible position.

a) A rating plate of weather proof material bearing the data specified in the appropriate clauses of IS: 2026/1977.

b) A diagram plate showing the internal connection and also the voltage vector relationship of the several windings in accordance with IS: 2026-1977 and a plan view of the transformer giving the correct physical relationship of the terminals.

3.8 Transformer shall be complete with control cable between transformers marshalling box upto HT panel including interconnection. Following fittings and accessories conforming to IS shall be provided with the transformer:

a) Inspection covers.

b) External hand operated off-circuit tap changing switch with position indicating plate & locking arrangement.

c) 2nos. (one connected & other as spare) PT -100 sensor in each LV windings wired up to the winding temp. scanner. The instrument shall have two sets of adjustable contacts for alarm & trip. The instrument shall have scanner to read & show temperature of all three phases sequentially and have RS 485 port.

d) Rating plates and terminal marking plate of stainless steel / brass / aluminium engraved containing the information specified in relevant IS.

e) Two earthing terminals for body earthing consisting of hexagonal bolts of size M-20 as per relevant IS.

f) Lifting lugs/cover lifting eyes.

g) Four bi-directional flat rollers of suitable size fitted on cross channels, corresponding to weight of transformer to facilitate movement of transformer.

h) Digital winding temperature indicator with alarm & trip contact shall be mounted on transformer enclosure.

i) Terminal box to terminate the control cables of thermometer etc.
(j) 33KV side cable end box suitable for heat shrinkable termination of maximum size and type of HT cable(s) as required/specified.

(k) **11KV side cable termination arrangement** suitable for rating & type as required/specified.

(l) Additional neutral separately brought out on a bushing for earthing for all transformers

(m) Surge arrester on HT side and any other accessories as per IS standard.

### 4.0 PERFORMANCE TEST:

The following performance test shall be conducted on one transformer for each design:

#### 4.1 TEMPERATURE RISE:

Rise in temperature of transformer when tested at continuous maximum rating at a peak ambient temperature of 50 deg. C shall not exceed the limits given below:

- **a) WINDINGS:** Average temperature rise as measured by increase in resistance of windings connected between terminals shall not exceed 115 deg. C in case of oil and 90deg. C for dry type transformer.
- **b) OIL:** Temperature rise as measured by thermometer in case of oil of the transformer shall not exceed 50 deg. C
- **c) CORES:** Temperature rise when measured by thermometer on the external surface of core shall not exceed the temperature permitted as per relevant IS.

#### 4.2 IMPULSE STRENGTH OF WINDINGS:

The impulse strength of winding of the transformer when tested with the standard 1.2/50 micro sec. positive wave shall not be less than specified in the IS. The transformer shall have fully insulated windings designed to meet impulse levels. If no test is carried out of such transformer, the same should be carried out for at least on one transformer. The copies of valid calibrated instruments shall also be submitted for record.

#### 4.3 FREQUENCY:

The transformer shall be designed for a normal frequency of 50 Hz and shall be capable of giving the rated output with the frequency varying by plus or minus 3% from the rated frequency.

#### 4.4 IMPEDANCE:

The percentage impedance shall be as per IS standard. Duration of short circuit with reference to impedance voltage for each transformer shall be in accordance with relevant IS.

#### 4.5 EXTERNAL SHORT-CIRCUIT:

Transformer shall be designed to be capable of withstanding without injury, the thermal and mechanical effect of short circuit at the terminals of any windings for the period in accordance with relevant IS. **OEM to submit only Certificate for similar or higher rating from CPRI or approved Govt. Lab.**

#### 4.6 EFFICIENCY AND REGULATION:

Efficiency and regulation shall be based on loading at rated KVA and at unity power factor and at 0.8 lagging power factor and shall be computed in accordance with relevant IS respectively.
4.7 **TRANSFORMER LOSSES:** The associated loss tolerance of oil filled STATION transformers shall be as per relevant IS & Cast Resin Dry type transformers shall comply as per relevant IS.

- Load Loss (kW) (Oil Type) = 33.0 KW IS Tol
- No Load Loss (kW) (Oil Type) = 3.5 KW IS Tol

5.0 **TESTS AT MANUFACTURER'S WORKS:**

The transformers are subject to inspection during their manufacture. All routine & other tests prescribed in IEC 60076 -11 and relevant IS-11171 & ECBC 2017 norms with up to date amendments shall be carried out before despatch at manufacturers works in presence of inspecting officer and of following:

5.1 **MEASUREMENT OF WINDING RESISTANCE TEST:**

- The resistance of each winding and the marking of the terminals between which it is measured shall be recorded. While measuring the resistance care shall be taken to determine the temperature of windings. The temperature at which the measurement is made shall be recorded.

5.2 **RATIO - POLARITY & PHASE RELATIONSHIP TEST:**

- The turns ratio shall be measured on each tapping and the polarity & winding phase relationship shall be checked.

5.3 **MEASUREMENT OF IMPEDANCE VOLTAGE:**

- The impedance voltage shall be measured at rated frequency, using an approximately sinusoidal supply. The measurement may be made at any current not less than 50% rated current and the value so obtained shall be increased in the ratio of the rated current to the test current. The test result shall be corrected to the reference temperature of the 75 deg.C.

5.4 **MEASUREMENT OF NO-LOAD LOSSES AND NO-LOAD CURRENT:**

- No load losses shall be measured at rated frequency with rated voltage applied to one of the three phase windings, the other windings being open circuited. No load current shall also be recorded.

5.5 **MEASUREMENT OF LOAD LOSSES:**

- This test shall be performed as per clause of relevant IS.

5.6 **MEASUREMENT OF INSULATION RESISTANCE:**

- The oil and windings temperature shall measured and recorded immediately prior to the test. The Insulation resistance of each windings, in turn, to all the other windings, cores and frame or tank connected together, and to earth shall be measured and recorded.

5.7 **INDUCED OVER VOLTAGE WITHSTAND TEST:**

- This test shall be performed as per clause of relevant IS.

5.8 **SEPARATE SOURCE VOLTAGE WITHSTAND TEST:**

- This test shall be performed as per clause of relevant IS.

5.9 **OIL TEST : IN CASE OF OIL COOLED TRANSFORMER**

- Oil test specified in British standard specifications No. 148/IS 335 shall be carried out and maker's certificate forwarded.
The offered equipment or the same equipment of higher capacity must have successfully type tested as per IS-2026 (with up-to-date amendment). The type test certificate and test equipment, valid test copies shall be submitted before inspection at works. If the impulse voltage withstand and temperature rise is not type tested, firm to carry out the same during inspection at works.

6.0 **Type test certificate of CPRI or any other approved test house for similar or higher rating of transformer to be submitted along with the approval of technical submittal & drawings.**

6.0 **PARALLEL OPERATION**

The transformer shall be suitable for parallel operation. Therefore, selection of transformer should be ensured for percentage impedance, voltage ratio, vector groups, phase sequence etc. are same for all units.

7.0 **TRANSFORMER INSPECTION AT SITE ON ARRIVAL**

   i. The transformer shall be inspected on arrival as per the inspection manual of the supplier.

   ii. The transformer shall be examined of any sign of damage and special attention shall be given to the following parts of oil cooled transformer as applicable:

       - Oil tank and cooling tubes.
       - Bushes cracks or broken.
       - Oil sight glass.

8.0 **INSTALLATION & COMMISSIONING:**

   (i). The transformer shall be installed as per installation manual of the transformer suppliers and conforming IS 10028 (Part II & III) - Code of practice for Installation and Maintenance of transformers. Necessary foundation and/or support channels shall be grouted in the flooring as required within the scope of works.

   (ii). The transformer supplied shall be lifted by lifting lugs for the purpose of avoiding imbalance in transit.

   (iii). The transformer shall be moved to its location on grouted channels & wheels shall be locked by suitable locking arrangement to avoid accidental movement of the transformer.

   (iv). The transformer cable end boxes shall be sealed to prevent absorption of moisture.

   (v). The transformer neutral earthing, body earthing & other wiring shall be done as shown on the approved drawings and as per specifications.

   (vi). All devices shall be checked for satisfactory operation.

9.0 **TESTS AT SITE:**

In addition to tests at manufacturer’s premises, all relevant pre-commissioning checks and tests conforming to IS code of practice No.10028 (Part II & III) shall be done before commissioning. The following tests are to be particularly done before cable jointing or connecting up the bus bar trunking.

   a. Insulation test between HV to earth and HV to MV with a 5000 Volts IR Tester.

   b. Insulation test between MV to earth with 500 volts IR tester.

   c. Winding resistance of all the windings on all the tap positions shall be taken.
d. Dielectric strength of transformer oil shall be checked in accordance with IS 335. In case the test is not satisfactory, the oil shall be filtered till proper dielectric strength of oil is obtained and also top up within the scope of the bidder.

e. Bucholtz relay operation by simulation test when fitted.

All test results are to be recorded and reports should be submitted to the Engineer In Charge for its acceptance.

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HT PANEL

1.0 General
The scope of these specifications cover the detailed requirements for design, supply, installation, testing and commissioning of High Voltage panel board suitable for BMS /SCADA system including all that reasonably inferred as necessary for the proper installation and putting the installations in operational of the type extended in the following specification, Technical data sheet enclosed and Scope of works (SOW) & as specified. The HT panel shall be manufactured and tested by the Original Equipment Manufacturer. The equipment supplied must have been in commercial production at least 5 years prior to supply with an established historical data base for good performance.

2.0 H.V. PANEL
The Panel board shall be of indoor type, having the incoming sectionalisation and outgoing switch gear as per IS 13118-1991 of VCB, IEC 62271-100 for Breakers and – 200 for Panels/IS 3427 of switch board. The degree of enclosure protection shall be minimum IP-4X. The panel should be from the factory of AAI approved makes of VCB only.

Rating: The panel shall be assembled to form a board shall be suitable for the nominal operation voltage and rupturing capacity as specified. They shall be rated as specified and suitable for operation on 3 phase, 50 Hz, 3 wire system. A circuit breaker for a given duty in service is best selected by considering the individual rated value required by load & that of fault conditions. The panel should be internal arc tested for 25 KA for 0.5 sec as per IEC 62271-200.

Type: The HV panel shall be metal clad cubicle pattern extensible on both sides, indoor, floor mounting & free standing type. It shall be totally enclosed dust, damp and vermin proof.

General Construction: Separately earthed compartment shall be provided for circuit breaker, bus bars, relay & instruments, CT & PT and cable boxes, fully and effectively segregating these from one another so that fault in any one compartment do not cause damage to equipment(s) in other compartment(s).

The housing shall be of bolted construction to ensure compact and rigid structure, presenting a neat and pleasing appearance. The sheet steel enclosure shall not be less than 2 mm thick.

The panel board shall be bolted together to form a continuous flush front switch gear suitable for front operation of board and for extension at both ends.

General Design Aspects: The HV panel board shall be designed such that the switchgear, instruments, relays, Busbars, small wiring etc. are arranged and mounted with due consideration for the followings:-

i) Facility for inspection, maintenance and repairs of testing terminals and terminal boards for ease of external connection.

ii) Minimum noises and vibrations.
   - Risk of accidental short circuits and open circuits.
   - Secured and vibration proof connections for power and control circuits.

iii) Risk of accidental contact and danger to personnel due to live connections.

iv) Mounting at approachable height.

3.0 CIRCUIT BREAKER:
GENERAL ARRANGEMENTS: The circuit breaker panel boards shall be complete with the following:-

(a) Racking in / Racking out mechanism.
(b) Single pole Isolating plugs and sockets.
(c) Mechanical inter-locks and automatic safety shutters.
(d) Internal Earth switch with electro-mechanical interlock. Cable earth switch on all outgoings and bus bar earth switch in each section.

(e) Minimum of 4 NO and 4 NC Auxiliary contacts directly operated by the circuit breaker. Additional NO & NC contacts shall be provided with auxiliary contactors for the functional requirement.

(f) Anti-condensation space heaters suitable for operation on 240V, single phase, 50 Hz, A.C. supply for each switch gear panel with manual ON/OFF switch.

(g) Suitable tripping arrangement with push button etc.

(h) Mechanical counters to assess the total number of operations of the breaker.

(i) Mechanical ON/OFF indicator, Auxiliary switches etc.

(j) Emergency trip push buttons etc.

(k) Wherever cassette design of CB is offered, two CB handling trolleys shall be provided with switchboard

(l) Lifting lugs shall be provided for lifting the entire shipping section without distortion of any part of any enclosure

**Type:** The circuit breaker shall be of Floor Mounted horizontal isolation, horizontal drawout pattern only.

**Breaker Truck:** The breaker carriage shall be fabricated from steel, providing a sturdy vehicle for the circuit breaker and its operating and tripping mechanism. The carriage shall be mounted on wheels, moving on guides, designed to align correctly and allow easy movement of the circuit breaker and for removing the carriage for inspection and maintenance purposes. Vacuum interrupters shall be fully encapsulated hermetically sealed and shall be designed for minimum contact erosion, fast recovery of dielectric strength, maintenance free vacuum interrupter, suitable for auto-reclosing. The drive mechanism shall preferably be provided with facility for pad locking at any position namely, ‘Service’, ‘Test’ and “Fully Isolated”. It shall be possible for testing the circuit breaker for its operation without energizing the power circuit in the ‘Testing’ position. The contacts shall be made only after the breaker is inserted into service position. Interlocking shall prevent contacts from being disconnected if circuit breaker is tried to be moved from service position.

**General Features:** Single break contacts are provided in sealed vacuum interrupter.

**Rating:** The circuit breaker shall be continuously rated for its required rating specified.

**Operating Mechanism:** The operating mechanism shall be with manual as well as motor wound spring charged with both mechanical and electrical release for closing. The operating mechanism shall be trip free.

The external auxiliary power required for HT panel board shall be extended by the successful tenderer within the quoted cost as under:

a) **DC Power:** This shall be extended from the battery charger to be provided under separate item and install in each substation.

b) **Single phase 240V AC power** shall be extended from nearest power DB or from nearby 15A power point(s).

The power shall be extended by supply & laying of copper XLPE insulated & PVC FRLS armoured cable including terminations. If cable is un-armoured then it shall be protected...
with metallic conduit. The cable extended from power point shall be provided with 15A ISI mark TOP at power point side or DP MCB from DB.

4.0 BUS BAR SECTION:
General Requirement: The switch board shall be single bus bar pattern with air insulated encapsulated bus bars housed in a separate compartment, segregated from other compartments.
Material: The bus bars shall be of high conductivity electrolytic copper rated as specified and it shall be sized for carrying the rated current. The bus bars shall be sized for carrying the rated and short circuit current of 25kA for 3 sec without over-heating. Maximum bus bar temperature shall not exceed 95 degree centigrade at the local climatic condition.

5.0 CURRENT TRANSFORMER (CT):
General Requirements: Accommodation shall be provided in the circuit breaker panel to mount set of HT CTs for metering and protection purposes as specified. Access to CTs for cleaning, testing or changing shall be from the front, back or top of the panel.
Rating: Dual core CTs of suitable burden (but not less than 15 VA) shall be preferred with 1 Amps secondary. The CT ratio shall be as specified & as required. The ratio shall be compatible with the loading pattern on HV side.
The CTs shall conform to relevant Indian Standards. The design and construction shall be robust to withstand thermal and dynamic stresses during short circuits. The CT shall be of cast epoxy resin construction. Secondary terminal of CTs shall be brought out suitably to a terminal block and shall be easily accessible for testing & terminal connections. The protection CTs shall be of class 5P10 of IS 2705- Part III- 1992.
The metering CTs shall conform to the metering ratio and accuracy class for incomer and outgoing VCB panels as specified and as required.
Note: Make of CT’s installed / supplied by HT board Manufacturer is acceptable

6.0 VOLTAGE TRANSFORMER (VT):
General Requirement: A voltage transformer of required burden of proper ratio & class of accuracy as required shall be provided at the incoming panel. The accuracy class for the VT shall be 0.5 as per IS 3156 parts I to III for incomer VCB Panel & class I for outgoing of Panel and as specified & as required. The VT shall be of cast epoxy resin construction. The basic impulse level (BIL) of the VT shall be same as that of switch gear. External connection to the VT secondary shall be through a test block. It shall be fixed type (draw out type VT shall be acceptable without any extra cost). HRC fuses & MCB’s of required breaking capacity shall be provided on both HV & LV sides respectively as protection.

7.0 PROTECTION AND TRIPPING ARRANGMENT:
7.1 The Relays shall be microprocessor based numerical type for over current, earth fault & short circuit protection with -
a) Triple pole non-directional IDMT & instantaneous (high test) characteristics.
b) Master trip relay for tripping against fault in circuit.
c) Trip circuit supervision relay for healthiness of trip circuit.
d) Suitable auxiliary relays for protection of transformer with electrical contact for alarm & trip for winding temperature, oil temperature & oil pressure etc. and as required.
Tripping relay shall be used for tripping signal to the Shunt Trip Coil of Circuit Breaker operating on 24V DC supply
7.2 Suitable contacts of the relays will be wired out to terminal blocks for remote Trip indication and these will be manually resettable.
7.3 Relay should have inbuilt facilities to change setting and record event, fault etc. and with open protocol software. Relay should have in built RS 485 port for communications.

8. **SAFETY ARRANGEMENT**
The following safety arrangement shall be provided for the safety of the personal & to prevent mal operation

8.1 Interlock to prevent the circuit breaker from being forwarded or reversed unless the breaker is off.
8.2 Interlock to prevent the truck from being withdrawn or replaced except in the fully withdrawn position.
8.3 Interlock to prevent the breaker from being closed unless it is fully engaged.
8.4 Interlock to prevent the earth connection from being made by the earthing device except than the circuit breaker is open.
8.5 Interlock to prevent the breaker from being made alive without its carriage in position.
8.6 Interlock to prevent the lockable and remote control apparatus from being in operation at the same time.
8.7 Interlock to prevent the circuit breaker from being racking in and racking out when closed.
8.8 Interlocking which prevents manual or electrical closing of the circuit breaker in the intermediate positions between connected or isolated.
8.9 Interlock to prevent earth connection from being made by the earthing device except than the circuit breaker is open.
8.10 Inter-lock to prevent the breaker from being made alive without its carriage in position.

The breaker should have test positions to facilitate testing of control circuit. Removable automatic dust proof safety shutter assembly should be provided for shrouding of live terminals while the breaker is drawn out.
The HT panel shall have a Hooter with acknowledge push button in case of tripping of any of its incoming or outgoing VCB breaker.

9. **PAINTING**
All metal sheets shall undergo 7 tank metal treatment, thorough derusting-rinsing-degreasing-rinsing-phosphating-rinsing and then passivation. All metal surfaces shall be thoroughly cleaned and degreased to remove all scales, rust, grease and dirt. Fabricated structures shall be pickled and treated to remove any trace of acid. The under-surface shall be prepared by applying a coat of phosphate paint and a coat of yellow zinc chromate primer.
The under surface shall be made free from all imperfections before undertaking the final coat.
After preparation of the under surface, the panel shall be spray painted with final two coats of approved enamel paint. Contractor shall obtain details of approved paint from the Client /consultant before final painting.
The finished panels shall be dried in dust free atmosphere. Panel finish shall be free from imperfections like pin holes, orange peels, run-off paint, etc.
All unpainted steel parts shall be cadmium plated or suitably treated to prevent rust, corrosion, etc.

8.0 **SMALL WIRING:**
The small wiring shall be carried out with FRLS insulated copper conductor cables of minimum 1.5sq. mm. For CT wiring shall be done with minimum 2.5sq mm. The color code of wire shall be: RYB, Gray for auxiliary DC circuits and Black for auxiliary AC circuits. The wiring shall be
securely fixed and neatly arranged to enable easy tracing of wires. Identification tags shall be fitted to all wire terminals to render identification easy facilitate checking in accordance with IS 375. Necessary terminal block and cable entries shall be provided for RTD relay wiring, power supply etc.

9.0 METERING INSTRUMENT, PANEL ACCESSORIES (DIGITAL):

9.1 Instrument Panel:
The instrument panel shall form part of the housing. Relays, meters and instruments shall be mounted as per general arrangement drawings to be submitted by the tenderer & approved by AAI. All instruments & switches shall preferably be flush mounting type at a maximum height of 1800mm.

All voltmeter and ammeter and other instruments shall be flushed mounted Digital type of suitable size to read conforming to class 1.0 or as specified to IS 1248 for accuracy. All volt meters shall be protected with Fuses/MCBs.

Multi-function meter: Since the Protection relay has the features of measuring characteristic. The Multi-function meter shall be of high quality with features explained in the following paras.

The Multifunction meter shall be of Flush / surface mounting technology, Back lit LCD / LED type Digital display, provided with isolated compatible serial port for BMS/SCADA system either inbuilt or separate is acceptable having bezel size as required. It shall be of AC, 3 phase, three wire CT/PT operated and suitable for measuring parameters like Voltages, Currents, Active power, Reactive power, Apparent power, Power Factor, Frequency, Phase angles, Maximum Demand, active (kW), reactive (kVAR) and apparent (kVA) energies, Current and Voltage total Harmonics distortion (THD). Measurement accuracy of kWH and kVARH as required with RS 485 port.

The Multifunction meter shall also be suitable for displaying all the three parameters, viz KW/KVAR/KVA simultaneously.

Multifunction meter shall be suitable for operation on 3 phase, 110 volts, AC power supply and shall be fully rated for operation at ambient conditions of proposed location of the Airport.

The panelassembly shall also take care of the following requirements:

i) Lamp indication shall be provided to indicate ON/OFF (by red/green respectively) of switch gear.

ii) Panel illuminating lamp.

iii) Mechanical indication for spring charged status. Indication by Blue lamp.

iv) Lamp indicating tripping at fault status.

v) Healthy trip supply shall be indicated by clear lamp.

vi) Separate Fuses/MCB's protection shall be provided for lamp, heaters, voltmeters and other instrumentations etc. on each panel as specified & as required.

vii) Anti- condensation space heater shall be provided, and shall be suitable for operation on 240 V, single phase, 50 Hz, A.C. for each panel.

viii) HT panel board receiving more than one incomer and bus section, these shall be castle key interlocked.

9.3 Cable Boxes:
Cable boxes shall be situated in a compartment at the rear of the housing as specified.
9.4 **Cable Entry:**
Provision for bottom side entry shall be made as per requirement with sufficient head room for cable termination. 3mm thick removable gland plate shall be provided for cable termination.

9.5 **Earthing:**
The earthing of the breaker body and moving portion shall be so arranged that the earthing of the non-current carrying structure to the frame earth bar is completed well before the main circuit breaker plugs enter the fixed house sockets. The entire panel board shall be a common tinned copper earth bar of suitable section with 2 earth terminals for effectively earthing metallic portion of the panels and shall be provided as per specifications.

9.6 **Installation:**
The installation work shall cover assembly of panel boards, lining up, grouting the units etc. After connecting up the bus bar, all joint shall be insulated with HV insulation tape or with approved insulation compound. A common earth bar shall be run preferably at the back of the switch board connecting all the sections for connecting to the earth system.

All protection, indication & metering connections and wirings shall be completed. Where trip supply battery is installed, the unit shall be commissioned, completing initial charging of the batteries. All relays, instruments & meters shall be mounted and connected with appropriate wiring. Calibration checks of unit as necessary and required by the licensee like CTs, VTs, metering etc. shall be completed before pre-commission checks are undertaken.

9.7 **TOOLS AND PLANTS (T&P):**
The successful tenderer shall supply two sets of T&P with tool box required for operation & maintenance of HT VCB & panel board **within the quoted cost** such as- 1) Spanners set. 2) Allen Keys set. 3) Spring charged handle, 4) Rotary Handles, 5) screw driver set, and as recommended by OEM complete.

9.8 **PRE-DELIVERY INSPECTION AT WORKS:**
The HT breaker shall be tested for routine and acceptance test at the manufacture works as per relevant IS specifications in presence of AAI authorized representative.

9.9 **TESTING AT SITE AND COMMISSIONING:**
Procedure for testing and commissioning of relay shall be in general accordance with good practice. Commissioning checks and tests shall include in addition to checking of all small wiring connections, relays calibration and setting tests by secondary injection method and primary injection method. Primary injection test shall be preferred for operation of relay through CTs. Before panel board is commissioned, provision of the safety namely fire extinguishers, rubber mats and danger board shall be ensured. In addition all routine IR tests shall be performed. Checks and test shall include following:

(a) Operation Checks and lubrication of all moving parts.
(b) Interlock function checks.
(c) Three pole timing tests
(d) Contact resistance test
(e) Continuity checks of wiring, protection control by Fuses/MCB’s etc. as required.
(f) Insulation tests.
(g) Trip test and protection gear tests.
(f) The complete panel shall be tested with 5000V IR test equipment for insulation between poles and poles to earth. Insulation test of secondary of CTs and VT to earth shall be conducted using 500V IR test equipment.
(g) Where specified, the entire switch board shall withstand high voltage test after installation.

(h) Any other tests as shall be required by the Licensee/Inspector shall be conducted.

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### TECHNICAL PARTICULARS OF SWITCHGEAR EQUIPMENT:

<table>
<thead>
<tr>
<th>S. No</th>
<th>Description</th>
<th>33 KV</th>
<th>11 KV</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Type</td>
<td>Indoor, cubicle type</td>
<td>Indoor, cubicle type</td>
</tr>
<tr>
<td>2.</td>
<td>System rated voltage</td>
<td>33 KV</td>
<td>11 KV</td>
</tr>
<tr>
<td>3.</td>
<td>System maximum voltage</td>
<td>36 KV</td>
<td>12 KV</td>
</tr>
<tr>
<td>4.</td>
<td>Frequency</td>
<td>50 Hz</td>
<td>50 Hz</td>
</tr>
<tr>
<td>5.</td>
<td><strong>Insulation Level</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>a) 1.2/50 microseconds impulse</td>
<td>170 KV peak</td>
<td>75 KV peak</td>
</tr>
<tr>
<td></td>
<td>withstand voltage</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>b) One minute power frequency</td>
<td>70 KV rms</td>
<td>28 KV rms</td>
</tr>
<tr>
<td></td>
<td>withstand voltage</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6.</td>
<td><strong>Rated Current</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>a) Continuous</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Bus bar</td>
<td>800 Amps</td>
<td>800 Amps</td>
</tr>
<tr>
<td></td>
<td>Incoming Vacuum circuit breaker</td>
<td>800 Amps</td>
<td>800 Amps</td>
</tr>
<tr>
<td></td>
<td>Outgoing Vacuum circuit breaker</td>
<td>800 Amps</td>
<td>800 Amps</td>
</tr>
<tr>
<td></td>
<td>b) Short time current for 1 seconds</td>
<td>Min. 26.3 KA rms</td>
<td>26.3 KA rms</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7.</td>
<td><strong>Vacuum Circuit Breaker:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>a) Quantity</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Incoming Feeder</td>
<td>1 No.</td>
<td>2 Nos.</td>
</tr>
<tr>
<td></td>
<td>Outgoing Feeder</td>
<td>2 Nos.</td>
<td>6 Nos.</td>
</tr>
<tr>
<td></td>
<td>Bus coupler</td>
<td>1 No.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>b) Rated breaking capacity</td>
<td>1250 MVA</td>
<td>500 MVA</td>
</tr>
<tr>
<td></td>
<td>symmetrical</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>c) Total breaking time</td>
<td>3 Cycles (maximum)</td>
<td>3 Cycles (maximum)</td>
</tr>
<tr>
<td></td>
<td>d) Auxiliary voltage</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Control Circuit</td>
<td>24V DC</td>
<td>24V DC</td>
</tr>
<tr>
<td></td>
<td>Space heater and illumination lamp,</td>
<td>230 V, 1 Ph., 50 Hz.</td>
<td>230 V, 1 Ph., 50 Hz.</td>
</tr>
<tr>
<td></td>
<td>etc.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8.</td>
<td><strong>Potential Transformers</strong></td>
<td>(At Incoming)</td>
<td>(At Incoming)</td>
</tr>
<tr>
<td></td>
<td>a) Quantity</td>
<td>One on each incoming</td>
<td>One on each incoming</td>
</tr>
<tr>
<td></td>
<td></td>
<td>panel</td>
<td>panel</td>
</tr>
<tr>
<td></td>
<td>b) Voltage Ratio</td>
<td>33 KV/110 V</td>
<td>11 KV/110 V</td>
</tr>
<tr>
<td></td>
<td>c) Over voltage factor</td>
<td>As per IS – 3156</td>
<td>As per IS – 3156</td>
</tr>
<tr>
<td></td>
<td>d) Accuracy class</td>
<td>1.0</td>
<td>1.0</td>
</tr>
<tr>
<td></td>
<td>e) Rated burden</td>
<td>100 VA</td>
<td>100 VA</td>
</tr>
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### 9. Current Transformer:

<table>
<thead>
<tr>
<th>Circuit</th>
<th>Ratio</th>
<th>Accuracy class</th>
<th>Burden</th>
<th>Circuit</th>
<th>Ratio</th>
<th>Accuracy class</th>
<th>Burden</th>
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<tr>
<td>33kV</td>
<td></td>
<td></td>
<td></td>
<td>11kV</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Incoming</td>
<td></td>
<td></td>
<td></td>
<td>For relay</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>For relay</td>
<td>100/1A</td>
<td>5P10</td>
<td>15VA</td>
<td>For relay</td>
<td>200/1A</td>
<td>5P10</td>
<td>15VA</td>
</tr>
<tr>
<td>For metering</td>
<td>100/1A</td>
<td>1.0</td>
<td>15VA</td>
<td>For metering</td>
<td>200/1A</td>
<td>1.0</td>
<td>15VA</td>
</tr>
<tr>
<td>For relay</td>
<td>100/1A</td>
<td>PS</td>
<td>15VA</td>
<td>As Required</td>
<td>PS</td>
<td>PS</td>
<td>15VA</td>
</tr>
<tr>
<td>For metering</td>
<td>100/1A</td>
<td>1.0</td>
<td>15VA</td>
<td>As Required</td>
<td>1.0</td>
<td>15VA</td>
<td></td>
</tr>
</tbody>
</table>

**DISTRIBUTION TRANSFORMER**

(UPTO 2500KVA)

IMPHAL AIRPORT C-nil l-nil O-nil 829
1.0 GENERAL

The scope of these specifications covers the detailed requirement of Supply Installation, Testing & Commissioning of oil filled/dry type transformers suitable for BMS/SCADA system either inbuilt or separate compatible including all that reasonably inferred as necessary for the proper installation and putting the installations in operational of the extended in the following specifications Scope of work (SOW) as specified.

The transformer shall be indoor / outdoor as specified. All transformers shall have thermal as well as dynamic ability to withstand external short circuit as per standard.

2.0 STANDARDS

The oil filled/ dry type Transformer shall comply with the following Indian standard specifications as amended up to date.

(i) IS 2026 Part – I to V - Power Transformers
(j) IS-1180 (LEVEL-2) - Distribution Transformers (OIL TYPE)
(k) IS 11171- 1985 - Dry type power transformers
(l) IS 335-1993 - Insulating oil.
(m) IS 10028 (Part-II & III) - Installation & Maintenance of Transformers.
(n) 2099 - Bushings
(o) IS 2705 - Current Transformer
(p) IS 2071 - Method of high voltage testing technique.
(q) IS 6600 - Guide for loading of oil immersed transformer.
(r) ECBC 2017 - Losses of transformer as per latest revision

2.0 OIL COOLED TRANSFORMER (Indoor / outdoor)

2.1 Transformer Operation

The transformer shall be suitable for operation on 11KV / 433V, three phase, 50 cycle, earth system, oil immersed natural air cooled (ONAN), double winding type, connected delta on HV side and star on LV side (Dyn-11) with neutral brought out separately for earthing. The transformer shall be suitable for continuous operation at the rated capacity under site conditions specified.

2.2 Transformer Characteristics

The no load voltage ratio of the transformer shall be 11 KV / 433 volts and the percentage impedance shall be as per IS 1180-2 as amended up to date.

2.3 Transformer materials & its enclosure

The material used in the manufacture of the transformer shall be of the best quality of their respective kind available as per standard specifications.

The transformer shall be provided with a mild steel Tank with adequate provision for ventilation. The degree of protection for Tank shall be IP 55. Thickness of Tank shall be as per IS-2026.

After rigorous cleaning & surface treatment, the transformer shall provide primer coat, finished with two coats of weather resisting or enamel machinery paint conforming to relevant IS.

2.4 CORE
The magnetic iron core shall be made up of high grade, low loss grain oriented CRGO steel stamping, HI-B grade steel or superior grades. The maximum flux density at any point in core and York shall not exceed 1.6 Tesla on normal rated voltage and frequency and 1.76 Tesla at 110% rated voltage & frequency. Each core lamina shall be insulated with a material that will not deteriorate due to pressure and hot oil. A margin of 10 to 12.5% for overfluxing may be provided for the worst combination of voltage and frequency within the range specified. The contractor shall provide the saturation curve of the core material proposed to be used and calculations.

**Note:**
No core of second grade / scarab materials will be acceptable. The manufacturer of the transformer shall select prime (first) grade core materials. OEM undertaking shall be submitted to the authority along with technical submittal for approval/acceptance by the bidder.

Core shall have boltless design.

**2.5 WINDING & ITS INSULATION:**
The winding shall be of copper wound. The insulation material used shall be insulation class ‘A’. The conductors shall be of electrolytic grade copper. Better insulating material shall be used and compression of the windings after drying out shall be carried out at a pressure exceeding one and a half to twice the force which can occur in the transformer; to impart greater mechanical strength to the windings against heavy short circuit stresses.

**2.6 EXPLOSION VENT:**
Explosion vent or pressure relief device shall be provided of sufficient size for rapid release of any pressure that may be generated within the tank and which might result in damage to the equipment. The device shall operate at a static pressure less than the hydraulic test pressure for transformer tank. Means shall be provided to prevent the ingress of moisture and of such a design to prevent gas accumulation.

**2.7 BUCHHOLZ RELAY**
Oil and gas actuated relay equipment shall confirm to IS 3637-1966 and shall be double float type having contacts which close falling oil surge or under incipient fault condition. Buchholz relay shall have contact for alarm / trip as required. The relay shall be provided with ateststock suitable forflexible pipe connection for checking its operation and taking gas sample. The device shall be provided with two electrically independent ungrounded contacts, one for alarm on gas accumulation and the other for tripping on sudden rise of pressure. The contacts of relay shall be properly housed, sealed and gasketed to make the arrangements water proof.

**2.8 OIL:**
The insulating oil should have non-sludging low viscosity property and comply with the requirement of relevant IS.

**2.9 TAPINGS:**
The tapping shall be arranged on the high voltage windings only to provide for a voltage adjustment of +5% to -10% in steps of 2.5% of rated voltage at constant KVA output. Full output shall be available on all the tapping’s specified above. The tapping shall be brought out to terminal block located just below the oil level. A triple pole off load hand wheel tap changing switch with position indicator and locking arrangement shall be provided for operation without removing the tank covers or lowering off the oil levels.

**2.10 TERMINALS:**
Primary terminal arrangement shall consist of 3 pole-single gland cable sealing box fitted to the underside of the connection chamber. Secondary terminal arrangement shall consist of 4 pole bus trunking/ cable(s) connections. Appropriate characters in accordance with relevant IS shall be indelibly and clearly marked upon on adjacent to terminal and sub-terminals.

2.11 RATING AND DIAGRAM PLATES

The following plates shall be fixed to transformer in a visible position.

c) A rating plate of weather proof material bearing the data specified in the appropriate clauses of IS: 1180.

d) A diagram plate showing the internal connection and also the voltage vector relationship of the several windings in accordance with IS: 1180 and a plan view of the transformer giving the correct physical relationship of the terminals.

2.12 JOINTS AND GASKETS

All gaskets used for making oil tight joints shall be of proven material such as granulated cork bonded with synthetic rubber gaskets or synthetic rubber or such other good material.

2.13 Transformer shall be complete with first filling oil, control cable between transformer marshalling box upto HT panel including interconnection and with following fittings & accessories conforming to IS 3639- (with upto date amendment) shall be provided with each transformer:

a. Inspection cover.
b. External hand operated off-circuit tap changing switch with position indicating plate & locking arrangement.
c. Oil conservator with filling hole and cap having detachable end cover.
d. Plain / Magnetic oil level gauge with minimum oil level marking.
e. Oil drain valve of size as per ISS with plug or cover plate.
f. Silica-gel dehydrating breather along with breather pipe of suitable size.
g. Rating plates and terminal marking plate of stainless steel / brass / aluminium engraved containing the information specified in relevant IS.
h. Two earthing terminals for body earthing consisting of hexagonal bolts of size M-20 as per relevant IS.
i. Lifting lugs/cover lifting eyes.
j. Radiator for the cooling system (natural air cooling) by means of pressed /round tubes and fins around transformer tank.
k. Four bi-directional flat rollers of suitable size fitted on cross channels, corresponding to weight of transformer to facilitate movement of transformer.
l. Thermometer pocket with plug.
m. Air release device.
n. Explosion vent.
o. 50 mm dial type winding and oil temperature indicator with potential free electrical contact for alarm & trip, fitted with Anti-vibrating mounting with maximum reading pointer.
p. Oil filter valve at TOP of the tank.
q. Marshalling box to terminate the control cables of thermometer etc.
r. HT side cable end box suitable for heat shrinkable termination of maximum size and type of HT cable(s) as required /specified.
s. LT side cable (up to 400KVA transformer) / bus trunking termination arrangements suitable for rating & type as required /specified.
t. Facility to connect Buchholz Relay (shall be applicable for transformer rating above 400KVA).

u. Additional neutral separately brought out on a bushing for earthing for all transformers.

PRE-COMMISSIONING TESTS

After the transformer is installed, the following pre-commissioning tests and checks shall be done before putting the transformer in service.

xi) IR Test
xii) DC Resistance measurement of windings
xiii) Ratio test on all taps
xiv) Phase relationship test (Vector grouping test)
xv) Buchholz relay alarm & surge operation test
xvi) Low oil level (in conservator) alarm
xvii) Temperature Indicators
xviii) Marshalling kiosk
xix) Protective relays
xx) Magnetizing current
xxi) Tests on OLTC

The following additional checks shall be made:

vi) All oil valves are in correct position closed or opened as required.
vii) All air pockets are cleared.
viii) Thermometer pockets are filled with oil
ix) Oil is at correct level in conservator, diverter switch & tank etc.
x) Earthing connections are made. Colour of Silica gel is blue. CT polarity and ratio is correct.

3.0 DRY TYPE TRANSFORMER (indoor / outdoor)

3.1 Transformer operation:

The transformer shall be suitable for operation on 11KV / 433V, three phase, 50 cycle earth system, natural air cooled (AN), cast resin double winding type insulated HV & LT winding with class H respectively, connected delta on HV side and star on LV side (Dyn-11) with neutral brought out separately for earthing. The transformer shall be suitable for continuous operation at the rated capacity under site conditions

The dry type transformer shall comply with the regulations of IEC 76, BS: 7806 & IS: 11171 as amended up to date.

3.2 Transformer Characteristics

The no load voltage ratio of the transformer shall be 11 KV / 433 volts and the percentage impedance shall be as per IS 2026 as amended up to date.

3.3 Transformer materials & its enclosure

The material used in the manufacture of the transformer shall be of the best quality of their respective kind available as per standard specifications.
The transformer shall be provided with a sheet steel enclosure with adequate provision for ventilation. The degree of protection for enclosure shall be IP 23 for indoor & IP-33 for outdoor installation. Thickness of enclosure shall be 2 mm thick mild steel CRCA sheet.

After rigorous cleaning & surface treatment, the transformer shall provide primer coat, finished with two coats of weather resisting or enamel machinery paint conforming to relevant IS.

Powder coating finish after rigorous cleaning and surface treatment.

3.4 CORE

The magnetic iron core shall be made up of high grade, low loss grain oriented CRGO steel stamping. The maximum flux density at any point in core and York shall not exceed 1.6 Tesla on normal rated voltage and frequency and 1.76 Tesla at 110% rated voltage & frequency.

Note:
No core of second grade / scarab materials will be acceptable. The manufacturer of the transformer shall select prime (first) grade core materials. Documentory evidence shall be submitted to authority along with technical submittal for approval/ acceptance.

Core design shall be boltless.

3.5 WINDING & ITS INSULATION:

The winding shall be of copper wound completely impregnated and cast under vacuum in to moulds. The insulation material used shall be insulation class 'H'.

3.6 TAPINGS:

The tapping shall be arranged on the high voltage windings only to provide for a voltage adjustment of +5% TO -10% in steps of 2.5% of rated voltage at constant KVA output. Full output shall be available on all the tapping’s specified above. The tapping shall be brought out to terminal block located just below the oil level. A rotary off Circuit tap changing switch with position indicator and locking arrangement shall be provided for operation without opening the Transformer Enclosure doors.

3.7 TERMINALS:

Primary terminal arrangement shall consist of 3 pole-single gland cable sealing box fitted to the underside of the connection chamber. Secondary terminal arrangement shall consist of 4 pole bus trunking/ cable(s) connections. Appropriate characters in accordance with relevant IS shall be indelibly and clearly marked upon on adjacent to terminal and sub-terminals.

3.8 RATING AND DIAGRAM PLATES

The following plates shall be fixed to transformer in a visible position.

c) A rating plate of weather proof material bearing the data specified in the appropriate clauses of IS: 2026/1977.

d) A diagram plate showing the internal connection and also the voltage vector relationship of the several windings in accordance with IS: 2026-1977 and a plan view of the transformer giving the correct physical relationship of the terminals.

3.9 JOINTS AND GASKETS

All the gaskets used shall be off proven material such as granulated cork bonded with synthetic rubber gaskets or synthetic rubber or such other good materials.

3.10 Following fittings and accessories conforming to IS shall be provided with the transformer:
n) Inspection covers.

o) External hand operated off-circuit tap changing switch with position indicating plate & locking arrangement.

p) 2nos. (one connected & other as spare) PT -100 sensor in each LV windings wired upto the winding temp. scanner. The instrument shall have two sets of adjustable contacts for alarm & trip. The instrument shall have scanner to read & show temperature of all three phases sequentially and have RS 485 port.

q) Rating plates and terminal marking plate of stainless steel / brass / aluminium engraved containing the information specified in relevant IS.

r) Two earthing terminals for body earthing consisting of hexagonal bolts of size M-20 as per relevant IS.

s) Lifting lugs/cover lifting eyes.

t) Four bi-directional flat rollers of suitable size fitted on cross channels, corresponding to weight of transformer to facilitate movement of transformer.

u) Digital winding temperature indicator with alarm & trip contact shall be mounted on transformer enclosure.

v) Terminal box to terminate the control cables of thermometer etc.

w) HT side cable end box suitable for heat shrinkable termination of maximum size and type of HT cable(s) as required /specified.

x) LT side cable (up to 400KVA transformer) / bus trunking termination arrangements suitable for rating & type as required /specified.

y) Additional neutral separately brought out on a bushing for earthing for all transformers

z) Surge arrester on HT side and any other accessories as per IS standard.

4.0 PERFORMANCE TEST: The following performance test shall be conducted on one transformer for each design:

4.1 TEMPERATURE RISE:
Rise in temperature of transformer when tested at continuous maximum rating at a peak ambient temperature of 50 deg. C shall not exceed the limits given below:

d) WINDINGS: Average temperature rise as measured by increase in resistance of windings connected between terminals shall not exceed 115 deg. C in case of oil and 90deg. C for dry type transformer.

e) OIL: Temperature rise as measured by thermometer in case of oil of the transformer shall not exceed as per IS-1180.

f) CORES: Temperature rise when measured by thermometer on the external surface of core shall not exceed the temperature permitted as per relevant IS-1180

4.2 IMPULSE STRENGTH OF WINDINGS:
The impulse strength of winding of the transformer when tested with the standard 1.2/50 micro sec. positive wave shall not be less than specified in the IS. The transformer shall have fully insulated windings designed to meet impulse levels. If no test is carried out of such
transformer, the same should be carried out for at least on one transformer. The copies of valid calibrated instruments shall also be submitted for record.

4.3 **FREQUENCY:**
The transformer shall be designed for a normal frequency of 50 Hz and shall be capable of giving the rated output with the frequency varying by plus or minus 3% from the rated frequency.

4.4 **IMPEDEANCE:**
The percentage impedance shall be as per IS standard. Duration of short circuit with reference to impedance voltage for each transformer shall be in accordance with relevant IS.

4.5 **EXTERNAL SHORT-CIRCUIT:**
Transformer shall be designed to be capable of withstanding without injury, the thermal and mechanical effect of short circuit at the terminals of any windings for the period in accordance with relevant IS. **OEM to submit only Certificate for similar or higher rating from CPRI or approved Govt. Lab.**

4.6 **EFFICIENCY AND REGULATION:**
Efficiency and regulation shall be based on loading at rated KVA and at unity power factor and at 0.8 lagging power factor and shall be computed in accordance with relevant IS respectively.

4.7 **TRANSFORMER LOSSES:** The associated losses of oil filled distribution transformers shall be as per IS-1180 (Level-2) & Cast Resin Dry type transformers shall comply as per latest ECBC-2017 at different loads.

5.0 **TESTS AT MANUFACTURER’S WORKS:**
The transformers are subject to inspection during their manufacture. All routine & other tests prescribed in IEC 60076 -11 and relevant IS-11171 & ECBC 2017 norms with up to date amendments shall be carried out before despatch at manufacturers works in presence of inspecting officer and of following :

5.1 **MEASUREMENT OF WINDING RESISTANCE TEST:**
The resistance of each winding and the marking of the terminals between which it is measured shall be recorded. While measuring the resistance care shall be taken to determine the temperature of windings. The temperature at which the measurement is made shall be recorded.

5.2 **RATIO - POLARITY & PHASE RELATIONSHIP TEST:**
The turns ratio shall be measured on each tapping and the polarity & winding phase relationship shall be checked.

5.3 **MEASUREMENT OF IMPEDANCE VOLTAGE:**
The impedance voltage shall be measured at rated frequency, using an approximately sinusoidal supply. The measurement may be made at any current not less than 50% rated current and the value so obtained shall be increased in the ratio of the rated current to the test current. The test result shall be corrected to the reference temperature of the 75 deg.C.

5.4 **MEASUREMENT OF NO-LOAD LOSSES AND NO-LOAD CURRENT:**
No load losses shall be measured at rated frequency with rated voltage applied to one of the three phase windings, the other windings being open circuited. No load current shall also be recorded.

5.5 MEASUREMENT OF LOAD LOSSES:
This test shall be performed as per clause of relevant IS.

5.6 MEASUREMENT OF INSULATION RESISTANCE:
The oil and windings temperature shall have measured and recorded immediately prior to the test. The Insulation resistance of each windings, in turn, to all the other windings, cores and frame or tank connected together, and to earth shall be measured and recorded.

5.7 INDUCED OVER VOLTAGE WITHSTAND TEST:
This test shall be performed as per clause of relevant IS.

5.8 SEPARATE SOURCE VOLTAGE WITHSTAND TEST:
This test shall be performed as per clause of relevant IS.

5.9 OIL TEST: IN CASE OF OIL COOLED TRANSFORMER
Oil test specified in British standard specifications No. 148/IS 335 shall be carried out and maker's certificate forwarded.

The offered equipment or the same equipment of higher capacity must have successfully type tested as per IS-2026 (with upto date amendment). The type test certificate and test equipment, valid test copies shall be submitted before inspection at works. If the impulse voltage withstands and temperature rise is not type tested, firm to carry out the same during inspection at works.

6.0 Type test certificate of CPRI or any other approved test house for similar or higher rating of transformer to be submitted along with the approval of technical submittal & drawings.

6.0 PARALLEL OPERATION
The transformer shall be suitable for parallel operation. Therefore, selection of transformer should be ensured for percentage impedance, voltage ratio, vector groups, phase sequence etc. are same for all units.

7.0 TRANSFORMER INSPECTION AT SITE ON ARRIVAL

iii. The transformer shall be inspected on arrival as per the inspection manual of the supplier.

iv. The transformer shall be examined of any sign of damage and special attention shall be given to the following parts of oil cooled transformer as applicable:

- Oil tank and cooling tubes.
- Bushes cracks or broken.
- Oil sight glass.

8.0 INSTALLATION & COMMISSIONING:-

(vii). The transformer shall be installed as per installation manual of the transformer suppliers and conforming IS 10028 (Part-II & III) - Code of practice for Installation and Maintenance of transformers. Necessary foundation and/or support channels shall be grouted in the flooring as required within the scope of works.
(viii). The transformer supplied shall be lifted by lifting lugs for the purpose of avoiding imbalance in transit.
(ix). The transformer shall be moved to its location on grouted channels & wheels shall be locked by suitable locking arrangement to avoid accidental movement of the transformer.
(x). The transformer cable end boxes shall be sealed to prevent absorption of moisture.
(xi). The transformer neutral earthing, body earthing & other wiring shall be done as shown on the approved drawings and as per specifications.
(xii). All devices shall be checked for satisfactory operation.

9.0 TESTS AT SITE:-

In addition to tests at manufacturer’s premises, all relevant pre-commissioning checks and tests conforming to IS code of practice No.10028 (Part II & III) shall be done before commissioning. The following tests are to be particularly done before cable jointing or connecting up the bus bar trunking.

f. Insulation test between HV to earth and HV to MV with a 5000 Volts Megger.
g. Insulation test between MV to earth with 500 volts Megger.
h. Winding resistance of all the windings on all the tap positions shall be taken.
i. Di-electric strength of transformer oil shall be checked in accordance with IS 335. In case the test is not satisfactory, the oil shall be filtered till proper dielectric strength of oil is obtained and also top up within the scope of the bidder.
j. Buchholz relay operation by simulation test when fitted.

All test results are to be recorded and reports should be submitted to the Engineer In Charge for its acceptance.
SANDWITCH INSULATED BUSTRUNKING

SCOPE
This section covers manufacture, supply, installation, testing and commissioning of sandwich insulated bus trunking for connection between the Transformer to LT panels or DG sets to DG Panel or DG Panel to LT Panels as required as per site conditions.

SUPPLY VOLTAGE
For 3 phase, 4 wire, 50 cycles AC supply, operating voltage 415 volts.

STANDARD FOR COMPLIANCE
Particular requirement of bus trunking system shall comply with IEC 61439-1 & 6 and IS 8623-2

IEC-60529 - Degree of protection
IS 3202 - Code of practice for climate proofing of electrical equipment.
IS : 8623/1993 I &II - Low-Voltage Switchgear and Control gear
IS 8623-2 - Assemblies
IEC 61439-6 - Low-Voltage Switchgear

CONSTRUCTION
The enclosure shall be made from 1.6 mm thickness galvanized sheet steel duly powder coated with IP 55 protections. Bus bars would be in ‘Sandwich’ construction and the conductors will be individually insulated with layers of insulating film. Inner layer shall be of Glass MICA and outer layer of polyester or multilayer PET insulation material having minimum class F. Alternatively extrusion of Class ‘F’ material in the form of epoxy insulation may be provided. No drilling of Bus bars is permitted. Length of section will be limited to max 3 Mtrs. Bus bars of one section will be connected to Bus bars of adjacent section by uniblock joint/single bolt joint system removable as separate sub-assembly, so that it can be inserted or removed without disturbing the adjacent sections. All busbar trunking products and fittings (straight length, elbow, tees, flanged ends, cable tap box etc.) shall be in accordance with relevant IEC 61439-6 standard and from the same manufacturer as the busbar trunking system. The whole busbar trunking system shall be capable of withstanding the short circuit of the electrical installation without damaging the electrical, mechanical and thermal stress under fault condition. The voltage drop (input voltage minus output voltage) specified shall be based on the busway operating at full rated current and at stabilized operating temperature in 30 degree Centigrade ambient. The voltage drop should be less than the permissible limits as per relevant standards. Hanger spacing shall be noted on layout drawings and shall not exceed manufacturer’s recommendations. The design of Bus duct should be as per relevant Standards considering all derating factors. Suitable flanged arrangements to be provided at both ends to match with MV circuit breaker panels/Transformers terminal box.

At the termination either on the transformer side or on generator end or on switchgear panel, busduct shall be provided with flange ends, adopter Box and copper flexible to connect Bus bars of bus duct to busbars of switchgear panel or transformer terminals or generator terminals.
The ducts shall be designed for a continuous current rating as specified in the Drawings. Cross section of neutral busbar shall be same as that of the phase-busbar. The short circuit
rating shall 50 KA at 415 volts and the Contractor shall satisfy the Engineer-in-charge in this regard by calculations to prove this capability

TECHNICAL PARAMETERS FOR COMPLIANCE:
Bus trunking will be designed to withstand short circuit current of 50 kA for one second.

Busbar system should be designed for an ambient temp. of 40 deg C. and temp. rise restricted to 55 Deg. C max. on conductor above ambient.

Maxmum operating voltage - 600 / 1000 Volts
Insulation voltage - 1000 Volts.

INSTALLATION

Necessary Vertical / Horizontal Bends/ Tees shall be provided as required as per approved layout drawings as per site requirements. Bus bars trunking will be rigidly fixed to the side walls or suspended from ceiling by supports as per site requirement. At the termination either on transformer side or on generator end or on switchgear panel, bus duct will be provided with flange ends, adopter Box and copper flexible (preferably multisheet types) to connect Bus bars of bus duct to bus bars of switchgear panel or transformer terminals or generator terminals.

All the components like Bus bars ducting, Bends, Hanger ends, and Adopter Boxes etc. will be made from galvanized steel sheets. All bus duct connections shall be checked through torque wrench or as per manufacturer recommendations.

EXPANSION JOINTS

Expansion joints shall be provided wherever necessary to take care of expansion & contraction of the bus bars under normal operating conditions. This shall be provided after every uninterrupted run of 50mtrs.

EARTH STRIP

Earth strip of Aluminium or Copper shall be provided, one on each side all along the bus duct of size 50 X 5 mm size Earth strip should be firmly fixed to the body of bus duct at regular intervals.

3.0 Contractor shall submit the bus bar sizing calculation for short circuit withstand capability and maximum temperature rise indicating the de-rating factors clearly for the approval of Engineer-In-Charge.

4.0 TESTS

4.1 FACTORY TESTS

Contractor / Supplier shall submit manufacturer copy of test certificates for Type test & original test certificates for Routine test & laid down in relevant IS.

4.2 SITE TESTS

Contractor / Supplier shall coordinate with erection Contractor for testing of Bus duct prior to commissioning and following tests shall be carried out at site and test results recorded.

i. Insulation resistance test with 500 volts megger. The insulation resistance shall be not less than 100 mega ohms. The testing shall be done as per IS 8084-1976 with upto date amendments.
ii. Earth continuity test.
1.0 GENERAL

HT/ LT Cables shall be supplied, laid, tested and commissioned in accordance with drawings, specifications, relevant Indian Standards specifications and cable manufacturer's instructions. The cable shall be delivered at site in original drums with manufacturer's name clearly written on the drums. The recommendations of the cable manufacturer with regard to jointing and sealing shall be strictly followed.

STORAGE AND HANDLING

Storage:

(i) The cable drums shall be stored on a well-drained, hard surface, so that the drums do not sink in the ground causing rot and damage to the cable drums paved surface is preferred, particularly for long term storage.

(ii) The drums shall always be stored on their flanges, and not on their flat sides.

(iii) Both ends of the cables should be properly sealed to prevent ingress/absorption of moisture by the insulation during storage.

(iv) Protection from rain and sun is preferable for long-term storage for all types of cables. There should be enough ventilation between cable drums.

(v) Damaged battens of drums etc. should be replaced, as may be necessary.

Handling:

(i) When the cable drums have to be moved over short distances, they should be rolled in the direction of the arrow marked on the drum.

(ii) For manual transportation over long distances, the drum should be mounted on cable drum wheels, strong enough to carry the weight of the drum, and pulled by means of ropes. Alternatively, they may be mounted on a trailer or on a suitable mechanical transport.

(iii) For loading into and unloading from vehicles, a crane or a suitable lifting tackle should be used. Small sized cable drums can also be rolled down carefully on a suitable ramp or rails, for unloading, provided no damage is likely to be caused to the cable or to the drum.

The following standards, amended up to date, shall be applicable:


4. IS: 6474 : Polythene insulation and sheath of electric cables.

5. IS: 3975 : Specification for mild steel wires, strips and tapes for armouring of cables.


8. IS: 3961 : Recommended current ratings of cables.


10. IS: 8130 : Electrical purity of Aluminium

2.0  a) H.T. CABLES

H.T. Cables shall be of 33kV OR 11kV grade, 3 Crore, XLPE insulated, Aluminium Conductor, armoured Cables with electrical purity of aluminium conductor manufactured & tested in accordance with IS: 7098 (Part II). HT Cable shall be of earthed, grade and shall be of stranded construction, comply to IS 8130. The conductor screen & insulation screen shall both be of extruded semi conducting compound and shall be applied along with XLPE insulation in a single operation of triple extrusion process so as to obtain continuously smooth inter-phase. The metallic screen of each core shall consist of copper wires or tape. The method of curing shall be dry / gar / steam curing. Metallic screen shall be suitable for carrying the fault current of minimum 0.6 KA (for combined 3 core) for 1 second 33KV OR 11KV. Outer sheath shall be of tough, PVC compound as per IS:5831 and shall be extruded over the armouring. Cables shall be tested for type tested & routine tested in accordance with IS:7098 (Part II).

Laying & termination of H.T. cables shall be with all required accessories. The cables shall be inspected in the OEM factory before dispatching.

b) LT CABLES

LT Power cables shall be XLPE insulated and PVC sheathed type stranded aluminium / copper conductor armoured cable whereas control cable shall be armoured/ unarmoured, conforming to IS : 7098 : 1988 (Part-I). Cables shall be of 1100volt and with ISI certification mark. Conductor of cables shall be made of electrical purity Aluminium confirming to IS: 8130-1984. All standards shall be with upto date amendments.

All inter-connecting cables within terminal building shall have outer sheath with FRLS.

The armouring for cables above 16 sqmm shall be galvanized steel strips and 16sqmm & below shall be with galvanized steel round wire.
3.0 **INSPECTION**

The cables shall be inspected in the OEM factory before dispatching as per standard and as per contract conditions.

4.0 **JOINTS IN CABLES**

The Contractor shall take care to see that the cables received at site are apportioned to various locations in such a manner as to ensure maximum utilization and avoiding of cable joints. This apportioning shall be got approved from Engineer-In-Charge before the cables are cut to lengths.

5.0 **INSTALLATION OF CABLES**

Cables shall be laid directly in ground, pipes, masonry ducts, on cable tray, surface of wall/ceiling etc. as per approved layout and/or as per the direction of Engineer-In-Charge. Cable laying shall be carried out as per CPWD specifications.

5.1 **CABLES LAYING IN GROUND**

Cables shall be laid by skilled experienced workmen using adequate rollers. The cable drums shall be placed on jacks before unwinding the cable. With great care, it shall be unrolled on over wooden rollers placed in trenches at intervals not exceeding 2 metres.

Cables shall be laid at depth of 750 mm below ground level & 1200 mm in case of HT, from ground level. A sand cushion of 80mm & 170 mm shall be provided below & above the cable respectively, joint boxes and other accessories. Cable shall not be laid in the same trench or along side a water main. Width of the trench shall be 350 mm (minimum) for laying single cable.

For all underground cables, route markers should be used. Separate cable route markers should be used for LT, HT and telephone cables. Cable markers should be installed at an interval not exceeding 50 M along the straight routes of cables at a distance of 0.5 M away from centre of cable with the arrow marked on the cable markers plate indicating the location of cable. Cable markers should also be used to identify change in direction of cable route and for location of every joint in underground cable.

The relative position of the cables, laid in the same trench shall be preserved. At all changes in direction in horizontal and vertical planes, the cables shall be bent smooth with a radius of bent not less than 12 times the diameter of cables. Minimum 3 metre long loop shall be provided at both end of cable.

Distinguishing marks may be made on the cable ends for identifications of phases. Insulation tapes of appropriate voltage and in red, yellow and blue colours shall be wrapped just below the sockets for phase identifications.

5.2 **PROTECTION OF CABLES**

The cables shall be protected by bricks laid on the top layer of the sand for the full length of underground cable. Where more than one cables is laid in the same trench, the bricks shall cover all the cables and shall project a minimum of approximately 50mm on either side of the cables. Cable under road crossings and any other places subject to heavy traffic, shall be protected by running them through Hume Pipes of suitable size.
5.3 **EXCAVATION & BACK FILL**

All excavation and back fill required for the installation of the cables shall be carried out by the contractor in accordance with the drawings and requirements laid down elsewhere. Trenches shall be dug true to line and grades. Back fill for trenches shall be filled in layer not exceeding 150mm. Each layer shall be properly rammed and consolidated before laying the next layer.

The Contractor shall restore all surface, roadways, side walks, kerbs wall or the works cut by excavation to their original condition to the satisfaction of the Engineer-In-Charge.

5.4 **LAYING OF CABLES ON CABLE TRAY/SURFACE OF WALL/CEILING**

Cable shall be laid on perforated M.S. Cable tray. Cables shall be properly dressed with nails/ with aluminium flat clamps and galvanised bolts. Wherever cable tray is not proposed, cables shall be fixed on surface of wall or ceiling slab by suitable MS clamps/ saddles. Care shall be taken to avoid crossing of cable. Entry of cables in trenches shall be sealed with bituminous MASTIC compound to stop entry of water in trenches.

5.5 **CABLES ON HANGERS OR RACKS**

The Contractor shall provide and install all iron hangers racks or racks with die cast cleats with all fixings, rag bolts or girder clamps or other specialist fixing as required. (Iron racks to be provided by Civil Contractor or their Sub associates). The cable racks shall be of adequate strength to carry the weight of cables with out sagging. Structural bracket grounded in the build up trenches to support the cable such supports shall be at intervals of not less than 750 mm centres. All the structural steel work shall be finished with two coats of paint over primer. Earthing flat/wire can also be laid in cable tray along with cables.

Where hangers or racks are to be fixed to wall sides, ceiling and other concrete structures, the Contractor shall be responsible for cutting away, fixing and grouting in rag bolts and making good.

The hangers or racks shall be designed to leave at least 25mm clearance between the cables and the face to which it is fixed. Multiple hangers shall have two or more fixing holes. These shall be designed to keep provision of some spare capacity for future development.

5.6 **TERMINATION AND JOINTING OF CABLES**

a) **Use of Glands**

All PVC cable upto 1.1 kV grade, armoured or unarmoured shall be terminated at the equipment/junction box/ isolators/push buttons/control accessories, etc. by means of suitable size compression type cable glands armour of cable shall be connected to earth point. The Contractor shall drill holes for fixing glands wherever necessary. Wherever threaded cable gland is to be screwed into threaded opening of different size, suitable galvanised threaded reducing bushing shall be used for approved type.

In case of termination of cables at the bottom of the panel over a cable trench having no access from the bottom, a close fit holes should be drilled in the bottom plate for all the cables in one line, then bottom plate should be split in two parts along the centre line of
holes. After installation of bottom plate and cables with glands, it shall be sealed with cold sealing compound.

b) Use of Lugs/Sockets

All cable leads shall be terminated at the equipment terminals, by means of crimped type solder less connectors unless the terminals at the equipment ends are suitable for direct jointing without lugs/sockets.

The following is the recommended procedure for crimped joints and the same shall be followed:

i) Strip off the insulation of the cable end with every precaution, not to severe or damage any stand. All insulation to be removed from the stripped portion of the conductor and ends of the insulation should be clean and square.

ii) The cable should be kept clean as far as possible before assembling it with the terminal/socket. For preventing the ingress of moisture and possibility of re-oxidation after crimping of the aluminium conductors, the socket should be fitted with corrosion inhibiting compound. This compound should also be applied over the stripped portion of the conductor and the palm surface of socket.

iii) Correct size and type of socket/ferrule/lug should be selected depending on size of conductor and type of connection to be made.

iv) Make the crimped joint by suitable crimping tool.

v) If after crimping the conductor in socket/lug, same portion of the conductor remains without insulation the same should be covered sufficiently with PVC tape.

c) Dressing of Cable inside the Equipment

After fixing of cable glands, the individual cores of cable shall be dressed and taken along the cableways (if provided) or shall be fixed to the panels with polyethylene straps. Cable shall be dressed in such a manner that small loop of each core is available inside the panel.

For motors of 20 HP and above, terminal box if found not suitable for proper dressing of an aluminium cables, the Contractor shall modify the same without any additional cost.

Cables inside the equipment shall be measured and paid for.

d) Identification of Cables/Wires/Cores

Power cables shall be identified with red, yellow & blue PVC tapes for trip circuits identification, additional red ferrules shall be used only in the particular cores of control cable at the termination points in the switchgear/control panels and control switches.

In case of control cables all cores shall be identified at both ends by their wire numbers by means of PVC ferrules or self sticking cable markers, wire numbers shall be as per
schematic/connection drawing. For power circuit also wire numbers shall be provided if required as per the drawings of switchgear manufacturer.

6.0 CABLES TAGS

Cable tags shall be made out of 2mm thick aluminium sheets of suitable size & tagged with GI wire before entry in to the panel(s)/ crossing/manholes. The cable tag shall indicate destination & origin point of cable alongwith its size.

7.0 TESTING OF CABLES

Prior to installation, burying of cables, following tests shall be carried out. **Insulation test**: (between phases, phase & neutral, phase & earth for each length of cable).

a. Before laying.
b. After laying.
c. After jointing.

On completion of cable laying work, the following tests shall be conducted in the presence of the Engineer-In-Charge.

a. Insulation Resistance Test (Sectional and overall).
b. Continuity Resistance Test.
c. Earth Test.

All tests shall be carried out in accordance with relevant Indian Standard code of practice and Indian Electricity Rules. The Contractor shall provide necessary instruments, equipments and labour for conducting the above tests & shall bear all expenses of conducting such tests.

8. GENERAL REQUIREMENTS FOR HANDLING OF CABLES

a) Before laying cables, these shall be tested for physical damage, continuity absence of cross phasing, insulation resistance to earth and between conductors. Insulation resistance tests shall be carried out with 500/1000 volt Insulation Resistance Tester.

b) The cables shall be supplied at site, wound on wooden drum or steel drum as far as possible. For smaller length and sizes, cables in properly coiled form can be accepted. The cables shall layed by mounting the drum of the cable on drum carriage. Where the carriage is not available, the drum shall be mounted on a properly supported axle, and the cable laid out from the top of the drum. In no case the cable will be rolled on, as it produces kinks which may damage the conductor.

c) Sharp bending and kinking of cables shall be avoided. The bending radius for PVC insulated and sheath armoured cable shall not be less than 12 D Where ‘D’ is overall diameter of the cable.

d) While drawing cables through GI pipes, conduits, RCC pipe, ensure that size of pipe is such that, after drawing cables, 40 % area is free. After drawing cable, the end of pipe shall be sealed with cotton/bituminous compound.

e) High voltage (11 kV and above), medium voltage (230 V and above) and other control cables shall be separated from each other by adequate spacing or running through independent pipes/trays.
f) Armoured cables shall never be concealed in walls/floors / roads without GI pipes, conduits RCC pipes.

g) Joints in the cable throughout its length of laying shall be avoided as far as possible and if unavoidable, prior approval of site engineer shall be taken. If allowed, proper straight through epoxy resin type joint shall be made, without any additional cost.

h) A minimum loop of 3 M shall be provided on both ends of the cable, or after every 50 M of unjointed length of cable and on both ends of straight through cable joint. This additional length shall be used for fresh termination in future. Cable for this loop shall be paid for supply and laying.

i) Cable shall be neatly arranged in the trenches/trays in such a manner so that criss-crossing is avoided and final take off to the motor/switchgear is facilitated. Arrangement of cables within the trenches/trays shall be the responsibility of the Contractor.

j) All cable routes shall be carefully measured and cable cut to the required lengths and undue wastage of cables to be avoided. The routes indicated in the drawings is indicative only and the same may be rechecked with the Engineer-in-charge before cutting of cables. While selecting cable routes, interference with structures, foundations, pipe line, future expansion of buildings, etc. should be avoided.

k) All temporary ends of cables must be protected against dirt and moisture to prevent damage to the insulation. For this purpose, ends of all PVC insulated cables shall be taped with an approved PVC or rubber insulating tape. Use of friction type or other fabric type tape is not permitted. Lead sheathed cables shall be plumbed with lead alloy.

l) Wherever cable rises from underground/concrete trenches to motors/switchgears/push buttons, these shall be taken in GI pipes of suitable size, for mechanical protection upto 300 mm distance of concerned cable gland or as instructed by the Engineer-in-charge.

m) Where cables pass through foundation/walls of other underground structures, the necessary ducts or openings will be provided in advance for the same. However, should it become necessary to cut holes in existing foundations or structures the electrical Contractor shall determine their location and obtain approval of the Engineer-in-charge before cutting is done.
SPECIFICATION FOR AMF DG SET

1.0 GENERAL CONDITIONS

This General Specifications cover the equipment and materials for the selection of AMF DG sets of upto 1250kVA or as per the design requirement, their testing and / or inspection as may be necessary for assembled silent DG set & AMF panel is dispatch from the works, it’s delivery at site, all preparatory works, assembling, installation and adjustments, commissioning, final testing, putting into operation and handing over of the complete system.

STANDARDS & CODES:
The design, manufacture and testing of the AMF DG sets & its components shall be carried out as per latest applicable Indian Standards, Indian Electricity Rules, relevant code of practices and requirement of Chief Electrical Inspectorate of the State Government and International Electro Technical Commission (IEC) Standards. However, for ready reference some of the Standards and Code of Practices are given below:
All components shall conform to relevant Indian Standard Specifications, wherever existing, amended to date.
All electrical works shall be carried out in accordance with the provisions of Indian Electricity Act, 2003 and Indian Electricity Rules, 1956 as amended up to date. They shall also conform to CPWD General Specifications for Electrical works, Part-I (Internal), 2013 and Part-II (External), 1994 and Part IV (Sub-station), 2013, as amended up to date.
Clearance/ Approval of the complete installation from CPCB/ State Pollution Control Board, Central Electricity Authority (CEA)/ Local Bodies and other licensing authorities, wherever required

IS 1601 : Performance and testing of 1C engines for General Purpose.
BS-649 : Performance and testing of diesel engines for General Purpose.
IS-4722 : Rotating electrical machines.
IS-4889 : Method of determination of efficiency of Rotating Electrical machinery.
IS-6491 : Degree of protection provided by enclosures for Rotating Electrical machinery.
IS-4729 : Measurement and evaluation of vibration of Rotating Electrical machines.
AIEE-606 : Recommended specification for speed governing of internal (1959) combustion engine generator units.
IS-2705 : Current transformers.
IS-1248 : Electrical indicating instruments.
ISO-8528 : Reciprocating IC engine driven AC Gensets Section (Part II)
IEC 60439 : Low voltage switchgear & control gear Assemblies
Part – I : Partially Type Tested Assemblies.
IEC 62208 / IS 2147 : Empty enclosures for low voltage switchgear and control gear assemblies – General Requirements
IEC 62262 : Degree of protection provided by enclosures for electrical equipments against external mechanical impacts (IK code)
IS IEC 60947 : Low voltage switch gears

1.1 **Works to be done by the contractor**

Unless otherwise mentioned in the tender documents, the following works shall be done by the contractor and therefore, their cost shall be deemed to be included in their tendered cost – whether specifically indicated in the schedule of work or not:-

i) AVM type pad shall be used as per recommendation of manufacturers. The design of the foundation for installation of complete DG set with canopy shall be submitted duly vetted by structural engineer for approval by Engineer In Charge.

ii) Making good all damages caused to the structure during installation and restoring the same to their original finish.

iii) Minor building works necessary for installation of equipments, foundation trench for fuel lines & cables, making of opening in walls or in floors and restoring them to their original condition / finish and necessary grouting etc., as required.

iv) All supports for exhaust pipes, sundry equipments, fittings, assemblies, accessories, hardware items, etc. as are necessary.

v) All electrical works and neutral earthing, body earthing, required for engine & alternator, main board/ control panels and control wiring including loop earthing, as required.

The Neutral connection inside the canopy shall be extended with flexible copper cable with lugs etc.

vi) All pipes, cable connections etc.

vii) POL i.e. HSD oil and lube oil for diesel engine for testing & commissioning and for trial run as per conditions of the contract. All tools and tackles required for unloading / handling of equipment and materials at site, their assembly, erection, testing and commissioning shall be the responsibility of the contractor.

viii) Painting of all exposed metal surfaces of equipment and components with appropriate colour.

ix) **Statutory Clearance(s)**

Approval / clearance of the complete installation shall be obtained by the contractor from CPCB / State Pollution Control Board / Local Bodies / Central Electricity Authority (CEA) / other licensing authorities, wherever required. However, application shall be made by Department and any statutory fee, as applicable, shall be paid by Department directly to the Govt. authorities.

x) Carry out routine and preventive maintenance as per manufacturer’s standards for a period of 24 months from the date of handing over i.e. during defect liability period shall be contractor scope of works. However, all consumables (fuel / lube oil etc.) and spare parts including filters will be supplied by the department.

1.2 **Location:** Substation building at proposed Airport.

1.3 **Climatic conditions:**

The output of DG set shall be considered under climatic conditions to be in conformity with CPCB approved type tests for the proposed location of the Airport for:

i) Outside maximum ambient temp.

ii) Height above Mean sea level

iii) RH
1.4 Special Conditions (Additional)

WARRANTY:

Clause of Condition of contract attached shall be substituted warranty / guarantee / defect
liability period of the generating set will be as under:

For diesel engine and alternator for period of 5000 hrs. of running or 2 years from the date of
commissioning, whichever is earlier.
5 Years / 5000 Hours of Warranty for Critical Engine Components like Cam Shaft, Crank Shaft,
Cylinder Head, Cylinder Block & Connecting Rod against manufacturing defect.
The contractor shall remain liable to replace any defective part in the plant of his own
manufacturing or those of his principals under the conditions provided in the contract under
proper use and arising solely form faulty design, a material or workmanship of premature
failure provided always that such defective parts are not repairable at site. The contractor has
to give an undertaking that the spares for these will be supplied such equipment then AAI will
be informed and alternative arrangements will be made by the manufacturer. The contractor
will have to give a separate guarantee bond for this purpose.
For other equipment, for a period of 24 calendar months from the date of completion or 30
months form the date of supply of the equipment to AAI, whichever is earlier.
If it becomes necessary for the contractor to replace any defective part of the plant under the
clause, warranty period of the parts to be replaced shall be considered concurrent with the
warranty of the main equipment.
If any defects are not remedied within a reasonable time. AAI will have liberty to do the work
at the risk and cost of the contractor but without prejudice to other rights which the AAI may
have against the contractor in respect of such contractor.
At the end of warranty period the contractors liability shall cease in respect of goods not
covered by the above paragraphs. AAI shall be entitled to the benefit of such guarantee given
to the contractor by the original supplier / manufacturer of goods.

1.5 After Sales Services

The contractor shall ensure adequate and prompt after sales service free of cost during
guarantee period, and against payment after the guarantee period is over, in the form of
maintenance, spares and personnel as and when required during normal life span of the
equipments and shall minimize the break down period. In case of equipment supplied by
other manufacturers the firm shall furnish a guarantee from the manufacturer for the same
before the DG set installation is taken over.

SHOP DRAWING SUBMISSION:

a) On award of work contractor shall submit shop drawing along with technical compliance
   of contract specification and supporting calculation sheets for selection of LV hybrid
   compensation system rating complete.
b) On approval of technical submittal, four sets of working drawings to be submitted by the
   contractor to Engineer – In – charge.
c) On completion of work, four sets of as built drawing to be submitted.

2.0 DIESEL ENGINE:

2.1 Standard: The Engine shall conform to IS;10000/ISO 3046/BS; 649/BS 5514 amended up to
date.
2.2 **Rating:** The engine shall be of standard design of the original manufacturers. It should be 4 stroke cycles, water cooled, turbo charged, diesel engine developing suitable BHP for giving a power rating as per ISO 8528-Part-1 in KVA at the load terminals of alternator at 1500 rpm after accounting for derating in engine output if any, as per the climate conditions of proposed site & due to acoustic enclosure.

2.2.1 The engine shall be capable for delivering specified Prime Power rating at variable loads for PF of 0.8 Lag with 10% overload available in excess of specified output for one hour in every 12 hours continuous operation. The average load factor of the Genset over period of 24 hours shall be atleast 85% for prime continuous power output.

2.2.2 Necessary certificate indicating the compliance of the above capacity requirement for the engine model so selected along with compliance of Noise and Emission norms as per latest CPCB guidelines for DG set capacities should be furnished from the manufacturer.

2.3 The engine shall be fitted with following accessories subject to the design of the manufacturer:
   i) Dynamically balanced fly-wheel.
   ii) Air cleaner (dry type).
   iii) An electronic governor to maintain engine speed at all conditions of load.
   iv) Dry exhaust manifold with suitable exhaust hospital grade silencer to reduce the noise level.
   v) Suitable self-starter for 12 V/24 V DC.
   vi) Battery charging alternator unit and voltage regulator, suitable for starting batteries, battery racks with interconnecting leads and terminals. The Charger shall be SMPS type.
   vii) Necessary gear driven oil pump for lubricating oil as well as fuel systems as per manufacturer standard.
   viii) Turbo charger.
   ix) Lubrication oil cooler.
   x) Cartridge type lubrication oil filters.
   xi) **Fuel injection:** Engine should have suitable fuel injection system in order to achieve low fuel consumption.
   xii) Fuel control solenoid
   xiii) Fuel pump with engine speed adjustment.
   xiv) **Engine Control Panel:** fitted and having digital display for following:
   a) Start /stop key and or switch.
   b) Water temperature indication
   c) RPM indication
   d) Engine Hours indications
   e) Battery charging indication
   f) Low lube Oil pressure trip indication
   g) High water temperature indication.
   h) Over speed trip indication.
   xv) All moving parts of the engine shall be mechanically guarded in such a manner that a human finger cannot touch any moving part.
   xvi) Radiator.
   xvii) Any other item not included / specified, but is a standard design of the manufacturer.
2.4 **Governor:** Electronic governor of class A1 as per ISO 3046/ BS 5514 with actuator shall be provided as per standard design of manufacturer. Governor shall be a self-contained unit capable of monitoring speed. Governor should maintain the speed within 1/8 cycles minimum, of 50 cycles from no load to full load generator output.

The governors shall have drooping characteristics so as to ensure proper load sharing. The governing system shall be complete with all devices / switches for auto / manual operation. The over speed trip mechanism shall also be provided to automatically shut off the supply of fuel in case the engine speed reaches 110% of rated speed.

2.5 **Frequency variation:**

The engine speed shall be so maintained that frequency variation at constant load including no load shall remain within a band of 1% of rated frequency.

2.6 **Fuel System:**

It shall be fed through engine drive fuel pump. A replaceable element of fuel fitter shall be suitably located to permit easy servicing.

The separate (not inbuilt) daily fuel tank shall be provided suitable for 990 Ltrs. capacity for each set. The tank shall be fitted with breather, drain plug, transparent PVC pipe connections with valves and calibration strip, low level contacts and alarm, connecting piping works with valves etc. and shall be made out of minimum 2mm thick MS sheet. The piping & valves etc. shall be selected / planned / design to meet the site requirements. Further, the two DG set tanks shall be interconnected with valves in such a way that each tank can use with either of DG set.

2.7 **Lubricating oil system:**

It shall be so designed that when the engine starts after a long shut down lubrication failure does not occur. Design / selection shall be as per OEM standard. The lubrication oil shall be recommended grade of engine manufacturer, marketed in India and suitable for climatic conditions of proposed airport site. Contractor shall provide motor driven lube oil pump if required to keep the bearings primed. Its power consumption to be indicated. The frequency and duration of the pump operation to be specified.

2.8 **Electric Starting System:**

This shall comprise of necessary set of heavy duty batteries 12V/24V DC suitable starter motors, axial type gear to match with the toothed ring on the fly wheel. A timer in the control panel to protect the starter motor from excessively long cranking runs shall be suitably integrated with the engine protection system and shall be included within the scope of the work. Battery capacity shall be suitable for meeting the needs of starting system (as three attempt starting), as well as the requirements of control panel, indications and auxiliaries such as priming pump as applicable etc. The scope shall cover all cabling, terminals, including initial charging etc. The system shall be capable of starting the DG set within 10 seconds, even in winter condition with an ambient temperature down to 0°C.

2.9 **Turbo Charger**

The turbo charger shall be suitable for being driven by waste gases from the engine and having a common shaft for the turbine and blower. It shall draw air from the air filters and
shall be of suitable capacity corresponding to engine requirements. The output of the turbo charger shall be suitably routed through an inter-cooler for obtaining better efficiency.

2.10 **Flywheel**:  
The engine shall be provided with suitable balanced flywheel to ensure and maintain the cyclic irregularity within the limits specified in BS : 5514. The combined inertia of the flywheel and alternator rotating shall be such that the angular deviation in either direction from the position of uniform rotation shall not at any time exceed limit.

2.11 **Piping Work**  
All pipe lines, fittings and accessories requirement inside the room/enclosure and outside for exhaust piping shall be provided by the contractor. This shall include necessary flexible pieces in the exhaust, fuel, lub. oil and water lines as are necessary in view of the vibration isolation requirement in the installation. Piping of adequate size shall be used for lub. oil of the material as per manufacturer standard. However, only M.S. pipes for the exhaust and fuel oil lines shall be used.  
For fuel lines within acoustic enclosure, PVC braided pipe as per manufacturer recommendations can only be used.

The pipe work shall be inclusive of all fittings and accessories required such as bends, reducers, elbows, flanges, flexible connections, necessary hardware etc. the installation shall cover clamps, supports, hangers etc. as are necessary for completing the work. However, the work shall be sectionalized with flanged connections as are necessary for easy isolation for purposes of maintenance of unit as approved by Engineer-in-charge.

2.12 **Common base plate**  
Engine and alternator shall be coupled by means of rigid coupling as per manufacturer standard design and both units shall be mounted on a common base plate together with all auxiliaries to ensure perfect alignment of engine and alternator with minimum vibrations. The base shall have suitable anti-vibration mounting system.

2.13 **Exhaust system**  
i) **Exhaust piping:**  
All M.S. Pipes for exhaust lines shall be conforming to relevant IS. The runs forming part of factory assembly on the engine flexible connections upto exhaust silencer shall be exclusive of exhaust piping item. The work includes necessary cladding of exhaust pipe work using 50mm thick glass wool / mineral wool/rock wool of density not less than 120 kg/m3 and aluminium cladding (0.6mm thick) for the complete portion. The exhaust pipe work includes necessary supports, Foundation etc. to avoid any load & stress on turbo charger / exhaust piping. The exhaust pipe support structure shall be got approved by engineer-in-charge before execution and with the following:

a) Exhaust system should create minimum back pressure.
b) Number of bends should be kept minimum and smooth to minimize back pressure.
c) Pipe sleeve of larger dia should be used while passing the pipe through concrete wall & gap should be filled with felt lining.
d) Exhaust piping inside the Acoustic Enclosure / Gen-set room should be insulated with mineral / rock wool along with aluminium sheet cladding to avoid heat input to the room.
e) Exhaust flexible shall have its free length when it is installed. For bigger engine, 2 flexible bellows can be used to meet the system design requirement.

f) ‘B’ class MS pipes and long bend/elbows should be used.

g) The exhaust outlet should be in the direction of prevailing winds and should not allow exhaust gases to enter air inlet/windows etc.

h) When tail end is horizontal, 45 degree downward cut should be given at the end of the pipe to avoid rain water entry into exhaust piping.

i) When tail end is vertical, there should be rain trap to avoid rain water entry. If rain cap is used, the distance between exhaust pipe and rain cap should be higher than diameter of pipe. Horizontal run of exhaust piping should slope downwards away from engine to the condensate trap. Silencer should be installed with drain plug at bottom.

ii) Support to exhaust piping:
Exhaust pipe should be supported in such a manner that load of exhaust piping is not exerted to turbo charger. In case of installation in sub-station room, the pipe support shall be provided with spring suspension.

iii) Exhaust Stack height:
In order to dispose exhaust above building height, minimum exhaust stack height should be followed as per CPCB/ standard and submitted for approval of engineer In Charge for its acceptance before start of work.

2.14 Air System

It is preferable to provide vacuum indicator with all engine to indicate choked filter. Maximum air intake restrictions with clean and choked filters should be within prescribed limit as per OEM / manufacturer recommendation for the particular model of the engine. Genset should be supplied with heavy duty air cleaner.

3.0 ALTERNATOR

3.1 Standards: The alternator shall be in accordance with:-


iii) Alternator shall be in accordance with the relevant Bureau of Indian Standards prevailing on date (IEC 60034) with up to date amendments.

3.2 Technical requirement of the Synchronous Alternator:
Self excited, screen protected self regulated, brush less alternator, Horizontal foot mounted in Single bearing construction suitable for the following:

Continuous output
Rated KVA under proposed site condition i/c considering de-ration, if any)
Rated PF
0.8 (lag)
Rated voltage
415 volts
Rated Frequency
50 Hz
No. of phases
3
Duty
Prime duty
Enclosure
SPDP (screen protected & Drip proof)
Degree of protection
IP -23
Ventilation
Self ventilated air cooled
Insulation Class
H or higher
Temperature Rise
With in class H limits at rated load
Voltage Regulation: ± 1%
Overload duration /capacity:
  a) 10% for one hour in every 12 hours of continuous operation.
  b) 50% over load for 15 seconds
Frequency variation: As defined by the Engine Governor (+/- 1%)
Excitation: As per system design of OEM (self or separately excited)
Type of AVR: Electronic /Digital
Type of Bearing & Lubrication arrangement: Long life anti-friction bearing with Grease lubrication at one end.
RTD & BTD: Suitable nos. of Resistance Temp. Device (RTD) & Bearing Temp Device (BTD) with wired upto terminal box & temp scanner shall be provided in control panel.
Termination box: IP55

3.3 Excitation:
The alternator shall be brushless type and shall be self excited or separately excited, self regulated having static excitation facility. The exciter unit should be mounted on the control panel or on the alternator assembly. The rectifier shall be suitable for operation at high ambient temperature at site.

3.4 Automatic Voltage Regulators (AVR):
In order to maintain output terminal voltage constant within the regulation limits i.e. ±1%, Automatic voltage regulator unit shall be provided as per standard practice of manufacture.

3.5 Fault tripping:
In the event of any fault e.g. over voltage or an external fault, the AVR shall remove the excitation voltage to the alternator. An emergency trip shall also be provided.

3.6 Performance:
Voltage dip shall not exceed 20% of the rated voltage for any step load or transient load as per ISO: 8528 (Part I). The winding shall not develop hot spots exceeding safe limits due to imbalance of 20% between any two phases from no load to full load.
The generator shall preferably be capable of withstanding a current equal to 1.5 times the rated current for a period of not more than 15 seconds as required vide clause 14.1.1. of IS 4722:1992.
The performance characteristics of the alternator shall be as below:
(a) Efficiency at full load 0.8 P.F. Above 250KVA - not less than 92.5 %
(b) Total distortion factor Less than 3%
(c) (i) 10% overload - One hour in every 12 hrs of continuous Operation.
   (ii) 50% overload - 15 seconds.

3.7 Terminal Boxes:
Terminal boxes shall be suitable for U.G. cables/ Bus trunking. The terminal box shall be suitable to withstand the mechanical and thermal stresses developed due to any short circuit at the terminals.

3.8 Earth Terminals: 2 Nos. earth terminals on opposite side with vibration proof connections, non-ferrous hardware etc. with galvanized plate and passivated washer of minimum size 12mm dia. hole shall be provided.

3.9 Space Heaters
Alternators of capacity more than 500 KVA shall be provided with suitable space heaters to maintain the winding temperature automatically such that it does not absorb moisture during long idle periods. The heater terminals shall be brought to a separate terminal box suitable for 230 V AC supply and a permanent caution notice shall be displayed.

4.0 AMF CONTROL PANEL WITH BYPASS ARRANGEMENT.

Detailed specification for switchgear, controls, metering, indications, painting etc shall be followed as described in LT panel sections

The design and construction of the AMF control panel shall be partially type tested design as per IEC 61439. The panel shall be manufactured by OEMs or their licence partner within approved make list of AAI.

4.1 General Features:

It shall be made into sections such that as far as feasible, there is no mixing of control, power, DC & AC functions in the same section and they are sufficiently segregated except where their bunching is necessary. Hinged doors shall be provided preferably double leaf for access for routine inspection from the rear. There is no objection to have single leaf hinged door in the front, all indication lamps, instruments meter etc. shall be flushed in the front. The degree of protection required will be IP-42 conforming to IS:2147.

4.2 Terminal blocks and wiring:

Terminal blocks of robust type and generally not less than 15 Amps capacity, 250/500 volts grade for DC upto 100 volts and 660/1100 volts grade for AC and rest of the junction shall be employed in such a manner so that they are freely accessible for maintenance. All control and small wiring from unit to unit inside the panel shall also be done with not less than 2.5 sq.mm copper conductor PVC insulated and 660/1100 volts grade. Suitable colour coding can be adopted. Wiring system shall be neatly formed and run preferably, function wise and as far as feasible segregated voltage-wise. All ends shall be identified with ferrules at the ends.

4.3 Labeling:

All internal components shall be provided with suitable identification labels suitably engraved. Labels shall be fixed on buttons, indication lamps etc.

AMF panel shall be provided with wiring diagram of all electrical and control circuit with laminated sheet, suitably fixed on inside of the panel doors.

4.4 Equipment requirements:

The control cubical shall incorporate into assembly general equipment and systems as under:

a) Control system equipments and components such as relays, contactors, timers etc. both for automatic operation on main failure and as well as for manual operation.

b) Equipment and components necessary for testing generating set’s healthiness with test mode and with load on mains.

c) Necessary instruments and accessories such as voltmeter, power factor meter, KW meter, KWH meter, Ammeter, Frequency meter, etc. in one energy analyzer unit with selector switch to obtain the reading of desired parameter.

d) Necessary indication lamps, circuit protected with MCB, terminal blocks, push buttons, control switches etc., as required.

e) Necessary engine/generating set shut down devices due to faults/abnormalities.

f) Necessary visual audio alarm indications and annunciations facility, as specified.

g) Necessary battery charger circuitry (suitable SMPS) with DC ammeter, voltmeter, selector switches, circuit protection by MCBs. ON/OFF switches, inbuilt auto regulating the charging current etc.

h) Necessary excitation control and voltage regulating equipment.

i) Necessary sandwich bus trunking terminations all internal wiring, connections etc., as required.
j) All incomer power circuit switchgears shall be of FOUR-pole type Switches &
   contactors as required & as specified.
k) By pass arrangement with changeover switches for isolating AMF panel from main
   supply for carrying out maintenance work in AMF panel.

4.6 System Operation:
The above-mentioned facilities provided shall afford the following operation requirements.

Auto Mode:
a) A line voltage monitor shall monitor supply voltage on each phase. When the mains
   supply voltage fails completely or falls below set value (variable between 80 to 95%
   of the normal value) on any phase, the monitor module shall initiate start-up of diesel
   engine. To avoid initiation due to momentary disturbance, a time delay adjustment
   between 0 to 5 second shall be incorporated in start-up initiation.
b) A three attempt starting facility shall be provided 6 seconds ON, 5 seconds OFF, 6
   seconds ON, 5 seconds OFF, 6 seconds ON. If at the end of the third attempt, the
   engine does not start, it shall be locked out of start and a master timer shall be
   provided for this function. Suitable adjustment timers are to be incorporated which
   will make it feasible to vary independently ON-OFF setting periods from 1-10
   seconds. If alternator does not build up voltage after the first or second start as may
   be, further starting attempt will not be made until the starting facility is reset.
c) Once the alternator has built up voltage, the alternator circuit breaker shall close
   connecting the load to the alternator. The load is now supplied by the alternator.
d) When the main supply is restored and is healthy as sensed by the line voltage
   monitor setting, both for under voltage and unbalance, the system shall be
   monitored by a suitable timer which can be set between 1 minute to 10 minutes for
   the load to be transferred automatically to main supply.
   Provision should also be made by way of selector switch for running the set atleast
   for 30 minutes, 10 minutes & 3 minutes after the restoration of healthy mains before
   the load is transferred to the mains (commercial supply).
e) The diesel alternator set reverts to standby for next operation as per (a), (b) and (c)
   above.

Manual mode:
a) In a manual mode, it shall be feasible to start-up the generator set by the operator on
   pressing the start push button.
b) Three attempts starting facility shall be operative for the start-up function.
c) Alternator circuit breakers closing and trip operations shall also be through operator
   only by pressing the appropriate button on the panel and closure shall be feasible
   only after alternator has built up full voltage. If the load is already on ‘mains’,
   pressure on close button shall be ineffective.
d) Engine shut down, otherwise due to faults, shall be manual by pressing a ‘stop’
   button.

Test mode:
a) When under ‘test’ mode, pressing of ‘test’ button shall complete the start up
   sequence simulation and start the engine. The simulation will be that of mains
   failure. Sequence I(a) and (b) shall be completed.
b) Engine shall build up voltage but the set shall not take load by closing of alternator
   circuit breaker. When the load is on the mains, monitoring of performance for
   voltage/frequency etc. shall be feasible without supply to load.
c) If during test mode, the power supply has failed, the load shall automatically get
   transferred to alternator.
d) Bringing the mode selector to auto position shall shut down the set as per sequence provided main supply is ON. If the mains supply is not available at that time, the alternator shall take load as in (c) above.

Engine shut down and alternator protection equipments:-

Following shut down and protection system shall be integrated in the control panel:

a) **Engine:**
   i) Low lubricating oil pressure shut down. This shall be inoperative during start up and acceleration period.
   ii) High coolant (water) temperature shut down.
   iii) Engine over speed shut down.

b) **Alternator Protection:**
   i) Over load
   ii) Short circuit
   iii) Earth fault
   iv) Over voltage

**Monitoring and metering facilities:**

a) Necessary energy analyzer unit for visual monitoring of mains, alternator and load voltage, current, frequency, KWH, power factor, etc.

b) A set of visual monitoring indication for:
   i) Load on set
   ii) Load on mains
   iii) Set on test (Alternator on operation duty, Alternator on standby duty).
   iv) Set of lamp for engine shut down for over speed, low lub. oil pressure and high coolant water temperature, overload trip of alternator, earth fault trip of alternator, engine lock out and failure to start etc. All these indications shall have an audio and visual alarm. When operator accepts the alarm, the hooter will be silenced and the fault indication will become steady until reset by operating a reset button.

**Operating Devices:** A set of operation devices shall be incorporated in the front of panel as under:

a) Master Engine Control Switch: This shall cut off in ‘OFF’ position DC control to the entire panel, thus preventing start-up of engine due to any cause. However, battery charger and lamp test button for testing the healthiness of indication lamps, DC volt meter/ammeter etc. shall be operative. It shall be feasible to lock the switch in OFF position for maintenance and shut down purposes.

b) Operation selector switches OFF/AUTO/MANUAL/TEST position.

c) Energy analyzer unit for display of various electrical parameters like voltage, current, frequency, KW, power factor etc.

d) A set of push button, as specified.

e) Relays, contactor, timers, circuit breakers, as required.

f) Necessary battery charger with boost/trickle selector, DC volt meter and DC ammeter.

**Battery / Electrical System**

Batteries supplied with Genset are generally dry and uncharged. First charging of uncharged batteries is very important and should be done from authorized battery charging centre. Initial charging should be done for 72-80 hours.

Batteries should be accommodated with enclosure in battery rack. Battery capacity and copper cable sizes for various engine capacities should be as per recommendation of
Manufacturer. Cable size shall be of 2m length. If length is more, cable size should be selected in such a way that voltage drop does not exceed 2V.

For AMF applications, a static battery charger working on mains supply is recommended to keep the batteries charged at all times.

1.5 Sq.mm copper wire should be used for wiring between junction box and Control panel. Cable and switchgear selection refer detailed specification in succeeding paragraphs.

Overheating due to loose thimbling/undersize cables causes most of electrical failures and hence correct size of cable and thimbles should always be used.

While terminating cables, avoid any tension on the bolts/busbars.

While terminating R,Y & B phase notations should be maintained in the alternator and control panel for easy maintenance.

Crimped cables should be connected to alternator and control panel through cable glands. Multi-core copper cables should be used for interconnecting the engine controls with the switchgear and other equipments.

For AMF application, multicore 1.5 sq.mm flexible stranded cooper cable for control cabling should be used.

All indications shall be LED type or as recommended by the manufacturer.

It is recommended to support output cables on separate structure on ground so that weights of cables should not fall on alternator/base rail.

**Alternator Termination Links**

i) For proper terminations between links and switchgear terminals, the contact area must be adequate. The situations should also be avoided as they lead to creation of heat sources at the point of termination:

   a. Point contact arising out of improper position of links with switchgear terminals.
   b. Gaps between busbars/links and terminals being remedied by connecting bolt/stud. In such cases the bolt will carry the load current. Normally these bolts/studs are made of MS and hence are not designed to carry currents.

Adequate clearance between busbars/links at terminals should be maintained.

5.0 **PCC FOUNDATION**

A PCC foundation (1:2:4, M-20 grade) of approximate depth of 300 mm below ground is required so as to provide leveled surface for placement of the acoustic enclosure. About 150 mm foundation height should be above ground level. The length and breadth of foundation should be at least 250 mm more than the size of the enclosure. Genset should be mounted on Anti-Vibration Mountings (AVM’s) inside the enclosure.

Foundation level should be checked diagonally as well as across the length for even flatness. The foundation should be within ±0.5 Degree (angle) of any horizontal plane.

6.0 **ACOUSTIC ENCLOSURE:**

6.1 **Standard:**

As per CPCB norms, the acoustic enclosure should be type tested at the climatic conditions specified in Para 1.3 through one of the authorized laboratory. A copy of type test to be submitted.

6.2 **General Design Guidelines**

a) To avoid re-circulation of hot air, durable sealing between radiator and canopy is must.

b) Exhaust piping inside the enclosure must be insulated.

c) Temperature rise inside the enclosure should not be more than 7°C for maximum ambient above 50°C.

d) There should be provision for oil, coolant drain and fill.
6.3 Service Accessibility
Genset / Engine control panel should be visible from outside the enclosure.
Routine/Periodical check on engine /alternator (filter replacement and tappet setting etc.)
should be possible without dismantling acoustic enclosure.
For major repairs/overhaul, it may be required to dismantle the acoustic enclosure.
Sufficient space should be available around the Genset for inspection and service.

6.4 Specification for Acoustic Enclosure
The acoustic enclosure shall be designed and manufactured confirming to relevant standards
suitable for outdoor installation exposed to weather conditions, and to limit overall noise
level to 75 Db (A) at a distance of one meter from the enclosure as per CPCB norms under
free field conditions.

The construction should be such that it prevents entry of rain water splashing into the
enclosure and allows free & quick flow of rain water to the ground in the event of heavy
rains. The detailed construction shall confirm to the details as under:-

i) The enclosure shall be fabricated out of the CRCA sheet of thickness not less than 1.6
mm on the outside cover with inside cover having not less than 0.6 mm thick
perforated powder coated CRCA sheet.

ii) The acoustic lining should be made up of high quality insulation material i.e. glass /
mineral wool / FOAM of minimum 50 mm thickness and 75 Kg/cubic meter to 100
KG/cubic meter for sound absorption as per standard design of manufacture’s to
reduce the sound level as per CPCB norms. The insulation material shall be covered
with fine glass fiber cloth and would be supported by perforated M.S. Sheet duly
powder coated.

iii) The hinged doors shall be made form not less than 16 SWG (1.6 mm) thick CRCA
sheet and will be made air tight with neoprene rubber gasket and heavy duty locks.

iv) All sheet metal parts should be processed through 7-tank process followed by
powder coating.

v) The enclosure shall be provide with suitable size and No. of hinged type doors along
the length of the enclosure on each side for easy access inside the acoustic enclosure
for inspection, operation and maintenance purpose. Sufficient space will be provided
inside the enclosure on all sides of the D.G. set for inspection, easy maintenance and
repairs.

vi) The canopy should be provided with high enclosure temperature safety device,
general illumination with LED light fixtures and 5A plug points for maintenance
purpose as required. The complete enclosure shall be of modular in construction,compact as possible with good aesthetic look.

vii) The forced ventilation shall be as per manufacture design using either engine radiator
fan or additional blower fan(s). If the acoustic enclosure is to be provided with forced
ventilation then suitable size of axial flow fan (with motor and auto-start
arrangement) and suitable size axial flow exhaust fan to take the hot air from the
enclosure complete with necessary motors and auto start arrangement should be
provided. The forced ventilation arrangement should be provided with auto stop
arrangement to stop after 5 minutes of the stopping of D.G. sets.

viii) The acoustic enclosure should be suitable for cable connection. Such arrangements
on acoustic enclosure should be water proof and dust-proof conforming to CPCB
norms.

6.5 Installation
Acoustic enclosures are supplied with built in Anti Vibration Mountings (AVMs). As such Genset can be installed directly on the levelled surface.

Exhaust piping outlet should not be turned towards window/ventilator of home or occupied building. Provision of rain cap should be ensured as per site condition & as per approved drawing.

The acoustic enclosure placement should be such that there is no restriction in front of air inlet and outlet from canopy.

7.0 INSPECTION AND TESTING

Pre-delivery inspection shall be conducted on assembled DG sets, AMF control panels etc. at the respective manufacturers work by the authorized inspecting officer of AAI prior to dispatch of these equipment.

7.1 Assembled DG set with canopy at OEM works:

DG set will be tested on load of unity power factor for the rated KW rating. During testing, each of the DG sets covered under scope of work, shall be operated for a period of 12 hours on the rated KW at DG set’s KW rating including, one hour on 10% overload after continuous run of the 12 hours. During testing all controls / operations safeties will be checked and proper record will be maintained. Any defect / abnormality noticed during testing shall be rectified. The testing will be declared successful only when no abnormality / failure are noticed during the testing. The DG set will be cleared for dispatch to site only when the testing is declared successful by authorized representative / Engineer-in-charge.

7.2 AMF panel at OEM works if offered separately:

a) General inspection to confirm compliance with specification approved, GA drawings and single line diagrams (SLD).

b) Insulation resistance test.

c) Functional check for all controls, switchgears and continuity of internal wiring etc.

7.3 Submission of test Certificates:

Copies of all documents of routine and type test certificates of the equipment, carried out at the manufacturers premises shall be furnished to the inspecting officer. The valid calibrated test report copy should also furnish for the equipments used during testing.

7.4 Site testing along with AMF Panel & arrangement loads:

After completion of the installation work in all respects, the contractor shall offer the performance test at site for the complete AMF DG set(s). Testing shall be carried out exactly as mentioned above at OEM works.

The load bank required for testing of DG set at site is to be arranged by the contractor, necessary cables for inter-connection of load bank with DG set & the main power required for carrying out successful testing of DG set are to be arranged by contractor. The cost of consumables like fuel & oil required, for testing etc to be borne by the contractor.

During these test periods the engine running data shall be recorded at an interval of half an hour.

Test to determine frequency, voltage regulations, switch overtime under the following conditions shall be carried out:-

a) No load to full load instantaneously

b) Full load to no load instantaneously

c) Load variation up & down in steps of approx. 20% of rated load.

7.3 Trial Run / Running-in-Period

After successful testing of the DG set, a trial run at available load will be carried out for each DG set for 120 hrs. or 15 days whichever is earlier. The DG set will be operated and a log of all relevant parameters will be maintained during this period. The arrangement of staff for trial run / running in period will be made by the successful tenderer. However, diesel shall be provided by Department. The contractor will be free to carry out necessary adjustments. The
DG set will be said to have successfully completed the trial run, if no break down or abnormal / unsatisfactory operation of any component of the entire installation included in the scope of work of the contract, occurs during this period, the DG set shall be taken over. After trouble free operation during the trial run / running-in-period, shall be the date of acceptance / taking over.
L.T. PANELS

1. M V SWITCHBOARD

1.1 General
This section covers the detailed requirements of medium voltage switchboard panel for 415 volts, 3 phase, 50 Hz, 4 wire system. These shall be TTA/PTTA panel as per IEC. All switchgears shall be fully rated at an ambient of 45 Deg C.

1.2 Standards and Codes
Updated and current Indian standard specifications and codes of practice will apply to the equipment and the work covered by the scope of this contract.

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Low Voltage switchgear & control gear:

- Part I : General rules | IEC60947-1
- Part II : Circuit Breakers | IEC60947-2
- Part III : Switches, disconnectors, switch disconnectors and fuse combination units. | IEC60947-3
- Part IV : Contactors and Motor starters | IEC60947-4
- Part V : Control circuit devices and switching elements | IEC60947-5

Degree of Protection of Enclosures for low voltage switchgear. | IEC60529 / IS 2147 : 1962
Internal arc tests | IEC61641
Seismic compliance | IS 1893

1.3 Switch Boards

1.3.1 General Construction
The LV switchboards shall be Type Tested as per the relevant IEC standards to form compartmentalization and suitable to withstand short circuit level as per Scope of works (SOW) and drawings for 1.0 sec. The LV switchboards shall be manufactured by OEM of switchgears OR their licence partner mentioned in AAI approved make list enclosed only.

The Switchboards shall be metal clad totally enclosed, floor mounted free standing type of modular extensible design suitable for indoor mounting.
Switchboard panel and cubicle shall be fabricated with CRCA Sheet Steel of thickness not less than 2.0 mm and shall be folded and braced as necessary to provide a rigid support for all components. The doors and covers shall be fabricated from CRCA sheet steel of thickness as per manufacturer standard to form a switch board panel compartmentalization as specified. Hylem / PVC sheets shall not be allowed for separation.

The enclosures shall be designed to take care of normal stress as well as abnormal electro-mechanical stress due to short circuit conditions. All covers and doors provided shall offer adequate safety to operating persons and provide ingress protection of IP 42 unless otherwise stated. Ventilating openings and vent outlets, if provided, shall be arranged such that same ingress protection of IP 42 is retained.
Incomer and bus section panel or section(s) shall be separate and independent and shall not be wired with sections required for feeder. The incomer and outgoing panel shall be suitable for receiving bus trunking or MV cable of sizes as specified or as required.

Switchboards shall be made up of requisite vertical sections, which when coupled together, shall form continuous dead front switchboards.

Switchboard shall be readily extensible on both sides by addition of vertical sections after removal of the end covers.

The switchboards shall be designed for use in high ambient temperature & humid tropical conditions and /or as per site conditions as specified. Ease of inspections, cleaning and repairs while maintaining continuity of operation shall be provided in the design.

Metal based neoprene/glue gaskets between all adjacent units and beneath all covers shall be provided to render the joints dust and vermin proof to provide required degree of protection as stipulated in SOQ/SOW. The unused openings within the switchboards shall be closed using suitable grommets.

Special care to be taken to ensure effective earthing of the frame and doors of the switchboards.

Each vertical section shall be provided with a rear or side cable chamber housing the cable end connections and power/control cable terminations. There should be generous availability of space for ease of installation and maintenance with adequate safety for working in one vertical section without coming into contact with any live parts. The design of the switchboard shall allow standard extension chambers if required to accommodate cables. It should be possible to access the ACB & MCCBs without opening the front door of the panel.

The overall height of the switchboard shall be limited to 2400 mm or less as per manufacturers standards for all the Busbar ratings and type of switchboards. The height of the operating handle, push buttons etc shall be restricted between 300 mm and 1800 mm from finished floor level.

Each section of MV switch board shall have base channel of MS section not less than 100mm x 50mm x 5mm.

All panels and covers shall be properly fitted. The holes in the panel shall be correctly positioned.

Switchboard shall be provided with “Danger Notice Plate” conforming to relevant Indian Standards.

In case of TTA switch board –
- design shall comply to requirement of Internal Arc test as per IEC61641 of 50KA for 0.3 sec.

- switchboard along with ACBs / MCCBs and connections should have been type tested design as per IEC 61439 1 & 2 for short circuit, temperature rise, protective earth short circuit test and dielectric tests of the ratings required and glow wire test.

- The panel design should be tested for an Impulse Withstand Voltage of 8kV.

- The panel design shall be type tested as per IS 1893 for seismic compliance as per seismic zone of location.

1.3.2 Switchboard Configuration

The Switchboard shall be configured with Air Circuit Breakers (ACB’s) , MCCB’s, MPCB, MCB’s and other equipment as called for in SOQ/SOW.
All MCCB’s & outgoing ACB’s (rating upto 630A ) shall be arranged in multi-tier formations. However, All Incoming ACBs & out going ACB above 630A rating shall be arranged in Single tier formation only.

The Switchboards shall be of adequate size with a provision of spare space to accommodate possible future additional switch gear as specified in SOQ/ SOW.

1.3.3 Switchboard Compartmentalization

For compartmentalized switchboards, separate totally enclosed compartments shall be provided for horizontal busbars, vertical busbars, ACBs, MCCBs, and cable alleys. Earthed metal or insulated shutters shall be provided between drawout and fixed portion of the switchgear such that no live parts are accessible with equipment drawn out. Degree of protection within compartments shall be at least IP 2X.

Sheet steel hinged lockable doors for each separate compartment shall be provided and duly interlocked with the breaker in "ON" and "OFF" position. For all Circuit Breakers, adequate compartments shall be provided for accommodating instruments, indicating lamps, control contactors and control MCB etc. These shall be accessible for testing and maintenance without any danger of accidental contact with live parts of the circuit breaker, busbars and connections. For Some MCCB feeders for critical loads like UPS it may be required to have operation only after opening the door, all other facilities like pad lockable rotary handle to be provided for such feeder.

Each switchgear cubicles shall be fitted with label in front and back identifying the circuit, switchgear type, rating and duty. All operating device shall be located in front of switchgear only.

A suitable wire way with cover shall be provided to take interconnecting control wiring between vertical sections.

Cable compartments running the height of the switchboard in the case of front access boards shall be provided for incoming and outgoing cables. Cable compartments shall be of adequate size for easy termination of all incoming and outgoing cables entering from bottom or top. The construction shall include necessary adequate and proper support in cable compartments to support and clamping the cable in the cable alley / cable chamber.

1.3.4 Switchboard Bus Bars

Busbars shall be made of high conductivity, 99.9% purity, high strength Aluminium of ETP grade and shall be of rectangular cross sections, suitable for full load current for phase bus bars and half/full rated current for neutral bus bar as required or as stipulated in SOQ/SOW. Busbar shall be suitable to withstand the stresses of fault level as specified in SOQ/SOW.

The bus bar system may comprise of a system of main horizontal bus bars and auxiliary vertical bus bars run in bus bar alley on either side in which the circuit could be arranged with front / rear access for cable entrances as per approved GA drawings.

The bus bars shall be supported on non-breakable, non-hygroscopic epoxy resin or glass fibre reinforced polymer insulated supports able to withstand operating temperature of 110 deg C at regular intervals, to withstand the forces arising from a fault level as specified in SOQ/SOW. The material and the spacing of the Busbar supports should be same as per the type tested assembly.

Auxiliary wires for control & space heater power supply or any other specified service shall be provided. These wires shall be insulated, adequately supported and sized to suit specific requirement. The material of wires/cables will be FRLS insulated electrolytic copper.

The busbar support to be supplied by OEM or by approved supplier of OEM. Minimum clearance between phases / live parts shall be as per IS IEC 61439.
1.3.5 **Switchboard Interconnection**
All connection and tap offs shall be through adequately sized connectors. This shall include and suitable for fault level for tap off to feeders and instrument/control transformers.
For switchgears rating upto 100 amps, FRLS copper conductor wires/cables of adequate size to carry full load current shall be used. The terminations of such interconnections shall be cramped. Solid copper strip connections shall be used for all ratings above 100 amps.
All connections, tapings, clamping, shall be made in an approved manner to ensure minimum contact resistance. All connections shall be firmly bolted and clamp with even tension. Before assembly joint surfaces shall be filed or finished to remove burrs, dents and oxides and silvered to maintain good continuity at all joints. All screws, bolts, washers shall be zinc plated. Suitable grade nuts and bolts shall be used for busbar connections.

1.3.6 **Draw out features**
Air Circuit Breakers (ACBs) shall be provided in fully draw out type design in such a way that draw out is possible without disconnection of the wires and cables. The power and control circuits shall have self-aligning and self-isolating contacts. Mechanical latches shall be integrated in ACB at service, test and isolated position to ensure that breaker is firmly latched in respective position. It shall not be possible to move the breaker from the position unless latch is manually operated.

1.3.7 **Instrument Accommodation**
All voltmeter, ammeter and other instruments shall be flushed mounted back lit LCD/LED Digital type of size 96 mm x 96 mm conforming to class 1.0 or as specified to IS 1248 for accuracy. The minimum display for Multi-function meter (MFM) for Incomer feeders shall have - A, V, Pf, Hz, Kw, KVA, KVAR, KWh, KVARh, average and maximum values, maximum demand values, % THD.
All meter shall have in-built RS485 port.
The current transformers for metering and for protection shall be mounted on the solid copper/aluminium busbars with proper supports. CT with inbuilt feature of ACB with terminations module is also acceptable.
On all the incomers of switch boards, ON/OFF (and Trip in case of ACB & for micro-processor MCCB provided) and for out going ON LED Type indicator lamps shall be provided suitable for operation on AC 230 volts supply.
All lamps & meter shall be protected by MCBs.

1.3.8 **Wiring**
All wiring for relays and meters shall be with 1.5 mm2 FRLS insulated copper conductor wires. The wiring shall be coded and labelled with approved ferrules for identification. The minimum size of copper conductor control wires shall be 1.5 sq. mm. For CT & current carrying, wiring shall be done with minimum 2.5 Sq.mm. Runs of wires shall be neatly bunched and suitably supported and clamped. Means shall be provided for easy identification of wires. Identification ferrules shall used at both end of wires. All control wires meant for external connections are to be brought out on a terminal board. The cables and control wires shall be suitable for withstanding 105 deg C.

1.3.9 **Space Heaters**
Anti-condensation heaters shall be fitted in each cubicle together with an ON/OFF isolating switch suitable for electrical operation at 240 volts A.C 50 Hz single phase of sufficient capacity to raise the internal ambient temperature by 50 Deg C. The electrical apparatus so protected shall be designed so that the maximum permitted rise in temperature is not exceeded if the heaters are energized while the switchboard is in operation. As a general rule, the heaters shall be placed at the bottom of the cubicle.
1.3.10 **Earthing**

Continuous earth bus sized for prospective fault current to be provided with arrangement for connecting to station earth at two points. Hinged doors / frames to be connected to earth through adequately sized flexible braids.

1.3.11 **Sheet Steel Treatment and Painting**

Sheet steel used in the fabrication of switchboards shall undergo a rigorous cleaning and surface treatment of minimum seven tank process comprising of alkaline degreasing, descaling in dilute sulphuric acid and a recognized phosphating process after which a coat of primer paint compactly with the final paint shall be applied over the treated surface. Final paint/ coat of oven baked powder coating, of minimum 50-micron thickness, of shade approved by Engineer-in-Charge shall then be provided.

1.3.12 **Name Plates and Labels**

Suitable engraved white on black name plates and identification labels of metal for all Switchboards and Circuits shall be provided. These shall indicate the feeder number and feeder designation.

**Note** – Main LT panel (in utility building) shall be equipped with surge protection device (SPD) Type-1 and their sub LT panels with SPD Type- 2 as per IEC 62305-4/ NBC 2016 part 8. These SPD's should have inbuilt fuse & tested by KEMA / VDE/ any other accredited international lab.

1.3.13 **3 PHASE AND SINGLE PHASE PREPAID ENERGY METERS:**

**Standard:**

The meters with accuracy class–1 are required measurement of Active Energy and shall conform to the latest edition of following standards:

<table>
<thead>
<tr>
<th>Standard</th>
<th>Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>IS:13779</td>
<td>A.C. Static Watt Hour Meters (Class–1)</td>
</tr>
<tr>
<td>CBIP Report No. 88</td>
<td>Specification for AC static Electrical Energy meters</td>
</tr>
<tr>
<td>IS:15884</td>
<td>AC Direct Connected Static Prepaid Meters for Active Energy (Class 1)</td>
</tr>
</tbody>
</table>

Meters meeting other authoritative standards which ensure an equal or better quality than the standard mentioned above, shall also be acceptable. All kinds of tests which are required as per mentioned standards shall be carried out.

**General requirement:**

The offered prepaid meters shall be approved as per the IS: 13779.

Meter shall be designed and constructed in such a way as to avoid introducing any danger in use and under normal conditions so as to ensure specially the following:

- Personnel safety against electric shock
- Personnel safety against effects of excessive temperature.
- Protection against penetration of solid objects, dust and water.
- Protection against spread of fire.
Accuracy:

Class of accuracy of meter shall be 1.0 and shall confirm to accuracy requirement as per specify IS.

Keypad prepaid meter:
The keypad buttons shall have numbers/letters on them, which shall be clearly visible and resistant to wear. The layout of the numbering shall be same as that used on standard telephones for numbers '1' through '9' and buttons such as '*' ', '0', and '#'. Button '5' shall have some form of physical identification (raised printing or a pip) to aid customers with poor sight.

The keypad IP rating shall be adequate to permit use with moist or wet hands whilst ensuring the safety of the user and preventing ingress of dirt and water to the unit. The keypad buttons shall provide audible feedback when pressed with differing tones to distinguish between valid and invalid entry. The entry of codes for credit or commands associated with programming functions such as tariff change shall be via numeric codes. Code encryption/decryption must be carried out using an internationally recognized standard (i.e. Triple DES). The meter shall permit a time delay of up to 20 seconds between keystrokes.

The meter has Keypad buttons which enables the user to view various displays available on the meter. The displays parameters shall be as follows:

- Days Left (based on consumption of last seven days).
- Value of recent consumption
  - The currently active rates, the prices charged for consumption at each rate, and the number of units consumed at each rate and the daily charges.
  - Last 5 recharge codes entered in to the meter
  - “Authenticated Billing Code (ABC)”
  - The total amount vended
  - Shows the Refund code
  - Displays monthly consumption in Rupees / kWh
  - Maximum Demand with occurrence of time and date
  - Instantaneous load and the projected hourly cost of use at this load
  - Date/Time, Serial no.
  - Voltage, current etc.
  - Key code mode for punching code in to the meter

“Authenticated Billing Code”:

The meter shall display the 20 digit authenticated meter reading code. The full 20 digit token shall contain the following frozen value at midnight (00:00 Hr) of month end

1. 5 digit cumulative kWh energy register.
2. Date of frozen data.
3. Credit balance, it may be positive or negative.
4. The tamper flag, which only indicates whether there is any tamper or not.

Communication capability:
The meter shall be provided with an optical communication port. It shall be possible to read the meter through the optical port with the help of Hand Held Unit.

Tests:

Type Tests:

Tests shall have been carried out from Laboratories which are accredited by the National Board of Testing and Calibration Laboratories (NABL) of Govt. of India to prove that the meters meet the requirements of the specification.

Prepaid functionality shall be tested by the MES as per IS: 15884 / 2010.

2. SWITCHGEAR
   2.1 LT Air Circuit Breakers (ACB)
      2.1.1 General
      The circuit breakers shall be of the air break type, robust and compact design suitable for indoor mounting and shall comply with the requirement of IEC 60947-1/ IS 13947-2 and 2. Rupturing capacity shall be as stipulated in SOQ/SOW.
      The breaker shall comply with the isolation function requirement of IEC 60 947-2/ IS 13947-2 section 7.12 to be marked as suitable for isolation / disconnection to facilitate safety of operating personal while the breaker is in use.
      The breaker shall provide IP 2X protection between the front panel and internal power circuits to avoid any accidental contact with the live main current carrying path with the front cover open.
      Protective devices, metering, CTs, PTs, push buttons and indicating lamps shall be provided as required and as specified in SOQ/SOW.
      ACB shall be type tested & certified for compliance to standards from~CPRI, ERDA / NABL accredited lab/ any international lab. The circuit breaker shall be suitable for 415 V ± 10%, 50Hz supply system. Manufacturer should submit Combined sequence test certificate.
      2.1.2 Constructional Features
      The Circuit Breaker shall be flush front, modular construction, horizontal draw-out pattern; three/four pole as required and fully interlocked. Each Circuit Breaker shall be housed in a separate compartment enclosed on all sides. In case of 4 pole breaker, neutral shall be fully rated with adjustable settings from 50% to 100% of In.
      The Circuit Breaker cradle shall be designed and constructed to permit smooth withdrawal and insertion. The movement shall be free of jerks, easy to operate. Mechanical Latch to be provided to identify the isolated, test & service position of breaker to prevent over racking.
      Main current carrying parts in the breaker shall be silver plated and suitable arcing contacts shall be provided to protect the main contacts which shall be separate from the main contacts and easily replaceable. In addition, Arc chutes shall be provided for each pole, and these shall be suitable for being lifted out for the inspection of the main and the arcing contacts without using any tools.
      The circuit breakers shall be for continuous rating and service short Circuit Breaking capacity (Ics) shall be as specified in SOQ/ SOW. Rated Ultimate breaking capacity (Icu) and short circuit withstand values(ICw) for 1 sec
      The ACB shall have double insulation with moving and fixed contacts totally enclosed for enhanced safety and in accessibility to live parts.
The circuit breakers shall be for continuous rating at 50 deg C ambient temperature. The Rated insulation voltage shall be 1000 volts AC & Rated impulse withstand Voltage shall be 12kV for main circuit.

The ACB shall be provided with a door interlock i.e. door should not be open when circuit breaker is closed and breaker should not be closed when door is open.

2.1.3 Operating Mechanism
The Circuit Breaker shall be trip free with independent manual spring operated or motor wound spring operated mechanism as specified and with mechanical ON/OFF indication. The operating mechanism shall be such that the circuit breaker is at all times free to open immediately the trip coil is energized. The breaker shall be provided with built anti pumping mechanism.

The closing time shall be less than or equal to 80 ms to ensure faster closing of the breaker. And tripping time should be less than 70 ms to reduce the let through energy in the event of fault.

The operating handle and mechanical trip push button shall be at the front of and integral with the Circuit Breaker. Handle for rack in & rack out shall have positive locking arrangement.

There shall be mechanical / electrical indicator on the front panel for ‘Ready to close’ situation for the breaker by checking all inter locking.

The Circuit Breakers cradle shall be so designed and constructed as to permit smooth withdrawal and insertion of the breaker into it. There shall be 3 distinct and separate position of the circuit breaker on the cradle-Service, Test & Isolated.

2.1.4 Circuit Breaker Interlocking
Sequence type strain free interlocks shall be provided to ensure the following:

It shall not be possible for the Breaker to be withdrawn from the cubicle when in the "ON" position. To achieve this, suitable mechanism shall be provided to lock the Breaker in the tripped position before the Breaker is isolated.

It shall not be possible for the Breaker to be switched "ON" until it is either in the fully inserted position or, for testing purposes, it is in the fully isolated position.

It shall not be possible for the Circuit Breaker to be plugged in unless it is in the OFF position.

The racking shutters should open only when ACB is OFF position.

Mechanical and electrical anti pumping devices shall be incorporated in the EDO ACB’s as required.

2.1.5 Circuit Breaker Auxiliary Contacts
The Circuit Breaker shall have minimum 4 NO/NC auxiliary contacts rated at 10 amps 415 volts 50 Hz. These contacts shall be approachable from the front for connecting all external wiring. They shall close before the main contacts of Circuit Breaker are plugged in and vice versa, when the Circuit Breaker is Drawn Out of the cubicle.

2.1.6 Circuit Breaker Releases
The breaker should be equipped with microprocessor based release to offer accurate and versatile protection with complete flexibility and shall offer complete over current protection to the electrical system in the following four zones:
- Long-time protection with adjustable time delay
- Short time protection with intentional delay.
- Instantaneous protection.
- Ground fault protection with instantaneous delay
All the protection release shall have following features and settings:

a. True RMS Sensing- Sense true RMS value of current to avoid nuisance tripping during starting.

b. Thermal Memory: Incorporates thermal memory feature to achieve faster tripping in case of repetitive overloads.

c. Defined time-current characteristics.

d. Trip Indication- Provide local LED indication for identification of type of fault, without requiring using external power supply.

e. Self-powered.

f. Manufacturer shall furnish total discrimination charts / curve study for coordination between upstream and downstream devices.

g. Meet the EMI / EMC requirements.

h. ACB shall display % loading, last 10 trip History for fault diagnosis and Current parameters, etc.

All ACBs shall be provided with Mechanical Operation counter

For incomer ACBs (except APFC Panels) shall have following additional protections by separate relay (in-built release with ACB is also acceptable without any extra cost):

- Under and over voltage
- Under and over frequency
- Reverse Power, in case DG incomer is provided.

2.1.7 Earthing
The frame of the Circuit Breaker shall be positively earthed when the Circuit Breaker is racked into the cubicle.

2.2 MOULDED CASE CIRCUIT BREAKERS (MCCB)

2.2.1 General
The circuit breakers shall comply with the requirement of IEC 60 947 / IS 13947-2 : 1993. All MCCBs shall be current limiting type features of load line reversibility and suitable for horizontal / vertical mounting without any derating.

MCCBs shall be suitable for 3 Phase 415 Volts AC 50 HZ supply. Rated insulation voltage (Ui) 690V AC and rated impulse voltage 8KV.

Three/ four phase MCCBs shall have a common handle for simultaneous operation and tripping of all the three phases. All MCCB shall be door interlock provision.

MCCBs should have Ics=100%Icu with Minimum fault level as specified in SOQ/SOW.

The MCCBs shall be made of halogen free high strength heat resisting and flame retardant thermo setting insulating material.

Manufacturer shall furnish total discrimination curve study for coordination between upstream and downstream devices.

2.2.2 Protection Functions
Microprocessor trip units shall comply with appendix F of IEC 60947-2 standard (measurement of RMS current values, electromagnetic compatibility, etc.).

All MCCBs 100 Amp and below with Thermal Magnetic release shall have Adjustable Thermal (O/L) & fixed Magnetic (S/C) protection settings.

All MCCBs above 100 Amp and upto 250 Amp with Thermal Magnetic release shall have Variable Thermal (O/L) & Variable Magnetic (S/C) protection settings.

All incomer MCCBs and outgoing above 250A shall be of Microprocessor based with adjustable - Overload, Short Circuit and In-Built Earth Fault protection settings. All microprocessor MCCBs should have trip indication on Panel door.
For Motor application, motor duty type MCCBs shall be selected with reference to Type 2 coordination chart provided by the manufacturer.

2.3 MOTOR PROTECTION CIRCUIT BREAKER (MPCB)
Motor circuit breakers shall conform to the general recommendations of standard IEC 947 -1,2 and 4 (VDE 660, 0113 NF EN 60 947-1-2-4, BS 4752) and to standards UL 508 and CSA C22-2 N°14.
The devices shall be in utilization category A, conforming to IEC 947-2 and AC3 conforming to IEC 947-4. MPCB shall have a rated operational and insulation voltage of 415 V AC (50 Hz) and MPCB shall be suitable for isolation conforming to standard IEC 60947-2 and shall have a rated impulse withstand voltage (Uimp) of 6 kV. The motor circuit breakers shall be designed to be mounted vertically or horizontally without derating. Power supply shall be from the top or from the bottom. In order to ensure maximum safety, the contacts shall be isolated from other functions such as the operating mechanism, casing, releases, auxiliaries, etc, by high performance thermoplastic chambers. The operating mechanism of the motor circuit breakers must have snap action opening and closing with free tripping of the control devices. All the poles shall close, open, and trip simultaneously. The motor circuit breakers shall accept a padlocking device in the “isolated” position.
The motor circuit breakers shall be equipped with a “PUSH TO TRIP” device on the front enabling the correct operation of the mechanism and poles opening to be checked. The auxiliary contacts shall be front or side mounting, and both arrangements shall be possible. The front-mounting attachments shall not change the breaker surface area. Depending on its mounting direction the single pole contact block could be NO or NC. All the electrical auxiliaries and accessories shall be equipped with terminal blocks and shall be plug-in type. The motor circuit breakers shall have a combination with the downstream contactor enabling the provision of a perfectly co-ordinated motor-starter. This combination shall enable type 1 or type 2 co-ordination of the protective devices conforming to IEC 60947-4-1. Type 2 co-ordination shall be guaranteed by tables tested and certified by an official laboratory.
The motor circuit breakers, depending on the type, could be equipped with a door-mounted operator which shall allow the device setting. The motor circuit breakers shall be equipped with releases comprising a thermal element assuring overload protection and a magnetic element for short-circuit protection. In order to ensure safety and avoid unwanted tripping, the magnetic trip threshold (fixed) shall be factory set to an average value of 12 I r. All the elements of the motor circuit breakers shall be designated to enable operation at an ambient temperature of 50° C without derating. The thermal trips shall be adjustable on the front by a rotary selector. The adjustment of the protection shall be simultaneous for all poles. Phase unbalance and phase loss detection shall be available.

2.4 MINIATURE CIRCUIT BREAKERS (MCB)
Miniature Circuit Breaker shall comply with IS/IEC 60898 and 60947-2. Miniature circuit breakers shall be quick make and break type for 240/415 VAC 50 Hz application with magnetic thermal release for over current and short circuit protection. The breaking capacity shall not be less than 10 KA at 415 VAC. MCBs shall be DIN mounted. The MCB shall be Current Limiting type (Class-3). MCBs shall be classified (B, C, D ref IS standard) as per their Tripping Characteristic curves defined by the manufacturer. The MCB shall have the minimum power loss (Watts) per pole defined as per the IS/IEC and the manufacturer shall publish the values. MCB shall ensure complete electrical isolation & downstream circuit or equipment when the MCB is switched OFF. MCB should provide separate mechanical indication for tripping due to Short circuit faults.
The housing shall be heat resistant and having high impact strength. The terminals shall be protected against finger contact to IP20 Degree of protection. All DP, TP, TPN and 4 Pole
miniature circuit breakers shall have a common trip bar independent to the external operating handle. MCB should have minimum Elect Endurance of 10,000 operating cycles.

3.0 Acceptance Tests
Acceptance tests on completed switchboards shall be as follows:
A general visual check shall be carried out. This shall cover measurement of overall dimension, location, number and type of devices, terminal boxes, location and connection of terminals etc.
Checking of bill of materials as per approved drawing.
Checking of operation of various feeders as per approved schematic drawings.
Operation check shall be carried out for every control function as per schematic drawings by manually simulating fault conditions and operation of control switches/relays etc.
Checking of interchange-ability of identical feeders.
Insulation resistance test and value measurement on power and control circuits before and after high voltage withstand test.
High voltage test on power and control circuit as per IEC-61439.
For equipment bought from other suppliers, certified test reports of tests carried out at the manufacturers works shall be submitted.

4.0 DOCUMENTATION
On award of work, bidder to prepare / submit three sets of following shop drawings and got approved by the Engineer-in-charge before commencement of panel manufacture:

a) General arrangement (GA) drawing of each panel duly endorsement of switchgears OEM complying applicable standard for fabrication etc. The set of GA drawings shall be supported with:
- Detailed drawings showing General Arrangement, plans, sections, elevations, foundation details, base plate details with dimensions and critical information.
- Single Line Diagram
- Control & Schematic Diagram
- Bill of Materials/quantities indicating makes, technical specs, quantity etc.
- Data sheets (where applicable)
- Control logic and write up (where applicable)
- Technical leaflets / specifications.
- Characteristic curves of equipment’s (where applicable)
b) Bus bar sizing calculation for various bus bars rating for incomer/outgoings.
c) Type test certificate of similar design panel, Internal Arc test etc as applicable

Final two sets on approval shop drawings shall also be submitted for manufacture of panel & execution of the works at site.

5.0 COMPLETION PLANS
On completion of work, the contractor shall submit 4 sets of following documents along with soft copy of as built drawings. The drawings shall be Computer aided design drawings (CADD).
- General Arrangement Layout drawings with dimensions, plans, sections, etc.
- Single Line Diagram
- Control & Schematic Diagram
- Bill of Materials/quantities indicating makes, technical specs, quantity etc.
- Data sheets
- Control logic (where applicable)
- Details of inventory
- Equipment name plate details
- Installation & Maintenance Manuals
- Test certificates (Factory tests, Site tests)
- Guarantee/Warranty certificates (where applicable)
LV HYBRID COMPENSATION SYSTEM -
(ACTIVE POWER FILTER + CAPACITOR BANK + INCOMER SWITCHGEAR)

1. GENERAL
This section covers the detailed requirement of LV hybrid compensation system suitable for
operation on 415V, 3 phase, 4 wire, AC supply. The panel shall be Hybrid compensation system
which will take care of power factor and harmonics both for the connected LV system.

2. STANDARDS & CODES:
The design, manufacture and testing of the LV hybrid compensation system & its components
shall be carried out as per latest applicable Indian Standards, Indian Electricity Rules, relevant
code of practices and requirement of Chief Electrical Inspectorate of the State Government
and International Electro Technical Commission (IEC) Standards. However, for ready reference
some of the Standards and Code of Practices are given below:

<table>
<thead>
<tr>
<th>Standard</th>
<th>Description</th>
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</thead>
<tbody>
<tr>
<td>IEC 60831-1 &amp; 2 / IS 2834</td>
<td>Shunt capacitors for power system</td>
</tr>
<tr>
<td>IS 60947</td>
<td>Low voltage switchgear</td>
</tr>
<tr>
<td>IEC 61921 / IS 16636</td>
<td>Low voltage power factor correction Panel.</td>
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<td>IEC 60076-6</td>
<td>Power transformers - Part 6: Reactors</td>
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<tr>
<td>IEC 60439</td>
<td>Low-Voltage Switchgear and Control gear Assemblies - Part 1: Partially Type-Tested Assemblies.</td>
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<td>IEC 62262</td>
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<tr>
<td>IEC 61326-1</td>
<td>Electrical equipment for measurement, control and laboratory use - EMC requirements - Part 1: General requirements.</td>
</tr>
<tr>
<td>IEC 61000-6-4</td>
<td>Electromagnetic compatibility – Generic standards – Emission standard for industrial environments</td>
</tr>
<tr>
<td>IS 1248</td>
<td>Electrical indicating Instruments</td>
</tr>
</tbody>
</table>

3. DESIGN and SCOPE OF WORK
The power factor of inductive load as assumed of the system shall be improved from 0.8 power
factor to 0.98 (minimum). The kVAR rating of the capacitor bank shall be as per system
requirement to be works out by the EPC contractor. It shall be able to maintain consistent high
power factor. It shall be designed to prevent leading power factor in the installation during low
load conditions and modularity should be available so that capacity can be enhanced as and
when required.

The harmonic levels of the system shall also be improved from 25% iTHD to less than 5% iTHD at
full load condition so as to ensure IEEE 519: 2014 standards as well as local utility regulations.
The system should be able to consistently maintain the harmonic levels in the system.

The scope of works broadly covers the following
1. Selection of active power filter + capacitor bank + incomer switchgears as per system design
requirement.
2. Provision of incomer switchgear with MFM to measure & display minimum parameters like
– I, V, pf, Frequency, KW, KVar, KVA, THD & provision of RS 485 port, etc., and LED
indications, auto/manual provision complete.
3. Provision of outgoing switchgear with ON/ OFF indications etc
4. Fabrications panel(s) switchgear, controls, metering, indications, painting etc shall be
followed as described in LT panel sections.
5. LV hybrid compensation system with a single integrated controller for active and passive or separate panel for passive (capacitor) and active (power filters) shall be acceptable as per OEM standard design complying detailed specifications as described in succeeding paras.

6. For sensing correction of PF and or harmonic, set of CT’s shall be provided in horizontal busbar section(s) as required.

7. **SHOP DRAWING SUBMISSION**
   a) On award of work contractor shall submit shop drawing along with technical compliance of contract specification and supporting calculation sheets for selection of LV hybrid compensation system rating complete.
   b) On approval of technical submittal, four sets of working drawings to be submitted by the contractor to Engineer – In – charge.
   c) On completion of work, four sets of **as built drawing** to be submitted.

The above is the minimum requirement for this package, for details refer special conditions of contract (SCC-E).

4. **Operation Philosophy:**
   The Active Correction device (active power filters) shall work on the principle of measurement of load current and decomposing it into harmonic currents, reactive (lead and lag), negative and zero sequences and generate actively the required reference to the measured requirement. Active power filter shall be installed to ensure that the installation is Power Quality ready from day 1. The equipment shall be able to reduce harmonic levels as per the local utility regulation and as described above. The active filter equipment shall be able to correct either leading (capacitive) or lagging (reactive) power factors and load balancing as well. The Passive AC capacitors (capacitor bank) shall work on the principle of measurement of network power factor and shall switch on required number of capacitor bank stages to improve the power factor of the electrical network.

The contractor should prove through third party calibrated power quality measurement equipments or submission of software simulation that the Total Demand Distortion (TDD) is less than 5%. The Total Harmonic Distortion Voltage (THD V) shall be within the limits as specified in IEEE Std 519-2014 (Standards on IEEE recommended practices and requirements for Harmonic Control in Electric Power System). The point of common coupling (PCC) for such calculations shall be at the transformer incomer secondary (415 V Supply). The simulation software should take into consideration the performance of the de-tuned capacitor bank. The Passive AC Capacitors device shall not amplify the existing system harmonics. The Hybrid Compensation System should comprise Active Correction and Passive Correction devices as per system design required. The Active Correction device would be capable of reactive, harmonics and unbalance compensation while the Passive Correction device should be Capacitor + reactor combination to improve the system displacement power factor. The same shall be achieved through single integrated controller or separate controllers provided, the end result is achieved. The active: passive ratio should be at least 1:1 or active may be higher.

5. **TECHNICAL SPECIFICATION**
   **General contractions**
Detailed specification for switchgear, controls, metering, indications, painting etc shall be followed as described in LT panel sections

The design and construction of the Hybrid capacitor panel shall be partially type tested design as per IS 16636 / IEC 61921. The panel shall be manufactured by OEMs or their licence partner as per approved make list of AAI.

**Passive Correction device (Capacitor Banks)**

**Capacitor banks:** It shall have multiple stages, which shall be switched ON / OFF automatically with the use of electromagnetic (capacitor duty) contactors. The contactor should be suitable for the type of loads connected to the network. The capacitor banks shall incorporate series de-tuning reactors to prevent amplification of system harmonics and prevent resonance.

The capacitor units shall be suitable for a supply voltage of 415 volts and shall be rated at 525 Volts. The de-rating shall be due to factors like temperature, voltage rise due to the connection of de-tuned reactors and harmonics. The capacitor unit shall be manufactured in full compliance with and tested to the requirements of IEC 60831, Part-1 and Part-2.

- **System fault level:** 50 kA
- **Maximum voltage variation:** +/- 10%
- **Max frequency variation:** +/- 5%

The dielectric film used in the capacitor shall be of the self-healing type, heavy duty (MPP-H), utilizing low loss metalized polypropylene with following parameters:

- 3 phase, delta connected, 50 Hz
- Overvoltage +10% (for 8h / 24h)
- Overcurrent: 1.8 x In;
- Inrush current of 250In
- Total watt-losses: < 0.5 W / kVAR
- Temperature category: -25° C to 55° C

**Type of unit connection:** The capacitor units shall be internally connected in delta and shall incorporate a 3-phase pressure switch dis-connector for protection against internal faults, over pressure, etc. The pressure switch dis-connector must isolate all the three phases simultaneously in the event of fault.

**Discharge resistance:** To be provided between all the phases. The built-in discharge resistors shall not be accessible (factory fitted) and tamper proof. The discharge resistors shall ensure reduction in capacitor voltage to less than 50 volts in 3 minute after switch off.

**Series Reactor:** 14% de-tuned type (135 Hz) for each capacitor stage. The de-tuning reactors shall copper wound be connected in series with each capacitor stage and shall be of iron cored type. The reactor insulation shall be Class “H” rated at 180°C. The maximum temperature of the reactor at maximum continuous RMS amperage shall be no higher than 145°C at a 50°C ambient. The de-tuning reactor shall be manufactured in full compliance with and tested to the requirements of IEC 60289 / IS 5553.

Each stage of the capacitor bank shall also have a suitably rated MCCBs (Thermal Magnetic type) with an overload & Short circuit protection. The MCCB shall be manufactured in full compliance with and tested to the requirements of IEC 60947-1, & 2.

**Stage Contactor:** The electromagnetic contactors shall be rated for 415 Volts and shall be 3-pole capacitor duty type with pre charging resistors and shall be employed for switching 'on' and switching 'off' operations in capacitor banks. The rated voltage of control coil shall be 415V (phase-to-phase). This voltage is subject to a variation of (+) 10% and (-) 15%. The
Contactor shall be AC type. The contactor shall be of certified design confirming to IEC 60947-1 & 4-1.

**Active Correction device (active power filter)**

The Active power filter (APF) shall be defined as a power electronic device consisting of power semiconductors known as insulated gate bipolar transistors (IGBT) that switch into the AC lines to modulate its output to mitigate detrimental harmonic current; correct the displaced reactive current (leading or lagging); and balance the current (also known as negative sequence current) for the power source. Spectrum Cancellation: from 2nd to 49st

The APF shall employ the most efficient 2 level inverter technology.

**Cooling Architecture:** Segregated Cooling (Separate for heat sink and separate for PCB's)

APF shall analyze the content of the supply current for harmonics from the 2nd to the 49th harmonic and shall determine the reactive current content representing displacement power factor and supply current balancing. APF shall have a spectrum cancellation from 2nd to 49th, discrete, fully selectable per harmonic order (amplitude and on/off).

APF shall have a Closed Loop Control: Source sense (at mains) CT or Load sense CT for single unit.

APF shall include an option to achieve optimized unity PF, leading (capacitive) or lagging (inductive) power factor to target.

APF shall provide field selection as harmonic filter, reactive current correction, or supply current balancing or any combination of the three modes. All modes shall be required for this project.

APF shall be designed with a current limiting function to protect the IGBT. APF shall have automatic restart capability upon power loss return and fault resets. APF shall monitor the incoming air temperature and invoke a hard trip of the unit at 50° C.

APF shall have a door-mounted human machine interface (HMI) with touch screen display.

HMI shall provide an oscilloscope feature to display specific parameters.

In addition, performance trend curves shall be displayed for load - total RMS current, load RMS harmonic current per phase, APF harmonic current output per phase, AC mains voltage per phase, THDi, TDD, load RMS reactive current, and APF RMS reactive current output. Display of the mains and load harmonic current amplitudes per harmonic order. HMI shall display a flashing warning screen in the event of a fault.

**DSP controller**

The Hybrid Power factor correction should have a 32 bit controller which shall be able to communicate through CAN with HMI and shall be able to control the capacitor banks. In case of separate controller, the APFC relay shall control switching of capacitor banks.

**Human Machine Interface**

HMI shall provide an oscilloscope feature to display specific parameters.

a. Minimum 7-inch, colour touchscreen LCD interface.

b. Support MODBUS TCP communication protocol with a provision of USB port and SD card.

c. Start, stop and trip status (with trip code) on the home screen

d. Active filters shall be with input surge suppression and forced air cooling system.

e. Active filter shall be able to connect in both open loop and closed loop configuration

f. Active filter should have a HMI touch screen display having the functionality of a power analyzer and should display parameters as mentioned below:
3 phase Current Parameters: $A_{rms}$, $A_{1rms}$, $I_{THD}$ (%), $A_{unb}$
Voltage Parameters: $V_{rms}$, $V_{1rms}$, $U_{rms}$, $V_{THD}$ (%), $V_{unb}$, Frequency
Power Parameters: Active, Reactive, Apparent Power
Power Factor
Displacement Power Factor
Filter Parameters: $A_{pk}$, Filter Utilization, Stack Temperature, DC Voltage, Filter Runtime, Fan Runtime, Panel Temperature
Voltage and current waveforms
Voltage and current Harmonic spectrum
Alarm indications & log details.

k. Active filter shall be isolated from the power supply when powered “off”
l. IGBT modules shall be self-protected for maximum reliability through semiconductor fuses.

In case of separate controller for Passive and active are used, the APFC controller shall allow the following settings and readings.
The power factor controller panel shall be microprocessor based and shall be able to sense the reactive current requirement of the network and shall switch ON / OFF the required stages of a capacitor bank. The power factor controller should be able to detect and correct abnormalities in wirings such as reversed CT connection. The controllers shall be suitable for 1A or 5 A current input and shall have Display.
a) Automatic initialization and stage rating detection
b) Any step sequence detection
c) Measurement of capacitance per stage
d) Capacitor bank over load current ratio
e) THD Voltage
f) The controller shall initiate alarms and warnings in the following events.
   ➢ Temperature limit is exceeded
   ➢ Insufficient capacitor output / Loss of capacitance
   ➢ Overload current ratio limit is exceeded
   ➢ Under voltage, Over voltage
   ➢ THDV limit is exceeded

6. EARTHING
Detailed specification of earthing shall be followed as described in specification of LT panel section. Two earth terminals shall be provided to the LV hybrid compensation system panel(s). The earth terminals provided on the body of the capacitor bank and the Active components shall be bonded to the main capacitor panel earth bus.

7. TEST AT MANUFACTURER WORKS
A general visual check shall be carried out. This shall cover measurement of overall dimensions, location, number and type of devices, terminal boxes, location and connection of terminals etc.
a. Checking of bill of material as per approved drawings
b. Checking of operation of various feeders as per approved schematic drawings
c. Operation check shall be carried out for every control function as per schematic drawings
d. Checking of inter changeability of identical feeders
e. IR test and value measurement on power and control circuits before and after HV withstand test
f. High voltage test on power and control circuit as per IS
g. For equipment brought from other suppliers, certified test reports of tests carried out at the manufacturer works shall be submitted. Normally all routine tests as specified in the relevant standards shall be conducted at the sub supplier at its works and copies of routine test reports shall be furnished
h. Heat run test for the active filter shall be performed
i. Functional test for harmonic compensation shall be done at manufacturer works
j. Any other test as per standard asked by AAI inspecting officials

BATTERY & BATTERY – CHARGER (SMPS TYPE)

1. Sealed Lead – Acid Maintenance free Battery
   (i) Codes & Standards

   All standards, specification and codes of practice, referred to herein, shall be the latest edition including all applicable official amendments and revisions as on date of opening of bid.

   In case of conflict between this specification and those (IS Codes Standards etc.) referred to herein, the former shall prevail. All works shall be carried out as per the following standards and codes:

   IS:266 - Specification for sulphuric acid
   IS:1069 - Specification for water for storage batteries
   IS:1146 - Specification for rubber & plastic containers for lead acid storage batteries.
   IS:1652 - Specification for stationary cells and batteries, lead acid type (with plant positive plates).
   IS:3116 - Specification for sealing compound for lead acid batteries.
   IS:8320 - General requirements and methods of tests for lead acid storage batteries.
   IS:6071 - Specification for synthetic separators for lead acid batteries. IEC: 60950 - Specification for Safety

   Equipment complying with other internationally accepted standards such as IEC, BS, DE etc. will also be considered if they ensure performance and constructional features equivalent or superior to standards listed above. In such a case, the Bidder shall clearly indicate the standard(s) adopted, furnish a copy in English of the latest revision of the standards along with copies of all official amendments and revisions in force as on date of opening of bid and shall clearly bring out the salient features for comparison.
2. General Technical Requirements

2.1 Scope

The Specifications give details of the Battery Charger suitable for HT/ LT Panels. The VRLA (valve regulated lead acid) Maintenance free Batteries up to 24V– 200 AH or as per the actual requirement whichever is higher, are to be housed in the Bottom Compartment of the Battery Charge. The Battery Charger is a composite Battery Charger cum DC Distribution Board.

2.2 General

The Battery Charger shall float cum Boost type, SMPS based. The Charger shall be user programmable using a laptop or mobile phone or display to set the - Maximum charging Current, Boost/charge, Absorption and Float Voltages. During Auto Float - Boost Mode, Automatic Changeover shall take place from Float Mode to Boost Mode and vice-versa. This means that when the Batteries are fully charged the charging shall automatically change from Boost charge to Float Charge. The charger shall be capable of charging Lead Acid (or Li Ion without any extra cost) Batteries, selected through user program.

2.3 Construction Feature

Float cum Boost Charger and DC Distribution Board with all necessary controls shall be housed in Upper Compartment whereas batteries will be placed at lower compartment of Sheet Steel Cubicle. The cubical shall be fabricated with CRCA sheet steel of 2mm thickness and shall be folded & braced as necessary to provide a rigid support for all compartments. The door & cover shall be of 1.6mm thickness. The all other details of fabrications, switches & components, painting etc shall be followed as described in LT panel section.

The D.C Output Voltage for Float/ Boost Charger shall be stabilized for A.C. Input variation up to of 230V ± 20%, frequency variation of 50Hz ± 10 % and D.C. Load variation of 0 – 100%. The Voltage Regulation shall be achieved by a constant voltage regulator having fast response through High Frequency PWM Control. The ripple content in output shall be within 0.5 % of D.C. Output Nominal Voltage.

No manual settings are allowed to be done. All the settings shall be done through the programming port / knob display with password protection available on the front panel of the charger. During Auto Float mode the Battery charging shall automatically changeover from Boost Mode to Float Boost and vice-versa. During Manual Float/ Boost Modes it shall be possible to set the output volts through the user settable program only. The charger shall have an LCD Display showing Set Modes, Voltage and Current limits, Temperature, Battery voltage charging current and Load current etc. Fault indications shall also be visible on the display. A potential free alarm shall be provided for alarm in case of mains failure, charger failure and Battery Low. Suitable arrangement shall be made for forced cooling.

D.C. Distribution Board

<table>
<thead>
<tr>
<th>Incoming</th>
<th>Outgoing</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 No. 63ADPMC</td>
<td>8 Nos. 16A DPMCB (or as per actual requirement plus one spare whichever is higher)</td>
</tr>
</tbody>
</table>
Visual and Audible Alarm shall be provided along with a potential free electrical contact for the following conditions:

a) A.C. MainsFail.
b) ChargerFail.
c) Load/ OutputOvervoltage.

Rating

- **ACInput**: 230v ± 20% ac 50 Hz SinglePhase.
- **DCOutput**: Float/ Boost Charge 24V – 200AH (or as per actual requirement whichever is higher)
- **CurrentRating**: 30.0Amps.
- **FloatMode**: 27.0 V Nominal (Adjustable 20V – 29.0V)
- **AbsorptionMode**: Adjustable 20.0 V to 29.0V
- **BoostMode**: 28.0 V Nominal (Adjustable 20V – 29.0V)
- **EqualizationMode**: Adjustable 20.0 V to 29.0V
- **LowVoltageTrip**: Adjustable, (Default value –22V )
- **Ripple**: Less than 0.5%
- **ProgramOptions**: Display Modes of charge and Temperature display compensation.

**BATTERY & BATTERY CHARGER**

1. **Battery**

<table>
<thead>
<tr>
<th>For Sealed Lead Acid Maintenance free (VRLA) Battery</th>
</tr>
</thead>
<tbody>
<tr>
<td>a) Battery Bank Voltage</td>
</tr>
<tr>
<td>b) Battery type</td>
</tr>
<tr>
<td>c) Capacity for ten (10) hour rate at 27 degree C as per IS</td>
</tr>
<tr>
<td>d) Nominal discharge voltage per cell/Battery</td>
</tr>
<tr>
<td>e) Float Voltage</td>
</tr>
</tbody>
</table>

2. **Battery- Charger**

<table>
<thead>
<tr>
<th>Float Cum Boost Charger</th>
<th>230V +/- 20%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Levels set as per prevailing IS standards for VRLABattery</td>
<td>0 – 100%</td>
</tr>
<tr>
<td>VRLA Battery of Approved Makes</td>
<td>160 AH</td>
</tr>
<tr>
<td>MS Powder Coated Enclosure for Charger and Battery</td>
<td>Input and Output Terminations</td>
</tr>
<tr>
<td>Incoming – 1 No. 63A DP MCB Outgoing –</td>
<td></td>
</tr>
</tbody>
</table>
IMPHAL AIRPORT

<table>
<thead>
<tr>
<th>Feature</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>i) Efficiency</td>
<td>➢ 90% at fullload</td>
</tr>
<tr>
<td>j) Input Power Factor</td>
<td>➢ 0.9 to Unity</td>
</tr>
<tr>
<td>k) Line Isolation Level</td>
<td>2500 V AC as per safety standard</td>
</tr>
<tr>
<td>l) Ingress Protection</td>
<td>IP21 for indoor use</td>
</tr>
</tbody>
</table>

1.0 PERFORATED TYPE

The cable tray shall be fabricated out of slotted/perforated MS sheets as channel sections, single or double bended. The channel sections shall be supplied in convenient lengths and assembled at site to the desired lengths. Cable tray and accessories shall be galvanised.

Typically, the dimensions, fabrication details etc. are shown in CPWD General Specification for Electrical Works Part-II-External.

The jointing between the sections shall be made with coupler plates of the same material and thickness as the channel section. Two coupler plates, each of minimum 200mm length, shall be bolted on each of the two sides of the channel section with 8mm dia round headed bolts, nuts and washers. Proper earth continuity to be ensured between the cable trays.

The maximum permissible uniformly distributed load for various sizes of cable trays and for different supported span are as per Table-IV of CPWD General Specifications of Electrical Work Part-II - 1994. The sizes shall be specified considering the same.

Factory fabricated bends, reducers, tee/cross junctions, etc. shall be provided as per good engineering practice (Details are typically shown in figure-3 of CPWD General specifications of Electrical Work Part-II – 1994). The radius of bends, junctions etc. shall not be less than the minimum permissible radius of bending of the largest size of cable to be carried by the cable tray.

The entire tray (except in the case of galvanised type) and the suspenders shall be painted with two coats of red oxide primer paint after removing the dirt and rust, and finished with two coats of spray paint of approved make synthetic enamel paint.

2.0 LADDER TYPE

Ladder type cable tray shall be fabricated out of double bended channel section longitudinal members with single bended channel section rungs of cross members welded to the base of the longitudinal members at a centre to centre spacing of 250mm. The channel sections shall be supplied in convenient lengths and assembled at side to the desired lengths. These may be galvanised or painted to the desired lengths.

Typically, the dimensions, fabrication details etc. are shown in CPWD General Specification for Electrical Works - Part II -External, 1994.

The jointing between the sections shall be made with coupler plates of the same material and thickness as the channel section. Two coupler plates, each of minimum 200mm length, shall be bolted on each of the two sides of the channel section with 8mm dia round headed bolts, nuts and washers. In order to maintain proper earth continuity bond, the paint on the contact surfaces between the coupler plates and cable tray shall be scraped and removed before the installation.

The maximum permissible uniformly distributed load for various sizes of cable trays and for different supported span are as per CPWD General Specification of Electrical Work Part II -1994. The sizes shall be specified considering the same.
The width of the cable tray shall be chosen so as to accommodate all the cable in one tier, plus 25% additional width for future expansion. This additional width shall be minimum 100mm.

Factory fabricated bends, reducers, tee/cross junctions, etc. shall be provided as per good engineering practice. Details are typically shown in figure 3 of CPWD General Specification of Electrical Work Part-II-1994. The radius of bends, junctions etc. shall not be less than the minimum permissible radius of bending of the largest size of cable to be carried by the cable tray.

The entire tray (except in the case of galvanized type) and the suspenders shall be painted with two coats of red oxide primer paint after removing the dirt and rust, and finished with two coats of spray paint of approved make synthetic enamel paint.

The cable tray shall be bonded to the earth Terminal of the switch bonds at both ends.

3.0 INSTALLATION & MEASUREMENT OF CABLE TRAY/ LADDER

The cable tray shall be suspended from the ceiling slab with the help of 10mm dia MS rounds or 25mm x 5mm flats at specified spacing as per of CPWD General Specification of Electrical Work Part II -1994. Flat type suspenders may be used for channels upto 450mm width bolted to cable trays. Round suspenders shall be threaded and bolted to the cable trays or to independent support angles 50mm x 50mm x 5mm at the bottom end as specified. These shall be grouted to the ceiling slab at the other end through an effective means, as approved by the Engineer, to take the weight of the cable tray with the cables.

XI EARTHING

1.0 SCOPE

This section covers the essential requirements of earthing system components and their installation. For details not covered in these specifications, IS Code of Practice on Earthing (IS : 3043-1987) CPWD General specifications for Electrical works (part-I-Internal) as amended upto date and in the regulations of the local Electrical Supply Authority shall be referred to.

1.1 APPLICATION:

i) The electrical distribution system is with earthed neutral (i.e. neutral earthed at the transformer/ generator end). In addition to the neutral earthing, provision is made for double earthing the metallic body of equipments and non-current carrying metallic components in the substation, as well as in the internal/ external electrical installations.

ii) Earthing requirements are laid down in Indian Electricity Rules, 1956 and Indian standard Specification IS:3043:1987 with latest amendment as amended from time to time, and in the Regulations of the Electricity Supply Authority concerned. These shall be complied with.

2.0 MATERIALS

2.1 EARTH ELECTRODES

The earth electrode shall be Plate/ Pipe earth electrode as required and the materials and size of earth electrodes shall be as specified.

2.2 EARTHING CONDUCTOR
2.2.1 The earthing conductor (protective conductor from earth electrode upto the main earthing terminal/ earth bus, as the case may be) shall be of the same material as the electrode, viz. GI or copper and in the form of wire or strip as specified. The size of earthing conductor shall be as specified.

2.2.2 Each equipment shall be connected with two independent earth conductors to earth bar located in respective area. Each earth bar shall be connected to Earth Grid by two independent earth conductors. Earthing Grid shall be directly connected by two independent earth electrodes. Earthing shall be of GI or Copper.

3.0 HARDWARE ITEMS

All hardware items used for connecting the earthing conductor with the electrode shall be of GI in the case of GI pipe and GI plate earth electrode and forged tinned brass in case of copper plate electrodes.

3.1 PROTECTIVE (EARTH CONTINUITY/ LOOP EARTHING) CONDUCTOR

i) The material and size of protective conductors shall be as specified.

ii) Unless otherwise specified, GI conductor should not be ordinarily used as protective conductor within any circuit beyond a Distribution Board downstream.

3.2 LOCATION FOR EARTH ELECTRODES

Normally an earth electrodes shall not be located closer than 1.5 m from any building. Care shall be taken to see that the excavation for earth electrode does not affect the foundation of the building; in such cases electrodes may be located further away from the building, with the prior approval of the Engineering-In-Charge.

The location of the earth electrode shall be such that the soil has a reasonable chance of remaining moist as far as possible. Entrances, pavements and roadways, shall be avoided for locating earth electrodes.

When more than one electrode (plate/ pipe) are to be installed, a separation of not less than 2m shall be maintained between adjacent electrodes.

4.0 INSTALLATION

4.1 ELECTRODES

4.1.1 PIPE ELECTRODE

Earthing electrode shall consist of a medium class GI Pipe of approved make not less than 40mm dia and 4.5 meters long. GI Pipe electrode shall be cut tapered at the bottom and provided with holes of 12mm dia drilled at not less than 75mm interval upto 2 meters length from bottom. The electrode shall be buried vertically in the ground as far as practicable below permanent moisture level with its top at not less than 20cm below ground level. The electrode shall be in one piece and no joints shall be allowed in the electrode. Wherever possible earth electrodes shall be located as near water tap, water drain or a down take pipe. Earth electrodes shall not be located in proximity to a metal fence. It shall be kept clear of the building foundations and in no case shall be nearer than 2 meters from the outer face of the wall.

The pipe earth electrode shall be kept vertically and surrounded with 150mm thick layer of charcoal dust and salt mixture upto a height of 2.0 meters from the bottom. At the top of the electrode a funnel with a mesh shall be provided for watering the earth. The main earth conductors shall be connected to the electrode just below the funnel, with proper terminal lugs and check nuts.
In locations where the full length of pipe electrode is not possible to be installed due to meeting a water table, hard soil or rock, the electrode may be reduced length, provided the required earth resistance result is achieved with or without additional electrodes, or any alternative method of earthing may be adopted, with the prior approval of the Engineer-In-Charge. Pipe electrodes may also be installed in horizontal formation in such exceptional cases.

4.1.2 PLATE EARTH ELECTRODE

Earthing shall be provided with GI /copper plate electrode as mentioned in BOQ of following.

i. GI Plate Electrode. : 600mm x 600mm x 6mm thick

ii. Copper Plate Electrode. : 600mm x 600mm x 3mm thick

The electrode shall be buried in ground with its faces vertical and not less than Three (3) metres below ground level. 20mm dia medium class GI pipe shall be provided and attached to the electrode. Earth electrode shall not effect the column footing or foundation of the building. In such cases electrode shall be further away from the building.

4.1.3 WATERING ARRANGEMENT

i) In the case of plate earth electrodes, a watering pipe of 20mm dia. medium class GI pipe shall be provided and attached to the electrodes as shown in the drawing and a funnel with mesh shall be provided on the top of this pipe for watering the earth.

ii) In the case of pipe electrodes, a 40mm x 20mm reducer shall be used for fixing the funnel with mesh.

iii) The watering funnel attachment shall be housed in a masonry enclosure of size not less than 300 mm x 300 mm x 350 mm deep.

A MS frame with 6mm thick MS cover and having LEN Key locking arrangement shall be suitably embedded in the masonry enclosure. The top enclosure shall be provided of 50mm thick PCC.

4.1.4 The details of Plate/ Pipe earth electrode, a detailed drawing as referred in CPWD specification of Internal EI shall be referred.

4.2 EARTH CONDUCTOR

In the case of plate earth electrodes, the earthing conductor shall be securely terminated on to the plate with two bolts, nuts, check nuts and washers.

In the case of pipe earth electrodes, wire type earthing conductor shall be secured as using through bolts, nuts and washers and terminating socket.

The earthing conductor from the electrode upto the building shall be protected from mechanical injury by a medium class, 15mm dia GI pipe in the case or wire, and by a minimum of 40mm dia, medium class GI pipe in the case of strip. The protection pipe in ground shall be buried at least 30 cm deep (to be increased to 60 cm in case of road crossing and pavements). The portion within the building shall be fixed on walls.

The earthing conductor shall be securely connected at the other end to the earth stud/earth bar provided on the switch board by Soldered or preferably crimped lug, bolt, nut and washer in the case of wire, and, Bolt nut and washer in case of strip conductor.

4.3 EARTH BUS AND MAIN EARTHING TERMINAL
In all installations, main earthing terminal shall be provided at the main switchboard. This may be in the form of earth stud or single earth bar depending on the type of the switchboard.

Following conductors shall be terminated on to the main earthing terminal.

a) Earth connection from electric supply company (where provided)
b) Earthing conductor from electrode.
c) Protective conductors
d) Equi-potential bonding conductors.

4.4 PROTECTIVE (LOOP EARTHING/ EARTH CONTINUITY) CONDUCTOR

Earth terminal of every switchboard in the distribution system shall be bonded to the earth bar/ terminal of the upstream switchboard by protective conductors.

Two protective conductors shall be provided for a switchboard carrying 3 phase switchgear thereon.

4.5 EARTH RESISTANCE

The earth resistance at each electrode shall be measured. No earth electrode shall have a greater ohmic resistance than 5 ohms as measured by an approved earth testing apparatus. In rocky soil the resistance may by upto 8 ohms.

Where the above stated earth resistance is not achieved, necessary improvement shall be made by additional provisions, such as additional electrode(s), different type of electrode, or artificial chemical treatment of soil etc., as may be directed by the Engineer-In-Charge.

4.6 MARKING

i) Earth bars/ terminals at all switch board shall be marked permanently, as ‘E’.

ii) Main earthing terminal shall be marked ‘SAFETY EARTH- DO NOT DISCONNECT’.

4.7 MEASUREMENT OF EARTH ELECTRODE RESISTANCE

4.7.1 Two auxiliary earth electrodes, besides the test electrode, are placed at suitable distance from the test electrode. A measured current is passed between the electrode ‘A’ to be tested and an auxiliary current electrode ‘C’ and the potential difference between the electrode ‘A’ and auxiliary potential ‘B’ is measured. The resistance of the test electrode ‘a’ is then given by

\[ R = \frac{V}{I} \]

Where,

\[ R \] - Resistance of the test electrode in ohms
\[ V \] - Reading of the voltmeter in volts
\[ I \] - Reading of the ammeter in amps

4.7.2 Stray currents flowing in the soil shall produce serious errors in the measurement of earth resistance. To eliminate this, hand driven generator is used.

If the frequency of the supply of hand driven generator coincides with the frequency of stray current, there shall be wandering of instrument pointer. An increase or decrease of generator speed shall cause this to disappear.

4.7.3 At the time of test, the test electrode shall be separated from the earthing system.
4.7.4 The auxiliary electrodes shall be of 13mm diameter mild steel rod driven up to 1 m into the ground.

4.7.5 All the three electrodes shall be so placed that they are independent of the resistance area of each other. If the test electrode is in the form of a rod, pipe or plate, the auxiliary current electrode C shall be placed at least 30m away from it and the auxiliary potential electrode’ B’ shall be placed mid-way between them.

4.7.6 Unless three consecutive readings of test electrode resistance agree, the test shall be repeated by increasing the distance between electrodes A and C up to 50m, and each time placing the electrode B mid-way between them.

CHEMICAL/MINERAL EARTHING

Chemical/mineral earthing shall be provided as per IS 2309, IEC 62305 part3, IEC 60364, IEC 62561 part 2, IS 3043, UL 467 & UL 96 standards.

Maintenance free earthing arrangement to carry fault current with 250 microns molecularly copper bonded solid high carbon steel rod of diameter 20mm and minimum length 3 Meters (1 meters³) tested for 10/350 micro second wave form, stainless steel connectors and fasteners for connecting electrode with earthing conductor/strip, etc. with earth enhancing mineral compound is recommended as per above mentioned standards. The electrode shall be hand driven or hammered in to earth for soft soil and drilling for rocky and hard soil.

Earthing System comprises of molecularly bonded copper of 99.9% purity on low carbon steel of 3m length (1mx 3 nos), having a diameter of 20mm with copper coating thickness of 250 microns with self-coupling bore and peg arrangement (without the need for external coupler) with fault current withstand capability of 15 KA rms value for 1 second. For obtaining desired length, the number of rods shall be increased and is provided with Universal Clamp made of SS 304 for clamping the cable/flat conductor to the rod. Impact point (219 20 IP) on the bottom rod for easy insertion.

Earth enhancing mineral compound is used for improving the soil conductivity. Earth enhancing mineral compound shall be so designed and constructed that in normal use their performance is reliable and without danger to persons and the surroundings. The material shall be mineral inert to sub soil and shall not pollute the environment. It shall provide a stable environment in terms of physical and chemical properties and exhibit low resistivity. It shall not be corrosive to the earth electrode itself. The material should have a resistivity less than 50 Ohm meter. It should be free from hazardous substances The mineral compound is required to have minimum 12.5 Kg of the total composite.

Earth electrode inspection chamber with heavy duty cover should be used to cover the Earth Rod. The dimension shall be as specified in SOQ. The earth resistance shall be less than 2 Ohms. Additional earth electrode shall be driven one over the other or using parallel earth electrodes to achieve the specified earth resistance value, if the soil resistivity is found high. For driven rod method the earth enhancing mineral compound has to filled at a depth of 0.6 meter from surface and excavating a manhole size of 0.275 meter length and breadth. For auguring method the earth enhancing mineral compound has to be mixed with garden soil and filled in the entire length of rod.

Marking
XI EARTHING

1.0 SCOPE
This section covers the essential requirements of earthing system components and their installation. For details not covered in these specifications, IS Code of Practice on Earthing (IS : 3043-1987) CPWD General specifications for Electrical works (part-I-Internal) as amended upto date and in the regulations of the local Electrical Supply Authority shall be referred to.

1.1 APPLICATION:
i) The electrical distribution system is with earthed neutral (i.e. neutral earthed at the transformer/ generator end). In addition to the neutral earthing, provision is made for double earthing the metallic body of equipments and non-current carrying metallic components in the substation, as well as in the internal/ external electrical installations.

ii) Earthing requirements are laid down in Indian Electricity Rules, 1956 and Indian standard Specification IS:3043:1987 with latest amendment as amended from time to time, and in the Regulations of the Electricity Supply Authority concerned. These shall be complied with.

2.0 MATERIALS

2.1 EARTH ELECTRODES
The earth electrode shall be Plate/ Pipe earth electrode as required and the materials and size of earth electrodes shall be as specified.

2.2 EARTHING CONDUCTOR
2.2.1 The earthing conductor (protective conductor from earth electrode upto the main earthing terminal/ earth bus, as the case may be) shall be of the same material as the electrode, viz. GI or copper and in the form of wire or strip as specified. The size of earthing conductor shall be as specified.

2.2.2 Each equipment shall be connected with two independent earth conductors to earth bar located in respective area. Each earth bar shall be connected to Earth Grid by two independent earth conductors. Earthing Grid shall be directly connected by two independent earth electrodes. Earthing shall be of GI or Copper.

3.0 HARDWARE ITEMS
All hardware items used for connecting the earthing conductor with the electrode shall be of GI in the case of GI pipe and GI plate earth electrode and forged tinned brass in case of copper plate electrodes.

3.1 PROTECTIVE (EARTH CONTINUITY/ LOOP EARTHING) CONDUCTOR
i) The material and size of protective conductors shall be as specified.

ii) Unless otherwise specified, GI conductor should not be ordinarily used as protective conductor within any circuit beyond a Distribution Board downstream.

3.2 LOCATION FOR EARTH ELECTRODES
Normally an earth electrode shall not be located closer than 1.5 m from any building. Care shall be taken to see that the excavation for earth electrode does not affect the foundation of the building; in such cases electrodes may be located further away from the building, with the prior approval of the Engineering-In-Charge.

The location of the earth electrode shall be such that the soil has a reasonable chance of remaining moist as far as possible. Entrances, pavements and roadways, shall be avoided for locating earth electrodes.

When more than one electrode (plate/ pipe) are to be installed, a separation of not less than 2m shall be maintained between adjacent electrodes.

4.0 INSTALLATION

4.1 ELECTRODES

4.1.1 PIPE ELECTRODE

Earthing electrode shall consist of a medium class GI Pipe of approved make not less than 40mm dia and 4.5 meters long. GI Pipe electrode shall be cut tapered at the bottom and provided with holes of 12mm dia drilled at not less than 75mm interval upto 2 meters length from bottom. The electrode shall be buried vertically in the ground as far as practicable below permanent moisture level with its top at not less than 20cm below ground level. The electrode shall be in one piece and no joints shall be allowed in the electrode. Wherever possible earth electrodes shall be located as near water tap, water drain or a down take pipe. Earth electrodes shall not be located in proximity to a metal fence. It shall be kept clear of the building foundations and in no case shall be nearer than 2 meters from the outer face of the wall.

The pipe earth electrode shall be kept vertically and surrounded with 150mm thick layer of charcoal dust and salt mixture upto a height of 2.0 meters from the bottom. At the top of the electrode a funnel with a mesh shall be provided for watering the earth. The main earth conductors shall be connected to the electrode just below the funnel, with proper terminal lugs and check nuts.

In locations where the full length of pipe electrode is not possible to be installed due to meeting a water table, hard soil or rock, the electrode may be reduced length, provided the required earth resistance result is achieved with or without additional electrodes, or any alternative method of earthing may be adopted, with the prior approval of the Engineer-In-Charge. Pipe electrodes may also be installed in horizontal formation in such exceptional cases.

4.1.2 PLATE EARTH ELECTRODE

Earthing shall be provided with GI /copper plate electrode as mentioned in BOQ of following.

i. GI Plate Electrode. : 600mm x 600mm x 6mm thick

ii. Copper Plate Electrode. : 600mm x 600mm x 3mm thick

The electrode shall be buried in ground with its faces vertical and not less than Three (3) metres below ground level. 20mm dia medium class GI pipe shall be provided and attached to the electrode. Earth electrode shall not effect the column footing or foundation of the building. In such cases electrode shall be further away from the building.

4.1.3 WATERING ARRANGEMENT
i) In the case of plate earth electrodes, a watering pipe of 20mm dia. medium class GI pipe shall be provided and attached to the electrodes as shown in the drawing and a funnel with mesh shall be provided on the top of this pipe for watering the earth.

ii) In the case of pipe electrodes, a 40mm x 20mm reducer shall be used for fixing the funnel with mesh.

iii) The watering funnel attachment shall be housed in a masonry enclosure of size not less than 300 mm x 300 mm x 350 mm deep. A MS frame with 6mm thick MS cover and having LEN Key locking arrangement shall be suitably embedded in the masonry enclosure. The top enclosure shall be provided of 50mm thick PCC.

4.1.4 The details of Plate/ Pipe earth electrode, a detailed drawing as referred in CPWD specification of Internal EI shall be referred.

4.2 EARTH CONDUCTOR

In the case of plate earth electrodes, the earthing conductor shall be securely terminated on to the plate with two bolts, nuts, check nuts and washers.

In the case of pipe earth electrodes, wire type earthing conductor shall be secured as using a through bolts, nuts and washers and terminating socket.

The earthing conductor from the electrode upto the building shall be protected from mechanical injury by a medium class, 15mm dia GI pipe in the case or wire, and by a minimum of 40mm dia, medium class GI pipe in the case of strip. The protection pipe in ground shall be buried at least 30 cm deep (to be increased to 60 cm in case of road crossing and pavements). The portion within the building shall be fixed on walls.

The earthing conductor shall be securely connected at the other end to the earth stud/earth bar provided on the switch board by Soldered or preferably crimped lug, bolt, nut and washer in the case of wire, and, Bolt nut and washer in case of strip conductor.

4.3 EARTH BUS AND MAIN EARTHING TERMINAL

In all installations, main earthing terminal shall be provided at the main switchboard. This may be in the form of earth stud or single earth bar depending on the type of the switchboard.

Following conductors shall be terminated on to the main earthing terminal.

a) Earth connection from electric supply company (where provided)

b) Earthing conductor from electrode.

c) Protective conductors

d) Equi-potential bonding conductors.

4.4 PROTECTIVE (LOOP EARTHING/ EARTH CONTINUITY) CONDUCTOR

Earth terminal of every switchboard in the distribution system shall be bonded to the earth bar/ terminal of the upstream switchboard by protective conductors.

Two protective conductors shall be provided for a switchboard carrying 3 phase switchgear thereon.

4.5 EARTH RESISTANCE
The earth resistance at each electrode shall be measured. No earth electrode shall have a greater ohmic resistance than 5 ohms as measured by an approved earth testing apparatus. In rocky soil the resistance may be up to 8 ohms.

Where the above stated earth resistance is not achieved, necessary improvement shall be made by additional provisions, such as additional electrode(s), different type of electrode, or artificial chemical treatment of soil etc., as may be directed by the Engineer-In-Charge.

4.6 MARKING

i) Earth bars/terminals at all switch board shall be marked permanently, as ‘E’.

ii) Main earthing terminal shall be marked ‘SAFETY EARTH- DO NOT DISCONNECT’.

4.7 MEASUREMENT OF EARTH ELECTRODE RESISTANCE

4.7.1 Two auxiliary earth electrodes, besides the test electrode, are placed at suitable distance from the test electrode. A measured current is passed between the electrode ‘A’ to be tested and an auxiliary current electrode ‘C’ and the potential difference between the electrode ‘A’ and auxiliary potential ‘B’ is measured. The resistance of the test electrode ‘a’ is then given by

\[ R = \frac{V}{I} \]

Where,

R- Resistance of the test electrode in ohms
V- Reading of the voltmeter in volts
I- Reading of the ammeter in amps

4.7.2 Stray currents flowing in the soil shall produce serious errors in the measurement of earth resistance. To eliminate this, hand driven generator is used.

If the frequency of the supply of hand driven generator coincides with the frequency of stray current, there shall be wandering of instrument pointer. An increase or decrease of generator speed shall cause this to disappear.

4.7.3 At the time of test, the test electrode shall be separated from the earthing system.

4.7.4 The auxiliary electrodes shall be of 13mm diameter mild steel rod driven up to 1 m into the ground.

4.7.5 All the three electrodes shall be so placed that they are independent of the resistance area of each other. If the test electrode is in the form of a rod, pipe or plate, the auxiliary current electrode C shall be placed at least 30m away from it and the auxiliary potential electrode B shall be placed mid-way between them.

4.7.6 Unless three consecutive readings of test electrode resistance agree, the test shall be repeated by increasing the distance between electrodes A and C up to 50m, and each time placing the electrode B mid-way between them.

CHEMICAL/MINERAL EARTHING

Chemical/mineral earthing shall be provided as per IS 2309, IEC 62305 part 3, IEC 60364, IEC 62561 part 2, IS 3043, UL 467 & UL 96 standards.

Maintenance free earthing arrangement to carry fault current with 250 microns molecularly copper bonded solid high carbon steel rod of diameter 20mm and minimum length 3 Meters
(1 meters*3) tested for 10/350 micro second wave form, stainless steel connectors and fasteners for connecting electrode with earthing conductor/strip, etc. with earth enhancing mineral compound is recommended as per above mentioned standards. The electrode shall be hand driven or hammered in to earth for soft soil and drilling for rocky and hard soil.

Earthing System comprises of molecularly bonded copper of 99.9% purity on low carbon steel of 3m length (1mx 3 nos), having a diameter of 20mm with copper coating thickness of 250 microns with self-coupling bore and peg arrangement (without the need for external coupler) with fault current withstand capability of 15 KA rms value for 1 second. For obtaining desired length, the number of rods shall be increased and is provided with Universal Clamp made of SS 304 for clamping the cable/flat conductor to the rod. Impact point (219 20 IP) on the bottom rod for easy insertion.

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Earth electrode inspection chamber with heavy duty cover should be used to cover the Earth Rod. The dimension shall be as specified in SOQ. The earth resistance shall be less than 2 Ohms. Additional earth electrode shall be driven one over the other or using parallel earth electrodes to achieve the specified earth resistance value, if the soil resistivity is found high. For driven rod method the earth enhancing mineral compound has to be filled at a depth of 0.6 meter from surface and excavating a manhole size of 0.275 meter length and breadth. For auguring method the earth enhancing mineral compound has to be mixed with garden soil and filled in the entire length of rod.

Marking

i) Earth bars/terminals at all switch boards shall be marked permanently as E

Main earth terminal shall be marked Safety Earth – Do Not Disconnect

**********
**PART-III**

**LIGHTNING PROTECTION SYSTEM**

**1.0 GENERAL:**

1.1 This section covers works out detailed risk analysis and provide Lightning Protection System (LPS) for terminal building, control tower, utility block & its structure etc as per latest Indian (IS) and IEC standard.

1.2 **Qualification criteria for supplier of the lightning protection system:**

The supplier of the lightning protection system should be OEM / authorized specialized agency of the OEM. The OEM of the lightning protection system should have authorized service setup in India. The makes should be an approved make of the LPS enclosed.

**Standard & Code:**

<table>
<thead>
<tr>
<th>Part</th>
<th>Description</th>
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<td>General Principles</td>
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<td>UL 467</td>
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<tr>
<td>Ground / Earth enhancement Chemical</td>
<td>IEEE 80</td>
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**1.3 Scope of work:**

The detailed requirement of installation of lightning conductor system for protection of following structures / building against lightning shall be worked out and executed as per IS/IEC:62305 (Part-I to IV) & NBC 2016 and as per enclosed layout drawings for the following location/installations:

Steelwork within reinforced concrete structures can be considered as down conductors for lightning protection and that to be electrically continuous, provided that major part of interconnections of vertical & horizontal bars are welded, clamped or overlapped a minimum of 20 times their diameter and bound or otherwise securely connected. While using structural reinforcement as down conductor, outer columns which are straight from terrace up to the ground floor shall be used as down conductor. Steel bars in this column shall be welded/bolted with proper overlapping at every floor to ensure, proper continuity throughout.
At ground level steel bars shall be taken out & welded/bolted to the GI tape and the tape will be carried out till the earthing pit at ground. Also at terrace level steel bars will be taken out & to be connected to the Air terminal.

It is recommended to carry HVI conductor from ATC tower to the nearest floor having provision to connect to earthing down conductor in the structure. HVI cables shall be used to avoid any interference of induced current to available electrical and electronic equipment. This HVI conductor can be brought down through glass using adhesive clamp to avoid any sight obstacle. In this case 4 nos Air terminal will be mounted at roof at 4 sides and HVI will be layed down accordingly. To lay conductors and Air terminal at roof, a feasible access to roof should be made available by making a permanent staircase so that maintenance can also be done accordingly, in future.

1.3.1 Control Tower & its associated structures
The LPS for Control tower & its structures shall be provided with level-I protection complying as per IS/IEC: 62305 (part-I to IV). The air termination shall be mounted on the Fire retardant polymer (FRP) pole top with FRP adapter. Pole height as permissible by site conditions and meeting IS/IEC guidelines shall be worked out & installed. The erection of pole structure shall be as under:

a) The pole shall be with frangible coupling & made up of different section(s) as required of UV protected FRP materials with suitable concrete foundation and having provision for test point at suitable height concealed in pole with lockable cover.

b) The pole(s) internal construction shall be such that the cable from air termination should pass through all pole sections upto test point & thereafter foundation & upto earth pit without any hindrances. Guy wires are not allowed.

1.3.2 Control Towers & its antenna
The LPS for Control Towers & its antenna(s) shall be provided with level-I protection complying as per IS/IEC: 62305 (part-I to IV). Details of poles etc shall be followed as described under para 1.3.1 above. However, the complete pole sections shall be in FRP only.

1.3.3 Terminal Building
The roof of the terminal building shall be provided with minimum level-I protection complying IS/IEC: 62305 (part-I to IV). Fixing of horizontal / vertical conductor or air termination installed with approved base block on the roof of the terminal building shall be done with special glue material. (The base connector shall be selected such that it should not pierce the roofing sheet). Alternatively the OEM of LPS to propose suitable clamps to fix the aluminum conductor with roofing sheet. Fixing the conductor holder or clamps with roofing sheet, approval of Engineer in Charge will be final and the EPC contractor to execute the same. There shall be close co-ordination with the roofing sheet vendor while selecting the clamps). The life of glue shall be life long at any atmospheric conditions of the site proposed. No drilling is allowed on the roof top of the terminal building.

While determining the position of the air-termination systems, a special attention must be paid to the corners and edges of the structure to be protected.

1.3.4 Utility building & its extended roof if any
Utility building(s) and its extended roof shall be provided with minimum level-I protection complying IS/IEC: 62305 (part-I to IV). The air termination shall directly be installed on the roof of the building with cement concrete base. Drilling shall be avoided on roof top. The location of utility block is shown in the enclosed layout drawing.

While determining the position of the air-termination systems, a special attention must be paid to the corners and edges of the structure to be protected.

1.4 Works to be done by the contractor:

Unless otherwise mentioned in the tender documents, the following works shall be done by the contractor and therefore, their cost shall be deemed to be included in their tendered cost – whether specifically indicated in the schedule of work or not.

a. Lightning protection system shall be worked out at climatic condition of proposed site and submitted with all supporting documents for approval of AAI.

b. All supporting holders, universal connectors, upper & lower termination & fixing/ holding clamp for High voltage insulated (HVI) cable etc. shall be used as per recommendation of the OEM for lightning protection system. The design of the pole structures & foundation for installation of complete lightning protection system shall be submitted duly certified / vetted by a recognized Govt. Engineering College viz. IIT / NIT etc. or by structural consultant of AAI for approval by Engineer–In-Charge.

c. Submission of test certificate of OEM for life time guarantee for glue being used for fixing block with roof of structures.

d. Bidder should submit certificate from manufacturer of LPS for complete support towards design & selection, supply of all parts, inspection at site etc. along with submission of shop drawings supported with risk calculation sheets, design etc for approval of Engineer – In-charge.

e. Making good all damages caused to the structure during installation and restoring the same to their original finish.

f. Minor building works necessary for installation of equipments including its required foundation, making of opening in walls or in floors and restoring them to their original condition / finish and necessary grouting etc., as required.

g. Supports for horizontal & vertical terminals including fittings, assemblies, accessories, hardware items complete as required.

h. All electrical works including interconnections, bonding etc. as required.

i. All tools and tackles required for unloading / handling of equipments and materials at site, their assembly, erection, testing and commissioning.

j. Painting of all exposed metal surfaces of equipments and components with appropriate colour as directed & approved by Engineer–In-Charge.

2.0 System Design:

The level of protection – LPL – I shall be considered as per NBC – 2016, however detail Risk assessment shall be submitted as per IS / IEC 62305 (with upto date amendments) for above building/ structure. Considering airport installations, the rolling sphere method of protection shall preferably be adopted.

While designing the External Lightning Protection (ELP), the separation distance shall be considered by maintaining the physical separation distance between the down conductor for
buildings and HVI cables for ATC Tower as down conductor to compensate the need of separation distance and to avoid creepage flashover.

The system design and layout shall be done in accordance with IS-IEC: 62305 – 2015 (with up-to-date amendments) and as specified in the tender documents. The design, shop drawing and bill of materials etc shall be prepared/ worked out by the bidder as per standards for the lightning protection system and submitted to AAI for approval after getting vetted from the manufacturer of LPS.

The work can be taken at site only after approval of technical submittal and shop drawing approval by AAI. The test certificate of the materials to be used as per IEC, attested in original by the manufacturer shall also be submitted by the bidder before being incorporated for the works to be executed.

3.0 All components shall meet the requirement of IEC 62305 (part I - IV) standard. The materials supplied like - air terminations, down conductors, earth termination etc. of the protective system shall be reliably resistant to corrosion, or be adequately protected against corrosion. Aluminium should not be used underground, or in direct contact with walls.

3.1 External Lightning Protection (ELP) components shall comply with the specification as under:

<table>
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<tr>
<th>Sl. No.</th>
<th>Components</th>
<th>Specifications</th>
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| i)     | Air terminal vertical as well as horizontal | a) Vertical air terminal rod shall be copper coated / copper / Aluminium of required dia & length and blunt point at top.  
b) The horizontal conductors shall be round conductor made of Aluminium/ GI or its alloy (long length & minimum joints). The clamp support shall be provided with necessary base block with glue or concrete block(s) for the support of roof conductor. No drilling is allowed on roof top. |
| ii)    | Down conductor from Air-termination upto test point / earth point | Round conductor (long length & minimum joints) made of Aluminium / GI or its alloy, dia 8 mm (min ) for buildings and High voltage isolated (HVI) cables of area of cross section shall not be less than 50 mm² for control tower building shall be used. The HVI cable should meet the requirements according to EN 62561-2 and test certificate from approved lab up to 200KA (lightening impulse current ) to be submitted.  
At control tower – HVI cable shall be used as down conductor as per site conditions OR as per recommendation of OEM. |
| iii)   | Clamp for support to conductor | All support / clamps/ universal connectors at crossing of round conductors/ holder for vertical conductor etc. shall be provided complying IS/IEC 62305 as per site requirement.  
All Clamps and connectors shall be tested as per IEC / EN 62561 from accredited test lab only. |
| iv)    | Test Joint (with box to be provided at | It shall be used for every down conductor at 1 Meter (approx.) above ground level (for connection /disconnection purpose). For buildings, the down conductor from test box to earth pit shall be protected with HDPE pipe which shall withstand min 6  |
| v) | Earthing system | Each down conductor shall be terminated to either earth electrode or ring earth, Earth electrode shall be not less than 17mm dia, 10 feet long, UL listed, copper coating over mild steel. Each earth electrode shall be supported with RoHS certified, low resistivity (≤0.12 ohm Mtr.) ground enhancement material (min 20Kg) which performs in all soil condition, increases the contact area with earth electrode. Suitable clamps shall be used for termination of down conductors to earth electrode.

Ground enhancement material shall be tested from NABL test labs only for all the parameters (i.e. resistivity, pH value, thermal stability, water solubility, Sulphur content, moisture retention, corrosive prevention etc).

Earth pit chamber shall be of polymer materials or approved equivalent with locking arrangement of size not less than 300 x 300 x 200mm and suitable to withstand load of 5T.

vi) Equi-potential bond | All metal (natural conductor) components shall be bonded together with roof/down conductor for equi-potential bonding, (Except - HVI as down conductor)

vii) Interconnection of earthing system | All earth pits shall be connected together, incase different earthing system can not be connected directly and same shall be interconnected using Isolating Spark Gap.

3.2 Air-termination systems:-

The function of the air-termination of lightning protection system is to prevent direct lightning strikes to damage the volume to be protected. They must be designed to avoid uncontrolled lightning strikes to the building / structure to be protected.

Correct dimensioning of the air-termination systems allows to reduce the effects of a lightning strike to a structure in a controlled way.

Air-termination systems shall consist of -

i) Air termination networks may consist of vertical or horizontal conductors, or combinations of both.

ii) For a flat roof, horizontal air termination along the outer perimeter of the roof shall be used. For a roof of larger area a network of parallel horizontal conductors shall be installed.

iii) Horizontal air terminations should be carried along the contours such as ridges, parapets and edges of flat roofs, and, where necessary, over flat surfaces, in such a way as to join each air termination to the rest, and should themselves form a closed network.

iv) All metallic projections including reinforcement, on or above the main surface of the roof which are connected to the general mass of the earth, should be bonded and form a part of the air termination network.
v) If portions of a structure vary considerably in height, any necessary air terminations or air termination network for the lower portions should be bonded to the down conductors of the taller portions, in addition to their own down conductors.

3.3 **Down Conductors:**

The down conductor is the electrically conductive connection between the air-termination system and the earth-termination system. The function of a down conductor is to conduct the intercepted lightning current to the earth-termination system without damaging the building e.g. due to intolerable temperature rises. To avoid damage caused during the lightning current discharge to the earth-termination system, the down conductors must be mounted to ensure that from the point of strike to the earth -

- Several parallel current paths exist,
- The length of the current paths is kept as short as possible (straight, vertical, no loops),
- The connections to conductive parts of the structure are made wherever required.

3.3.1 **Routing of down conductors:**

3.3.1.1 A down conductor should follow the most direct path possible between the air terminal network and the earth termination network. Where more than one down conductor is used, the conductors should be arranged as evenly as practicable around the outside walls of the structures.

3.3.1.2 The walls of lift wells may be used for fixing down conductors, but lift shafts should not be used for this purpose.

3.3.1.3 Metal pipes leading rainwater from the roof to the ground may be connected to the down conductors, but cannot replace them, such connections should have disconnecting joints.

3.3.1.4 In deciding on the routing of the down conductor, its accessibility for inspection, testing and maintenance should be taken into consideration.

3.3.1.5 **Provision when External Route is Not Available**

Where the provision of external routes for down conductors is impracticable, for example, in buildings of cantilever construction from the first floor upwards, down conductors should not follow the outside contours of the building. To do so would create a hazard to persons standing under the overhang. In such cases, the down conductors may be housed in an air space provided by a non-metallic and non-combustible internal duct and taken straight down to the ground.

Any suitable covered recess, not smaller than 76 mm x 13 mm, or any suitable vertical service duct running the full height of the building may be used for this purpose, provided it does not contain an unarmoured or a non-metal sheathed cable.

In cases where an unrestricted duct is used, seals at each floor level may be required for fire protection. As far as possible, access to the interior of the duct should be available.

3.3.1.6 The lightning protective system should be so installed that it does not spoil the architectural or aesthetic beauty of the building.

3.3.2 **Determination of the number of down conductors:**

Depending on the structural conditions (e.g. gates, precast components), the distances between the various down conductors can be different. In each case, there must be at least the total number of down conductors required for the respective class of LPS. The IEC 62305-
3 Table 5.2.1.1 specifies the typical standard distances between down conductors and ring conductors for each class of LPS to be followed.

3.4 SPECIFICATION FOR POLE

3.4.1 Design & approval

The thickness and dia of steel / FRP pole shall be workout by the bidders as per system design requirement. Successful bidder to examine the same and its foundation taken into account seismic activity at proposed site and also the Basic wind speed of 47 Mtr/sec. as per clause 5.2 of IS:875 (Part-3) 1987 with up to date amendment.

The design shall be such that wind excited oscillation shall be dampened as much as possible and an adequate allowance shall be made to resist stresses due to these oscillations. On award of work, the bidder shall furnish full calculations of the forces involved for approval after getting vetted from the manufacturer of pole(s)/specialized agency.

3.4.2 Pole Construction

The steel / FRP pole manufacturing unit shall be ISO 9001:2000 certified & preferably ISO 14001 certified to ensure consistent quality & environmental protection.

The sections of FRP pipes of suitable thickness shall be inter-connected with tapped adapter of suitable dia & length. The upper part of tapped adapter shall be positioned such that it should not accumulate any dust and bottom part should be secured with SS nut & bolt to the FRP poles. All pipes shall be internally threaded for connection and smooth finish from outside.

The bottom section of steel pole shall be hot dip galvanized internally and externally having uniform thickness of minimum 65 microns. To enable clear access to the test point with cable connections, inside the bottom steel pole, a vandal resistant weather proof door opening has to be provided with a secured heavy duty lock. The lock should not be easily accessible and special arrangements are to be made to open the door for undertaking test check / maintenance. This opening has to be adequately reinforced with welded steel section, thereby restoring the section modules and preventing trickle.

The mast shall be delivered in sections and to be assembled at site by using FRP adapter for FRP poles and slip stress fit in steel pipe (if supply in two sections). The top and bottom dia of the pole shall be not less than 50mm & 100mm A/F respectively. There shall not be any site welding in the pole. The connection between steel pole and FRP mast (above counterpoise structure) shall be with frangible coupling.

The vent shall be provided in all pipes to prevent pressurization due to seasonal variations. The vent provided shall have IP 66 protection.

The air terminal rod shall be inserted into the TOP FRP pole with HDPE adapter. The adapter shall have tapered outer end.

3.4.3 Pole Foundations

Concrete foundation required for the pole shall be designed as per IS: 875 (Part-3) -1987/ IS: 456/78 / IS: 4091-79 and with due consideration to the seismic activities of site. Foundation shall be designed for safe bearing capacity of 10.0 tones per sq.mtr available at a depth of 1.50 m below ground level. Footing can be taken deeper if required from structural considerations.

The foundation design of pole(s) structure shall be certified / vetted by a recognized Govt. Engineering College viz. IIT / NIT etc. or by structural consultant of AAI and submitted for
approval. The cost for the same shall be borne by the contractor. The pole foundation shall be 300 mm above finish surface.

3.4.4 **Casting of Foundation:**

Reinforced cement concrete (RCC) foundation shall be casted as per approved drawing. The curing shall be done for two weeks before loading the pole. The foundation shall project above ground by 300 mm which shall be neatly finished with sand cement plaster.

3.4.5 **Cable Guard pipe:**

50mm (OD) ISI marked DWC HDPE pipe as required shall be laid for easy laying & relaying of HVI cable in concrete foundation without any change to the RCC foundation work. The end of the pipe shall be sealed after cable is laid & tested.

3.4.6 **Installation of Pole**

The steel/FRP poles shall be installed in a workman like manner so that it is leveled, properly aligned and oriented.

Care shall be taken in handling the pole to avoid any distortion to the supporting structure or damage to any other parts.

After erection of pole(s) with overlapping at joints, and flexible coupling at joint between steel & FRP sections, the pole should be numbered as per the direction of Engineer-in-charge and the exposed portion of concrete foundation shall be painted.

On erection of poles, all sections of poles including all fixing accessories shall be coated with polyurethane corrosion resistance paint. The outer colour of pole paint shall be white.

3.5 **Specifications of Down Conductor :**

The down conductor to be used shall be PVC insulated & PVC Sheathed unarmored flexible High voltage insulated (HVI) cables for ATC building. The cable shall be pure Electrolytic type. The size of cable shall not be less than 50 sq.mm.

3.6 **Earthing & Grounding**

a) Earth pits must be made using chemically earth enhancing compounds and must be maintenance free.

b) The earth resistance of the individual earth pit must not exceed 2 ohms static impedance.

c) Earth electrode shall be min of 17mm dia, 10 feet long, UL listed, min 254 micron copper coating over mild steel. - Each earth electrode shall be supported with RoHS certified, low resistivity (≤0.2 ohm Mtr) Ground enhancement Material, at least 3 meter depth and back filled with Chemically earth enhancing compound including excavation & back filling (if required) of pit etc.

d) A minimum quantity of 20Kg of Earth enhancing compound must be used per earth pit.

e) An earth pit chamber shall be casted with PCC. The top cover shall be made of 6mm thick MS sheet with MS angle frame embedded in PCC of chamber & Allen Key lockable arrangement as inspection chamber shall be provided.

After completion of the work the manufacturer or manufacturer’s representative shall check and attest the test certificate of the materials used in the work and certify that the installation along with the materials used are compling IS –IEC-62305 ( Part I - IV) standards.
4.0  The quoted rate by the bidder is deemed to be inclusive of all cost pertaining to the design, manufacture, supply, installation, testing and commissioning of Lightning protection to ATC building & its allied structure as described in the previous pages as a complete job and nothing extra shall be paid on this account.

5.0  Testing:-

On completion of the installation the following measurements checks have to be made and the results to be recorded:

i)  The resistance to earth of each local earth electrode and resistance to earth of complete earth termination system.

ii) Each local earth electrode has to be measured in isolation and the test point between the down conductor and the earth electrode in the disconnected position (isolated measurement).

iii) A further measurement has to be taken with the test point in the connected position (combined measurement).

iv)  The result of visual check of all conductors, bonds and joints and their measured electrical continuity.

If the resistance to earth of a lightning protection system exceeds 10 ohms, the value must be reduced. Necessary remedial action needs to be taken to reduce the value below or equal to 10 ohms.

All connections of air termination systems, down conductors, equipotential bonding conductors, shielding measures etc. should have low-impedance continuity. The recommended value is < 1 Ω.

The contact resistance to the earth-termination system at all test joints must be measured to establish the continuity of the lines and connections (recommended value < 1 Ω).

An inspection report shall be prepared & submitted to AAI along with the technical documents & drawings. The report should contain the following information:

i)  General: Firm’s name and address, Name & address of the OEM of lightning protection system, year of construction.

ii) Information on the structure: Location, use, type of construction, type of roofing, lightning protection level (LPL).

iii) Information on the lightning protection system.

iv) Material and cross-section of the conductors.

v)  Number of down conductors, e.g. test joints (designation according to the information in the drawing); separation distance calculated.

vi) Type of earth-termination system (e.g. ring earth electrode, earth rod, foundation earth electrode), material and cross-section of the connecting lines between the single earth electrodes.

vii) Connection of the lightning equipotential bonding system to metal installations, electrical installations and existing equipotential bonding bars.

viii) Description and drawings of the lightning protection system.

ix)  Lightning protection standards and provisions at the time of installation
x) Deviations from the applicable standards, regulations, requirements and application guidelines applicable at the time of installation.

xi) Defects found if any.

xii) Earth resistance or loop resistance at the individual test joints with information on the measuring method and the type of measuring device.

xiii) Total earth resistance (measurement with or without protective conductor and metal building installation).

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**List of Approved/Acceptable Make**

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Items</th>
<th>Approved/Acceptable Makes</th>
</tr>
</thead>
<tbody>
<tr>
<td>1)</td>
<td>Lightning protection system &amp; materials as per IS–IEC (Air terminal, and its connected accessories like – holders, universal connectors, upper &amp; down terminations &amp; holding clamp for HVI cable, earth enhancing compound etc.)</td>
<td>DEHN / FURSE / ERICO/ OBO or Manufacturers approved by AAI</td>
</tr>
<tr>
<td>2)</td>
<td>HVI copper flexible cable</td>
<td>CCI / DEHN / GLOSTER / NICCO / UNIVERSAL / RPG (ASIAN) / HAVELLS / TORRENT / POLYCB / RAVIN / FINOLEX / OEM of LA approved (This is subject to approval of AAI.)</td>
</tr>
<tr>
<td>3)</td>
<td>FRP pole &amp; its accessories</td>
<td>JINDAL / ERCON / AERON or Manufacturers approved by AAI</td>
</tr>
<tr>
<td>4)</td>
<td>Steel pole &amp; its accessories</td>
<td>IEP / PMP / JINDAL or Manufacturers approved by AAI</td>
</tr>
<tr>
<td>5)</td>
<td>HDPE pipe</td>
<td>DURALINE / DUTRON or Manufacturers approved by AAI</td>
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PART-IV
Air Field Lighting & LMS

TECHNICAL SPECIFICATION – CI BOX AND GI PIPE IN APRON.

SPECIFICATION FOR CI BOX

Scope:
This specification covers the requirements of CI shallow boxes and CI normal boxes on which taxiway edge lights are fixed and transformers are installed respectively.

CI shallow Boxes
Cylindrical CI Boxes shall be of size 330mm outer dia and 150mm height. Thickness of the box shall be 15mm at top and 10mm at other places. It would have a clear opening of 220mm dia at top with 6 nos. tapped holes at 260 PCD and 3/8” * 1” cadmium plated threaded bolt with spring washer suitable for fixing taxiway edge light. This should have 1 no. collar for 50mm dia pipe entry on one side. All CI Boxes shall be machined suitably to achieve the dimensions mentioned and it should be free from furs and fissures. All CI Boxes should be provided drain hole at the bottom. The CI Boxes should be castled out of good quality of casting materials and without any blowhole. Box with bad casting will be rejected. The approved boxes shall be painted with one coat of anticorrosive paint and two coats of black enamel paint. A sample box shall be got approved from the engineer in charge prior to its bulk Manufacturing.

CI normal boxes
Cylindrical CI Boxes shall be of size 330mm outer dia and 400mm height. Thickness of the box shall be 15mm at top and 10mm at other places. It would have a clear opening of 220mm dia at top with 6 nos. tapped holes at 260 PCD and 3/8” * 1” cadmium plated threaded bolt with spring washer suitable for fixing taxiway edge light. This should have 1 no. collar for 50mm dia pipe entry on one side. All CI Boxes shall be machined suitably to achieve the dimensions mentioned and it should be free from furs and fissures. All CI Boxes should be provided drain hole at the bottom. The CI Boxes should be castled out of good quality of casting materials and without any blowhole. Box with bad casting will be rejected. The approved boxes shall be painted with one coat of anticorrosive paint and two coats of black enamel paint. A sample box shall be got approved from the engineer in charge prior to its bulk Manufacturing.

Installation of CI Boxes:
The CI shallow box shall be installed in cement concrete 1:2:4 all around and plastering. The CI shallow boxes may be fixed in the shoulder of the link taxi after cutting the bitumen to house the CI shallow base. The location of the CI Boxes/fixtures should be properly aligned with theodolite and should be as per relevant ICAO specifications. The detailed drawing showing the locations of the CI Boxes and fixture should be prepared and got approved from the Engineer-in-charges before the commencement of installation.

GI Pipes in Airside:
2 nos of 150mm dia B class GI pipe shall be laid in airside in the complete length of the terminal building having junctions in every 25 mtrs.

Due consideration shall be given for the likely provision of shoulders or widening of shoulder on a future date. To facilitate this, 50 mm diameter GI pipe (‘B’ class) for a length of 9 M shall be provided from transformer housing box to away from the shoulder. This would avoid dismantling of the cable system at a later stage. Similarly, GI earth wire up to the CI box shall be laid in a separate GI pipe of 15 mm diameter ‘B’ class for a length of 9 meters from the CI box. For the
runway end/threshold lights the transformer housing boxes shall be interconnected with 50 mm diameter GI pipe ('B' class) to avoid laying cable in the paved area. In case of main & standby circuits the transformer housing boxes shall be independently interconnected with GI pipe.

LIGHTING MANAGEMENT SYSTEM-COMPONENTS AND ACCESSORIES

The system components and their capabilities shall have individual microcontroller/microprocessor and shall not depend on centralized processor. The basic requirements are defined hereunder. Contractor shall ensure that lighting system control devices and assemblies are fully compatible and can be integrated into a system that operates as described in the lighting control notes on drawings and as described within this specification. Any incompatibilities between devices, assemblies, and system controllers shall be resolved between the contractor and the system provider, to ensure proper system operation and maintainability. All the sensors shall conform to BS/IEC/IS standards.

The Lighting Management System (LMS) shall provide automatic control of lights based up on the occupancy and user requirements to avoid unnecessary energy consumption and reduce operating costs on a sustainable basis.

The LMS system shall include design, supply, installation, testing and commissioning of all related Digital Networkable PIR Sensors, Bus Power Supply, Interface Controllers light control modules, Enclosure Cabinet and Cables, LMS routers/controllers, LMS software and PC that required to control the Lights. The contractor shall execute the job with all respect as mentioned.

The components and accessories shall include but not be limited to the following:

a) PIR Stand Alone Multi- Sensors (PIR/Microwave/Ultrasonic)
b) Corridor Sensors (PIR/Microwave/Ultrasonic)
c) Relay controllers
d) Interfacing Modules
e) Routers/controllers
f) Keypads
g) LMS Server and client software

LMS FEATURES

a. This specification is intended for the design, engineering, programming, hardware, software, ancillary devices and associated technical services required to provide a networked lighting control system. This system is specified to perform scheduled and automated lighting control sequences.

b. Each relay channel shall be controlled from the main controller as well as from the LMS software. The relay channels shall take inputs from the networking sensors and switch On/Off accordingly.

c. The networking sensors and the LMS shall be of same make but standalone sensors can be different make.
d. The lighting management system shall include a fully distributed network of controller/routers, individually addressable System Field Devices, sensors, switches, relays and other ancillary devices required for a complete and operable system.

e. Daylight Harvesting (Light Regulation Averaging): The system shall rationalize changes to light levels when ambient (natural) light is available and shall maintain a steady light level by switching off or dimming lights which are under its circuits as per the specified lux level. The System shall operate with multiple users in harmony and not react adversely to manual override inputs.

f. Monitor & control the entire system on any area/zone within from a single location through PC.

g. IR programmable remotes has to be supplied along with LMS system (10% of each type of sensors)

SCOPE OF WORK:
The scope shall cover the Design, supply, installation, testing, commissioning and handing over of the Lighting Management System (LMS) including all necessary hardware.

All wiring, cable laying inside raceways/trays, cable termination, tagging, ferruling, lugging and installation of control devices or instruments that are required to complete the job.

The contractor shall coordinate with other stakeholders to complete the installation and commissioning of LMS work in all respect.

The contractor shall provide both on-site and classroom training to the Client’s representative and maintenance personnel. Also provide the operation and maintenance manual, standard operating procedure documents after successful commissioning of the system.

The contractor shall provide the factory test certificate of all equipment and conduct Acceptance Test at site as per the test procedure. Contractor shall provide the Acceptance Test Procedure document for approval from Client/Consultant.

The Contractor shall prepare shop drawing of building, schematic drawing and As Built Drawing of the complete system and take approval from Client/Consultant before execution of LMS work. Complete sets of as build drawings & documents shall be provided by Contractor which includes drawings, O&M manuals, test certificates, quality reports etc.

The LMS system shall comprise of following hardware and software components:

Lighting Control Module
Networkable Digital PIR Sensors
Standalone PIR Sensors.
Standalone Corridor Sensors
Interface Controller compatible with BMS
Bus Power Supply
Handheld Programmer/Commissioning Tool

The control logic for LMS shall be developed and integrated by the contractor as per the requirement. The Control logic and operating procedure of LMS work should be approved by the
Client/ Consultant before implementation in the project. Its contractors’ responsibility to approve the same from Client/Consultant before commissioning of LMS activity.

The scope also include the supply, installation & commissioning of any material or equipment including civil works that are not specifically mentioned in the specifications but are required for successful commissioning of the project.

All Sensors supplied shall be recess mounting type or surface mounted. Necessary mounting clamps and hardware shall be supplied along with the sensors.

Lighting Control Module shall be mounted inside an IP-42 Enclosure Cabinet with all necessary wiring and mounting hardware.

Keypad shall be installed on wall surface at a suitable working height. All supporting hardware, frames, tagging shall be supplied along with keypad.

All Control/ Communication Cables shall be laid inside the raceway shall supplied by the Contractor.

The Lighting Control system shall be programmed in such a way that unnecessary usage of power is minimized in the area provided with occupancy based and day light controls.

**PIR OCCUPANCY SENSORS:**

The sensor shall have advanced detection by passive infrared (PIR) technology along with Sensitivity level adjustments which is sensitive to the heat emitted by the human body as well as daylight sensor which shall have communicating with the controller for measuring daylight and controlling lights in the associated zone for switch on/off. Lux reading of the sensor should be measurable and readable on the system if the sensor is networkable. In order to trigger the sensor, the source of heat must move from one zone of sensing to another. Non-moving hot objects will not cause the lights to turn ON (like incandescent lights). Fast, Simple Installation: Easy base mount, three wire connection (low voltage) and twist-and-lock detector attachment. Non-Volatile Memory: Learned and adjusted settings saved in protected memory are not lost during power outages. Timer setting feature the sensor has Adjustable off delay timing 10 sec– 30 min which can be programmed & changed using IR programming device with auto exit programming. The sensor has inbuilt IR receiver to be used in conjunction with IR Remote Control for manual override. PIR Masking: Pre-scored masking disks are provided with the device for fine tuning the field-of-view. High Motion Sensitivity: Large lens area and multi-element lens design gives excellent range and sensitivity. Ambient Light Mode: Integrated photocell prevents lights turning on under adequate ambient light. Auto-Adapting Mode: Internal microprocessor continually analyzes and adjusts the sensitivity and time delay. Walk-Through Mode: Provides increased energy savings by decreasing the time delay to 2.5min when someone momentarily walks through the monitored space. The sensor shall have the provision for wall mounting/ Ceiling mounting facility as per the site requirement. Sensor shall include mounting hardware, decorator wall plate cover and screws to mount cover. Wall plate cover color shall match the sensor. With Detection speed: 1.0m/s & Lux level of 10-2000lux (illumination of non-reflective surface in sensor’s field of view)

**PIR PRESENCE DETECTOR:**

High detection sensitivity enables the presence detector shall register the slightest movements perfectly and to react to minimal changes in the thermal image. In order to detect the occupancy of a room, the presence detector shall have a bridge between 2 movements. Every movement
resets the switch-off delay – the internal clock – to zero. As long as the time limit has not been reached, the room is regarded as occupied. The switch-off delay time can increase to a maximum of 15 minutes. The minimum set switch-off delay time represents a lower limit which is not reduced even by adaptive behavior. If very short or very long switch-off delay times are selected (< 2 min. or > 15 min.) the adaptive behavior is deactivated and the set switch-off delay time remains unchanged. Presence detector is to reliably detect the slightest movements of persons and at the same time to suppress interfering heat sources. It shall behave to a demand oriented lighting control system shall detect a person’s presence but also be able to judge the room’s brightness. All functionality is fully programmable using an IR handset. With Detection speed: 1.0m/s & Lux level of 10-2000lux (illumination of non-reflective surface in sensor’s field of view) With Detection speed: 1.0m/s & Lux level of 10-2000lux (illumination of non-reflective surface in sensor’s field of view)

MICROWAVE SENSORS:

The sensors shall detect movement using a highly sensitive microwave detector. It shall works by emitting low power microwave signals and measuring the reflections as the signals bounce off moving objects. The output channel shall comprise a mains voltage relay capable of simple on/off switching.

Functioning as a presence detector, the unit can turn lights on when a room is occupied and off when the room is empty. Optional settings shall allow lights to be turned off in response to ambient daylight. All functionality is fully programmable using an IR handset. When movement is detected the load will automatically turn on. When the area is no longer occupied the load will automatically switch off after an adjustable time period. In either case, sensitivity to movement of the Microwave sensor can be adjusted using the Sensitivity parameter. Occupancy detection shall be made dependent on the ambient light level using the Lux on Level and Lux off Level parameters. The microwave radiation emitted by these units is extremely low power and complies with BS and IEC Standard for Safety Levels with Respect to Human Exposure to Radio Frequency Electromagnetic Fields 3kHz 300GHz. The sensor shall drive a minimum load 10A of lighting or ventilation. Sensor shall include mounting hardware, decorator wall plate cover and screws to mount cover. Wall plate cover color shall match the sensor. Timer Setting Feature: Automatic – 30sec – 30min. With Detection speed: 1.0m/s & Lux level of 10-2000lux (illumination of non-reflective surface in sensor’s field of view)

ULTRASONIC SENSORS:

The sensor fills the room with continuous reflective high frequency (ultrasonic) sound waves. Any movement within the sensor’s range causes a shift in the original emitted frequency. The sensor’s receiver shall identify any change in frequency as motion and either turns the lights on or maintains lights on. Non-Volatile Memory shall Learn and adjust the settings saved in protected memory are not lost during power outages. Timer Setting Feature: Automatic – 30sec – 30min. Sensor shall include mounting hardware, decorator wall plate cover and screws to mount cover. Wall plate cover color shall match the sensor. Timer Setting Feature: Automatic – 30sec – 30min. All functionality is fully programmable using an IR handset. With Detection speed: 1.0m/s & Lux level of 10-2000lux (illumination of non-reflective surface in sensor’s field of view)

DIN-rail mounted DALI Nodes:
DIN-rail mounted controller or DALI routers for DALI-compliant digital addressable loads. It provides DALI bus power and control for two independent DALI buses with up to 64 DALI compliant digital addressable loads each. The DALI Node unit shall also provide direct connections and power for the following devices: Occupancy sensors, Daylight sensors, IR receivers, Relay channel controllers etc. It shall provide power for two buses of DALI-compliant digital addressable loads. 128 mA guaranteed current, 250 mA maximum supply current per bus. Each DALI Bus can control a maximum of 16 zones and in case of power failure memory of the system shall retain control unit programming. With the help of daylight sensor inputs it shall automatically adjust light levels based on the amount of natural light entering through the windows.

**Relay Channel:**

Networkable Relay channel must be separately controllable via the communication network. The Relay shall be DIN rail mountable or can be mounted in separate cubicle have separately addressable provision and each pole being separately controllable from the network. Each channel shall be fitted with a hardware override switch which is accessible from the front panel. Each relay in a relay channel controller shall be programmable capable of carrying a minimum of 10 A.

**Graphical User Interface and Controller (GUI):**

The controller includes all the sub controllers, main controllers & routers in the lighting management system. The software shall be heavy emphasis on ease of use.

The LMS Server shall provide high level integration and control options to a LMS network via USB/Serial port connected to a PC. The Monitoring software shall include graphical user interface with a capability to navigate through the floor plans to operate the lighting zones in the system. Client software for Soft Switch application shall reside in the tool tray of user’s PC’s in the open plan office and use the existing LAN to communicate with central dedicated Lighting Management System (LMS) PC. Diagnostic and maintenance data such as lamp burn time shall be readily available. Once connected to a network, the Server shall automatically scan the network and build and maintain a database containing a model of the network and all devices connected to it. The software shall be possible to upgrade when the system expands to cover more buildings.

There should be a list of zones and list of areas in the building. It is preferred to have a GUI based setup for showing the building view, freely rotatable on X and Y axes. It is further preferred to have a GUI which provides the user with an ability to zoom in and out of the display in any mode. The display should preferably have a system of showing light levels and energy consumption levels in an easily understandable view with color graded displays. The software should further provide reports for the benefit of the end client, for the purpose of analyses of the building's energy consumption. For example, the report should contain the details of savings provided by the use of daylight sensors in terms of percentage or by any other easily readable means. This is to enable the end client to fine tune their energy saving plans after the analyses which they make on the regular periodic basis. The software should be license free to enable the client to install on as many systems as needed and at any time as per clients convenience. A preferred solution is to have no installation necessary but to provide a password based access to the server so as to operate the lights and rescind control to the facilities manager. Updates to the software should be free and should not require or mandate any changes to the commissioning, zoning, or any other settings. This is to prevent inconvenience to the users. It shall have a provision for integrating to BACnet protocol. The LMS software to be installed in the PC under BMS package.
Control Philosophy

A.) Control Philosophy 1:

1. Switching of light circuits for the areas like Check in Hall, Baggage Collection area, Level-1 and Level-2 Security Hold Area having major ambient light component have been considered with Day-Light sensors for automatic switching On/Off as per ambient light levels.

2. Logic can be developed with lighting control modules for switching of outgoing circuits as per input received from sensors connected to modules.

3. Override facility shall be available with BMS to control the lighting module operation.

4. Programming of the Lighting control module shall be done locally. However, the parameters shall be visible at LMS/BMS servers.

B.) Control Philosophy 2:

1. Switching of Light circuits for the areas like toilets, Aerobridges, Fixed link bridges have been considered with Daylight + Occupancy sensors (stand-alone type).

2. 230V (1- Phase) supply should be given to Daylight+ Occupancy Sensors through switchboxes and switching of light connected to the sensors shall be done by sensors only.

3. Each sensor shall relate to bus power supply and parameters shall be visible at LMS/BMS.

4. Control remote shall be provided for controlling sensor operation locally.

SYSTEM FEATURES:
The system should cover the lighting control based on one or more applications/requirements such as movement detection/Ambient Day Light.

Standalone based lighting control shall be worked with 1-Phase, 230V AC power supply PIR Sensor and Normal LED Lights.

Corridor sensor shall have a minimum coverage of 25mtrs horizontally.

All devices in the system should conform to CE/UL standards and should be manufactured in accordance with the EMC guidelines and the low voltage guidelines.

COMMISSIONING

a. The LMS vendor shall supply factory trained representatives to commission the lighting control system. Manufacturer shall start up all lighting control equipment and verify that it meets the requirements of this specification.

b. As part of the standard commissioning process, the manufacturer shall train the owner’s representatives in the operation of the system to a maximum of 4 hours per building. Manufacturer shall also provide owner’s representatives with system operating manuals together with a system training video.
c. The LMS vendor shall supply 24/7 technical telephone support to the client. The manufacturer shall be able to ship replacement parts within 24 hours for any component that fails during the warranty period.

d. Maintenance agreements shall be available from the manufacturer to provide service for the system both during and after the warranty period.

e. Factory appointed personnel shall provide commissioning services for the lighting control system.

i. Verify proper communication over control wires.

ii. Map addresses of occupancy sensors (via Input Modules), light level sensors (via Input Modules), lighting controllers to control units and system server.

iii. Verify communication to control units and system server.

iv. Configure occupancy sensors, light level sensors, lighting controllers and other contacts to suit design specifications.

v. Configure and program lighting control sequences.

TRAINING

Upon completion of all line, load and interconnection wiring, and after all fixtures are installed, a qualified factory representative shall completely configure and test the System. At the time of checkout and testing, the owner’s representative shall be thoroughly instructed in the proper operation of the system. The contractor shall train the owner’s representatives in the operation of the system. Manufacturer shall also provide owner’s representatives with system operating manuals together with a system training video.

WARRANTY

All equipment shall be warranted free of defects in materials and workmanship. All System hardware and software components shall have full warranty (non-prorated) for at least five (5) years from the date of handing over. Manufacturer’s warranty is in addition to, not a limitation of other rights the Client may have under contract documents, or warranties of third party component manufacturers.

SUBMITTALS:

The following drawings and documents shall be submitted at various stages with requisite number of prints / copies

1) Schematic Diagram of the LMS with all wiring details.
   a. Coordination Drawings: Submit evidence that lighting controls are compatible with connected monitoring and control devices and systems specified in other Sections:
   b. Show interconnecting signal and control wiring and interfacing devices that prove compatibility of inputs and outputs.
c. For networked controls, list network protocols and provide statements from manufacturers that input and output devices meet interoperability requirements of the network.

2) As built drawings indicating the location of various LMS components.
3) Product CE/BS Certificates.
4) Software Operational Documentation:
   a. Software operating and upgrade manuals.
   b. Program Software Backup: On compact disc or DVD, complete with data files.
   c. Printout of software application and graphic screens, or upon request, a live demonstration of Control, Configure and Analyze functionality.

6) Backup of all documents, software and project program files in a CD.

List of Approved Makes

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<th>Make of Materials/Equipment</th>
<th>Remarks</th>
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<td>Lighting Management System</td>
<td>Schneider, Philips, Osram, Lutron, Philips</td>
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<td>Dynalite, Honeywell</td>
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<td>50</td>
<td>Day light/Occupancy Sensors</td>
<td>Schneider, Philips, Osram, Lutron, Philips</td>
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<td>Dynalite, Theben, Honeywell</td>
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TS–05
UPS SYSTEM
I. **Technical Specifications of 1KVA - 20 KVA Online UPS**

(Single phase input and single phase output Online UPS)

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<tr>
<th>S. No.</th>
<th>Parameters</th>
<th>Specification</th>
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<tbody>
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<td>1.</td>
<td>General</td>
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<tr>
<td>i.</td>
<td>Make/ Model</td>
<td>As per the list of approved makes</td>
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<tr>
<td>ii.</td>
<td>Load Capacity and Configuration</td>
<td>KVA (with individual Battery Bank) connected in redundant parallel load sharing mode</td>
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<tr>
<td>iii.</td>
<td>Topology &amp; Technology</td>
<td>(a) True On line UPS using latest IGBT &amp; DSP Technology or microprocessor based</td>
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<tr>
<td></td>
<td></td>
<td>(b) Double conversion</td>
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<tr>
<td></td>
<td></td>
<td>(c) IGBT based Converter and Inverter with PWM</td>
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<tr>
<td>iv.</td>
<td>Type of UPS</td>
<td>True on line UPS</td>
</tr>
<tr>
<td>v.</td>
<td>Automatic restart</td>
<td>Upon restoration of mains AC power, after a mains AC power outage and complete battery discharge, the UPS shall automatically restart and resume supplying power to the critical load and the rectifier shall automatically recharge the battery.</td>
</tr>
<tr>
<td>vi.</td>
<td>Efficiency</td>
<td>Greater than 90% (AC to AC) at all load capacities including full rated capacity</td>
</tr>
<tr>
<td>vii.</td>
<td>Cabinet</td>
<td>Powder coated steel finish cabinet for UPS. UPS display should be kept at appropriate height.</td>
</tr>
<tr>
<td>viii.</td>
<td>Quality certification</td>
<td>ISO 9001 14001</td>
</tr>
<tr>
<td>2.</td>
<td>Input parameters</td>
<td></td>
</tr>
<tr>
<td>i.</td>
<td>Input Voltage</td>
<td>3 wire, 1Ø, 220 VAC +/- 10% at 100 % of rated load</td>
</tr>
<tr>
<td>ii.</td>
<td>Input frequency</td>
<td>50 Hz +/-5 Hz and compatible with diesel Gen Set</td>
</tr>
<tr>
<td>iii.</td>
<td>Input Power factor</td>
<td>Greater than 0.98 at 25% to 100 % rated load.</td>
</tr>
</tbody>
</table>
iv. Input current Harmonic distortion  
THD should be less than 5 percentage at 100% load

v. Reverse Phase Sequence  
Reverse phase sequence detection and Automatic Synchronization capability without any performance degradation.

### 3. Output Parameters

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>i.</td>
<td>Output Voltage</td>
</tr>
<tr>
<td>ii.</td>
<td>Output Voltage Regulation</td>
</tr>
</tbody>
</table>
| iii. | Output Voltage THD | <3% for Linear Load  
<5% for Non-linear Load |
| iv. | Transient response | +/-5% for 100% output load step or better |
| v. | Recovery time | 20 milliseconds or better |
| vi. | Output frequency | 50 Hz Plus or minus 1 Hz or better |
| vii. | Output power factor | 0.8 at full rated load capacity or better |
| viii. | Output waveform | Pure sine wave |
| ix. | Overload rating (on inverter) | 05 minutes up to 105% Load or better, 1 minute up to 125% Load or better |
| x. | Switching frequency | More than 15 KHz |
| xi. | Maintenance Bypass | The integral bypass shall perform an automatic transfer of the critical load from the inverter to the bypass, in the events of overload, over temperature, or inverter failure conditions without any load break. |

### 4. DC Circuit

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>i.</td>
<td>DC Bus Voltage</td>
</tr>
<tr>
<td>ii.</td>
<td>Permissible DC voltage variation</td>
</tr>
<tr>
<td>iii.</td>
<td>DC ripple</td>
</tr>
<tr>
<td>iv.</td>
<td>Maximum Battery Charging current</td>
</tr>
<tr>
<td>v.</td>
<td>Charging</td>
</tr>
<tr>
<td>vi.</td>
<td>Battery</td>
</tr>
<tr>
<td>------</td>
<td>-------------</td>
</tr>
</tbody>
</table>
| vii. | Battery backup | a) The battery system shall have a capacity to withstand full load (KVA) for 30 minutes or more per system.  
b) The batteries will be installed in a battery rack.  
(The calculation Sheet for battery capacity and make, model & quantity, charging current of batteries should also be furnished.) |

5. **Display and Monitoring**

<table>
<thead>
<tr>
<th>i.</th>
<th>Display</th>
<th>LCD Display and at least 30 Events or more Log facility, Input-Voltage, Current, Frequency &amp; KVA, Output-Voltage, Current, Frequency, Load &amp; KVA Battery -Voltage, Current</th>
</tr>
</thead>
<tbody>
<tr>
<td>ii.</td>
<td>Monitoring</td>
<td>LED/LCD Panel for real time monitoring. Audible alarm and Battery operation.</td>
</tr>
<tr>
<td>iii.</td>
<td>PC interface &amp; Communication</td>
<td>Desirable, SNMP / web adapter to be included to connect the UPS to a TCP/IP network using SNMP (Simple Network Management Protocol). The SNMP adapter shall be a plug-in card in the UPS itself. It should work with Internet/Intranet/LAN available at the AAI Site.</td>
</tr>
</tbody>
</table>

6. **Safety**

| i.   | Protection | UPS output:- Short circuit, Over load protection.  
UPS input:- Over voltage protection and UPS over temperature protection  
Over shoot, under Shoot shall not be greater than 4% of the rated voltage  
Protection from deep discharging of the batteries |

7. **Environmental Parameters**

<table>
<thead>
<tr>
<th>i.</th>
<th>Operating Temperature</th>
<th>-5 Degree to 55 degree C</th>
</tr>
</thead>
<tbody>
<tr>
<td>ii.</td>
<td>Storage Temperature</td>
<td>-5 Degree to + 60 Degree C</td>
</tr>
<tr>
<td>iii.</td>
<td>Relative Humidity</td>
<td>0 to 95 % RH</td>
</tr>
<tr>
<td>iv.</td>
<td>Max altitude with full rating</td>
<td>1000 mtrs.</td>
</tr>
<tr>
<td>v.</td>
<td>Acoustic Noise</td>
<td>Less than 45 dBA at 1 meter</td>
</tr>
<tr>
<td>----</td>
<td>----------------</td>
<td>-----------------------------</td>
</tr>
</tbody>
</table>

**8. Services**

i. On Site Warranty | UPS – two year, Batteries – two years |

ii. Installation | Supply, Installation, Testing and Commissioning (SITC) by the supplier. |

iii. Input Wiring | Standard Input Wiring of 200 M distance to be carried out from the AAI Panel for each UPS as per rating. |

iv. Service Centre | Manufacturer should have service centre at major cities. Authorized service certificate should be enclosed. |

v. 24 X 7 Toll free number / Time frame for service | Should be provided. Service calls should be attended within 24 Hrs. Spares if required, for repair should be arranged within 72 Hrs. |

vi. UPS delivery submittals | The specified UPS shall be supplied with 2 User manuals having: 1. Operating procedures 2. Details of Functional description with block diagrams and location diagrams. 3. Maintenance guidelines and safety precautions. |
Technical Specifications for 12 V, AH Batteries:
(AH to be provided by supplier)

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Specification</th>
<th>Value/Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Environment</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Operating temperature</td>
<td>-5°C - 55° C</td>
</tr>
<tr>
<td></td>
<td>Operating Humidity</td>
<td>0-95%</td>
</tr>
<tr>
<td>2</td>
<td>Battery</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Type</td>
<td>Sealed Maintenance Free (SMF)</td>
</tr>
<tr>
<td></td>
<td>Technology</td>
<td>Valve Regulated Lead Acid (VRLA)/ Absorbed Glass Mat (AGM)</td>
</tr>
<tr>
<td></td>
<td>Nominal Voltage</td>
<td>12 V</td>
</tr>
<tr>
<td></td>
<td>Rated Capacity</td>
<td>To be decided by supplier as per backup of 30 minutes</td>
</tr>
<tr>
<td>3</td>
<td>Dimensions</td>
<td>Compact design and weight</td>
</tr>
<tr>
<td>4</td>
<td>Protection</td>
<td>“Fire Retardant Containers” to prevent the occurrences of fire because of batteries</td>
</tr>
<tr>
<td>5</td>
<td>Warranty</td>
<td>2 year onsite warranty</td>
</tr>
</tbody>
</table>

II. SPECIFICATION FOR 10-30 KVA UPS

SUPPLY, INSTALLATION, TESTING AND COMMISSIONING OF 10 KVA-30 KVA ON-LINE UNINTERRUPTED POWER SUPPLY SYSTEM (UPS) WITH MICROPROCESS CONTROLLED ALONG WITH SEALED MAINTENANCE FREE BATTERIES FOR PROVIDING 30 MINUTES BACK-UP, COMPLETE AS PER GIVEN BELOW TECHNICAL SPECIFICATION AND FEATURES,

- Manufacturer should essentially have ISO 9000 certificate.
- The acoustic noise should be less than 70 dB at one meter distance.
- All system parameters and monitoring of rectifier battery charging and inverter functions should be carried out digitally. (i.e. by using microprocessor)
- The system should use high frequency IGBT Based rectifier with PWM based system.
- The system should use high frequency IGBT inverter with PWM, VFI technology.
- Galvanic isolation transformer are optional.
- The system should provide in-built static as well as manual by-pass.
- Programmable battery testing facility should be provided to know the battery status. By using the battery test mode the system should disconnect input power supply at set time period and battery should discharge through the load. Programmed battery testing should be selectable through the front panel of the system.
- The system should provide “EVENT RECORDING” facility. It means the system should store last 100 events i.e. input voltage variation or out of tolerance operating condition of the system at any time and should also include cause of the fault should also give the name of the faulty component in terms of rectifier controller card, inverter controller card, snubber circuit fault etc., all events should readable from front panel LCD of the system and it should be able to take print out through RS 232 interface port.
- The system should provide battery-monitoring facility. This system should check battery capacity in regular intervals during normal operation of the UPS. The front panel LCD should show the capacity of the battery and calculate for how long the load can be supplied.
- Front panel of the system should have LCD display for displaying of input voltage, input frequency, input voltage and frequency of the supply connected in by pass line, battery
remaining time, output voltage out frequency and load connected to the system. It should also display event occurred by using event recorder. It should also provide facility to switch UPS ON/OFF, Emergency OFF and manual by-pass ON/OFF.

- Mimic diagram should provide to know the status of the rectifier, inverter, battery and output bus bar.
- Emergency switching OFF of the UPS system (remotely).
- In case of Input supply phase reversal the system should not trip and should not go to battery. It should work on mains alarm indication. It should be inbuilt feature of the system.

**TECHNICAL DATA:**

**INPUT:**
1. **Input phase voltage**: 400 V +/- 20 % (operating Range : 320-480 V)
2. **Supply frequency**: 45 to 65 Hz.
3. **Input power factor**: >0.99
4. **Input current distortion/harmonics**: <3%
5. **Rectifier Technologies**: IGBT with PWM technologies.

**BY-PASS LINE:**
1. **Three phase voltage**: 400 V +/- 15 %
2. **Over load capacity for 1 min.**: 150 %
3. **Over load capacity for 10 min.**: 125%

**OUTPUT:**
1. **Inverter technologies**: IGBT with PWM Technologies.
2. **Voltage three phase**: 415 V and should be selected to 380 or 400 V
3. **Voltage stability**: +/- 1 % static, +/- 3% dynamic.
4. **Wave form**: sinusoidal with 2% total harmonic distortion
5. **Frequency**: 50 Hz
6. **Frequency stability**: +/- 0.05%
7. **Crest factor**: 3:1
8. **Accepted over load**: 110% for 60 min. 125 % for 1 min.
9. **Load power factor**: 0.8
10. **Rated power**: KVA
11. **Active power**: KW
**SYSTEM:**
1. Total efficiency of the UPS: more than 90% at 50% of load.
2. Standard RS 232 interface facility should be provided.
3. Battery should be SMF VRLA type.
4. Battery Ah calculation should be enclosed along with the bid

**GUARANTEED TECHNICAL PARTICULAR FOR UPS & BATTERIES (TO BE FILLED IN BY THE VENDOR WITH DOCUMENTARY EVIDENCE)**

<table>
<thead>
<tr>
<th>S. No.</th>
<th>DESCRIPTION</th>
<th>DESIRED</th>
<th>OFFERED BY VENDOR</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>MAKE</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>MODEL</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Rated output power in KVA</td>
<td>KVA</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Rated output power in KW @ 0.8 P.F.</td>
<td>KW</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Input voltage</td>
<td>400 +/- 20% (320-480 V)</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Input frequency</td>
<td>45-55 Hz</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Rectifier type</td>
<td>IGBT Based with PWM controller</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Inverter type</td>
<td>IGBT Based with PWM controller</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>Input power factor</td>
<td>&gt; 0.99</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td><strong>Total harmonic current</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Input harmonic distortion (%)</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>- Full load</td>
<td>&lt; 3%</td>
<td></td>
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<tr>
<td></td>
<td>- 75%</td>
<td>&lt; 4%</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- 50%</td>
<td>&lt; 5%</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Output voltage distortion (%) with linear load</td>
<td>&lt;1%</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Output voltage distortion (%) with nonlinear load</td>
<td>&lt;3%</td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>Power walk in</td>
<td>0-120 Sec (settable)</td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>Output voltage</td>
<td>380/400/415 V (selectable in steps)</td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>Output voltage Stability (linear load)</td>
<td>+/- 1%</td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>Output voltage Stability (dynamic load)</td>
<td>+/- 5%</td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>Output frequency</td>
<td>50 Hz</td>
<td></td>
</tr>
<tr>
<td>16</td>
<td>Output frequency stability</td>
<td>+/- 0.05 %</td>
<td></td>
</tr>
<tr>
<td>17</td>
<td>Frequency slew rate</td>
<td>1 Hz / sec</td>
<td></td>
</tr>
<tr>
<td>18</td>
<td>Voltage recovery time within +/- 1%</td>
<td>20 ms</td>
<td></td>
</tr>
<tr>
<td>19</td>
<td><strong>Over load capability</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>110 % for</td>
<td>30 min</td>
<td></td>
</tr>
<tr>
<td></td>
<td>125 % for</td>
<td>10 min</td>
<td></td>
</tr>
<tr>
<td></td>
<td>150 % for</td>
<td>1 Min</td>
<td></td>
</tr>
<tr>
<td>20</td>
<td><strong>Short circuit current</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Specification</td>
<td>Description</td>
<td></td>
<td></td>
</tr>
<tr>
<td>---------------------------------------------------</td>
<td>----------------------------------</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Phase to phase</td>
<td>180% for 1 sec</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Phase to neutral</td>
<td>300% for 1 sec</td>
<td></td>
<td></td>
</tr>
<tr>
<td>21 Overall efficiency</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>100 % load</td>
<td>Specify</td>
<td></td>
<td></td>
</tr>
<tr>
<td>75 % load</td>
<td>Specify</td>
<td></td>
<td></td>
</tr>
<tr>
<td>50 % load</td>
<td>Specify</td>
<td></td>
<td></td>
</tr>
<tr>
<td>25 % load</td>
<td>Specify</td>
<td></td>
<td></td>
</tr>
<tr>
<td>22 Heat dissipation</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>100 % load</td>
<td>Specify</td>
<td></td>
<td></td>
</tr>
<tr>
<td>75 % load</td>
<td>Specify</td>
<td></td>
<td></td>
</tr>
<tr>
<td>50 % load</td>
<td>Specify</td>
<td></td>
<td></td>
</tr>
<tr>
<td>25 % load</td>
<td>Specify</td>
<td></td>
<td></td>
</tr>
<tr>
<td>23 Static Bypass</td>
<td>In-built</td>
<td></td>
<td></td>
</tr>
<tr>
<td>24 Manual By-pass</td>
<td>In-built</td>
<td></td>
<td></td>
</tr>
<tr>
<td>25 Galvanic isolation transformer</td>
<td>Optional</td>
<td></td>
<td></td>
</tr>
<tr>
<td>26 Event recording facility</td>
<td>In-built</td>
<td></td>
<td></td>
</tr>
<tr>
<td>27 Battery type</td>
<td>SMF VRLA Type</td>
<td></td>
<td></td>
</tr>
<tr>
<td>28 Designed life of battery</td>
<td>5 Years</td>
<td></td>
<td></td>
</tr>
<tr>
<td>29 Battery backup</td>
<td>Min.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>30 Battery Ah calculation sheet</td>
<td>Should attach with offer</td>
<td></td>
<td></td>
</tr>
<tr>
<td>31 Phase reversal protection Feature</td>
<td>Optional</td>
<td></td>
<td></td>
</tr>
<tr>
<td>32 UPS dimension</td>
<td>Specify</td>
<td></td>
<td></td>
</tr>
<tr>
<td>33 Battery bank dimension</td>
<td>Specify</td>
<td></td>
<td></td>
</tr>
<tr>
<td>34 Protection</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Over load</td>
<td>Should available</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Short circuit</td>
<td>Should available</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Input low voltage</td>
<td>Should available</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Input high voltage</td>
<td>Should available</td>
<td></td>
<td></td>
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<tr>
<td>Output over voltage</td>
<td>Should available</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Output low voltage</td>
<td>Should available</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Battery over charging</td>
<td>Should available</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Battery over discharging</td>
<td>Should available</td>
<td></td>
<td></td>
</tr>
<tr>
<td>35 Control &amp; indication</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Alarm</td>
<td>Should available</td>
<td></td>
<td></td>
</tr>
<tr>
<td>UPS fault</td>
<td>Should available</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Battery discharge</td>
<td>Should available</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Inverter OFF/ failed</td>
<td>Should available</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rectifier OFF/ failed</td>
<td>Should available</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Over temperature</td>
<td>Should available</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Over load</td>
<td>Should available</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Emergency stop</td>
<td>Should available</td>
<td></td>
<td></td>
</tr>
<tr>
<td>36 Indication/display</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Input voltage</td>
<td>Should available</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Input current /phase</td>
<td>Should available</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Input frequency</td>
<td>Should available</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Parameter</td>
<td>Availability</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-----------------------------------------------</td>
<td>----------------</td>
<td></td>
<td></td>
</tr>
<tr>
<td>By pass input voltage</td>
<td>Should available</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bypass input frequency</td>
<td>Should available</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Inverter output voltage</td>
<td>Should available</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Inverter output current/phase</td>
<td>Should available</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Inverter output KVA and KW</td>
<td>Should available</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Battery voltage</td>
<td>Should available</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Battery charging voltage</td>
<td>Should available</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Battery discharging voltage</td>
<td>Should available</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Battery backup remaining time.</td>
<td>Should available</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Overall system temperature</td>
<td>Should available</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Inverter temperature</td>
<td>Should available</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rectifier temperature</td>
<td>Should available</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
III. SPECIFICATION FOR 30 KVA-100 KVA UPS

SUPPLY, INSTALLATION, TESTING AND COMMISIONING OF 30 KVA -100 KVA ON-LINE UNINTERRUPTED POWER SUPPLY SYSTEM (UPS) WITH MICROPROCESS CONTROLLED ALONG WITH SEALED MAINTENANCE FREE BATTERIES FOR PROVIDING 30 MINUTES BACK-UP COMPLETE AS PER GIVEN BELOW TECHNICAL SPECIFICATION AND FEATURES,

- Manufacturer should essentially have ISO 9000 certificate.
- The acoustic noise should be less than 70 dB at one meter distance.
- All system parameters and monitoring of rectifier battery charging and inverter functions should be carried out digitally. (i.e. by using microprocessor)
- The system should use high frequency IGBT Based rectifier with PWM based system.
- The system should use high frequency IGBT inverter with PWM, VFI technology.
- Galvanic isolation transformer are optional.
- The system should provide in-built static as well as manual by-pass.
- Programmable battery testing facility should be provided to know the battery status. By using the battery test mode the system should disconnect input power supply at set time period and battery should discharge through the load. Programmed battery testing should be selectable through the front panel of the system.
- The system should provide “EVENT RECORDING” facility. It means the system should store last 100 events. i.e. input voltage variation or out of tolerance operating condition of the system at any time and should also include cause of the fault should also give the name of the faulty component in terms of rectifier controller card, inverter controller card, snubber circuit fault etc., all events should readable from front panel LCD of the system and it should be able to take print out through RS 232 interface port.
- The system should provide battery-monitoring facility. This system should check battery capacity in regular intervals during normal operation of the UPS. The front panel LCD should show the capacity of the battery and calculate for how long the load can be supplied.
- Front panel of the system should have LCD display for displaying of input voltage, input frequency, input voltage and frequency of the supply connected in by pass line, battery remaining time, output voltage out frequency and load connected to the system. It should also display event occurred by using event recorder. It should also provide facility to switch UPS ON/OFF, Emergency Off and manual by-pass ON/OFF.
- Mimic diagram should provide to know the status of the rectifier, inverter, battery and output bus bar.
- Emergency switching OFF of the UPS system (remotely).
- In case of Input supply phase reversal the system should not trip and should not go to battery. It should work on mains alarm indication. It should be inbuilt feature of the system.
**TECHNICAL DATA:**

**INPUT:**
6. Input phase voltage: 400 V +/- 20% (operating Range: 320-480 V)
7. Supply frequency: 45 to 65 Hz.
8. Input power factor: >0.99
9. Input current distortion/harmonics: <3%

**BY-PASS LINE:**
4. Three phase voltage: 400 V +/- 15%
5. Over load capacity for 1 min.: 150%
6. Over load capacity for 10 min.: 125%

**OUTPUT:**
13. Voltage three phase: 415 V and should be selected to 380 or 400 V
14. Voltage stability: +/- 1% static, +/- 3% dynamic.
15. Wave form: sinusoidal with 2% total harmonic distortion
16. Frequency: 50 Hz
17. Frequency stability: +/- 0.05%
18. Crest factor: 3:1
19. Accepted over load: 110% for 10 min. 125% for 1 min.
20. Load power factor: 0.9
21. Rated power: KVA
22. Active power: KW

**SYSTEM:**
5. Total efficiency of the UPS: more than 93% at 50% of load.
6. Standard RS 232 interface facility should be provided.
7. Battery should be SMF VRLA type.
8. Battery Ah calculation should be enclosed along with the bid

**GUARANTEED TECHNICAL PARTICULAR FOR UPS & BATTERIES (TO BE FILLED IN BY THE VENDOR WITH DOCUMENTARY EVIDENCE)**

<table>
<thead>
<tr>
<th>S. No.</th>
<th>DESCRIPTION</th>
<th>DESIRED</th>
<th>OFFERED BY VENDOR</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>MAKE</td>
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<tr>
<td>2</td>
<td>MODEL</td>
<td></td>
<td></td>
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<tr>
<td>3</td>
<td>Rated output power in KVA</td>
<td>KVA</td>
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<tr>
<td>4</td>
<td>Rated output power in KW @ 0.9 P.F.</td>
<td>KW</td>
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<td></td>
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<tr>
<td>5</td>
<td>Input voltage</td>
<td>400 +/- 20% (320-480 V)</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Input frequency</td>
<td>45-55 Hz</td>
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<tr>
<td>7</td>
<td>Rectifier type</td>
<td>IGBT Based with PWM controller</td>
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</tr>
<tr>
<td>8</td>
<td>Inverter type</td>
<td>IGBT Based with PWM controller</td>
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</tr>
<tr>
<td>9</td>
<td>Input power factor</td>
<td>&gt; 0.99</td>
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<tr>
<td>10</td>
<td>Total harmonic current</td>
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<td>Input harmonic distortion (%)</td>
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<td></td>
<td>• Full load</td>
<td>&lt; 3%</td>
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<td></td>
<td>• 75%</td>
<td>&lt; 4%</td>
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<td>• 50%</td>
<td>&lt; 5%</td>
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<tr>
<td></td>
<td>Output voltage distortion (%) with linear load</td>
<td>&lt;1%</td>
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<tr>
<td></td>
<td>Output voltage distortion (%) with nonlinear load</td>
<td>&lt;3%</td>
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<td>11</td>
<td>Power walk in</td>
<td>0-120 Sec (settable)</td>
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<td>12</td>
<td>Output voltage</td>
<td>380/400/415 V (selectable in steps)</td>
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<td>13</td>
<td>Output voltage Stability (linear load)</td>
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<td>14</td>
<td>Output voltage Stability (dynamic load)</td>
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<td>15</td>
<td>Output frequency</td>
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<td>16</td>
<td>Output frequency stability</td>
<td>+/- 0.05 %</td>
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<td>17</td>
<td>Frequency slew rate</td>
<td>1 Hz / sec</td>
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<td>18</td>
<td>Voltage recovery time within +/- 1%</td>
<td>20 ms</td>
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<td>19</td>
<td>Over load capability</td>
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<tr>
<td></td>
<td>110 % for</td>
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<td></td>
<td>125 % for</td>
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<td></td>
<td>150 % for</td>
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<td>20</td>
<td>Short circuit current</td>
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<td>Phase to phase</td>
<td>180% for 1 sec</td>
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<td></td>
<td>Phase to neutral</td>
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<td>21</td>
<td>Overall efficiency</td>
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<td>100 % load</td>
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<td>75 % load</td>
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<td>50 % load</td>
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<td>75 % load</td>
<td>Specify</td>
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<tr>
<td></td>
<td>50 % load</td>
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<td>25 % load</td>
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<td>23</td>
<td>Static Bypass</td>
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<td>Manual By-pass</td>
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<td>25</td>
<td>Galvanic isolation transformer</td>
<td>Optional</td>
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<td>26</td>
<td>Event recording facility</td>
<td>In-built</td>
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<td>27</td>
<td>Battery type</td>
<td>SMF VRLA Type</td>
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<tr>
<td>28</td>
<td>Designed life of battery</td>
<td>5 Years</td>
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<tr>
<td>29</td>
<td>Battery backup</td>
<td>10 Min.</td>
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<tr>
<td>30</td>
<td>Battery Ah calculation sheet</td>
<td>Should attach with offer</td>
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</tr>
<tr>
<td>31</td>
<td>Phase reversal protection Feature</td>
<td>Inbuilt</td>
<td></td>
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<tr>
<td>32</td>
<td>UPS dimension</td>
<td>Specify</td>
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<tr>
<td>33</td>
<td>Battery bank dimension</td>
<td>Specify</td>
<td></td>
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<tr>
<td>34</td>
<td><strong>Protection</strong></td>
<td></td>
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<tr>
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<td>Over load</td>
<td>Should available</td>
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<td></td>
<td>Short circuit</td>
<td>Should available</td>
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<tr>
<td></td>
<td>Input low voltage</td>
<td>Should available</td>
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<td></td>
<td>Input high voltage</td>
<td>Should available</td>
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<td></td>
<td>Output over voltage</td>
<td>Should available</td>
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<td></td>
<td>Output low voltage</td>
<td>Should available</td>
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<tr>
<td></td>
<td>Battery over charging</td>
<td>Should available</td>
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<td></td>
<td>Battery over discharging</td>
<td>Should available</td>
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<tr>
<td>35</td>
<td><strong>Control &amp; indication</strong></td>
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<tr>
<td></td>
<td>Alarm</td>
<td>Should available</td>
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<tr>
<td></td>
<td>UPS fault</td>
<td>Should available</td>
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<tr>
<td></td>
<td>Battery discharge</td>
<td>Should available</td>
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<tr>
<td></td>
<td>Inverter OFF/ failed</td>
<td>Should available</td>
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<td></td>
<td>Rectifier OFF/ failed</td>
<td>Should available</td>
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<td></td>
<td>Over temperature</td>
<td>Should available</td>
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<td></td>
<td>Over load</td>
<td>Should available</td>
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<tr>
<td></td>
<td>Emergency stop</td>
<td>Should available</td>
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<tr>
<td>36</td>
<td><strong>Indication/display</strong></td>
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<tr>
<td></td>
<td>Input voltage</td>
<td>Should available</td>
<td></td>
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<tr>
<td></td>
<td>Input current /phase</td>
<td>Should available</td>
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<td></td>
<td>Input frequency</td>
<td>Should available</td>
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<td></td>
<td>By pass input voltage</td>
<td>Should available</td>
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<tr>
<td></td>
<td>Bypass input frequency</td>
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<tr>
<td></td>
<td>Inverter output voltage</td>
<td>Should available</td>
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<tr>
<td></td>
<td>Inverter output current /phase</td>
<td>Should available</td>
<td></td>
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<tr>
<td></td>
<td>Inverter output KVA and KW</td>
<td>Should available</td>
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<tr>
<td></td>
<td>Battery voltage</td>
<td>Should available</td>
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<tr>
<td></td>
<td>Battery charging voltage</td>
<td>Should available</td>
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<td></td>
<td>Battery discharging voltage</td>
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<tr>
<td></td>
<td>Battery backup remaining time.</td>
<td>Should available</td>
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<tr>
<td></td>
<td>Overall system temperature</td>
<td>Should available</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Inverter temperature</td>
<td>Should available</td>
<td></td>
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<tr>
<td></td>
<td>Rectifier temperature</td>
<td>Should available</td>
<td></td>
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</tbody>
</table>
TS–06
SOLAR SYSTEM
1.0 GENERAL:

This section covers the requirement of grid tied solar roof top photovoltaic (SPV) solar plant with frame structures to design & select of products/ equipments to achieve rated power in order to obtain at list GRIHA Version V– 4 star rating in his bid.

Grid tied solar roof top photovoltaic (SPV) solar plant with frame structures shall be guaranteed for FIVE years from the date of installation and therefore, all inclusive comprehensive maintenance are covered in the scope of EPC contractor.

2.0 STANDARD & CODE:

The solar plant work shall be executed in compliance with the technical specifications and requirements contained in the contract, codes of practices as published by the Bureau of Indian Standard (BIS) or its equivalent standard as well as “guidelines issued by MNRE as applicable with upto date amendment.

<table>
<thead>
<tr>
<th>Standard/Code</th>
<th>Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>IEC 61215/ IS 14286</td>
<td>Crystalline silicon solar cell module</td>
</tr>
<tr>
<td>IEC 61730</td>
<td>Part-I Requirement of construction</td>
</tr>
<tr>
<td></td>
<td>Part-II Requirement of testing for safety</td>
</tr>
<tr>
<td>IS IEC 61701</td>
<td>Mounting structure</td>
</tr>
<tr>
<td>IS 2062 : 1992</td>
<td>Galvanizing</td>
</tr>
<tr>
<td>IS 4759</td>
<td>Efficiency measurement &amp; environmental test</td>
</tr>
<tr>
<td>IS IEC 61683</td>
<td>Testing of power conditioners/inverters</td>
</tr>
<tr>
<td>IEC 60068-1</td>
<td>Testing of charge controller/MPPT units</td>
</tr>
<tr>
<td>IEC 60227/ IS 674</td>
<td>UV resistant for outdoor installation</td>
</tr>
<tr>
<td>IEC 60502/ IS 1554</td>
<td>Connectors-safety of switches/circuit breakers/connector</td>
</tr>
<tr>
<td>IS 7098 part –I</td>
<td>Requirements of junction boxes/enclosures</td>
</tr>
</tbody>
</table>

IMPHAL AIRPORT C-nil I-nil O-nil 928
3.0 The proposed projects shall be commissioned as per the technical specifications given below.

3.1 DEFINITION
A Grid Tied Solar Rooftop Photo Voltaic (SPV) power plant consists of SPV array, Module Mounting Structure, Power Conditioning Unit (PCU) consisting of Maximum Power Point Tracker (MPPT), Inverter, and Controls & Protections, interconnect cables and switches. PV Array is mounted on a suitable structure. Grid tied SPV system is without battery and should be designed with necessary features to supplement the grid power during day time. Components and parts used in the SPV power plants including the PV modules, metallic structures, cables, junction box, switches, PCUs etc., should conform to the BIS or IEC or international specifications, wherever such specifications are available and applicable.

Solar PV system shall consist of following equipments/components,

- Solar PV system consisting of required number of crystalline PV modules.
- Grid interactive Power Conditioning Unit with Remote Monitoring System
- Mounting structures
- Junction Boxes.
- Earthing and lightning protections.
- IR/UV protected PVC Cables, pipes and accessories

3.1.1 SOLAR PHOTOVOLTAIC MODULES:

i) The PV modules used should be made in India.

ii) The PV modules used must qualify to the latest edition of IEC PV module qualification test or equivalent BIS standards Crystalline Silicon Solar Cell Modules IEC 61215/IS14286. In addition, the modules must conform to IEC 61730 Part-1 – requirements for construction & Part 2 – requirements for testing, for safety qualification or equivalent IS.

a) PV modules to be used in a highly corrosive atmosphere throughout their lifetime, they must qualify to IS/IEC61701.

b) Minimum Module efficiency shall be 17%.

c) The total solar PV array capacity should not be less than allocated capacity (kWp) and should comprise of solar crystalline modules of minimum 330 Wp and above wattage. Module capacity less than minimum 330 watts shall not be accepted.

d) Protective devices of PV module at string level are surge protection devices & Low voltage drop bypass diodes at module level shall be provided.

e) PV modules must be tested and approved by one of the IEC authorized test centers.

f) The module frame shall be made of corrosion resistant materials, preferably having anodized aluminium.

g) The bidder shall carefully design & accommodate requisite numbers of the modules to achieve the rated power in order to obtain at least GRIHA version V, 4 star rating.
in his bid. AAI shall allow only minor changes at the time of execution.

**h)** Other general requirement for the PV modules and sub-systems shall be the Following:

- The rated output power of any supplied module shall have positive tolerance. Negative tolerances is not acceptable.
- The peak-power point voltage and the peak-power point current of any supplied module and/or any module string (series connected modules) shall not vary by more than 2 (two) per cent from the respective arithmetic means for all modules and/or for all module strings, as the case maybe.
- The module shall be provided with a junction box with either provision of external screw terminal connection or sealed type and with arrangement for provision of by-pass diode. The box shall have hinged, weather proof lid with captive screws and cable gland entry points or may be of sealed type and IP-65 rated.
- IV curves at STC (Standard Test Condition) should be provided by bidder.

**III)** Modules deployed must use a RF identification tag. The following information must be mentioned in the RFID used on each modules (This can be inside or outside the laminate, but must be able to withstand harsh environmental conditions).

a) Name of the manufacturer of the PV module.
b) Name of the manufacturer of Solar Cells.
c) Month & year of the manufacture (separate for solar cells and modules).
d) Country of origin (separately for solar cells and module).
e) I-V curve for the module Wattage, Im, Vm and FF for the module.
f) Unique Serial No and Model No of the module.
g) Date and year of obtaining IEC PV module qualification certificate.
h) Name of the test lab issuing IEC certificate.
i) Other relevant information on traceability of solar cells and module as per ISO 9001 and ISO14001.

**IV)** Material & performance warranty:

a) **Warranty of Solar PV Modules:**

PV modules used in Solar power plants / systems must be warranted for their output peak watt capacity, which should not be less than 90% at the end of 10 years and 80% at the end of 25 years.

b) **Performance Warranty for other equipments / accessories (Except Solar PV Module)**

The mechanical structures, electrical works including power conditioners/ investors/ charge controllers/ maximum power point tracker units/ distribution boards/ digital meters/ switch gear/ cables etc. and over all workmanship of the SPV power plants/ systems must be warranted against
any manufacturing/design/installation defects for a minimum guaranteed period of 5 years.

3.2 ARRAYSTRUCTURE

a) Hot dip galvanized MS mounting structures to be used for mounting the modules/panels/arrays. Each structure should have angle of inclination as per the site conditions to take maximum insolation. However to accommodate more capacity the angle inclination may be reduced until the plant meets the specified performance ratio requirements.

b) The Mounting structure shall be so designed to withstand the speed for the wind zone of the location where a PV system is proposed to be installed. It may be ensured that the design has been certified by a recognized Lab/Institution in this regard and submit wind loading calculation sheet to AAI. Suitable fastening arrangement such as grouting and clamping should be provided to secure the installation against the specific wind speed.

c) The mounting structure steel shall be as per latest IS 2062: 1992 and galvanization of the mounting structure shall be in compliance of latest IS4759.

d) Structural material shall be corrosion resistant and electrolytically compatible with the materials used in the module frame, its fasteners, nuts and bolts. Aluminium structures also can be used which can withstand the wind speed of respective wind zone. Necessary protection towards rusting need to be provided either by coating or anodization.

e) The fasteners used should be made up of stainless steel. The structures shall be designed to allow easy replacement of any module. The array structure shall be so designed that it will occupy minimum space without sacrificing the output from the SPV panels.

f) Regarding civil structures the bidder need to take care of the load bearing capacity of the roof and should arrange suitable structures based on the quality of roof. Further civil arrangement for installation at roof top shall be such that there is no ingress of water through the roof & no holes/pit etc. shall be allowed on the roof top for mounting PV modules. Agency shall make suitable size of foundation keeping in view load requirement & wind speed at proposed site.

g) The total load of the structure (when installed with PV modules) if install on the terrace should be less than 60kg/m2.

h) Mostly the solar panels are proposed in the CAR Parking area

If the panels to be erected on the existing structure of CAR parking area, EPC contractor to provide mounting frame structure in such a way that the proposed SPV panels to be fitted into it with so that the roof structure shall be waterproof. All
joints shall be provided with sealant Tape of reputed make having life time guarantee of SPV panles. The sealant tape shall have the features to fix and remove easily for maintenance purpose. The EPC contractor has to ensure the entire installation is waterproof all time.

i) EPC contractor to design select all structure, panels and fixing etc to meet the wind velocity at the proposed locations.

3.3 JUNCTION BOXES (JBs)

a) The junction boxes are to be provided in the PV array for termination of connecting cables. The J. Boxes (JBs) shall be made of GRP/FRP/Powder Coated Aluminium /cast aluminium alloy with full dust, water & vermin proof arrangement. All wires/cables must be terminated through cable lugs. The JBs shall be such that input & output termination can be made through suitable cable glands.

b) Copper bus bars/terminal blocks housed in the junction box with suitable termination threads Conforming to IEC 62208 standard and IP-65 Hinged door with EPDM rubber gasket to prevent water entry. Single compression cable glands. Provision of earthings. It should be placed at 5 feet height in roof top area and in carpark as shade above for ease of movement of vehicles /accessibility.

c) Each Junction Box shall have High quality Suitable capacity Metal Oxide Varistors (MOVs) / surge arrestors, suitable Reverse Blocking Diodes. The Junction Boxes shall have suitable arrangement monitoring and disconnection for each of the groups.

d) Suitable markings shall be provided on the bus bar for easy identification and the cable ferrules must be fitted at the cable termination points for identification.

3.4 DC DISTRIBUTIONBOARD:

a) DC Distribution panel to receive the DC output from the array field.

b) DC DPBs shall have sheet enclosure of dust & vermin proof conform to IP 65 protection. The bus bars are made of copper of desired size. Suitable capacity MCBs/MCCB shall be provided for controlling the DC power output to the PCU along with necessary surge arrestors.

3.5 AC DISTRIBUTION PANEL BOARD:

a) AC Distribution Panel Board (DPB) shall control the AC power from PCU/ inverter, and should have necessary surge arrestors. Interconnection from ACDB to mains at LT Bus bar while in grid tied mode.

b) All switches and the circuit breakers, connectors should conform to IEC 60947, part I, II and III/ IS60947 part I, II and III.

c) The changeover switches, cabling work should be undertaken by the bidder as part of
the project.

d) All the Panel’s shall be metal clad, totally enclosed, rigid, floor mounted/wall mounted, air-insulated, cubical type suitable for operation on three phase / single phase, 415 or 230 volts, 50 Hz, with all protective devices.

e) The panels shall be designed for minimum expected ambient temperature of 45 degree Celsius, 80% humidity and dusty weather.

f) All indoor panels will have protection of IP54 or better. All outdoor panels will have protection of IP65 or better.

g) Should conform to Indian Electricity Act and rules (till last amendment).

h) All the 415 AC or 230 volts devices / equipment like bus support insulators, circuit breakers, VTs etc., mounted inside the switchgear shall be suitable for continuous operation and satisfactory performance under the following supply conditions

| Variation in supply voltage | +/- 10 % |
| Variation in supply frequency | +/- 3 Hz |

3.6 PCU/ARRAY SIZE RATIO:

a) The system design output should be designed and selected for required DC output only.

b) The combined wattage of all inverters should not be less than rated capacity of power plant under STC.

c) Maximum power point tracker (MPPT) shall be integrated in the PCU/inverter to maximize energy drawn from the array.

3.7 PCU/Inverter:

As SPV array produce direct current electricity, it is necessary to convert this direct current into alternating current and adjust the voltage levels to match the grid voltage. Conversion shall be achieved using an electronic Inverter and the associated control and protection devices. All these components of the system are termed the “Power Conditioning Unit (PCU)”. In addition, the PCU shall also house MPPT (Maximum Power Point Tracker), an interface between Solar PV array & the Inverter, to the power conditioning unit/inverter should also be DG set interactive, if necessary. Inverter output should be compatible with the grid frequency. Typical technical features of the inverter shall be as follows:

<table>
<thead>
<tr>
<th>Feature</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Switching devices</td>
<td>IGBT/MOSFET</td>
</tr>
<tr>
<td>Control</td>
<td>Microprocessor/DSP</td>
</tr>
<tr>
<td>Nominal AC output voltage and</td>
<td>400 +/- 20%V, 3 phase, 50Hz</td>
</tr>
<tr>
<td>frequency</td>
<td></td>
</tr>
<tr>
<td>Grid Frequency Synchronization</td>
<td>+/- 3 Hz or more</td>
</tr>
<tr>
<td>range</td>
<td></td>
</tr>
<tr>
<td>Ambient temperature considered</td>
<td>- 20°C to 50°C</td>
</tr>
<tr>
<td>Humidity</td>
<td>95 %Non-condensing</td>
</tr>
</tbody>
</table>
**Protection of Enclosure**
- IP-20 (Minimum) for indoor
- IP-65 (Minimum) for outdoor

**Grid Frequency Tolerance range**
- +/- 3 Hz or more

**Grid Voltage tolerance**
- - 20% & + 15%

**No-load losses**
- Less than 1% of rated power

**Inverter efficiency (minimum)**
- > 95% (In case of 5kW or above)
- > 93% (In case of less than 5kW)

**Current THD (I THD)**
- < 3%

**PF**
- > 0.9

a) Three phase PCU/inverter shall be used with each power plant system (5kW or above) but in case of less than 5kW single phase inverter can be used.

b) PCU/inverter shall be capable of complete automatic operation including wake-up, synchronization & shutdown.

c) The output of power factor of PCU inverter is suitable for all voltage ranges or sink of reactive power, inverter should have internal protection arrangement against any sustainable fault in feeder line and against the lightning on feeder.

d) Built-in meter and data logger to monitor plant performance through external computer shall be provided.

e) The power conditioning units/inverters should comply with applicable IEC/ equivalent BIS standard for efficiency measurements and environmental tests as per standard codes IEC 61683/IS 61683 and IEC 60068- 2(1,2,14,30) /Equivalent BIS Standard.

f) The charge controller/MPPT units environmental testing should qualify IEC 60068-2(1, 2, 14, 30)/Equivalent BIS STD. The junction boxes/enclosures should be IP 65(for outdoor)/IP 54 (indoor) and as per IEC 529 specifications.

g) The PCU/inverters should be tested from the MNRE approved test centres/NABL/BIS /IEC accredited testing-calibration laboratories. In case of imported power conditioning units, these should be approved by international test houses.

### 3.8 INTEGRATION OF PV POWER WITH GRID:

The output power from SPV would be fed to the inverters which converts DC produced by SPV array to AC and feeds it into the main electricity grid after synchronization. In case of grid failure, or low or high voltage, solar PV system shall be out of synchronization and shall be disconnected from the grid. Once the DG set comes into service PV system shall again be synchronized with DG supply and load requirement would be met to the extent of availability of power. 4 pole isolation of inverter output with respect to the grid/DG power connection need to be provided. Necessary reverse power relay shall be provided for safety purpose.
3.9 DATA ACQUISITION SYSTEM / PLANT MONITORING

i. Data Acquisition System shall be provided for the solar PV plant.

Data Logging Provision for plant control and monitoring, time and date stamped system data logs for analysis with the high quality, suitable PC. Metering and Instrumentation for display of systems parameters and status indication to be provided.

iii. **Solar Irradiance:** An integrating Pyranometer (Class II or better, along with calibration certificate) provided, with the sensor mounted in the plane of the array. Readout integrated with data logging system.

iv. Temperature: Temperature probes for recording the Solar panel temperature and ambient temperature to be provided complete with readouts integrated with the data logging system.

v. The following parameters are accessible via the operating interface display in real time separately for solar power plant:

a. AC Voltage.

b. AC Output current.

c. Output Power

d. Power factor.

e. DC Input Voltage

f. DC Input Current.

g. Time Active.

h. Time disabled.

i. Time Idle.

j. Power produced.

k. Protective function limits (Viz-AC Over voltage, AC Under voltage, Over frequency, Under frequency, ground fault, PV starting voltage, PV stopping voltage).

vi. All major parameters available on the digital bus and logging facility for energy auditing through the internal microprocessor and read on the digital front panel at any time and logging facility (the current values, previous values for up to a month and the average values) should be made available for energy auditing through the internal microprocessor and should be read on the digital front panel.

vii. PV array energy production: Digital Energy Meters to log the actual value of AC/ DC voltage, Current & Energy generated by the PV system provided. Energy meter along with CT/PT should be of 0.5 accuracy class. A Bi-directional meter in addition to the display of PCU shall be installed.

viii. Computerized DC String/Array monitoring and AC output monitoring shall be provided as part of the inverter and/or string/array combiner box or separately.

ix. String and array DC Voltage, Current and Power, Inverter AC output voltage and current (All 3 phases and lines), AC power (Active, Reactive and Apparent), Power Factor and AC energy (All 3 phases and cumulative) and frequency shall be
monitored.

x. The time interval between two sets of data shall not be more than 15 minutes. (A min. of 4 samples of data shall be recorded per hour)

xi. Data Acquisition System shall have real time clock, internal reliable battery backup (2 hours) and data storage capacity to record data round the clock for a period of minimum 1 year.

xii. Computerized AC energy monitoring shall be in addition to the digital AC energy meter.

xiii. The data shall be recorded in a common work sheet chronologically date wise. The data file shall be MS Excel compatible. The data shall be represented in both tabular and graphical form.

xiv. All instantaneous data shall be shown on the computer screen.

xv. Software shall be provided for USB download and analysis of DC and AC parametric data for individual plant.

xvi. Provision for Internet monitoring and download of data shall be also incorporated.

xvii. Remote Server and Software for centralized Internet monitoring system shall also be provided for download and analysis of cumulative data of all the plants and the data of the solar radiation and environment monitoring system.

xviii. Solar Radiation and Environment Monitoring System

xix. Centralized computerized solar radiation and environment monitoring system shall be installed on one of the buildings along with the solar PV power plant.

xx. The system shall consist of various sensors, signal conditioning, data acquisition, LCD display and remote monitoring.

xxi. Global and diffuse beam solar radiation in the plane of array (POA) shall be monitored on continuous basis.

xxii. Ambient temperature and relative humidity near PV array at the level of array plane shall be monitored on continuous basis.

xxiii. Solar PV module back surface temperature shall be also monitored on continuous basis.

xxiv. Simultaneous monitoring of DC and AC electrical voltage, current, power, energy and other data of the plant for correlation with solar and environment data shall be provided.

xxv. Solar radiation and environment monitoring system shall have real time clock,
internal reliable battery backup and data to record data round the clock for a period of min. 1 year.

xxvi. The data shall be recorded in a common work sheet chronologically date wise. The data file should be MS Excel compatible. The data shall be represented in both tabular and graphical form.

xxvii. All instantaneous data shall be shown on the computer screen.

xxviii. Historical data shall be available for USB download and analysis.

xxix. Provision for Internet monitoring and download of data shall be incorporated.

xxx. Remote Monitoring and data acquisition through Remote Monitoring System software at the respective airport/AAI remote location with latest software/hardware configuration and service connectivity for online/real time data monitoring/control complete to be supplied and operation and maintenance/control to be ensured by the supplier. Provision for interfacing these data on AAI server and portal in future.

3.10 METERING:

a) The bidirectional electronic energy meter (0.5S class) shall be installed for the measurement of import/Export of energy at HT/EHT level (11KV/33KV/66KV) as per site requirement.

b) The bidder must take approval/NOC from the Concerned DISCOM for the connectivity, technical feasibility, and synchronization of SPV plant with distribution network and submit the same to AAI before commissioning of SPV plant.

c) Reverse power relay shall be provided by bidder (if necessary), as per the local electricity authority requirement.

3.11 POWERCONSUMPTION:

a) Regarding the generated power consumption, priority need to give for internal consumption first and thereafter any excess power can be exported to grid.

3.12 PROTECTIONS:

The system should be provided with all necessary protections like earthing, Lightning, and grid islanding as follows:

3.12.1. LIGHTNING PROTECTION:

a) The SPV power plants shall be provided with lightning & overvoltage protection. The main aim in this protection shall be to reduce the over voltage to a tolerable value before it reaches the PV or other sub system components. The source of over voltage can be lightning, atmosphere disturbances etc. The entire space occupying the SPV array shall be suitably protected against Lightning by deploying required number of Lightning
Arrestors. Lightning protection should be provided as per IEC 62305 standard. The protection against induced high-voltages shall be provided by the use of metal oxide varistors (MOV) and suitable earthing such that induced transients find an alternate route to earth.

b) A manual disconnect 4Pole isolation switch beside automatic disconnection to grid would have to be provided at utility end to isolate the grid connection by the utility personnel to carry out any maintenance. This switch shall be locked by the utility personnel as per site requirements.

3.12.2 SURGE PROTECTION:

a) Internal surge protection shall consist of three MOV type surge-arrestors connected from +ve and –ve terminals to earth (via Y arrangement)

3.13.3 EARTHING PROTECTION:

a) Each array structure of the PV yard should be grounded/earthed properly as per IS:3043-1987. In addition, the lightning arrester/masts should also be earthed inside the array field. Earth Resistance shall be tested in presence of the representative of Engineer-In-Charge as and when required after earthing by calibrated earth tester. PCU, ACDB and DCDB should also be earthed properly.

b) Earth resistance shall not be more than 5ohms. It shall be ensured that all the earthing points are bonded together to make them at the same potential.

3.13.4 GRID ISLANDING:

a) In the event of a power failure on the electric grid, it is required that any independent power-producing inverters attached to the grid turn off in a short period of time. This prevents the DC-to-AC inverters from continuing to feed power into small sections of the grid, known as “islands.” Powered islands present a risk to workers who may expect the area to be unpowered, and they may also damage grid-tied equipment. The Rooftop PV system shall be equipped with islanding protection. In addition to disconnection from the grid (due to islanding protection) disconnection due to under and over voltage conditions shall also be provided.

b) A manual disconnect 4pole isolation switch beside automatic disconnection to grid would have to be provided at utility end to isolate the grid connection by the utility personnel to carry out any maintenance. This switch shall be locked by the utility personnel as per site requirements.

3.14 CABLES:

Cables of appropriate size to be used in the system shall have the following characteristics:

i. Shall meet IEC 60227/IS 694, IEC 60502/IS1554, IS 7098 Part – I standards
ii. Temp. Range: -10°C to +80°C

iii. Voltage rating: 660/1000V

iv. Excellent resistance to heat, cold, water, oil, abrasion, UV radiation

v. Flexible

vi. Sizes of cables between array interconnections, array to junction boxes, junction boxes to Inverter etc. shall be so selected to keep the voltage drop (power loss) of the entire solar system to the minimum. The cables should be insulated with a special grade PVC compound formulated for outdoor use.

vii. Cable Routing/Marking: All cable/wires are to be routed in a GI cable tray or as approved by Engineer In charge as per site requirements and suitably tagged and marked with proper manner by good quality ferule or by other means so that the cable easily identified.

viii. The Cable should be so selected that it should be compatible up to the life of the solar PV panels i.e. 25 years.

ix. Bidder to indicate size and length as per system design requirement. All the cables required for the plant to be provided by the bidder. Any change in cabling sizes if desired by the bidder/ approved after citing appropriate reasons. All cable schedules/layout drawings approved prior to installation be got approved from Engineer in-charge prior to installation.

x. Multi Strand, Annealed high conductivity copper conductor PVC type ‘A’ pressure extruded insulation or XLPE insulation. Overall PVC/XLPE insulation for UV protection Armored cable for underground laying. All cable trays including covers to be provided. All cables conform to latest edition of IEC/ equivalent BIS Standards as specified: BoS item / component Standard Description Standard Number Cables General Test and Measuring Methods, PVC/XLPE insulated cables for working Voltage up to and including 1100 V , UV resistant for outdoor installation IS/IEC69947.

xi. The size of each type of AC as well as DC cable selected shall be based on minimum voltage drop however; the maximum drop shall be limited to 2%.

3.15 TOOLS & TACKLES AND SPARES:

a) After completion of installation & commissioning of the power plant, necessary tools & tackles are to be provided by the bidder for maintenance purpose. A list of tools and tackles to be supplied by the bidder for approval of specifications and make before supply of the same.

b) A list of requisite spares in case of PCU/inverter comprising of a set of control logic cards, IGBT driver cards etc Junction Boxes. Fuses, MOVs / arrestors, MCCBs etc along with spare set of PV modules be indicated, which shall be supplied along with the equipment. A minimum set of spares shall be maintained in the plant itself for
the entire period of warranty and Operation & Maintenance which upon its use shall be replenished.

c) The maximum allowable down time per inverter shall be 8 hours. All other terms and conditions for penalty etc shall be as per separate sections under O & M contract to be followed.

3.16 DANGER BOARDS AND SIGNAGES:

a) Danger boards should be provided as and where necessary as per IE Act. /IE rules as amended up to date. Three signages shall be provided one each at battery – cum-control room, solar array area. Text of the signages may be finalized in consultation with AAI.

3.17 FIRE EXTINGUISHERS:

a) The firefighting system for the proposed power plant for fire protection shall be consisting of.

b) Portable fire extinguishers in the control room for fire caused by electrical short circuits.

c) Sand buckets in the control room.

d) The installation of Fire Extinguishers should confirm to TAC regulations and BIS standards. The fire extinguishers shall be provided in the control room housing PCUs as well as on the Roof or site where the PV arrays have been installed.

4.0 PLANNING AND DESIGNING:

a) For complete electro-mechanical works, bidders shall supply complete design, details and drawings for approval to AAI before progressing with the installation work. Approved ISI and reputed makes for equipment be used.

b) The Contractor shall furnish the following drawings after Award/Intent and obtain approval:
   - General arrangement and dimensioned layout.
   - Schematic drawing showing the requirement of SV panel, Power conditioning Unit(s)/ inverter, Junction Boxes, AC and DC Distribution Boards, meters etc.
   - Structural drawing along with foundation details for the structure.
   - Itemized bill of material for complete SV plant covering all the components and associated accessories. If selected in carpark, necessary clearances of vehicle movements to be considered.
   - Layout of solar Power Array capacity wise & total worked out capacity.
   - Shadow analysis of roofs.

c) The bidder should carry out Shadow Analysis at the site and accordingly design strings & arrays layout considering optimal usage of space, material and labor. The bidder should submit the array layout drawings along with Shadow Analysis Report.
to AAI for approval after award of work.

d) AAI reserves the right to modify the landscaping design, Layout and specification of sub-systems and components at any stage as per local site conditions/requirements.

e) The bidder shall submit preliminary drawing for approval & based on any modification or recommendation, if any. The bidder submit three sets and soft copying CD off in all drawing for formal approval to proceed with construction work.

5.0 **DRAWINGS & MANUALS TO BE SUBMITTED BY BIDDER AFTER COMPLETION OF WORK:**
Three sets of Engineering, electrical drawings and installation and O&M manuals are to be supplied. Bidders shall provide complete technical data sheets for each equipment giving details of the specifications along with make/makes with basic design of the power plant and power evacuation, synchronization along with protection equipment.
Detailed submission shall be as per SCC (E) shall also be followed.

6.0 **SAFETY MEASURES:**
The bidder shall take entire responsibility for electrical safety of the installation(s) including connectivity with the grid and follow all the safety rules & regulations applicable as per Electricity Act, 2003 and CEA guidelines etc.

7.0 **LIST OF APPROVED SPECIAL MAKES OF SOLAR EQUIPMENT AND MATERIALS**

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Item</th>
<th>Make of Materials/Equipment</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Inverter/Charge Controller</td>
<td>Delta, SMA, ABB, Refusol, Fronius, Bonfiglioli, APC, KACO or Equivalent with approval from AAI.</td>
</tr>
<tr>
<td>2</td>
<td>SPV PANEL</td>
<td>EMMVEE, VIKRAM Solar, TATA Power Solar, Yingli, MISTUBISHI Electric, Canadian Solar or Equivalent with approval from AAI.</td>
</tr>
<tr>
<td>3</td>
<td>Distribution board</td>
<td>As per AAI list of approved makes.</td>
</tr>
<tr>
<td>4</td>
<td>MCB, RCCB</td>
<td>As per AAI list of approved makes.</td>
</tr>
<tr>
<td>5</td>
<td>660/1100 volt grade stranded pvc unsheathed wire with copper conductor</td>
<td>As per AAI list of approved makes.</td>
</tr>
<tr>
<td>6</td>
<td>Modular type switches, Sockets, bell push, etc</td>
<td>As per AAI list of approved makes.</td>
</tr>
<tr>
<td>7</td>
<td>Cement</td>
<td>As per AAI list of approved makes.</td>
</tr>
<tr>
<td>8</td>
<td>Paints</td>
<td>As per AAI list of approved makes.</td>
</tr>
<tr>
<td>9</td>
<td>Primer</td>
<td>As per AAI list of approved makes.</td>
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<tr>
<td>10</td>
<td>1.1kV Cu/Al Cable</td>
<td>As per AAI list of approved makes.</td>
</tr>
<tr>
<td>11</td>
<td>Conduits PVC</td>
<td>As per AAI list of approved makes.</td>
</tr>
</tbody>
</table>
TS– 07
MECHANICAL SYSTEM
Part I
ELEVATORS & ESCALATORS
ELEVATOR SYSTEM

1. General
This section covers the detailed requirement of MRL passenger elevator & MR type Goods lift suitable for operation on 415V, 3phase, 50HZ, 4wires, AC supply.

2. Standards and Specifications
All materials, plants, equipment's and Lift car to be incorporated in the system shall be of highest standards and as per latest practices in design and manufacturer. The Lifts shall be of robust construction, liberally rated and capable of operating efficiently and economically under the service conditions and conforming to the following relevant IS specifications and associated specifications mentioned herein:

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
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</thead>
<tbody>
<tr>
<td>i)</td>
<td>Indian Electricity Act 1910 (and the rules issued there under upto date)</td>
</tr>
<tr>
<td>ii)</td>
<td>CPWD - General Specifications for Electrical works – Part - I (Internal) 2013 and Part-II (External) 1994 with upto date amendments.</td>
</tr>
<tr>
<td>iii)</td>
<td>CPWD - General Specifications for Electrical works – Part - III (Lifts &amp; Escalators) 2003 with upto date amendments.</td>
</tr>
<tr>
<td>iv)</td>
<td>IS 14665 (Part 4 Sec 1): 2001 Lift Buffers</td>
</tr>
<tr>
<td>v)</td>
<td>IS 14665 (Part 4 Sec 2): 2000 Lift Guide Rails</td>
</tr>
<tr>
<td>vi)</td>
<td>IS 14665 (Part 4 Sec 3): 2001 Lift Car Frame</td>
</tr>
<tr>
<td>vii)</td>
<td>IS 14665 (Part 4 Sec 4): 2001 Lift Safety Gears &amp; Governors.</td>
</tr>
<tr>
<td>viii)</td>
<td>IS 14665 (Part 1 Sec 6): 2001 Lift Doors &amp; Locking Devices &amp; Contacts</td>
</tr>
<tr>
<td>ix)</td>
<td>IS 14665 (Part 4 Sec 7): 2001 Machine &amp; break.</td>
</tr>
<tr>
<td>x)</td>
<td>IS 14665 (Part 4 Sec 8): 2001 Lift Ropes.</td>
</tr>
<tr>
<td>xi)</td>
<td>IS 14665 (Part 4 Sec9): 2001 Controller and operating device for lift.</td>
</tr>
<tr>
<td>xii)</td>
<td>EN81 Safety rules for the construction and installation of glass lifts.</td>
</tr>
</tbody>
</table>

In case of any discrepancy in specifications between the State Act / Rule and the relevant IS-specifications, the superior specifications shall be accepted.

For all materials and equipment, IS specifications shall be applicable. Where IS-specifications are not available, British / European standard specifications shall become applicable. All specifications, standards, publications specified mean the latest editions of such publications with upto date amendments.

3. Scope of works
The scope of work covers Design, Fabrication, Supply, Installation, Testing & Commissioning of Electric Traction Type Fully Automatic Machine Room Less (MRL) Passenger Elevators / Machine Room Goods lift as detailed below in full working order including all that is reasonably inferred as necessary for proper installation and putting in operation the Elevators of the type and extent described in the drawings, specification & Scope of works (SOW) including necessary adjustment and correction.
DETAILS OF MRL PASSENGER ELEVATOR WITH GLASS /SS ENCLOSURE & MR GOODS LIFT

- MRL PASSENGER GLASS ELEVATOR (FOUR SIDEGLASS)/SS ELEVATOR

<table>
<thead>
<tr>
<th>SL No</th>
<th>No. of Pax</th>
<th>No. of Floor Served</th>
<th>Approx. Travel</th>
<th>Stops &amp; Opening</th>
<th>Type of Operation</th>
<th>Qty.</th>
</tr>
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<td>06</td>
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</tbody>
</table>

**Passenger terminal Building (Glass)**

1. 20 02 6 mtr. 02 (Lvl 1, Lvl 2) Ground & First Floor Microprocessor based Duplex Selective Collective. Landing & opening on both sides

2. 8 (min) 06 22.5 mtr. 06-(Lvl 1, Lvl 2, Lvl 3, Lvl 4, Lvl 5, Intermediate Level) Microprocessor based Duplex Selective Collective.

**Note:** The travel distance mentioned above are indicative. The actual travel shall be designed and supplied after the finalization of building Plan.

- GOODS ELEVATOR (SS) WITH MACHINE ROOM

<table>
<thead>
<tr>
<th>SL No</th>
<th>Load</th>
<th>No. of Floor Served</th>
<th>Approx. Travel</th>
<th>Stops</th>
<th>Type of Operation</th>
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<td>02</td>
</tr>
</tbody>
</table>

**Passenger terminal Building**

1. 3000 Kg 03 (Basement, Lvl 01 and Lvl 02) 11mtr. 03 (Basement, Lvl 01 and Lvl 02) Microprocessor Based Simplex Selective Collective. 01 Job

2. 2500 Kg 03 (Basement-Lvl 01) 5 mtr. 02 (Basement & Lvl 01) Microprocessor Based Simplex Selective Collective. 01 Job

**Note:** The travel distance mentioned above are indicative. The actual travel shall be designed and supplied after the finalization of building Plan.
The Passenger Elevators shall have a speed of 1.0 Mtr./Sec. complete with automatic power operated doors, indicating signals, protective devices, controls and all other accessories suitable for operation on 415V, 50 Hz, 3 phase, AC supply system and conforming to all relevant IS specification and in accordance with the local State / Municipal rules for Electric Traction Lifts and as specified. Elevators shall be fitted with audio visual alarm system.

The Passenger Elevators shall be provided with a Hand Rail not less than 600 mm long at 900 mm above floor level which shall be fixed adjacent to the control panel for the physically challenged passengers also. The time of an automatically closing door shall be minimum 05 seconds and closing speed should not exceed 0.25 Mtr./Sec. The interior of the cage shall be provided with a device that audibly indicates the floor the cage has reached and indicate that the door of the cage for entrance / exit is either open or closed.

Intercom (Press & speak Type as per manufacturer standard) – Between car and top landing ECU box and should be able to hook up AAI EPABX. The EPABX connection will be provided near the top landing (wires/ cables extended upto control panel).

Provision for monitoring of parameters of elevators through Building Management system (BMS). The elevator should be capable of interconnected with BMS and shall have open code architecture.

Every item of machinery, likely to produce vibration or sound must be isolated from structure so as to eliminate any possibility of vibration and sound travelling to the structure and other parts of the building with best quality of isolation materials.

Making end termination of all power, telephone & fire alarm cables & earth at controller side.

The contractor is required to obtain the approval of the Lift Inspector and other local authorities on completion of work. All expenses incurred in obtaining the approval of the Lift Inspector / local authorities including fee’s etc. shall be borne by the contractor.

Operation of Elevators for 30 days as “Running in period” to ensure trouble-free running of Elevator before taking over by AAI.

NOTE: The scope of work for items / works as mentioned in above Para’s shall be included within the quoted cost.

The cost for the Maintenance/Service during DLP period of 24 months is covered under the scope of work and quoted rates shall be deemed to cover regular examination of the installations by the trained technician of the contractor including necessary adjustments, greasing, oiling cleaning including replacement of parts etc. to keep the equipment in excellent operational state.

The contractor shall also provide 24 hour emergency repair service to attend the Elevators at any time of the day or night including Sundays and Holidays.

All Inclusive Comprehensive Maintenance Contract (AICMC) to be undertaken by the EPC Contractor for the next five years after completion of the guarantee / warranty & defect liability period of TWO year. Refer separate schedule of cost & billing.

The detailed terms and conditions of the all-inclusive Comprehensive Maintenance Contract for Elevators are appended under section 14 Operation & All inclusive
comprehensive Maintenance contract. The quoted amount for AICMC will be taken into consideration for evaluation of the bids.

4. CIVIL AND OTHER WORKS TO BE INCLUDED:

In addition to the manufacture, supply, installation, testing and commissioning of the Lift including all auxiliary equipment, following civil and other works shall be deemed to be included within the scope of work lift contractor.

i) All minor building work necessary for installation of equipment such as making of openings in walls / floors, either of RCC or brick masonry etc. and restoring them to original condition & finish. The scope of minor building work includes all grouting of foundation, concrete pads to be formed or made as base for supporting RS joists etc. grouting & anchoring of all boards, clamps, supports, foundation bolts, installation in position of RS joists, Lift well or in the pit. Such work shall exclude cutting of marble work and construction of partition wall wherever involved.

ii) Supply of necessary RS joists or angle iron supports brackets buffer support channels, tees, bearing plates, machine beams, hitch beams, steel brackets for guide rails and other steel works as required etc. for installations of the Lift either for machine or at other places as may be necessary including their installation in position.

iii) All scaffolding as may be necessary in the Lift well during erection work and subsequent removal.

iv) Temporary barricades with caution boards at each landing to prevent accident during execution of work.

v) Supply and installation of landing facia plates made of steel, car apron plates, sill support angles with necessary clamps, foundation bolts supports etc. as are necessary in connection with the installation of the Lift.

vi) Steel ladder to be provided for access to lift pit wherever required under regulations.

vii) If hanging pit, necessary control shall be included.

5. WORK SERVICES TO BE PROVIDED BY EPC CONTRACTOR

Unless otherwise mentioned in the tender specifications, the following works shall be carried out by the EPC Contractor.

i. Construct Lift well, Lift Pit, door cut out, ventilation cutout (at overhead of lift well) etc as required of dimensions given by OEM of lift;

ii. After finished lift well, lift pit & all cut out of doors, ventilation etc are to be treated & painted suitably to prevent accumulation & circulation of dust and also make it fire resisting and water proof.

iii. Provide marble cladding of all front doors as required & approved by AAI.

iv. Provide Bulk head LED light fixtures & 5A modular switch socket outlets near the machines, Lift pit & Lift well.

v. Extend 3 phase four wire electric supply from nearest switch room and single phase supply with suitable size power cables & earthing near each controller panel. The power will be terminated with ELMCB DB of required rating & type.

vi. Provide Aluminium lovers for ventilation / smoke window as required.

vii. Provide telephone & fire alarm loop cables upto each controller.
viii. Making end termination of all above cables (of power, telephone & fire alarm) & earth at controller side is within the scope.

6. Execution of Work / Workmanship

6.1 The work shall be executed as per the plans approved by the Engineer-in-Charge together with all such additions / alteration required to be made subsequently in best workmanship and in accordance with the particular specifications conforming to regulations of all State local codes.

6.2 The entire work of fabrication, assembly and installation shall conform to sound engineering practice. The mechanical fastening subject to wear and replacement shall be of easily replaceable type. Use of rivets or similar devices should not be acceptable as mechanical fastenings for such parts.

7. Structural Detail / Drawing:

The drawings showing the building plans, where the Lifts are to be installed with other details etc shall be as specified/ shown in enclosed layout. As the Lift system is to be designed to suit these details only, the tenderers are advised to go through these and satisfy themselves as to the adequacy of these items with respect to the IS specification / local state rules and base their offers on these drawing. The tenderer should design their equipment to suit these cut-outs only.

8. Completeness of Tender

All fittings, equipment’s, units, assemblies and accessories, hardware, foundation bolts, terminal lugs for electrical connections cable glands, junction box and all other items which are useful and necessary for efficient assembly in operation and installation shall be deemed to have been included in the scope of work. The installation shall be complete in all respect whether such details have been mentioned in the specifications or not.

9. Completion Certificate by the Lift Inspector:

On completion of installation, the contractor shall furnish a completion certificate issued by the State / Municipal Lift Inspector to the affect that the installation has been carried out as per the codes and laws and the installation is completed and is safe in operation. All expenses to be incurred for obtaining the certificate including fee’s etc. shall be borne by the contractor.

10. GUARANTEE

The contractor shall guarantee the entire Lift installation as per specification. All elevator system shall be guaranteed for two years from the date of acceptance against unsatisfactory performance or break down due to defective design, manufacture and installation. The installation shall be covered by the condition that whole installation or any part thereof found defective within two years from the date of acceptance shall be replaced or repaired by the contractor free of charge as decided by the Engineer-in-Charge.

The warranty shall cover the following: -

a) Quality, strength and performance of the materials and equipment used.

b) Safe electrical and mechanical stresses on all parts of the equipment under all specified conditions of operation.

c) Satisfactory performance during guarantee period including free replacement to be done in accordance with the maintenance instructions and schedules.
d) Performance figures and other values as specified in schedule of guaranteed technical particulars.

e) Prompt service during maintenance period for repairs and break down.

f) Attending to consequential damages to consignment of Lift items supplied and installed due to defective workmanship, material designs etc. in any part from manufacturers work.

There should not be more than 08 hours delay in attending to breakdowns / defects reported in station where the Contractor has his service organization. At other places the contractor shall specify this service period which should not be more than 24 hrs along with his tender and this shall be strictly adhered to. The OEM has to submit the name, address and contact number of the person to be contacted in case of breakdown and preventive maintenance to be carried out.

11. Running in Period

After the satisfactory completion of work the contractor shall demonstrate the trouble free running of the installation for a period of not less than 30 days. During this 30 days period the elevator shall be deemed to have run trouble free. The contractor has to provide at his cost skilled operation and maintenance personnel at site during this period.

12. Equipment Specifications

The broad and at a glance specifications of the equipment to be supplied and installed are given below. The Contractor are requested to refer detailed specifications & sub-paras given below for additional information’s and their compliance during execution of work.

**Technical Requirement:**

**Passenger terminal building**

**Glass Lift**

<table>
<thead>
<tr>
<th>Sl. No</th>
<th>Items</th>
<th>Specification for Each Lift</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Type &amp; No. of Lifts</td>
<td>Machine Room Less (MRL) Passenger Elevator with Glass Enclosure – 6 Nos.</td>
</tr>
<tr>
<td>2</td>
<td>Capacity / Load of each Lift</td>
<td>20 Pax / 1360 Kg</td>
</tr>
<tr>
<td>3</td>
<td>Lift car size Width x Depth</td>
<td>As per standard design of manufacturer meeting AAI requirement</td>
</tr>
<tr>
<td>4</td>
<td>Lift car door Entrance</td>
<td>1000mm</td>
</tr>
<tr>
<td>5</td>
<td>Size of Lift well (W x D in MM)</td>
<td>As per Architectural layout</td>
</tr>
<tr>
<td>6</td>
<td>Pit Depth (in MM)</td>
<td>As per standard design of manufacturer meeting AAI requirement.</td>
</tr>
<tr>
<td>7</td>
<td>Overhead (in MM)</td>
<td>As per standard design of manufacturer meeting AAI</td>
</tr>
</tbody>
</table>

*Note: The above dimensions are approx. These dimensions may be suitably correct subject to meeting the requirements as per standard & as per site requirements with the approval of Engineer-In-Charge.*
<table>
<thead>
<tr>
<th></th>
<th>requirement.</th>
</tr>
</thead>
<tbody>
<tr>
<td>8</td>
<td>Total travel of lift As per Architectural layout (To serve from Ground to First Floor)</td>
</tr>
<tr>
<td></td>
<td><strong>Note:</strong> The dimensions mentioned above for lift shaft, pit &amp; overheads are as per architectual drawing enclosed and are approximate.</td>
</tr>
<tr>
<td>9</td>
<td>Type of Control System Microprocessor based Duplex Selective Collective.</td>
</tr>
<tr>
<td>10</td>
<td>Speed 1.0 MPS</td>
</tr>
<tr>
<td>11</td>
<td>Stops &amp; Opening 02 stops. Entrance and exit on two floors at opposite sides as per site requirement.</td>
</tr>
<tr>
<td>12</td>
<td>Type of Drive AC variable voltage &amp; variable frequency drive (AC V 3F) with gearless machine placed in shaft.</td>
</tr>
<tr>
<td>13</td>
<td>Car &amp; Landing Door Opening Power Operated Centre Opening Sliding Door.</td>
</tr>
<tr>
<td>14</td>
<td>Car Operating Panel (COP) Full height hairline finish stainless steel face plate with:</td>
</tr>
<tr>
<td></td>
<td>- Luminous push buttons numbered to correspond to the car call to be served.</td>
</tr>
<tr>
<td></td>
<td>- Braille buttons shall be provided</td>
</tr>
<tr>
<td></td>
<td>- Emergency alarm button.</td>
</tr>
<tr>
<td></td>
<td>- Digital display of floor position and illuminated arrow indications for UP &amp; DOWN movements.</td>
</tr>
<tr>
<td></td>
<td>- Overload warning features with audio visual indication. Visual indication shall flash &quot;Over loaded&quot; and a buzzer shall operate in this period. The Elevator doors shall remain open till the overload is removed.</td>
</tr>
<tr>
<td></td>
<td>- Push buttons for opening &amp; closing of doors at landing points.</td>
</tr>
<tr>
<td></td>
<td>- Push button for non-stop operation to top landing position (Specific floor service) – Optional – As per Manufacturer’s standard.</td>
</tr>
<tr>
<td></td>
<td>- Fan switch.</td>
</tr>
<tr>
<td></td>
<td>- Intercom (Press &amp; speak Type as per manufacturer standard) – Between car and top landing ECU box and should be able to hook up AAI EPABX.</td>
</tr>
<tr>
<td></td>
<td>- Push buttons shall glow when pressed indicating acceptance of command.</td>
</tr>
<tr>
<td>15</td>
<td>Landing Operating Panel (LOP) (One panel per landing)</td>
</tr>
<tr>
<td></td>
<td>Landing push button box with hairline finish stainless steel face plate with:</td>
</tr>
<tr>
<td></td>
<td>- Luminous/suitable push buttons for UP &amp; DN travel (02 nos.) (Except for top most &amp; bottom most landing where only UP or DN travel luminous push button to be provided).</td>
</tr>
<tr>
<td></td>
<td>- Braille buttons shall be provided</td>
</tr>
<tr>
<td></td>
<td>- Digital display of UP and DN travel indicator of</td>
</tr>
</tbody>
</table>
9. **Car Wall**: Car enclosure provided with toughened glass on all sides, round hairline stainless steel handrail on 2 sides of car as applicable.

10. **Car Floor**: Granite Stone finish as per respective floor &/or Approved by Engineer-in-Charge.

11. **Car Ceiling**: Suspended stainless steel False ceiling with concealed diffused LED lights and Ventilation fans as per OEM standard.

12. **Car Interior**:
   - Hand rail at rear wall. The hand rail shall be straight type stainless steel in mirror polish.
   - One specification plate showing rated load, passenger capacity & other installation details / ratings.
   - Lift Inspectors certificate duly framed with acrylic sheet front or laminated to be fixed on one side wall. Provision should be made for proper replacement of certificate without affecting the Car interior.
   - Emergency light unit.

13. Elevator shall be compatible with disability norms

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14. **Safeties, Protection & Rescue**

   - Overload warning feature shall be provided with audio-visual indication. Visual indication shall flash "overloaded" & a buzzer shall operate in this period. The elevator door shall remain open until the overload is removed.
   - Battery operated alarm bell (solid state siren type) & emergency light during power failure. The emergency light unit will use dry cell battery power pack & LED lights fitted in a stainless steel face plate & shall operate automatically in case of power failure.
   - Fireman’s switch at main lobby at Ground floor which shall permit a fireman to call the elevator to the Ground floor by cancelling all car & landing calls.
   - Infra red full lengths door detector and mechanical safety by pressure sensor.
   - **Over Speed**: Car safety device shall be provided to stop the car whenever excessive descending speed is attained through over
speed governor.
- Counter Weight.
- Machined steel guides shall be installed for the car & counter weight. Steel guide rails & guide shoes shall conform to IS 14665 Part 4 Sec 2): 2000.
- Slack rope safety switch shall be fitted to the drive & shall automatically cut off supply if the rope becomes slack. A suitable instantaneous safety with safety switch shall be provided for complete safety in the event of rope slack.
- Terminal Limit Switch for cutting off the energizing current in case of car travelling the top most or bottom most landing to bring the car to stop.
- Terminal final limit switch to automatically cut off the power from Elevator drive machine independent of the functioning of normal terminal stopping devices, operating device or any emergency terminal stopping device after the car pass a terminal landing.
- Spring loaded DC brakes designed to provide smooth stops under variable load.
- Reverse phase relay to be provided on the controller to protect against phase reversal and phase failure.
- Spring /oil buffers based on OEM standards.

<table>
<thead>
<tr>
<th>18</th>
<th>Car Door Operation</th>
</tr>
</thead>
<tbody>
<tr>
<td>-</td>
<td>When the car stops at a landing, car door &amp; landing door will open automatically. Also before the car gets started, car door &amp; landing doors must be closed. The car cannot start unless the car door is in closed position &amp; all hoist way doors are locked electro-mechanically in closed position.</td>
</tr>
<tr>
<td>-</td>
<td>The car doors and hoist way doors can be stopped and reversed in their closing motion.</td>
</tr>
<tr>
<td>-</td>
<td>The car with its door open will be parked for a pre-determined time at landing to enable passengers to enter or leave the car.</td>
</tr>
<tr>
<td>-</td>
<td>By the actuation of car buttons the closing of door can be quickened or reversed.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>19</th>
<th>Other items to be provided</th>
</tr>
</thead>
<tbody>
<tr>
<td>-</td>
<td>Landing sill as required.</td>
</tr>
<tr>
<td>-</td>
<td>Main beam in shaft for machine.</td>
</tr>
<tr>
<td>-</td>
<td>Pit ladder.</td>
</tr>
<tr>
<td>-</td>
<td>Scaffolding (to be removed after completion of erection work)</td>
</tr>
<tr>
<td>-</td>
<td>Minor civil works.</td>
</tr>
</tbody>
</table>
### Automatic Rescue Devices (ARD)

Elevator system shall have automatic battery operated solid state emergency rescue device to automatically rescue passengers trapped in the Elevator car in between floors in the event of power failure having following features:

1. Automatic operation & immediate actions in the event of mains failure capable to move the Elevator to the nearest landing & open the doors automatically.
2. Shall have sealed maintenance free battery back-up of suitable rating with automatic charging unit and auto change over unit on mains failure.

### Manual Emergency Rescue Device

Manual emergency rescue device shall be provided to rescue the passengers trapped in the Elevator car in the event of failure of battery operated automatic emergency rescue device. The elevator car stopped in between floors due to power failure shall be brought to the nearest landing by releasing the brake by means of pulling the mechanical lever provided in the last landing. The lever shall require continuous pressure to keep the break open. The standard constructional feature of OEM for such manual emergency rescue device is acceptable.

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### Goods Lift -2500 Kg

<table>
<thead>
<tr>
<th>Sl. No</th>
<th>Items</th>
<th>Specification for Each Lift</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Type &amp; No. of Lifts</td>
<td><strong>Machine Room (MR)</strong> Goods Elevator with stainless steel Enclosure – 1No</td>
</tr>
<tr>
<td>2</td>
<td>Capacity / Load of each Lift</td>
<td>2500 Kg</td>
</tr>
<tr>
<td>3</td>
<td>Lift car size Width x Depth</td>
<td>As per standard design of manufacturer meeting AAI requirement</td>
</tr>
<tr>
<td>4</td>
<td>Lift car door Entrance</td>
<td>1200 mm</td>
</tr>
</tbody>
</table>

**Note:** The above dimensions are approx. These dimensions may be suitably correct subject to meeting the requirements as per standard & as per site requirements with the approval of Engineer-In-Charge.

<table>
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<tr>
<th>Sl. No</th>
<th>Items</th>
<th>Specification for Each Lift</th>
</tr>
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<tbody>
<tr>
<td>5</td>
<td>Size of Lift well (W x D in MM)</td>
<td>As per Architectural layout</td>
</tr>
<tr>
<td>6</td>
<td>Pit Depth (in MM)</td>
<td>As per standard design of manufacturer meeting AAI requirement.</td>
</tr>
<tr>
<td>7</td>
<td>Overhead (in MM)</td>
<td>As per standard design of manufacturer meeting AAI requirement.</td>
</tr>
<tr>
<td>8</td>
<td>Total travel of lift</td>
<td>As per Architectural layout (To serve from Basement to</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>---</td>
<td>---</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>Type of Control System</td>
<td>Microprocessor based Simplex Selective Collective.</td>
</tr>
<tr>
<td>10</td>
<td>Speed</td>
<td>0.5 MPS</td>
</tr>
<tr>
<td>11</td>
<td>Stops &amp; Opening</td>
<td>Entrance and exit at same sides.</td>
</tr>
<tr>
<td>12</td>
<td>Type of Drive</td>
<td>AC variable voltage &amp; variable frequency drive (AC V 3F) with gearless machine placed in Machine Room.</td>
</tr>
<tr>
<td>13</td>
<td>Car &amp; Landing Door Opening</td>
<td>Fully automatic doors with central horizontal bi-parting/sliding type</td>
</tr>
<tr>
<td>14</td>
<td>Car Operating Panel (COP)</td>
<td>Full height hairline finish stainless steel face plate with:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Luminous push buttons numbered to correspond to the car call to be served.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Emergency stop switch, emergency alarm button.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Digital display of floor position and illuminated arrow indications for UP &amp; DOWN movements.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Overload warning features with audio visual indication. Visual indication shall flash “Over loaded” and a buzzer shall operate in this period. The Elevator doors shall remain open till the overload is removed.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Push buttons for opening &amp; closing of doors at landing points.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Push button for non-stop operation to top landing position (Specific floor service) – Optional – As per Manufacturer’s standard.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Fan switch.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Intercom (Press &amp; speak Type as per manufacturer standard) – Between car and top landing ECU box and should be able to hook up AAI EPABX.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Push buttons shall glow when pressed indicating acceptance of command.</td>
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<td>15</td>
<td>Landing Operating Panel (LOP) (One panel per landing)</td>
<td>Landing push button box with hairline finish stainless steel face plate with:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Luminous/suitable push buttons for UP &amp; DN travel (02 nos.) (Except for top most &amp; bottom most landing where only UP or DN travel luminous push button to be provided).</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Digital display of UP and DN travel indicator of Elevator with position of Car.</td>
</tr>
</tbody>
</table>
- Push buttons shall glow when pressed indicating acceptance of command for UP or DN travel and shall remain lighted up till the car arrives.
- LOP to be available on all floors.
- Lift announcement system as in-built feature.

<table>
<thead>
<tr>
<th>16</th>
<th>Finish</th>
</tr>
</thead>
<tbody>
<tr>
<td>14. <strong>Car Wall:</strong> Stainless Steel (minimum 18 SWG) in vandal proof finish.</td>
<td></td>
</tr>
<tr>
<td>15. <strong>Car Floor:</strong> Chequered plate (Aluminium) finish as per respective floor &amp;/or Approved by Engineer-in-Charge.</td>
<td></td>
</tr>
<tr>
<td>16. <strong>Car Ceiling:</strong> Suspended stainless steel False ceiling with concealed diffused LED lights and Ventilation fans as per OEM standard</td>
<td></td>
</tr>
<tr>
<td>17. <strong>Car Interior:</strong></td>
<td></td>
</tr>
<tr>
<td>- Hand rail at rear wall. The hand rail shall be straight type stainless steel in mirror polish.</td>
<td></td>
</tr>
<tr>
<td>- One specification plate showing rated load, passenger capacity &amp; other installation details / ratings.</td>
<td></td>
</tr>
<tr>
<td>- Lift Inspectors certificate duly framed with acrylic sheet front or laminated to be fixed on one side wall. Provision should be made for proper replacement of certificate without affecting the Car interior.</td>
<td></td>
</tr>
<tr>
<td>- Emergency light unit.</td>
<td></td>
</tr>
<tr>
<td>18. Elevator shall be compatible with disability norms</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>17</th>
<th>Safeties, Protection &amp; Rescue</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Overload warning feature shall be provided with audio-visual indication. Visual indication shall flash “overloaded” &amp; a buzzer shall operate in this period. The elevator door shall remain open until the overload is removed.</td>
<td></td>
</tr>
<tr>
<td>- Battery operated alarm bell (solid state siren type) &amp; emergency light during power failure. The emergency light unit will use dry cell battery power pack &amp; LED lights fitted in a stainless steel face plate &amp; shall operate automatically in case of power failure.</td>
<td></td>
</tr>
<tr>
<td>- Fireman’s switch at main lobby at Ground floor which shall permit a fireman to call the elevator to the Ground floor by canceling all car &amp; landing calls.</td>
<td></td>
</tr>
<tr>
<td>- Infra red full lengths door detector and mechanical safety by pressure sensor.</td>
<td></td>
</tr>
<tr>
<td>- <strong>Over Speed:</strong> Car safety device shall be provided to stop the car whenever excessive descending speed is attained through over speed governor.</td>
<td></td>
</tr>
<tr>
<td>- Counter Weight.</td>
<td></td>
</tr>
</tbody>
</table>
- Machined steel guides shall be installed for the car & counter weight. Steel guide rails & guide shoes shall conform to IS 14665 Part 4 Sec 2: 2000.
- Terminal Limit Switch for cutting off the energizing current in case of car travelling the top most or bottom most landing to bring the car to stop.
- Terminal final limit switch to automatically cut off the power from Elevator drive machine independent of the functioning of normal terminal stopping devices, operating device or any emergency terminal stopping device after the car pass a terminal landing.
- Spring loaded DC brakes designed to provide smooth stops under variable load.
- Reverse phase relay to be provided on the controller to protect against phase reversal and phase failure.
- Spring /oil buffers based on OEM standards.

18 Car Door Operation
- When the car stops at a landing, car door & landing door will open automatically. Also before the car gets started, car door & landing doors must be closed. The car cannot start unless the car door is in closed position & all hoist way doors are locked electro-mechanically in closed position.
- The car doors and hoist way doors can be stopped and reversed in their closing motion.
- The car with its door open will be parked for a pre-determined time at landing to enable passengers to enter or leave the car.
- By the actuation of car buttons the closing of door can be quickened or reversed.

19 Other items to be provided
- Landing sill as required.
- Main beam in shaft for machine.
- Pit ladder.
- Scaffolding (to be removed after completion of erection work)
- Minor civil works.

20 Automatic Rescue Devices (ARD)
Elevator system shall have automatic battery operated solid state emergency rescue device to automatically rescue passengers trapped in the Elevator car in between floors in the event of power failure having following features:
- Automatic operation & immediate actions in the event of mains failure capable to move the Elevator to the nearest landing & open the doors automatically.
- Shall have sealed maintenance free battery
back-up of suitable rating with automatic charging unit and auto change over unit on mains failure.
- Message indicator in the Elevator car.

21 Manual Emergency Rescue Device

Manual emergency rescue device shall be provided to rescue the passengers trapped in the Elevator car in the event of failure of battery operated automatic emergency rescue device. The elevator car stopped in between floors due to power failure shall be brought to the nearest landing by releasing the brake by means of pulling the mechanical lever provided in the last landing. The lever shall require continuous pressure to keep the break open. The standard constructional feature of OEM for such manual emergency rescue device is acceptable.

<table>
<thead>
<tr>
<th>Sl. No</th>
<th>Items</th>
<th>Specification for Each Lift</th>
</tr>
</thead>
</table>
| 1     | Type & No. of Lifts         | Machine Room (MR)  
Goods Elevator with stainless steel Enclosure – 1Nos.                                         |
| 2     | Capacity / Load of each Lift| 3000 Kg                                                                                     |
| 3     | Lift car size Width x Depth | As per standard design of manufacturer meeting AAI requirement                               |
| 4     | Lift car door Entrance      | 1200 mm                                                                                     |

**Note:** The above dimensions are approx. These dimensions may be suitably correct subject to meeting the requirements as per standard & as per site requirements with the approval of Engineer-In-Charge.

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<tr>
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<td>Size of Lift well (W x D in MM)</td>
<td>As per Architectural layout</td>
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<tr>
<td>6</td>
<td>Pit Depth (in MM)</td>
<td>As per standard design of manufacturer meeting AAI requirement.</td>
</tr>
<tr>
<td>7</td>
<td>Overhead (in MM)</td>
<td>As per standard design of manufacturer meeting AAI requirement.</td>
</tr>
<tr>
<td>8</td>
<td>Total travel of lift</td>
<td>As per Architectural layout (To serve from Basement to 1st Floor)</td>
</tr>
</tbody>
</table>

**Note:** The dimensions mentioned above for lift shaft, pit & overheads are as per architectural drawing enclosed and are approximate.

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<th>Sl. No</th>
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<th>Specification for Each Lift</th>
</tr>
</thead>
<tbody>
<tr>
<td>9</td>
<td>Type of Control System</td>
<td>Microprocessor based Simplex Selective Collective.</td>
</tr>
<tr>
<td>10</td>
<td>Speed</td>
<td>0.5 MPS</td>
</tr>
<tr>
<td>11</td>
<td>Stops &amp; Opening</td>
<td>Entrance and exit at same sides.</td>
</tr>
<tr>
<td>12</td>
<td>Type of Drive</td>
<td>AC variable voltage &amp; variable frequency drive (AC V 3F) with gearless machine placed in Machine Room.</td>
</tr>
</tbody>
</table>

**Goods Lift -3000 KG**
<p>| | | |</p>
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<tr>
<th></th>
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</thead>
<tbody>
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<td>Car &amp; Landing Door Opening</td>
<td>Fully automatic doors with central horizontal bi-parting/sliding type</td>
</tr>
<tr>
<td>14</td>
<td>Car Operating Panel (COP)</td>
<td>Full height hairline finish stainless steel face plate with:</td>
</tr>
<tr>
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<td></td>
<td>- Luminous push buttons numbered to correspond to the car call to be served.</td>
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<td>- Push buttons for opening &amp; closing of doors at landing points.</td>
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<tr>
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<td>- Push button for non-stop operation to top landing position (Specific floor service) – Optional – As per Manufacturer’s standard.</td>
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<td>16</td>
<td>Finish</td>
<td>19. <strong>Car Wall</strong>: Stainless Steel (minimum 18 SWG) in vandal proof finish.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>20. <strong>Car Floor</strong>: Chequered plate (Aluminium) finish as per respective floor &amp;/or Approved by Engineer-in-Charge.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>21. <strong>Car Ceiling</strong>: Suspended stainless steel False ceiling with concealed diffused LED lights and</td>
</tr>
</tbody>
</table>
22. **Car Interior:**
- Hand rail at rear wall. The hand rail shall be straight type stainless steel in mirror polish.
- One specification plate showing rated load, passenger capacity & other installation details / ratings.
- Lift Inspectors certificate duly framed with acrylic sheet front or laminated to be fixed on one side wall. Provision should be made for proper replacement of certificate without affecting the Car interior.
- Emergency light unit.

23. Elevator shall be compatible with disability norms

17. **Safeties, Protection & Rescue**
- Overload warning feature shall be provided with audio-visual indication. Visual indication shall flash “overloaded” & a buzzer shall operate in this period. The elevator door shall remain open until the overload is removed.
- Battery operated alarm bell (solid state siren type) & emergency light during power failure. The emergency light unit will use dry cell battery power pack & LED lights fitted in a stainless steel face plate & shall operate automatically in case of power failure.
- Fireman’s switch at main lobby at Ground floor which shall permit a fireman to call the elevator to the Ground floor by cancelling all car & landing calls.
- Infra-red full lengths door detector and mechanical safety by pressure sensor.
- **Over Speed:** Car safety device shall be provided to stop the car whenever excessive descending speed is attained through over speed governor.
- Counter Weight.
- Machined steel guides shall be installed for the car & counter weight. Steel guide rails & guide shoes shall conform to IS 14665 Part 4 Sec 2): 2000.
- Terminal Limit Switch for cutting off the energizing current in case of car travelling the top most or bottom most landing to bring the car to stop.
- Terminal final limit switch to automatically cut off the power from Elevator drive machine independent of the functioning of normal terminal stopping devices, operating device or
| 18 | Car Door Operation       | - Any emergency terminal stopping device after the car pass a terminal landing.  
- Spring loaded DC brakes designed to provide smooth stops under variable load.  
- Reverse phase relay to be provided on the controller to protect against phase reversal and phase failure.  
- Spring/oil buffers based on OEM standards.  
- When the car stops at a landing, car door & landing door will open automatically. Also before the car gets started, car door & landing doors must be closed. The car cannot start unless the car door is in closed position & all hoist way doors are locked electro-mechanically in closed position.  
- The car doors and hoist way doors can be stopped and reversed in their closing motion.  
- The car with its door open will be parked for a pre-determined time at landing to enable passengers to enter or leave the car.  
- By the actuation of car buttons the closing of door can be quickened or reversed. |
| 19 | Other items to be provided | - Landing sill as required.  
- Main beam in shaft for machine.  
- Pit ladder.  
- Scaffolding (to be removed after completion of erection work)  
- Minor civil works. |
| 20 | Automatic Rescue Devices (ARD) | Elevator system shall have automatic battery operated solid state emergency rescue device to automatically rescue passengers trapped in the Elevator car in between floors in the event of power failure having following features: -  
- Automatic operation & immediate actions in the event of mains failure capable to move the Elevator to the nearest landing & open the doors automatically.  
- Shall have sealed maintenance free battery back-up of suitable rating with automatic charging unit and auto change over unit on mains failure.  
- Message indicator in the Elevator car. |
| 21 | Manual Emergency Rescue Device | Manual emergency rescue device shall be provided to rescue the passengers trapped in the Elevator car in the event of failure of battery operated automatic emergency rescue device. The elevator car stopped in between floors due to power failure shall be brought to |
the nearest landing by releasing the brake by means of pulling the mechanical lever provided in the last landing. The leaver shall require continuous pressure to keep the break open. The standard constructional feature of OEM for such manual emergency rescue device is acceptable.

### ATC Building

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Items</th>
<th>Specification for Each Lift</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Type &amp; No. of Lifts</td>
<td><strong>Machine Room Less (MRL)</strong> Passenger Elevator– 2 Nos.</td>
</tr>
<tr>
<td>2</td>
<td>Capacity / Load of each Lift</td>
<td>8 PAX / 544 KG</td>
</tr>
<tr>
<td>3</td>
<td>Lift car size Width x Depth</td>
<td>As per standard design of manufacturer meeting AAI requirement</td>
</tr>
<tr>
<td>4</td>
<td>Lift car door Entrance</td>
<td>800-900mm</td>
</tr>
<tr>
<td></td>
<td><strong>Note</strong>: The above dimensions are approx. These dimensions may be suitably correct subject to meeting the requirements as per standard &amp; as per site requirements with the approval of Engineer-In-Charge.</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Size of Lift well (W x D in MM)</td>
<td>As per Architectural layout</td>
</tr>
<tr>
<td>6</td>
<td>Pit Depth (in MM)</td>
<td>As per standard design of manufacturer meeting AAI requirement</td>
</tr>
<tr>
<td>7</td>
<td>Overhead (in MM)</td>
<td>As per standard design of manufacturer meeting AAI requirement</td>
</tr>
<tr>
<td>8</td>
<td>Total travel of lift</td>
<td>As per Architectural layout (To serve from level 0 to level 06)</td>
</tr>
<tr>
<td></td>
<td><strong>Note</strong>: The dimensions mentioned above for lift shaft, pit &amp; overheads are as per architectural drawing enclosed and are approximate.</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>Type of Control System</td>
<td>Microprocessor based Duplex Selective Collective.</td>
</tr>
<tr>
<td>10</td>
<td>Speed</td>
<td>1.0 MPS</td>
</tr>
<tr>
<td>11</td>
<td>Stops &amp; Opening</td>
<td>Entrance and exit at same sides</td>
</tr>
<tr>
<td>12</td>
<td>Type of Drive</td>
<td>AC variable voltage &amp; variable frequency drive (AC V 3F) with gearless machine placed in shaft.</td>
</tr>
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<td>Finish</td>
<td>a) <strong>Car Wall:</strong> Stainless Steel (minimum 18 SWG) in vandal proof finish.</td>
</tr>
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<td></td>
<td>b) <strong>Car Floor:</strong> Granite Stone finish as per respective floor &amp;/or Approved by Engineer-in-Charge.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>c) <strong>Car Ceiling:</strong> Suspended stainless steel False ceiling with concealed diffused LED lights and Ventilation fan as per OEM standard.</td>
</tr>
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<td></td>
<td></td>
<td>d) <strong>Car Interior:</strong></td>
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<td>- Hand rail at rear wall. The hand rail shall be straight type stainless steel in mirror polish.</td>
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|   |   | - Lift Inspectors certificate duly framed with acrylic.
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<th>17</th>
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<td>-</td>
<td>Sheet front or laminated to be fixed on one side wall. Provision should be made for proper replacement of certificate without affecting the Car interior.</td>
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<td>Emergency light unit.</td>
</tr>
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<td>e)</td>
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<td>Battery operated alarm bell (solid state siren type) &amp; emergency light during power failure. The emergency light unit will use dry cell battery power pack &amp; LED lights fitted in a stainless steel face plate &amp; shall operate automatically in case of power failure.</td>
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<td>Counter Weight.</td>
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- The car doors and hoist way doors can be stopped and reversed in their closing motion.  
- The car with its door open will be parked for a pre-determined time at landing to enable passengers to enter or leave the car.  
- By the actuation of car buttons the closing of door can be quickened or reversed. |
| 19 | Other items to be provided | - Landing sill as required.  
- Main beam in shaft for machine.  
- Pit ladder.  
- Scaffolding (to be removed after completion of erection work)  
- Minor civil works. |
| 20 | Automatic Rescue Devices (ARD) | Elevator system shall have automatic battery operated solid state emergency rescue device to automatically rescue passengers trapped in the Elevator car in between floors in the event of power failure having following features:  
i) Automatic operation & immediate actions in the event of mains failure capable to move the Elevator to the nearest landing & open the doors automatically.  
ii) Shall have sealed maintenance free battery back-up of suitable rating with automatic charging unit and auto change over unit on mains failure.  
iii) Message indicator in the Elevator car. |
| 21 | Manual Emergency Rescue Device | Manual emergency rescue device shall be provided to rescue the passengers trapped in the Elevator car in the event of failure of battery operated automatic emergency rescue device. The elevator car stopped in between floors due to power failure shall be brought to the nearest landing by releasing the brake by means of pulling the mechanical lever provided in the last landing. The leaver shall require continuous pressure to keep the break open. The standard constructional feature of OEM for such manual emergency rescue device is acceptable. |

The detailed specifications of the components incorporated in the Elevator shall be as under:
**Machine:** The machine shall be gearless, single wrap traction type of suitable design & manufacture and shall include a motor, electric & mechanical brake, steel sheave shaft and ferro-molybdenum / cast iron sheave all compactly mounted on a single base of bed plate. The machine shall be equipped with an arrangement for manual winding of the machine for testing purposes or for operation when the power supply fails. The equipment installed shall be rated as per system requirement for its efficient and reliable operations. The machine shall be placed directly in the hoist way with the hoisting beams etc.

**Motor & Control:** The motor shall be of suitable rating and energy efficient one. The Elevators shall have a modern closed loop control system using solid state components including AC thyristors and electronic speed pattern generator to command the AC Permanent Magnet Synchronous Motor (PMSM) speed. Digital speed feedback from a velocity transducer may be provided for better riding comfort (jerk less). Also an automatic load compensation circuit shall be provided for better leveling accuracy. The acceleration and de-acceleration shall be adjustable.

**Sheaves & Supporting:** Deflector and overhead sheaves with their steel supporting beams shall be provided as needed for obtaining proper load of the ropes to the car and the counter balance. All sheaves shall be fixed by means of two sunk keys of sufficient strength and quality. Drum sheaves and pulleys shall be of steel. They shall have machined ropes grooves and shall be provided with suitable flanges. The grooving of drum diverters, sheaves or pulleys shall have radius larger than the radius of the rope but not less than the amount as shown in table 4 of IS 14665 and shall extend at least over one third of the circumference of the rope.

**Terminal Buffers:** Heavy duty spring buffers shall be provided as a means of stopping the car and counter weight at the extreme limits of travel as required vide IS: 14665 (Part 4 / Sec 1 ) – 2001. Buffers in the pit shall be mounted on steel channels which shall extend between both car and counter weight guide rails. The buffers shall be placed symmetrically with respect to the centre of gravity of the lift car and shall be so arranged that the lift car in normal operation cannot strike them.

**Counter Balance:** A suitable guided structural steel frame with appropriate filler weights shall be provided to promote smooth and economical operation. The counter weight shall consist of cast iron weights contained in rigid structural steel frame and shall be equal to the weight of empty Elevator car plus approximately 40 – 50 % of the capacity specified or as per the design of the manufacturer.

**Counter Weight Guard:** The contractor shall provide and install expanded metal, counter weight guard of required length in the hoist way.

**Ropes/Belt:** The hoist ropes shall be traction steel of suitable size, construction and number to ensure the safe operation of Elevator and shall give satisfactory wearing qualities. The governor ropes shall be of steel. The factor of safety should be as given in IS 14665 (Part 4 – Sec 8) 2001. No car or counter weight ropes shall be repaired or lengthened by splicing. Rope specification and fixing arrangement shall conform to IS 14665-2001.
**Car & Car Frame:**

a) The internal dimensions of the lift car shall be of suitable size for the specified number of passengers / load and in accordance with statutory requirements. The inside car measurements shall be based on lift well dimensions as specified/ attached Architectural drawings. The roof shall be solid or perforated capable of supporting a weight of at least 75 Kgs.

b) The passenger cars shall be insulated from frames to prevent vibrations being transmitted from ropes and guide shoes. Lateral and upward motion of the cars shall be restrained by locking blocks but there shall not be metal to metal contact between the car and the frame. The top of the car shall be held firmly by rubber faced clamps welded to each side of the car canopy. In addition, the side panels shall be coated with a layer of bituminous sound deadening compound/ isolated rubber pad. The car frame which supports the car platform and enclosure shall be made of structural steel properly and securely braced with suitable guides and car safety device mounted underneath the car platform. The hoist-rope shall include adjustable self aligning hitches. The frame shall be sufficiently rigid to withstand the operation of safety gear.

c) The car safety shall be provided to stop the car whenever excessive descending speed is attained.

**Lift Car Doors and Landing Doors:**

i) For passenger terminal building –
   - (Passenger Elevator) the entrance and exit on opposite sides.
   - (Goods lift), Entrance to lift car shall be on same side only

ii) For ATC building – (Passenger elevator) and. Lift car door and landing doors for passenger lift shall comprise of power operated 02 nos. Glass/stainless steel central bi-parting type (horizontally operated sliding) doors. The landing doors shall have automatic opening and closing devices. Door shall be fitted with efficient electro-mechanical locking so as to ensure that it cannot be opened except when the lift car is at landing and that the lift car cannot be moved away from the landing until the door is closed and locked. However, means should be provided for opening the same by special way during emergency or inspection. The landing doors for all lifts shall be 1 hours fire rated.

- **Operating Car Doors and Fixture:** The car doors of the lift shall be operated quietly and smoothly by electricity, which shall open and close both the car and landing doors simultaneously. It should be possible to open the door manually from within the car or from outside with lock and key in case of power failure.

- **Safety Shoe:** Safety shoe (one for each door panel) shall extend the full height of door and project beyond the front edge of the car door. Should this shoe touch a person or object while the car door is closing, the car and hoist way doors shall return to the open position. The doors shall remain open until the expiration of a pre-determined interval and then close automatically. Reversal of the doors may also be accomplished by pressing a button in the car operating panel. In case, firm wish to
provide some other latest device than safety shoe that may be provided but it should meet the functional requirement of safety shoe.

- **Landing Entrance Materials:** These shall consist of headers, extruded aluminum sills and strut angles.

- **Door Hanger and Tracks:** For the car and each landing sliding door, sheave type two point suspension hangers complete with tracks shall be provided. Sheaves and rollers shall be of steel and shall include shielded ball bearing to retain grease lubrication. Adjustable ball bearing rollers shall be provided to take the upward thrust of the doors. Tracks shall be of suitable steel section with smooth surface.

**Car Safety and Governor:** - A suitable car safety to stop the car whenever excessive descending speed is attained shall be operated by a centrifugal speed governor located at the top of the hoist way and connected to the governor through a continuous steel rope. The governor shall be provided with self-tensioning device to keep the governor ropes in proper tension even after rope stretch. A suitable means shall be supplied to cut off power from motor and apply the brake on application of the safety. Governors for car safety gears shall be adjusted to actuate the safety gears as mentioned in IS: 14665 (Part 4 / Sec.4): 2001.

**Controller:** - A microprocessor based controller shall be provided to perform all the functions of safe elevator operation and elevator door control. This shall include all the hardware required to connect, transfer and interrupt power and protect the motor against overloading. The system shall also perform car operation control. Controller cabinet containing memory equipment shall be properly shielded from line pollution. The microprocessor system shall be designed to accept re-programming with minimum down time. It shall be equipped with devices to monitor the parameters through BMS.

**Emergency Safety Devices:** - Every lift suspended by wire ropes shall be provided with one or more safety devices attached to the lift car frame and placed beneath the car. The safety devices shall be capable of stopping and sustaining the lift car with full rated load in the car at tripping speed. Safety gear shall operate to stop and sustain the lift car in the event of lift exceeding the pre-determined maximum speed in the descending direction when a speed governor is fitted. Every safety gear shall operate positively & mechanically independent and any spring used in the construction design shall conform to IS 14665 – 2001.

**Lift Control System and Operation for Lift:**

a) **Control System**

   - **Simplex control**

   Each intermediate hoist way landing level will be serviced by “UP” and “DOWN” luminous buttons. A single luminous button shall be provided at each terminal landing. At the landing, wherein the calls are registered by momentary actuation of the landing buttons, stops shall be made in order in which the landings are reached in each direction of travel after the buttons have been actuated. With this type of operation all up landing calls are to be answered when the car is traveling up directions and all down landing calls are to be answered when the car is traveling down direction except in the case of upper most and the lower most calls which are answered as soon as they are reached irrespective of direction of travel. After the car stops at a landing in response to a call, the car will remain inoperative from landing buttons for a pre-
determined interval to allow car passengers to leave or landing passengers to enter and register his call. This shall be achieved through a time relay. The interval for which car remains inoperative shall be adjustable.

**Duplex control**

When both cars are away from the landing of designated point of entry and all calls have been answered, one car will return automatically to the landing of designated point of entry and is referred to as the ‘Next’ car. The second car remains at the floor at which it last deposited passengers and is referred to as the ‘Free’ car. Both cars stand with doors closed. With the cars standing with doors closed as described above the first landing call will be answered as follows :-

(1) For a landing call from the landing of designated point of entry, by the ‘Next’ car.

(2) For any other floor landing call, by the ‘Free’ car. With the ‘Free’ car answering calls, the ‘Next’ car will not start for ‘Down’ calls behind the ‘Free’ car until the “Free” car is descending. The passenger entering the ‘Free Car’ at the landing of designated point of entry would be able to register a call and travel to any destination. With both cars standing at the landing of designated point of entry with doors closed, the ‘Next’ car (i.e. the one that arrived first) will answer the first landing call. Directional preference should be maintained when a car stops for its last call until the doors close.

b) Besides, the lift operation shall meet the following requirements: -

i. It shall not be possible to start the lift car under normal operation unless every landing door and car doors are in the closed position.

ii. The landing push buttons shall remain inoperative until the passengers using the lift have vacated the lift car and the landing doors again have been closed.

iii. A retractable safety shoe will extend to full height of the protection beyond the front edge of the door. When the car doors are in open position, the safety shoe will retract thus assuring a substantially clear opening. Should the above touch a person or object while the car doors are closing, the car and the hoist way doors will return to the open position.

**Painting:** All the metal part, likely to be rusted, should be painted with paint / powder coating / anodizing after an anti-corrosive treatment.

13. **Test on Lift Installation: -**

**Test at Site:** -

a) **Levelling Test:**

Accuracy of the floor levelling shall be tested with the lift empty / fully loaded. The lift shall be run to each floor while travelling both in upward and downward directions and the actual distance of car floor above / below landing floor shall be measured. In each case there shall not be any appreciable difference in these measurements for levelling at the floors when the car is empty and when it is fully loaded. The tolerances for levelling shall be specified and guaranteed by the OEM.

b) **Safety Gear Tests:**

Instantaneous safety gear controlled by a governor should be tested with contract load and a contract speed, the governor being operated by hand. Two tests should be made, however, with wedge clamp or flexible clamp safeties, one with contract load in the car
and other with 75 Kgs. in the car. The stopping distance obtained should be compared with the specified figures and the guides. Car platform and safety gear should be carefully examined afterwards for signs of permanent distortion.

Wherever pit is hanging type of the lift, the counterweight safety gear should be provided (within the quoted cost of item) to trip by the counter weight governor and the stopping distance noted. In this case, however the governor tripping speed should exceed that of the car safety governor but by not more than 10 percent.

During the safety gear tests, the car speed (from the governor or the main sheave) should be determined at the instant or tripping speed with that stated in IS. The governor jaws and rope should be examined for any undue wear.

c) **Contract Speed:**
   This should be measured with contract load in the car, with half load and with no load and should not vary from the contract speed by more than 10 percent. The speed can be measured by a tachometer applied directly to shaft immediately below the sheave.

d) **Car and Landing Door Interlocks:**
   The lift shall not move with any door open. The car door relay contact and the retiring release cam must be tested. The workings of the door operation and the safety edges and light equipment, if any, provided shall also be examined.

e) **Controllers:**
   The operation of the contactors and interlocks shall be examined and it shall be ascertained whether all the requirements laid down in the specifications have been met.

f) **Normal Terminal Stopping Switches:**
   These shall be tested by letting the car run to each terminal landing in turn, first with no load and then with contract load and by taking measurement, top and bottom over travels can be ascertained.

g) **Final Terminal Stopping Switches:**
   The normal terminal stopping switches shall be disconnected for this test. It shall be ensured that these switches operate before the buffers are engaged.

h) **Insulation Resistance:**
   This shall be measured between power & control lines & earth and shall not be less than 5 mega ohms when measured with DC voltage of 500V. The test shall be carried out with contactors so connected together as to ensure that all parts of every circuit are simultaneously tested.

i) **Earthing:**
   All conduits, switches, casing and similar metal work shall have earthing continuity.

j) **Ropes:**
   The size, number, construction and fastenings of the ropes should be carefully examined and recorded.
k) **Buffers:**

The car should be run on to its buffers at contract speed and with contract load in the car to test whether there is any permanent distortion of the car or buffers. The counter weight buffers should be tested similarly.

**Tests at Manufacturers Works:**

a) **High Voltage Test:** The di-electric or electrical apparatus (excluding motors, generators and instruments which are tested in accordance with the appropriate Indian Standard wherever they exist) shall be capable of withstanding a test voltage of ten times of the working voltage with a maximum of 2000V when applied.

i) Between the live parts and case or frame with all circuits completed.

ii) Between main terminals or equivalent parts with all circuits open and;

iii) Between any live parts of independent circuits.

**NOTE:** Owing to the impracticability of applying tests (ii) and (iii) mentioned above on controllers and similar apparatus after controller wiring has been completed, these tests may be made at convenient stages of manufacture.

i) **Method of applying High Voltage:**

The test shall be made with alternating voltage of any convenient frequency, preferably between 49 and 60 cycles per second. The test voltage shall be of approximately sine-wave form and during the application of voltage with peak value as would be determined by spark gap by oscillograph or by any other approved method shall not be more than 1.45 times the RMS value. The RMS values of the applied voltage shall be measured by means of a voltmeter used with a suitably calibrated potential transformer or by means of a voltmeter used in connection with a special calibrated voltmeter winding or testing transformer by any other suitable voltmeter connected to the output side of the testing transformer.

ii) **Duration of High Voltage Test:**

The test shall be commenced at a voltage of above one third of the test voltage which shall be increased to the full test voltage as rapidly as is consistent with the value being indicated by the measuring instrument. The full test voltage shall be maintained for one minute. At the end of this period, the test voltage shall be rapidly diminished to one third of its full value before switching off.

b) **Buffer Test:**

A copy of the test report shall be intimated after testing at works.

c) **Service Temperature Test:**

A continuous run of one hour should be made with number of starts & stops to reproduce as nearly as practical the anticipate duty in service. (The standard duty cycle is for 90 to 180 start per hour). It is very difficult in practice to carry out this test with alternate starts at full load and no load and it is necessary therefore to simulate these cycles. A suitable test for a motor except squirrel cage motors is to run the car up from the bottom landing with contract load and stop at each floor. From the top floor a nonstop run is made to the lowest floor and the upward journey with stop is then repeated. The time intervals between stops & starts at the floors should be uniform and such as to give about 150 start in one hour. At the end of this run the temperatures of the armatures and fields of the motor & generator are recorded. The temperature rise should not exceed 55°C or 75°C for classes A or B insulation respectively.
1. **SCOPE OF WORK:**
   i) The scope of work covers design, fabrication, supply, installation, testing & Commissioning of 4 nos. monolithic step reversible type Escalators for proposed Integrated Terminal Building at proposed Airport, site for ascending / descending passengers to be installed at 30 degree from the horizontal for handling 9000 passengers per hour at a speed of 30 linear meter per minute having a step width of approximately 1000 mm.
   
   ii) The quoted rate shall be deemed to include for all labours, materials, equipment's, transportation, insurance, tools and all connected works for the completion of work to the extent described in the specifications. The work shall be completed in all respects i/c safety measures to the entire satisfaction of Engineer-in-charge and accepting Authority.
   
   iii) The contractor will be responsible to make good all the floors / walls columns or any other structure which are broken / damaged by him during execution of work.
   
   iv) Preventive maintenance during defect liability period (DLP) of 2 years.
   
   v) Comprehensive maintenance / service of the escalators provided under the contract, for a period of Five years after DLP. Maintenance service shall cover regular examination of the installations by the trained technician of the contractor including necessary adjustments, greasing, oiling, cleaning replacement of parts etc. to keep the equipment in excellent operational state and emergency repair service to attend the escalator at any time of the day or night including Sundays and holidays.
   
   vi) Every item of machinery, likely to produce sound owing to vibration or any other causes, must be isolated from structure so as to eliminate any possibility of sound travelling to other parts of the building. The cost of isolation material required for this purpose shall be deemed to be covered in the scope of work and quoted rate.
   
   vii) The detailed terms and conditions of the all-inclusive Comprehensive Maintenance Contract for Escalator are appended under SCC for Operation & All inclusive comprehensive Maintenance contract. The quoted amount for AICMC will be taken into consideration for evaluation of the bids.

2. **Standards and Specifications**

   All materials, plants, equipment’s to be incorporated in the system shall be of highest standards and as per latest practices in design and manufacturer. The Escalator shall be of robust construction, liberally rated and capable of operating efficiently and economically under the service conditions and conforming to the following relevant IS specifications and associated specifications mentioned herein:

<table>
<thead>
<tr>
<th>i)</th>
<th>Indian Electricity Act 1910 (and the rules issued there under upto date)</th>
</tr>
</thead>
<tbody>
<tr>
<td>ii)</td>
<td>CPWD General Specifications for Electrical works – Part - I (Internal) 2013 and Part-II (External) 1994 with upto date amendments.</td>
</tr>
<tr>
<td>iii)</td>
<td>CPWD General Specifications for Electrical works – Part - III (Lifts &amp; Escalators) 2003 with upto date amendments.</td>
</tr>
<tr>
<td>iv)</td>
<td>EN115 Safety of escalators and moving walks. Construction and installation.</td>
</tr>
</tbody>
</table>
In case of any discrepancy in specifications between the State Act / Rule and the relevant IS specifications, the superior specifications shall be accepted.

For all materials and equipment, IS specifications shall be applicable. Where IS specifications are not available, British / European standard specifications shall become applicable. All specifications, standards, publications specified mean the latest editions of such publications with upto date amendments.

3. **BUILDING PLAN & SECTION:**
The building plans / sections showing the proposed location of the escalators to be installed with details of slabs, floors, roof etc. are enclosed.

4. **DETAILS OF ESCALATORS:**
**Design, Data & Capacity:**

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Capacity</td>
<td>9000 passenger / hr.</td>
</tr>
<tr>
<td>Travel rise from floor to floor</td>
<td>6 mtr. (Approx.)</td>
</tr>
<tr>
<td>Angle of inclination</td>
<td>30 degree.</td>
</tr>
<tr>
<td>Speed</td>
<td>30 linear mtrs. /minute</td>
</tr>
<tr>
<td>Power Supply</td>
<td>415V, 3 phase, 50 Hz. AC supply.</td>
</tr>
<tr>
<td>No. of horizontal steps</td>
<td>03 nos. Step</td>
</tr>
<tr>
<td>Embarkation / disembarkation</td>
<td></td>
</tr>
<tr>
<td>Width</td>
<td>1000mm</td>
</tr>
</tbody>
</table>
| Balustrade                                     | Clear glass balustrade with handrails.  
The color of the handrail shall be Black in color or as approved by AAI |
| Balustrade                                     | 900mm                          |
| Skirt Panel                                    | Stainless Steel                |
| Decking’s                                      | Stainless steel                |
| Width between handrails                        |                                |
| Handrail center distance                        | As per standard design of manufacturer meeting AAI requirement. |
| Width of Pit                                   |                                |
| Depth of Pit                                   |                                |
| Width of truss                                 |                                |
| Depth of truss                                 |                                |
| Special features to be provided                | i. Yellow demarcation lines on pallet side and back  
ii. Traffic flow light at both ends.  
iii. Over speed governor  
iv. Under pallet demarcation lighting  
v. Pallet band lock  
vi. Lubrication free chain  
vii. Provision for remote monitoring status through BMS. |
| Power Supply                                   | The escalator shall be suitable for operations on 3 Phase, 415 Volts, 50 Hz AC power system with Applicable tolerances as per the I.E rules. |
Note: The travel rise mentioned above is indicative. The actual travel shall be designed and supplied after the finalization of building Plan and approved cut out drawings & technical submittal to AAI.

5. GENERAL ARRANGEMENT:
   i) The contractor shall prepare GA drawings as per AA requirement.
   ii) During and after construction of pit and supporting beam, OEM's representative for Escalator should visit the site and check all the important dimensions and point out deficiency, if any. Any modifications in dimensions required after wards have to be carried out by the EPC contractors at their own cost.

6. WORKS / SERVICES TO BE PROVIDED BY EPC CONTRACTOR:
   The Contractor shall include in his tender the cost of the following civil works:
   i) All necessary walls, columns, supports Cutting holes in walls, floor covered under civil works etc. and making good to match the existing surface of walls, floors etc. as required
   ii) Providing Cladding for Escalators on three sides
   iii) Supply and fixing necessary bolts, nuts, washers etc. required for execution of work.
   iv) Hoisting arrangement including providing and placing required angles, channels etc. as required in the building.
   v) Providing arrangement for protection of Escalator from water, dust, etc. during storing and execution.
   vi) All miscellaneous works that may be required for execution, testing and commissioning of escalator.
   vii) Providing intermediate supports as required as per standard requirement.
   viii) Suitable pit in slabs, floors, roofs etc. Any changes / modifications to the same have to be carried out by the contractor
   ix) Extend 3 phase four wire electric supply from nearest switch room and single phase supply with suitable size power cables & earthing near each controller panel. The power will be terminated with ELMCB DB of required rating & type.
   x) Open space shall be provided for storing material at site during execution. However necessary watch and ward, covers, railing etc. shall be EPC contractor's responsibility.

7. EXECUTION OF WORK / WORKMANSHIP & SPECIFICATION
   Work shall be carried out in conformity with the following:
   i) Wiring shall be carried out in concealed or surface conduit. The PVC sheathed, armored cables shall be used wherever required. Wiring shall be suitable for a 3 phase, 50 Hz. 4 wire supply with 415 volts between phases. The voltage and frequency of supply shall be subject to variations, permissible under the Indian Electricity Act and Rules.
   ii) All materials shall be of the best quality complying with the appropriate IS/BS specifications. Materials used shall be subject to the approval of the Engineer-in-charge and samples of the same shall be furnished when required.
   iii) For all three phases, 415V, equipment wires used shall be of 660V grade. Cables shall be of 1100V grade. Wire / Cable shall be of make as mentioned in list of approved make for electrical works.
iv) Introduction of the escalator into the building & its erecting. The EPC contractor shall closely co-ordinate all activities related to preparation of the site, delivery, unloading, and introduction of the escalator into the building and its erection on the designed place. The delivery of the Escalator fully assembled, in one part, will be preferable. However, if there is sufficient clearance, the Escalator may be supplied with the balustrades not mounted. The Escalator may also be delivered in two or more parts, where unavoidable. However, no extra cost shall be payable on any account.

8. EARTHING:
All the equipment and accessories forming part of the Escalator installation and normally carrying electric current and all the metallic parts which are likely to be electrically charged shall be earthed by means of insulated 4 sq. mm. copper wires / 6 SWG GI wire as per Indian Electricity Rules revised up to date & IS code No. 3043-1966 as amended up to date for earthing.

9. Technical Datasheet & Drawings to be supplied by EPC Contractor:
EPC Contractor shall submit 4 sets of following documents with technical submittal for approval to AAI.
- Dimensional and sectional drawing of the escalator and manufacturers catalogue giving detail specification of equipment offered.
- Catalogue of spare parts.
- Installation and service manual.
- Details of foundations for equipment’s load data, location etc. of various assembled equipment’s as may be needed generally by other agencies for purpose of their work.
- Complete layout dimensions for every unit / group of units with dimensions required for erection purposes.
- Any other drawing / information not specifically mentioned above but deemed to be necessary for the job by the contractor.

10. Completeness of Tender
All fittings, equipment’s, units, assemblies and accessories, hardware, foundation bolts, terminal lugs for electrical connections cable glands, junction box and all other items which are useful and necessary for efficient assembly in operation and installation shall be deemed to have been included in the scope of work. The installation shall be complete in all respect whether such details have been mentioned in the specifications or not.

11. APPROVAL OF DRAWINGS:
EPC Contractor shall submit detailed working drawings showing exact position of equipment with foundation detail and location of suspenders / supports with the details of suspending arrangements. Contractor shall not proceed with installations work until drawings are approved by Engineer-in-Charge. Approval of the drawings shall not absolve the contractor of any of his obligations to meet the requirements of specifications and meeting the requirement of relevant Acts / Rules for commissioning and operation of the Escalators provided under the contract.

12. COMPLETION CERTIFICATE / LICENSE BY LIFT THE INSPECTOR:
On completion of Installation, the contractor shall furnish a completion certificate issued by the State / Municipal Lift Inspector / competent authorities to the affect that the installation has been carried out as per the codes and laws and the installation is
completed and is safe in operation. All expenses to be incurred for obtaining the certificate including fees/s etc. shall be borne by the contractor.

13. COMPLETION DRAWINGS:
04 sets of completion drawings along with soft copy in USB Pendrive incorporating all modifications from time to time shall be submitted to the Engineer-in-Charge after completion of work showing the plan and sectional elevation of Escalators and location of machine etc. along with the following in line with SCC of Electrical.
   a) Manufacturer’s catalogue giving detailed specification of equipment offered.
   b) Installation, operation and maintenance manual along with sequence operation notes explaining the sequence of operations when an operation button is pressed.
   c) Wiring diagrams, location diagram of various electrical components.
   d) Trouble shooting guide.
   e) Lists of lubricants recommended.
   f) Spare parts catalogue.
   g) Test certificates for major components.

14. GUARANTEE
The contractor shall guarantee the entire installation as per specification. All equipment shall be guaranteed for Two years. The installation shall be covered by the condition that whole installation or any part thereof found defective within DLP shall be replaced or repaired by the contractor free of charge as decided by the Engineer-in-Charge.

The warranty shall cover the following:
   a) Quality, strength and performance of the materials and equipment used.
   b) Safe electrical and mechanical stresses on all parts of the equipment under all specified conditions of operation.
   c) Satisfactory performance during guarantee period including free replacement to be done in accordance with the maintenance instructions and schedules.
   d) Performance figures and other values as specified in schedule of guaranteed technical particulars.
   e) Prompt service during maintenance period for repairs and break down.
   f) Attending to consequential damages to consignment of items supplied and installed due to defective workmanship, material designs etc. in any part from manufacturers work.

There should not be more than 08 hours delay in attending to breakdowns / defects reported in station where the Contractor has his service organization. At other places the contractor shall specify this service period which should not be more than 24 hrs along with his tender and this shall be strictly adhered to. The OEM has to submit the name, address and contact number of the person to be contacted in case of breakdown and preventive maintenance to be carried out.

15. RUNNING INPERIOD
After the satisfactory completion of work the contractor shall demonstrate the trouble free running of the installation for a period of not less than 30 days. During this 30 days period the escalator shall be deemed to have run trouble free. The contractor has to provide at his cost skilled operation and maintenance personnel at site during this period.
16. TRAINING
   Training at Site
   EPC Contractor shall impart training to the designated staff and Engineer of AAI about the operation / maintenance and safety operation of the equipment for seven days after completion of the installation of the Escalators. All necessary expenditure shall have to be borne by the EPC contractor.

17. EQUIPMENT SPECIFICATION

17.1 GENERAL CONSTRUCTION:
   Each escalator system should comprise of truss, step devices units, step chains, comb plates, handrails, driving machines controller, safety devices, and balustrades and all other parts required to provide a complete escalator suitable for ascending and descending of passengers from floor to floor having a rise as specified.

17.1.1 MACHINES:
   The drive shall be geared type having low noise levels. The motor insulation shall be class ‘F’ and protection class IP-55. The power transmission between the machine sprocket and the main drive sprocket shall be accomplished via a duplex main drive chain.

   The operational brake shall be located between motor and gear box and shall have an AC commercial magnet with asbestos free brake linings. The double acting shoe brake shall be fail safe and operate automatically via spring in the event of power failure or one of the safety switches tripping.

   The escalator shall have quiet and smooth operation, the machines should operate on higher efficiency to reduce energy consumption. The first check of oil should be only necessary after 20,000 operating hours.

17.1.2 CONTROLLER:
   The machine switches shall be provided in metal cabinet housing. The cabinet shall be easily lifted out for ease of maintenance.

   The controller be equipped with modular electronic boards with an easily replaceable mother board which shall cover all basic functions.

   It shall have interface capabilities for remote monitoring by potential free contact and interface for intermittent operation by contact mats.

   The controller should have the following functions / protections:
   - Directional settings.
   - Supervision of power supply voltage.
   - Full motor protection against overheating.
   - Fault indicator by means of display.
   - Control of safety contacts.
   - Asymmetric relay.
   - Earth leakage protection.
   - Single phasing preventer.
   - Phase reversal.

17.1.3 LUBRICATION SYSTEM:
   All main bearings, step chain wheel bearings and step wheel bearings shall be self-lubricated for life.
All chains shall be lubricated from a central oil drip feeding system. The drip feeding system and all lubrication points should be easily reached and monitored from the upper landing machine room.

17.1.4 TRACKSYSTEM:
The escalator should have a closed track system to minimize the risk of step displacement by provision of up thrust track.

The escalator should be assembled in high precision tolerance specialized manufacturing jigs. The track system shall ensure that the escalator will run with minimum noise and vibration levels.

17.1.5 MAIN DRIVE:
The main drive should be located in the upper landing. The electric motor provided shall be suitably rated for 415 +/-10%V, 3 phase, 50 c/s, screen protected, totally enclosed, fan cooled, moderate speed, squirrel cage type suitable for high starting torque and for escalator application.

17.1.6 TENSION CARRIAGE:
The tension carriage for tensioning of the step chain should be located at the lower landing of the escalator.

17.1.7 STEP CHAIN:
Step chain systems should be as per manufacturer’s standard, however material is to be high precision rolled, flat link, hardened chains, provided in pairs of equal length.

17.1.8 STEP:
The steps shall be of one piece die-cast aluminum design with cleated treads and risers. The design developed shall ensure maximum safety as each step meshes with the adjacent step.
The step rollers shall have polyurethane tyres. The diameter of the rollers shall be designed adequately and the bearing should be self-lubricated for life.
The visible areas of the steps be powder coated and the tread area shall not be finished. Yellow demarcation lines should be provided on all 3 sides so that the foot of the passenger rests within that portion.
The steps shall be fastened to the step chain by means of spring loaded pins providing a positive fixing to the axle and for easy removal of step for maintenance.
The escalator steps be designed with passenger safety in mind. The step removal should be possible without dismantling of skirting and balustrade parts.

17.1.9 HANDRAIL DRIVESYSTEM:
The handrail drive system shall be linear driven through a self-adjusting pressure system to eliminate the need for severe bending of the hand rail thereby reducing wear and tear on the handrail. The system shall be driven directly from the step chain via a drive sprocket and a reinforced toothed belt. The handrail drive units shall be located on both sides of the escalator in the incline section close to the upper landing.
The linear drive system ensures that there is no severe bending of the handrail. Thus resulting in less wear and smooth operation of the handrail. The drive system shall be driven directly from the step chain via drive sprocket ensuring synchronous speed of step and handrail.
The handrail return line be guided above the step chain and no dust or lubricant from the step chain shall endanger the appearance or running quality of the hand rail. The design and positioning of the drive system shall be such that they can be inspected without removal of steps. The handrail drive system shall have minimum vibration and low noise.

17.1.10 HANDRAIL:
The handrails shall be provided as endless vulcanized loops. All handrails have an endless inner steel cord member. This shall make the handrail free of elongation so that a frequent re-tensioning is not needed. The material of the hand rail be rubber with cotton inner layers.

17.1.11 HANDRAIL GUIDES:
The handrail guide profiles shall be made from extruded aluminum or some other belts material profiles which have a special polymer cover through its length to reduce friction between the guide and handrail to a minimum. The handrail guide design shall allow a wide range of materials which allow a better adaptation to the escalator design and to the building design and safety. There shall be no wedge action between floor and the handrail. The safety switch should be located such that misuse and abuse is avoided.

17.1.12 BALUSTRADE:
The purpose of the balustrade shall be the safe transportation and assurance of the passengers. The balustrade profile should be of aluminum or any other approved color finish.

17.1.13 INTERIOR / EXTERIOR PANELS:
Interior panels shall consist of self-supporting safety glass panels, not less than 10mm thick, the panel joints shall be at right angles to step nose line. Tinted glass in approved shade shall be provided as interior panels. Stainless steel exterior panelling with minimum 1.2 mm thick stainless steel sheet shall be provided as exterior panelling on the escalator, which shall give a smooth finish.

17.1.14 SKIRT PANEL:
The skirt panels shall be powder coated / stainless steel. The gap between the skirt and the step shall be kept to the minimum and will not exceed 3.0mm.

17.1.15 COMBS, COMB PLATES AND FLOOR PLATES:
COMBS: The combs shall be made of aluminum yellow powder coated. These shall be screwed to the comb plate for ease of replacement if necessary. The comb teeth shall have intentional rupture points so as to allow them to break easily in the event of an object getting trapped between the step and the comb thereby preventing serious damage. When escalator stops at least three steps should come in horizontal position at top and bottom landing for ease of boarding and lighting passengers from escalator.

COMB PLATES: The comb plates should be made from extruded aluminum profiles with laterally extending grooves preventing passengers from slipping. The grooves shall be powder coated black and the surfaces are finished.

FLOOR PLATES: There shall be a fixed floor plate and a removable floor plate allowing access to both machine room and maintenance room.
The fixed floor plates should be made from extruded aluminum profiles with laterally extending grooves to match the comb plate. The grooves shall be powder coated black and the surface finished. The removable floor plate shall be constructed from low weight extruded aluminum profile sections for ease of maintenance and removable by one service mechanic. The standard removable floor plate shall be recessed.

17.1.16 OPERATION PANEL & ESCALATOR MANAGEMENT PACKAGE:
Two different operation panels should be installed at upper and lower landing. They should be located in the panels next to the handrail entry guard on the right hand side looking onto the escalator from each landing.
The operation panel at the lower landing should be equipped with key switch and stop button only.
The operation panel at the upper landing should be equipped with key switch, key board display and stop button.
The standard operation panel shall be provided for easy identification if the handrail entry devices or the stop buttons have been tripped. This should reduce the service downtime as precise information about status of escalator is received.
The escalator management package should at least provide the following information on the operation and the status of the escalator:
- Nature of faults.
- Memory of faults (50 messages deep) e.g. amount of faults within a definite period of time.
- Operating hour counter (total and per week).
- Start counter (total and per week).
- Stopping distance and deceleration indicator.

17.2 ELECTRICAL SAFETY DEVICE:

17.2.1 EMERGENCY STOP BUTTONS AND KEY SWITCHES AT BOTH LANDINGS:
The emergency stop buttons and starting key switches shall be integrated in the operation panels which shall be installed at upper and lower landings. They shall be located in the panel next to the handrail entry guard on the right hand side looking into the escalator from each landing.

17.2.2 Operational Brake: The operational brake located between motor and gear box shall be an AC operated / DC commercial magnet.

17.2.3 NON-REVERSAL DEVICE: In case of an unintentional change of the escalators travel direction, the safety circuit will be interrupted and the operational brake applied.

17.2.4 HANDRAIL ENTRY DEVICE: The handrail entry devices shall be located in each hand rail entry box on both sides at the upper and lower landing. Should an object be drawn between the handrail and rubber guard it will push the guard and activate a contact to stop the escalator.

17.2.5 BROKEN STEP CHAIN DEVICE: The contacts shall be located at the lower landing at both sides of the tension carriage. In case of breaking or stretching of step chain, the tension carriage shall recoil by spring tension and release the contact. The contacts will get locked after being released and must be reset manually.
17.2.6 **COMB PLATE SAFETY DEVICE ACTING IN VERTICAL AND HORIZONTAL DIRECTION (AT BOTH LANDINGS):** The safety switches shall be located at both sides of each comb plate. If an object is drawn between the step and the combs, it will shift or lift the comb plate and activate the contact and stop the escalator. The comb plate shall be held down by adjustable springs.

17.2.7 **MAIN CIRCUIT BREAKER:** It shall be located inside the upper landing. The main switch should have locking arrangement in the “OFF” position.

17.2.8 **CIRCUIT BREAKER:** It shall be located inside the lower landing.

17.2.9 **GROUND CONTACT:** Two separate connections should be located in the upper landing on the top of the lower chord and in the lower landing.

17.2.10 **MOTOR THERMIC DEVICE:** If the motor winding temperature reaches more than 155 degree C, the escalator should switch off by this protection against overheating. The motor thermic device shall be located inside the winding of the motor.

17.2.11 **STEP CHAIN ROLLER MONITORING SWITCH:** The safety switches should be located at both sides on the upper landing. Proper running of step chain / rollers should be monitored by these switches. In case of lowered rollers e.g. due to breaking of step chain tyres, the escalator shall stop.

17.2.12 **SOCKETS FOR MANUAL INSPECTION & MANUAL INSPECTION CONTROL DEVICE:** It shall be provided to facilitate service adjustment and repair. Consisting of one portable switch box and two sockets one of which is attached to the controller cabinet and the other to the junction box at the lower landing. The escalator will be moved by turning the up or down rotary switch and then pressing the start button.

17.2.13 **HAND LAMP:** A hand lamp should be provided with the escalator. In both, upper and lower maintenance rooms, sockets shall be provided.

17.2.14 **ASYMMETRIC RELAY / PHASE MONITORING DEVICE:** It shall be integrated in the controller. This relay shall stop the escalator in case of non-symmetrical main current supply.

17.2.15 **OVERSPEED GOVERNOR:** It shall be located at the upper end of the motor shaft. A centrifugal governor should interrupt the over-speed switch and stop the escalators in case the motor exceeds its nominal speed by 20%.

17.2.16 **BROKEN STEP AND CHAIN WHEEL CONTROL CONTACT (AT BOTH LANDINGS):** The broken step and chain wheel control contacts shall be located at both landings. The contact shall activate if either a step or chain wheel breaks or if a step is lowered due to rupture.

17.2.17 **SKIRT PANEL SAFETY SWITCH:** If a foreign object is trapped between the side of a step and the skirt panel, the safety switch shall activate. The skirt panel switches shall be mounted to the chain wheel track at the upper and lower landings on both sides of the escalator.
17.2.18 **CONTROL CONTACT FOR LIFTED BRAKE:** The operational brake control switches should prevent starting of the machine in case the operational brake is closed.

17.2.19 **CONTROL CONTACT FOR BRAKE LINING WEAR:** When brake linings are worn, switches should activate and prevent the machine from starting. After this brake lining should be replaced immediately.

17.2.20 **MAIN DRIVE CHAIN SAFETY DEVICE:** An abnormal movement of the tension device piston should activate the switch, applying the main drive brake.

17.2.21 **STEP WHEEL UP THRUST TRACK DEVICE:** The device shall be provided to prevent any accident in case of foreign bodies trapped between two steps entering the landing section. The step trailer wheel up thrust contacts are attached to the brackets mounted on the up thrust tracks. The contacts shall activate, when a step is lifted up and not level with the flat landing section.

17.2.22 **FLOOR PLATE CONTROL CONTACT AT BOTH LANDINGS:** Safety switches shall be located at upper and lower landing. The floor plates shall be safety switch controlled. In case during operation one or both floor plates are not properly closed, the escalator should stop.

17.2.23 **EARTH LEAKAGE PROTECTION:** Earth leakage fuse to protect users and maintenance staff on and inside escalator should be provided against electric shock.

17.2.24 **SAFETY STRIP OR BRUSH GUARD:** A safety strip or brush guard should be fitted at the corner of the balustrade and moving step on both sides to prevent objects from being trapped in that area.

17.2.25 **STEP SAFETY DEMARCATION:**
  i) Yellow resin on 3 sides to be provided as step safety demarcation.
  ii) Traffic Light: LED traffic light with movable arrow sign shall be provided.
  iii) Skirting Brush: Skirting brush to be provided at left/right skirting panel to cover the gap between step and skirting.
  iv) Skirting Lighting: Skirting lighting to be provided in the skirting panel on both left and right sides.

17.3 **ESCALATOR REMOTE SYSTEM:**
Provision shall be made for remote operation of Escalator and status indication in case of Building Automation.
17.4 LIGHTING:
   i) TRAFFIC FLOW LIGHT AT BOTH LANDINGS:
      Traffic flow lights shall be provided for intermittent operation. To prevent
      passenger confusion, both landings must be equipped with one traffic flow light.
      They shall be situated on the horizontal outer decking.
      Traffic flow light should be located either on the left or right hand side to suit the
      site requirements. It should have dynamic signs illuminated by a single LED
      matrix and shall be contained within sloped transparent cylinders which are
      directly fixed at the outer decking. The background color of the stop sign shall
      be red and the horizontal bar shall be yellow.
      The background of the direction sign shall be dark and the arrow illumination
      shall be green.
   ii) COMB LIGHTS AT BOTH LANDINGS:
      The first step leaving or entering the combs be highlighted by the comb lights at
      each landing thereby increasing passenger awareness and facilitating boarding
      and exiting of the escalator. The comb light allows the passengers to
      differentiate clearly between the fixed comb plate and moving steps.

17.5 INFRARED SENSOR:
   Sufficient number of infra-red sensors shall be used for intermittent operation or to
   accelerate the escalator from standby to normal speed and will not require any
   human touch. The whole system shall be extremely reliable and grit, water or dust
   shall not influence its function.

17.6 PAINTING:
   All the metal part, likely to be rusted, should be painted with paint / powder coating /
   anodizing after an anti-corrosive treatment.

18. INSPECTION AND TESTING:
   PRE-DELIVERY INSPECTION:
   Authorized representative of AAI shall carry out the pre-delivery inspection of
   escalators at manufacturers’ works before dispatch (advance intimation at least 30
   days prior shall be given to inspect the material). Following tests shall be carried
   out:
   A. Dimensional checks of the different items shall be carried out as per technical data
      sheet / confirmed by contractor.
   B. Test certificate for the items procured from other origin shall be produced.
   C. Various parameters like current, voltage, etc. shall be recorded during these tests.
   D. Detailed inspection of all the components of escalators, which shall comprise of
      mechanical and electrical checks.

   TESTING OF INSTALLATION AFTER COMPLETION:
   • The escalator be tested at site in accordance with test specified in IS specification
     4591-1968 with up to date amendment.
   • All the relays, contactors, indicating lamps shall be functionally tested for their
     smooth and efficient operation to the satisfaction of the Engineer-in-charge.
   • Noise level shall be tested at various points, one meter away from the escalator.
   • Insulation resistance of the electrical system shall be tested in accordance with IS
     standards.
   • Necessary testing equipment’s and other requirements for tests shall be arranged
     by the contractor during the test.
Part II – FIRE FIGHTING
SYSTEM
FIRE DETECTION SYSTEM & ALARM SYSTEM
ADDRESSABLE FIRE DETECTION & ALARM SYSTEM

1.0 GENERAL DESCRIPTION AND SCOPE OF WORK

1.1 This section covers the requirement of intelligent analog addressable fire alarm system as per specification under the scope of work (SOW).

1.2 The work described in this specification consists of all labour, materials, equipment and services necessary and required to complete, test and commission the fire detection and alarm system. Any material not specifically mentioned in this specification but required for proper performance and operation shall be provided and installed for a complete and operational system, by the contractor without any extra cost to AAI.

1.3 The contractor shall furnish, and install complete and ready for intended use and operation, an intelligent, addressable fire detection and alarm system including Fire alarm panel(s), response indicators, relay modules, control module, repeater panel, initiating devices (manual call stations, addressable multi sensor detectors, etc.) indicating devices (sounders, bells, visual warning signals etc.) and supervisory devices, annunciators, wiring apparatus and accessories.

1.4 The installation and locations of equipment and devices in the building shall be governed by the relevant codes / standards with due regard to actual site conditions, manufacturers’ recommendations, ambient factors affecting the equipment and other operations in the vicinity.

1.5 Materials and equipment supplied shall be new, standard; current models of the manufacturer and shall be suitable for this system. Where two or more pieces of equipment performing the same function are required, they shall be exact duplicates produced by the same manufacturer.

1.6 All materials, devices, and equipment shall be compatible with the circuits or systems in which they are utilized.

1.7 Provision shall be made for interfacing Fire System Panel(s) through BMS / PA. The panel shall be capable of inter-connected with BMS and shall have open code architecture / open protocol.

1.8 In addition to SITC of Fire detection and alarm system, the following work shall also be deemed to have included in the scope of work to be executed by the Contractor within his quoted amount.

i) It includes obtaining approvals from Chief Fire Officer / Fire Department concerned and all other statutory authorities for complete scope of work as per the prevailing rules & regulations etc.
ii) The Fire Detection and Alarm System of the building shall be integrated with respective to the zoning of PA system so that, in case of fire, the PA system shall automatically come in announcement mode of that particular zone and play pre-recorded evacuation messages from PA system.

iii) Providing repeater panel at Main Fire Station Control Room and interconnecting the same with main FACP installed in the Terminal Building.

1.9 This installation shall be made in accordance with the specifications i/c local codes and local fire authorities having jurisdiction over this project.

1.10 Fire Detection & Alarm System Installation work shall be carried out in accordance with Indian Standard Code of Practice for Electrical Wiring Installation IS: 732 - 1989, IS: 2274-1963 and IS 2189-2008 with up to date amendment.

1.11 It shall also be in conformity with the current Indian Electricity rules and regulations and requirements of the Local Fire Authority. The Intelligent Addressable Fire Detection & Alarm system in general shall be carried out as Specified.

2. Standards & Codes

All equipment and installation shall be installed in compliance with the following codes and listing with update amendments:

**LOCAL CODES**

<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
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<tbody>
<tr>
<td>CPWD – General Specifications for Electrical Work – Part VI</td>
<td>Fire Alarm and Detection System - 2018</td>
</tr>
<tr>
<td>National Building Code-2016</td>
<td>Fire and Life safety</td>
</tr>
<tr>
<td>IS: 2175</td>
<td>Specification for Heat Sensitive Fire Detectors for Use In Automatic Fire Alarm System</td>
</tr>
<tr>
<td>IS : 2189</td>
<td>Selection, installation and Maintenance of automatic fire detection and alarm system code of practice</td>
</tr>
<tr>
<td>IS: 11360</td>
<td>Specification for smoke detectors for use in automatic electrical fire alarm system</td>
</tr>
</tbody>
</table>

**NATIONAL FIRE PROTECTION ASSOCIATION (NFPA) - USA**

<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
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<tbody>
<tr>
<td>NFPA 71 &amp; 72</td>
<td>National Fire Alarm Code</td>
</tr>
<tr>
<td>UL 464</td>
<td>Audible Signaling Appliances</td>
</tr>
<tr>
<td>UL 38</td>
<td>Manually Actuated Signaling Boxes</td>
</tr>
</tbody>
</table>

**BRITISH STANDARD (BS EN54) – EUROPE**

<table>
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<tr>
<th>Code</th>
<th>Description</th>
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<tbody>
<tr>
<td>BS 5839</td>
<td>Fire alarm system Design</td>
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</table>
Wherever these specifications calls for a higher standard of material and or workmanship than those required by any of the above mentioned regulations and specification then the specification here under shall take precedence over the said regulations and standards.

3. TECHNICAL DATA AND SHOP DRAWINGS SUBMISSION

Technical submittals and shop drawings for all equipments/ materials are to be submitted by EPC Contractor as per functional / site requirement to the Engineer-in-Charge in 3 sets and be approved by him before procurement and commencement of work. All such drawings shall show the dimensions of all equipment and installation. Drawings include the following not limited to:

iv. Block Diagram showing all detectors and devices area wise, their connectivity to the panel including wire description.

v. Point-to-point wiring diagrams showing the points of connection and terminals used for all electrical field connections in each system, all equipment or systems which are supervised and controlled by the fire alarm system. Diagrams shall show all connections from field devices to the control panel initiating modules, output modules, switches, relays and terminals. Diagrams shall show interconnection of all devices, modules, output modules, switches, relays and terminals.

A further set (4 copies ) of all approved shop drawings shall be supplied by the EPC Contractor for use of the Engineer-in-Charge for execution of work.

4. POWER SUPPLY

a. The control panel shall drive from 230 Volts main power supply. In case of failure of main power supply, the panel shall be automatically switched over to standby power supply i.e.UPS along with battery. The standby supply shall be such that when charged by associated battery charging equipment it can operate independently for a period of 24 hours normal working and then be capable of operating the system for 30 minutes during an emergency / fault conditions. Batteries shall be of Lead Acid type sealed Maintenance free / Li-ion (lithium batteries are also accepted without any additional cost to AAI).

b. In addition to the batteries, an automatic SMPS battery charger suitable for operation on the auxiliary power (available in the plant) shall be installed by EPC contractor. The capacity of the charger shall be such that the same can charge the battery (within 8 hrs) while supplying the rated load of the fire detection system. Facilities shall be provided to limit the voltage supplied to fire detection and alarm system to their rated values during the time of charging. The charger shall normally supply the battery trickle charging current and the DC load of the fire detection and alarm system. In case the AC supply on the input side of the charger fails the necessary power for the complete fire detection and alarm system shall be supplied by the UPS.

c. Visible and audible annunciation for troubles or failure in the power supply system like "charger Failure", "Battery Low Voltage", etc. shall be provided.

d. Battery fault indication/annunciation shall be included in the panel.
5. DESIGN REQUIREMENT

a) The system shall be provided with multiple loops and distributed as per site requirement on award of work. All devices shall be connected directly to the loop with suitably sized fire survival Circuit Integrity armoured cables. The system shall be compatible to integrate with the PA / BMS system.


c) The Panel shall have necessary Logic Software and Hardware built into it for time delay starting of strobe.

d) Suitable racks shall be provided for housing control panel & equipments if required etc.

6. SPECIFICATION

The design, supply, installation testing & commissioning of entire fire alarm system shall conform to BS / NFPA 72. All devices including Main Fire Alarm Panel shall be UL / EN listed.

6.1 ADDRESSABLE MAIN FIRE ALARM PANEL

a) The Fire Alarm Control Panel shall be Modular Microprocessor based expandable fully intelligent Addressable Control Unit which shall control all intelligent addressable detectors, manual call stations Control / Monitor module etc. connected to it with QWERTY keypad / separate keyboard.

b) All Addressable Units shall be connected to the Panel through the Loop Cards and shall be addressed through individualized numbers. The Panel shall be able to obtain intelligent value for all detectors in the circuit through a pulsed digitalized current data. The panel shall be able to analyze all intelligent inputs from all addressable units and through its own software and ambient level screening the panel shall be able to identify fire, possible fire or fault conditions. The unit supervision shall be dynamic and continuous.

c) The Fire Alarm Panel itself shall have all loop cards in it. No isolated mother board or transponder is allowed. Each loop shall be able to access a minimum of 240 addressable detectors / devices (in any combination) per loop. Panel shall be expandable.

d) The Panel shall also give adequate warning signal whenever there is Dust Accumulation in Detectors, and upto the point of its replacement it should be possible to change the level of ambient alarm calibration condition either by the use of software programme operable by the AAI or by resetting the detector.

e) Short-circuiting, loose wiring or missing units shall also be reported at the panel with pinpoint or segment-wise location. In such cases, the system through the use of Fault Isolators shall be able to isolate that segment between the two Fault Isolators.

f) The panel shall have a LED / liquid crystal display (LCD) type on it to indicate immediately all conditions. In case of testing of the system from the panel, the display shall be able to give readouts of intelligent value of all detectors being tested. The panel shall also be able to carry out continuous self-monitoring when in normal condition.

g) Number of detectors / devices per loop should not be exceeding 80 percent of the full
capacity of each loop as per IS code.

h) The panel shall have either an in-built or external printer coupled to the panel which shall log all events with time. The **printer shall be suitable for printing panel's event logs or as per the configuration to print automatically any of the events such as Fire, Fault, Alarm or Test, the unit address, time along with option for printing the Inputs, Outputs, Disablements, Network Faults etc.**

i) The panel shall also be able to discriminate between false alarms and fire conditions, as well as priority selection of alarm address in case alarm activates in two or more remotely located units simultaneously. In such cases, the manual call box shall be reported first, group of sequentially laid detectors (in one room for example) second and a detector with the greatest obscuration over a period of time third.

j) Any time, the operator shall have following manual capacities at fire alarm panel under password control:
   - Operator privileges & ID number of upto four digits shall be assignable only by the main operator or designated official.
   - Action taken by operator shall be automatically printed on FAP printer with operator initial, date and time.

k) The panel shall also be able to actuate switches automatically in case of fire condition that of AHU’s power supply or other systems like smoke extract fans, fire damper etc

l) The system shall be fail safe and adequate safe guards should be under taken that in the event of a failure of a part of the system it shall not handicap the complete system. The motherboard shall be of modular construction.

m) The Contractor shall undertake the responsibility of the complete installation, commissioning, user trials, training and maintenance of the system as required. The software shall be such so as to be easily operated by the operator , is secured against Software errors, ability to be upgradable so as to incorporate more detector units or replacement / changing of detector units, can incorporate more features at a later date such as illumination control, security etc.

n) It shall be able to withstand temperature variations from 0 degree to 49 degree Centigrade. The acceptable Relative Humidity (non condensing type) shall be upto 93%. The voltage rating shall be from as per OEM, though the voltage may be changed depending upon the working voltages of a proprietary fire alarm panel.

o) The rack for panel/ panel enclosure shall be totally enclosed dust and vermin proof type made of **suitable** gauge dust inhibited sheet with finish. The panel shall be of completely solid state design.

p) The logic circuitry shall be based on high noise immunity solid state hardware employing modular construction. Logic cards shall be of epoxy fiber glass construction.

q) The system shall meet the BS / NFPA 71 & 72 standards and shall be listed with UL / EN (Latest Versions).
r) The panel shall have facility to connect printer to printout log and facility to have seamless integration with analog/digital voice evacuation system (PA-System), fire fighter telephone system and shall be complete with all accessories. The panel shall be compatible for IBMS system with open protocol BACnet/Modbus over IP complete as required. Programming software for the system, Automatic system test activates, Detector sensitivity adjustments, Alarm verification, Alpha/numerical display.

s) The design of the panel hardware and software shall incorporate the capability to accept additional input from fire protection system such as sprinkler and water flow switch, operation of fire dampers, pressurization fans, AHUs etc.

t) The fire alarm panels shall have a possibility of being interlinked by direct connectivity or an optical cable link between the various locations and should further have connectivity to the main control center.

u) There shall be minimum 20% spare capacity in the looping system for future expansions. The Contractor has to intimate the maximum number of devices/detectors can be connected in one loop based on the manufacturer design.

v) Central graphical fire alarm management system to centrally monitor and operate the fire alarm system complete as required. The fire alarm management system shall be a multuser graphical management system to centrally monitor and operate the fire alarm system by a computer having a graphical software. The Operator workstation shall be with i7 processor, 4GHz mother board, 8 GB RAM, 2TB HDD, CDWR, 32" LED colour monitor, Wireless mouse - key board, speakers, UPS, inter connecting connectors,USB 3.0 and all other accessories, licensed latest Windows Operating system Software & Licensed Anti-Virus Software and laser printer suitable for ‘A-4’ size. The fire alarm management system shall also have the following facilities.

   i. All the messages and status of the connected detectors & devices with main control panel shall be displayed on the PC monitor to operate via keyboard and mouse.

   ii. All devices & detectors should be visible on building plans superimposed in fire alarm system.

   iii. The modular expansion of the system should be possible by adding software modules.

   iv. Power graphics with a dynamic zoom function should be available.

   v. The system shall have password system with individual password and access privileges shall also be available.

   vi. The system should be capable of monitoring status of detector.

   vii. The operator should be able to define the entire database for the fire system.

   viii. The operator should be able to acknowledge alarm or trouble messages by the fire alarm system.
6.2 INTELLIGENT ADDRESSABLE MULTI SENSOR DETECTOR

a) The detector shall have both optical and thermal sensor and shall be capable of working in combined mode (Optical + Thermal) or heat mode (only Thermal) or smoke mode with inbuilt fault isolator or to provide fault isolator at every 20 nos. complying NFPA guidelines.

b) The combined modes of operation both the inputs from the optical and thermal sensors are processed using special algorithms before an alarm decision are made. If the presence of smoke is detected above a threshold value for a period of time or if heat sensor temperatures rise above certain fixed temp or rate of rise, than an alarm condition will be generated. In “heat only” mode only temperature above certain fixed level will generate an alarm conditions.

c) The microprocessor design shall be capable of selecting the appropriate sensitivity levels based on the environment type it is in (office, kitchen etc.) and then have the ability to automatically change the setting as the environment changes in order to avoid nuisance alarm.

d) The multi sensor detector shall be a combination of smoke & heat and it can be used as a smoke detector, as a heat detector or as a combined smoke/heat detector upon demand and is programmed and set-up specifically for the environmental conditions that it is part of. It should detect smoldering and open fires at an initial stage by being able to detect and evaluate the characteristics of fire and smoke (Tyndall or relevant applicable principle) as well as heat (NTC sensor / thermistor principle). The sensitivity of the detector can be adjusted, if required as per site conditions.

e) The multi sensor detector shall activate on receiving smoke particles in the 0.5 to 10 micrometer range or as per OEM specification. The detector shall be completely solid state with LED indication.

f) The detector shall be able to sense incipient fire by detecting the presence of visible and invisible products of combustion. The detector shall be suitable for low voltage two wire supply as per OEM. The sensitivity of the detector shall not vary with change in ambient temperature, humidity, pressure and voltage variation.

g) Neither its performance shall be affected by air current upto 10 mtr. per second. The detector shall be suitably protected against dust accumulation / ingress and it shall be free from maintenance and functional test at intervals. All detectors shall be identical in construction design and characteristic to facilitate easy replacement. The detector housing shall be damage resistant made of Fire resistant polycarbonate or proprietary self-extinguishing material.

h) The coverage per detector shall be as listed with UL / EN. This coverage area will reduce depending upon structural configurations or partitions etc. The sensitivity of detector shall be set adjusted by the supplier to suit the site requirement.

i) The multi sensor detector shall be intelligent addressable detector with electronic addressing or manually-set digital code and be able to give intelligent output to the fire alarm panel regarding its condition.

j) The Base of the detector shall be interchangeable with other detectors and the construction shall be of polycarbonate or any approved flame retardant material. The enclosure shall at least meet IP 54 protection grade.

k) It shall be able to withstand temperature variations from 0 degree Centigrade to 50 degree
Centigrade. Relative humidity (non condensing type) upto 93% shall not hamper its performance. The voltage rating shall be as per OEM, though the voltage may be changed depending upon the working voltages of a proprietary Fire Alarm Panel.

l) The Detector shall meet the requirements of UL / EN and be approved by UL / EN. It shall be possible to test the detector’s working both from the Panel as well as locally by means designed by the Contractor.

m) Signals from detectors that are normally not visible shall be extended in the shape of Response Indicators to a suitable location, which is easily visible. The response Indicator shall be lit by means of twin LED’s in red colour and shall be housed in MS box / Aluminium die cast box. For detectors above false ceiling, the Response Indicators shall be installed either right below on the false ceiling or on the nearby wall/column with bottom 300 mm below false ceiling. Alternatively all Response Indicators shall be located at convenient places as approved. The cover plate of the Response Indicators shall also boldly display the detector number to which they correspond.

6.3 ADDRESSABLE MANUAL CALL POINT

Manual Call Station shall be of Pull / Push down Reseetable type units with inbuilt fault isolator or to provide fault isolator at every 20 nos. complying NFPA guidelines, completely encased in a cast aluminium housing or in 16 gauge MS / LEXAN / Polycarbonate, with provision for cable or conduit coupling. The Manual call station shall have the word prescribed in clear bold letters on facia window “In Case of Fire / Push In / Pull Down / as per OEM”. Its casing shall be of red color:

The Manual Call Box Station shall be fully addressable with its own set code and operated by digitized signals sent from the Panel. The Voltage range shall be as per OEM. It shall have protection as per IP 54 for indoors & IP 65 enclosure for outdoor applications. The operating temperature range shall be from 0 degree C to 50 degree C. Relative Humidity (non condensing) range for performance parameters shall be between 0 to 93%.

6.4 ADDRESSABLE HOOTER CUM STROBE

The wall mounted Hooters cum Strobe with inbuilt fault isolator or to provide fault isolator at every 20 nos. complying NFPA guidelines, shall be suitable for indoor and outdoor application with adjustable sound level of 90 db to 120 db at 1M distance. Strobe shall be of red colour. It shall flash at 1Hz over the strobe’s entire operating voltage. The Hooters cum Strobe shall be addressable and loop powered or the same shall be made addressable using required input and control modules and suitable power supply unit to be considered with the item if it is not loop powered.

6.5 ADDRESSABLE DUCT SMOKE DETECTOR

The smoke detector housing shall accommodate an intelligent photoelectric detector, of that provides continuous intelligent monitoring and alarm verification from the panel. The Duct Casting Units shall be directly installed in the air conditioning ducts (Return air) for detecting any hazardous quantity of products of combustion being carried through the ducts.
The complete unit shall consist of a housing to accommodate Photo Electric Detector with plug - in facility and sampling tubes, one for air inlet and other as the air outlet. The Inlet tube shall extend into and across the duct width (from 0.5 meter to 3.0 meter), the outlet tube shall be of fixed length of 7.5 cm length.

When the AHU blower fan operates, a continuous cross sectional sampling of air from the duct shall flow through the housing containing the Detector. The outlet tube shall return the sampled air into the duct.

The housing shall be mounted outside the duct; the probe tubes shall be inserted through the duct by cutting precision sized holes into the duct and sealed with rubber gaskets.

6.6 ADDRESSABLE NETWORK REPEATER PANEL

The Network Repeater Panel shall be provided to display all system intelligent points (Devices). It shall be capable of displaying all information for all points (devices) on the network.

Network repeater panel shall have with minimum 320-character LCD (minimum) touch screen coloured LCD display / HMI Display with touch sensor. It shall be possible to silence alarms, evacuate and reset.

6.7 MODULES

6.7.1 MONITOR MODULE (FOR INPUT TO FIRE ALARM PANEL)

The Input Device and inbuilt fault isolator or to provide fault isolator at every 20 nos. complying NFPA guidelines shall provide an addressable input for N.O. or N.C. contact devices such as manual water flow switches, pressure switches, etc. The input device shall provide a supervised initiating circuit.

An open-circuit fault shall be annunciated at the Fire Alarm panel (Subsequent alarm shall be reported.) The device shall contain an LED which blinks upon being scanned by the Fire Alarm panel. Upon determination of an alarm condition, the LED shall be latched on. The operating voltage shall be in the range of 15 to 32 VDC, Maximum current draw 5.0 mA (LED on).

6.7.2 CONTROL MODULE (FOR OUTPUT FROM FIRE ALARM PANEL)

The Output Device shall provide a control relay where required as per site / equipment locations. The relay contacts shall be SPDT rated at one amps / per OEM, 24 V DC. The device module shall contain an LED which blinks upon being scanned by the Fire Alarm panel. Upon activation of the device, the LED shall be latched on.

Relay modules shall be of addressable type available for HVAC control and other building functions. The relay shall be rated for a minimum of 2.0 Amps resistive or 1.0 Amps inductive. The relay coil shall be magnetically latched to reduce wiring connection requirements, and to insure that 100% of all auxiliary relay or NACs may be energized at the same time on the same pair of wires. Monitor module shall be addressable type and shall derive power from the loop for its operation.
6.8 FIRE SURVIVAL CIRCUIT INTEGRITY ARMOURED CABLES
Fire survival Circuit Integrity armoured cables (600/1000V) shall be LPCB certified having class-2 Copper conductor as per BS EN 60228 & having extruded layer of cross-linkable halogen free ceramified silicon insulation as per BS EN 50363. The Inner & outer sheath of cable should have low smoke zero halogen (LSZH). The cable should meet fire performance circuit integrity tests as per BS 6387 CWZ & BS EN 50200 PH -120 in accordance to clause 26.2 of BS 5839-1. Outer sheath should be in red colour with Anti-Rodent properties.

Fire survival Circuit Integrity cable shall comply to EN 61034-2 for Light Transmittance Test & EN 60754-1 for Halogen Acid Gas Contents.
Additional Make: AFW / INDIA-IMPEX / PRYSMIAN

7. TESTING
7.1 RANDOM SAMPLE TESTING:
About 5% of all fire alarm components shall be subjected to random testing by connecting to the panels. All smoke detectors shall be tested as given above and later cleaned with a vacuum cleaner. Hooters shall also be tested through direct 24V supply for 10 minutes.

7.2 TESTING OF EARTHING SYSTEM:
The earth continuity conductor including metallic parts of the equipments shall be tested for earth to electrical continuity. All tests shall be carried out as per IS 3043 and resistance of complete installation shall not be more than one ohm.

7.3 TESTING AT SITE:
i) All commissioning tests at site will be in line with NFPA / EN (Latest)/IS/CPWD.

ii) Following test shall be conducted:
   - Loop Checking.
   - Checking of multi sensor detectors etc. by simulation/functional test by Aerosol Spray or as recommended by the manufacturer.
   - CHECKING
   - Functional tests for fire alarm panel.
   - The Mock trial of the complete Fire Detection and Alarm system.

7.4 Tests Certificates
Tests certificates will be furnished for all Fire alarm system devices by the manufacturer.

8. COMMISSIONING AND ACCEPTANCE TESTS
The commissioning and acceptance tests shall be apart from the standard or routine tests prescribed and normally conducted by the manufacturer or their authorized channel partner / EPC Contractor and will be irrespective of the fact whether the same are covered by such tests or not. All commissioning tests at site will be in line with NFPA 71 and 72.

a. Each sounder circuit shall be energized separately and the sound level reading taken to check for conformity with the minimum standards.
b. Mains failure performance.
c. Battery disconnection test.
d. Open circuit of each sounder circuit to be tested.
e. Short circuit of each sounder circuit to be tested.

The results of the above tests either by fault warning or fire alarm shall be recorded in the log books which will be signed both by the Contractor and the AAI’s Representative.

9. ASPIRATING SMOKE DETECTION SYSTEM

9.1 Scope of Work

i. This specification covers the requirements of design, supply of materials, installation, testing and commissioning of Aspirating Smoke Detection System. The system shall include all equipment’s, appliances and labour necessary to install the system, complete with highly sensitive Smoke Detectors with aspirators connected to network of sampling pipes.

ii. The Contractor shall also make provision in the Aspirating Smoke Detectors to give trip alarm to trip AHU and to shut fire dampers in the event of fire through the relay contacts as per site requirements.

iii. Zoning and panels for the system shall be designed and proposed by the contractor.

iv. The system shall be integrated with the main fire alarm control panel.

9.2 Codes and standards

The entire installation shall be installed to comply one or more of the following codes and standards:

NFPA Standards-75 / 76 / 72
British Standards, BS 12839 part: 1

9.3 Approvals

All the equipments shall be designed, tested, approved, and/or listed by: LPCB (Loss Prevention Certification Board), UK
FM (Factory Mutual), US
UL (Underwriters Laboratories Inc.), US
ULC (Underwriters Laboratories Canada), Canada
VDS (Verbandder Sachversicherer e.V), Germany

The manufacturer shall be certified as meeting ISO 9001:2008 for manufacturing.

9.4 Design Requirements

i. The System shall consist of a highly sensitive short wavelength Laser based detection chamber with particle imaging, aspirator, and filter with memory.

ii. It shall have a display featuring LCD / LEDs and Reset / Isolate button. The system shall be configured by a programmer that is either integral to the system, portable or PC based.
iii. The system shall allow programming of:
   a) Multiple Smoke Threshold Alarm Levels.
   b) Time Delays.
   c) Faults including airflow, detector, power, filter block and network as well as an indication of the urgency of the fault.
   d) Configurable 4 relay outputs for remote indication of alarm and fault Conditions.

iv. It shall consist of an air sampling pipe network to transport air to the detection system, supported by calculations from a FM approved computer-based design-modeling tool. Maximum transport time shall not exceed 90 seconds.

v. Optional equipment may include intelligent remote displays and/or a high level interface with the building fire alarm system and a dedicated System Management graphics package.

vi. Performance Requirements
   a) Shall provide very early smoke detection and provide multiple output levels corresponding to Alert, Action, and Fire 1 & 2. These levels shall be programmable and shall be able to set sensitivities ranging from 0.0015–20% obscuration / meter.
   b) Shall report any fault on the unit by using configurable fault output relays or via the graphics Software.
   c) Shall monitor for filter contamination automatically.
   d) Shall incorporate a flow sensor in each pipe and provide staged airflow faults.
   e) Shall have a clean air supply to maintain chamber clean all the time.

9.5 Materials and Equipment's

i. Both Light Scattering and Particle Counting shall be utilized in the device as follows:
   The detection Chamber shall be of the mass Light Scattering type combined with particle imaging and capable of detecting a wide range of smoke particle types of varying size. A particle counting method shall be employed for the purposes of
   a) Preventing large particles from affecting the true smoke reading.
   b) Monitoring contamination of the filter (dust & dirt etc.) to notify automatically when maintenance is required.

ii. The Detection Chamber shall incorporate a separate secondary clean air feed from the filter; providing clean air barriers across critical detector optics to eliminate
internal detector contamination.

iii. The detection chamber shall be factory calibrated and shall not use adaptive algorithms or drift compensation to adjust the sensitivity from the set values during commissioning. A learning tool shall be provided to ensure the best selection of appropriate alarm thresholds during the commissioning process.

9.6 Detector Assembly

i. The Detection chamber, Filter, Aspirator and Relay Outputs shall be housed in a mounting box and shall be arranged in such a way that air is drawn continuously from the fire risk area by the Aspirator and a sample passed through the Filter and then to the detector.

ii. The detector shall have an obscuration sensitivity range of 0.0015 – 20% obscuration per meter.

iii. The detector shall have four independent field programmable smoke alarm thresholds across its sensitivity range with adjustable time delay for each threshold level in the range of 0 to 60 secs.

iv. The Detector shall also incorporate facilities to transmit the following faults:

   a) Detector
   b) Airflow
   c) Filter
   d) System
   e) Zone
   f) Network
   g) Power
   h) Urgent and Minor faults. Minor faults shall be considered as servicing or maintenance signals. Urgent fault shall indicate that the unit may not be able to detect.

v. The detector shall have four pipe inlets, which must contain a flow sensor. Both Minor and Urgent flow faults shall be reported.

vi. The filter must be a disposable filter cartridge capable of filtering particles in excess of 20 microns from the air sample. The second filter shall be ultra-fine, removing more than 99% of contaminant particles of 0.3 microns or larger, to provide a clean air barrier around the detector's optics to prevent contamination and increase service life.

vii. The aspirator shall be a purpose-designed impeller air pump. It shall be capable of allowing / supporting for a single pipe run / multiple sampling pipe runs with a transport time of less than 90 seconds.
viii. The Assembly must contain relays for fire alarm and fault conditions. The relays shall be software programmable (latching or non-latching). The relays must be rated at 2 A at 30V DC. Remote relays shall be offered as an option and either configured to replicate those on the detector or programmed differently.

ix. The Assembly shall have built-in event and smoke logging. It shall store smoke levels, alarm conditions, operator actions and faults. The date and time of each event shall be recorded. Each detector (Zone) shall be capable of storing up to minimum 18,000 events.

9.7 Displays on the Detector Assembly

The detector shall have a LCD / LED / Bar graph display for the multiple alarm threshold levels indicated and faults such as detector fault, airflow fault and indication for Isolate and Reset.

9.8 Programmers

i. When required, a Programmer module may be located within the detector, or in remote mounting box, or in a portable hand-held unit.

ii. Each Programmer at a minimum shall support the following features:

a) Programming of any device on the system.

b) Viewing of the status of any device in the system.

c) Adjustment of the alarm thresholds of a nominated detector.

d) Setting of Day/night, weekend and holiday sensitivity threshold settings.

e) Initiation of Auto Learn, to automatically configure the detectors alarms threshold settings to suit the current environment.

f) Multi-level password control.

g) To Program latching or non-latching relay operation.

h) To Program energizing or de-energizing relays.

i) To Program high and low flow settings for airflow supervision.

j) To Program aspirator speed control.

k) To Program maintenance intervals.

l) Facilities for referencing with time dilution compensation.

m) Testing of relays assigned to a specific zone to aid commissioning.
9.9  Network

The devices in the smoke detection system shall be capable of communicating with each other via twisted pair RS4812 cable or be a part of Fire alarm loop. The network shall be able to support up to 200 devices (detectors, displays units and programmers), of which at least 100 detectors can be supported.

The network shall be capable of being configured in a fault tolerant loop for both short circuit and open circuit. Any communication faults shall be reported unambiguously and shall be clearly attributable to an individual device or wire link in the fault messages.

PC based configuration tools shall be available to configure and manage the network of detectors.

The detector shall support monitoring on Android or iOS based devices through Wi-Fi. In addition, the detector shall support on board TCP/IP. Connectivity via wireless access shall support WPA2 encryption with encryption key. Access to a detector via Ethernet or WiFi shall be protected using a detector password specific to the detector and in addition to the WiFi encryption key.

Digital Communication Port shall comply with EIA RS4812 Protocol.

9.10  System Manager Graphic Software for Complete Monitoring and Control of Very Early Warning Smoke Detection System:

The software package shall centrally monitor and configure very early warning smoke detection and fire protection systems in multiple local or remote locations.

The software package shall be compatible with smoke detection and fire protection systems that are approved by global approvals bodies and meet all local codes, standards and regulations.

The software shall consist of monitoring and configuration components:

The configuration component shall allow users to configure all detectors remotely by using a connected PC.

The monitoring component shall allow users to monitor individual detectors, multiple detectors connected via a HLI or multiple HLIs.

9.11  System Description

i.  Access and Usability

The software shall support local and remote password-based access control: Three local password-protected levels of software access: designer, user and administrator. Multiple user accounts with unique user-ID and password based access control. Remote password-management of remote fire networks. The software shall have a user-friendly graphics user interface.
The software shall support cut and paste functionality for common tasks. The software shall provide support for multiple languages including English. The software shall support translations of messages from one supported language to another. The software shall support disk space monitoring.

ii. Monitoring Functionality

The software shall have the capacity to monitor multiple connections: The software shall enable one or more workstations to monitor and configure multiple detector systems in multiple buildings and multiple sites.

The software shall provide an event list that provides a single integrated view of all events (faults / troubles and alarms) across multiple sites.

The software shall prioritize all events presented in the event list according to logical precedence rules.

The software shall allow management of all events from the event list including acknowledgement of events and resetting of devices.

The software shall allow colors to be assigned to different event types. The software shall allow printing of event lists.

The software shall be able to provide an all-in-one monitoring solution:

Using standard RS232 ports (or Ethernet) on existing and future monitoring and control systems, PCs using the software shall connect to and interpret status change data transmitted from the ports and provide graphic annunciation, control, history logging and reporting as specified herein.

Network systems that cannot interface to Network systems or systems requiring the use of a “dry contact” or “voltage monitoring” interfaces to connect to Network shall not be accepted.

The software shall be able to connect to multiple remote sites via IP-based LAN or WAN using virtual serial port emulation.

The software shall communicate with one or more Network-compliant detectors via a high-level interface (HLI) natively using the Network protocol without the necessity for using protocol translation or other communications equipment.

The software shall be able to monitor up to 2120 devices. The software shall be compatible with 4 alarm levels:

Alert (Alarm Level 1) – may be used to activate a visual and audible alarm in the fire risk area.

Action (Alarm Level 2) – may be used to activate the electrical/electronic equipment shutdown relay and activate visual and audible alarms in the Security Office or other appropriate location.
Fire 1 (Alarm Level 3) – may be used to activate an alarm condition in the Fire Alarm Control Panel to call the Fire Brigade and activate all warning systems.

Fire 2 (Alarm Level 4) – may be used to activate a suppression system and/or other suitable countermeasures (e.g. evacuation action or shutdown of systems).

The software shall allow importation of .wav files for event notification.

The software shall have a text-to-speech option to allow natural language annunciation of all faults and alarms:

The text-to-speech component of the software shall use Nuance's Real Speak speech engine.

The text-to-speech functionality shall be available in a number of different languages.

The software shall support sophisticated floor plan development and management functionality:

The software shall enable floor plan drawings to be used in the software to graphically notify users where a smoke event is occurring in their monitored system.

The software shall allow development of multiple levels of interconnected floor plans.

The software shall allow importation of AutoCAD, jpg, bmp and other common image files.

The software shall include software to allow designers to create and manipulate CAD images for incorporation in meaningful context-sensitive multi-level floor plans the software shall allow for multiple device smoke trending on a single graph. The software shall support printing on a printer such as a line printer that supports Unicode.

The software shall support sophisticated event log management functionality:

Event logs from all networked detectors shall be able to be retrieved and viewed.

Event logs for each monitored site and/or combined event logs for multiple sites.

Event logs shall be able to be archived and sorted.

Total event integration, consolidation and archiving across multiple networks shall be provided. All system, network and device events shall be stored in an ODBC-compliant database.

A remote notification facility shall enable the use of email (or SMS) to provide immediate and up-to-date information the system's operational status irrespective of location.

The software shall enable presentation of unique customized corporate response procedures upon occurrence of specific events in defined parts of the facility.

iii. Configuration Functionality

The software shall allow configuration of all models of detectors: Full remote programming of all detector functions.
Saving of detector configurations for safe storage.

The software shall allow creation of off-line configurations for all such detectors and allow a merge and compare of off-line configuration with on-line configurations.

iv. Performance Requirements

The Operator workstation shall be with i7 processor, 4GHz mother board, 8 GB RAM, 2TB HDD, CDWR, 32” LED colour monitor, Wireless mouse - key board, speakers, inter connecting connectors, USB 3.0 and all other accessories, licensed latest Windows Operating system Software & Licensed Anti-Virus Software and laser printer suitable for ‘A-4’ size

Hard Disk – 1 by 80 GB system Disk; 2 by 80 GB if connected to Raid Storage


9.12 Sampling Pipe (CPVC ISO Certified Pipes)

i. The sampling pipe shall be smooth bore with outer dia. of 25 mm. and inner diameter of 21mm.

ii. The pipe material should be suitable for the environment in which it is installed, or should be the material as required by the specifying body.

iii. All joints in the sampling pipe must be airtight and made by using solvent cement, except at entry to the detector.

iv. The pipe shall be identified as Aspirating Smoke Detector Pipe along its entire length at regular intervals not exceeding the manufacturer’s recommendation or that of local codes and standards.

v. All pipes should be supported at not less than 1.12 m at centres, or that of the local codes or standards.

vi. The far end of each trunk or branch pipe shall be fitted an end cap and drilled with a hole appropriately sized to achieve the performance as specified and as calculated by the system design.

vii. The pipe shall be fire retardant type.
9.13 Sampling Holes

i. Sampling Holes of 2mm, or otherwise appropriately sized holes, shall not be separated by more than the maximum distance allowable for conventional detectors as specified in the local codes & standards. Intervals may vary according to calculations.

ii. Each sampling point shall be identified in accordance with Codes or Standards.

iii. Consideration shall be given to the manufacturer's recommendations and standards in relation to the number of Sampling Points and the distance of the Sampling Points from the ceiling and roof structure and forced ventilation systems.

9.14 Installation

i. The Contractor shall install the system in accordance with the manufacturer's recommendation.

ii. Where false ceilings are available, the sampling pipe shall be installed above the ceiling and Capillary Sampling Points shall be installed on the ceiling and connected by means of a capillary tube.

iii. The minimum internal diameter of the Capillary tube shall be 12mm, the maximum length of the capillary tube shall be 2m unless the manufacturer in consultation with the engineer have specified otherwise.

iv. The Capillary tube shall terminate at a ceiling Sampling Point specifically approved by AAI. The performance characteristics of the sampling points shall be taken into account during the system design.

v. Air Sampling Piping network shall be laid as per the approved pipe layout. Pipe work calculations shall be submitted with the proposed pipe layout design for approval.

vi. The equipment supplier/installer shall be trained by the manufacturer to calculate/design, install, test and maintain the air sampling system and shall be able to produce a certificate stating such on request.

9.15 Testing

i. Commissioning Test

a) Commissioning of the entire installation shall be done in presence of AAI representative.

b) All necessary instrumentation, equipment, materials and labour shall be provided by the Contractor.

c) The Contractor shall record all tests and system calibrations and a copy of these results shall be retained on site in the system Log Book.
ii. Functional Test
   a) Introduce Smoke into the Detector Assembly to provide a basic functional test.
   b) Introduce smoke to the least favorable Sampling Point in each Sampling Pipe. Transport time is not to exceed 90 Secs.

10. FIREMEN TELEPHONE SYSTEM

   The fireman telephone system (FTS) shall be suitable for Class-B wiring. It shall have provision to accept the range of 230V ± 10% single phase, 50 Hz Leaner power supply. It consists of master Control panel with multiple zone location alarm indications, Phone jack and Handset. The Phone jack senses the insertion of the Fireman’s handset into jack and immediately signals the status to the Control panel. The Control Panel in turn will indicate the location of the call and provide an audio visual indication to alert the operator’s attention. Group or all call can also be selected. Once connected a clear full duplex audio Conversation can take place. The call is ended by, replacing the master handset

   Command Center

   1. The Digital Voice Command Center located with the FACP, shall contain all equipment required for all audio control, emergency telephone system control, signaling and supervisory functions. This shall include speaker zone indication and control, telephone circuit indication and control, digital voice units, microphone and main telephone handset.

   2. Function: The Voice Command Center equipment shall perform the following functions:
      a. Operate as a supervised multi-channel emergency voice communication system.
      b. Operate as a two-way emergency telephone system control center.
      c. Audibly and visually annunciate the active or trouble condition of every speaker circuit and emergency telephone circuit.
      d. Audibly and visually annunciate any trouble condition for digital tone and voice units required for normal operation of the system.
      e. Provide all-call Emergency Paging activities through activation of a single control switch.
      f. As required, provide vectored paging control to specific audio zones via dedicated control switches.
      g. Provide a factory recorded “library” of voice messages and tones in standard WAV. File format, which may be edited and saved on a PC running a current Windows® operating system.
      h. Provide a software utility capable of off-line programming for the VCC operation and the audio message files. This utility shall support the creation of new programs as well as editing and saving existing program files. Uploading or downloading the VCC shall not inhibit the emergency operation of other nodes on the fire alarm network.
      i. Support an optional mode of operation with four analog audio outputs capable of being used with UL 864 fire-listed analog audio amplifiers and SCL controlled switching.
j. The Digital Voice Command shall be modular in construction, and shall be capable of being field programmable without requiring the return of any components to the manufacturer and without requiring use of any external computers or other programming equipment.

k. The Digital Voice Command and associated equipment shall be protected against unusually high voltage surges or line transients.

L. Audio Amplifiers

1. The Audio Amplifiers will provide Audio Power for distribution to speaker circuits.

2. Multiple audio amplifiers may be mounted in a single enclosure, either to supply incremental audio power, or to function as an automatically switched backup amplifier(s).

3. The audio amplifier shall include an integral power supply, and shall provide built-in LED indicators.

4. The audio amplifier shall provide the following built-in controls:
   - Amplifier Address Selection Switches
   - Signal Silence of communication loss annunciation Reset
   - Level adjustment for background music
   - Enable/Disable for Earth Fault detection on DAP A
   - Switch for 2-wire/4-wire FFT riser

5. Adjustment of the correct audio level for the amplifier shall not require any special tools or test equipment.

6. Includes audio input and amplified output supervision, back up input, and automatic switch over function, (if primary amplifier should fail).

M. Portable Emergency Telephone Handset Jack

1. Portable emergency telephone handset jacks shall be flush mounted on stainless steel plates as indicated on plans. Handset jacks shall be approved for emergency telephone system application.

2. Insertion of a remote handset plug into a jack shall send a signal to the fire command center which shall audibly and visually indicate the on-line condition, and shall sound a ring indication in the handset.

3. The two-way emergency telephone system shall support a minimum of seven (7) handsets on line without degradation of the signal.
FIRE PROTECTION
SYSTEM
1. GENERAL

The Fire Protection System (FPS) design criteria & construction specifications for proposed Airport is covered under this section.

The design specification indicated is minimum guidelines to enable the contractor to carry out engineering and execute entire FPS works to meet the design intent / employer’s functional requirement.

The types of fire protection systems considered in this section are as listed below:

a) Fire Hydrant System
b) Automatic Sprinkler System / water curtain
c) Pumps & Panels
d) Portable fire Extinguishers
e) Total flooding Gas suppression system for server rooms and localized panel suppression system for main distribution MV electric panels, DVOR, ILS, GP, elevator & escalator panel and for Precision air conditioning system.

The Fire protection system shall be generally designed based on the requirements of National Building Code of India (NBC), relevant Indian standard codes CPWD, NFPA, UL/FM specifications and as per local fire authority.

2. CODES & STANDARDS

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<td>Colors for ready mixed paints and enamels (Fifth revision)</td>
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<td>IS: 903 -1993</td>
<td>Specification for fire hose delivery couplings, branch pipe, nozzles and nozzle spanner (Fourth revision)</td>
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<td>IS: 1239</td>
<td>Mild steel, black ERW pipes up to 150 mm dia, with fittings. (Part 1)-2004 Specification for steel tubes, tubular and other wrought steel fittings Part 1: steel tubes (Sixth revision). (Part 2) -1992 MS tubes, tubular and other wrought steel fittings, Part 2 MS tubular and other wrought steel pipe fitting (Fourth revision).</td>
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<td>IS: 1255</td>
<td>Code of practice for installation and maintenance of power cables.</td>
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<td>Steel for General Structural Purposes</td>
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<td>IS: 2379 -1990</td>
<td>Color code for identification of pipe lines (First revision).</td>
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<td>IS: 3043</td>
<td>Code of practice for earthing,</td>
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<td>IS: 3589</td>
<td>Mild steel, black ERW pipes 200 mm dia and above, with fittings.</td>
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<td>IS: 3844 -1989</td>
<td>Code of practice for installation and maintenance of internal fire hydrants and hose reels on premises (First revision)</td>
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<td>IS: 5216</td>
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<td>IS: 5290-1983</td>
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<td>IS: 5578</td>
<td>Guide for marking of insulated conductors</td>
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<td>IS: 5714 -1981</td>
<td>Specification for Hydrant Stand-Pipe for Fire Fighting (First revision)</td>
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<td>IS: 5959</td>
<td>Specification for polyethylene insulated PVC sheathed heavy duty electric cables, voltage not exceeding 1100 V — do — voltage 3.3 kV to 11 kV</td>
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<td>IS: 9972 - 2002</td>
<td>Specification for Automatic Sprinkler Heads for Fire Protection Service (First revision)</td>
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<td>IS: 10221</td>
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<td>IS: 11101 - 1984</td>
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<td>IS: 12349 - 1988</td>
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<td>IS: 15683</td>
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<tr>
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IT rules

All applicable relevant FM/UL, NFPA standards and guidelines.

CPWD General specifications for electrical works, Part-V

Local Fire Department standard.


Relevant Indian standards & codes, consultation with Local Fire Authority/Local Fire Brigade.

In case of any discrepancy in specifications between the State Act / Rule and the relevant IS specifications, the superior specifications shall be accepted. For all materials and equipment, IS specifications shall be applicable. Where IS specifications are not available, British / European standard specifications shall become applicable. All specifications, standards, publications specified mean the latest editions of such publications with up to date amendments.
3. SCOPE OF WORK

The broad scope of work shall include Design, Procurement, Construction, Completion, Testing and Commissioning of item as detailed below but not limited to the following:

a) The scope of work includes design, supply, Erection, coordination among different trades, liaison/coordination with relevant local government departments, Testing and Commissioning of complete Fire Protection system for the proposed passenger terminal building, ATC building, utility buildings, DVOR, ILS and Glidepath. The Fire Protection scope covers internal as well as external periphery of the buildings.

b) A Fire water tank (Underground) is proposed below the utility building. The fire pumping system for the proposed buildings shall be planned, designed, constructed from this fire water tank. The filling of the fire water tank should be automatic, water level indicator shall be provided along with auxiliary alarm output in case of empty tank.

c) Fire Water Pumps & Panel along with associated piping, valves, slave panel and accessories shall be as per system requirements. Electrical control panel for Fire Pumps and cabling/wiring including connection to various FPS equipments.

d) Fire Hydrant System with piping network, landing valves, Hose Reels, Hose box and Hose Cabinets.

e) Internal and External yard Hydrants with associated piping and valves. Location of the yard hydrant & Hydrant Cabinets shall be coordinated with Architects, other services & shall comply with the applicable codes & standards.

f) Automatic sprinkler system consisting of sprinkler, alarm valves and pipe network. Adequate spares shall be provided as per relevant Codes.

g) Portable Fire Extinguishers to fight fire at incipient stage. Fire Extinguishers shall be provided as per travel distance and area coverage throughout the building, as per the codes as specified.

h) Sealing of cut-outs/openings with Fire sealants. The fire rating of the sealant shall be compatible with the structure (Floor/Wall), as the case may be.

i) Interface with various other disciplines as per the Specifications. FPS piping shall not run inside the water sensitive areas like Control room/Equipment room, Electrical room, Substations, Generators rooms, battery/UPS rooms, etc.

j) To develop System Schematic diagrams, detail working drawings showing hydrant pipe network, fire hose stations, sprinkler pipe network, sprinkler locations, pump room layout, portable Fire Extinguisher locations etc. complete.

k) Excavation works (Mechanical or Manual depending upon the site conditions) for laying the fire protection pipes, making of trenches, road cutting if required, excavating any type of soil including rocky strata, refilling the trench or pit, disposal of surplus earth at the approved location by AAI.

l) Minor civil works related to fire protection system such as penetrating through walls, floors and filling up all these holes with fire sealant (Fire Stop Mortar), thrust block and
anchor block for supporting underground pipes. Providing all the valve chambers, along with the manhole covers, designed for appropriate loading.

m) Obtaining clearances before start of work and Completion Certificate (and Fire Approval and occupancy certificate) on completion of works from the Local Fire Officer.

n) The Contractor shall be responsible for the Supply & Installation of all the above mentioned Fire Protection Systems in accordance with the Specifications, Standards and the contract drawings/documents. The entire work shall be carried out strictly in accordance with the true intent and meaning of the specifications and drawings taken together, regardless of whether the same may or may not be shown particularly on the drawings or described in the specification, provided that the same can be reasonably inferred from there.

4. DESIGN CRITERIA
The objective of this report is to design & provide fire protection system that shall be based on the standards and code as specified.

- Life safety of occupants
- Property protection - Building and Contents.
- Compliance with all relevant statutory requirements.
- Minimum disruption to operation during emergency to the operations.

Classification: The building classification shall be as per NBC, IS standard, NFPA, UL/FM to be followed.

4.1 Storage Tanks and Pumping System
The capacity of the fire water tank shall be as per requirements in NBC, relevant IS codes and local fire regulations. The storage capacity shall be adequate to meet the FPS requirements for the proposed terminal building, ATC building and utility buildings. Water tank shall be complete with compartments, overflow arrangements and digital water indicator. Inlet to the tank will be fed from the raw water line(s). The overflow for the fire water tank shall be connected to the inlet of domestic water tank.

Pumping system including pumps, pipes, Air valves, isolation valves, etc shall be installed in accordance with the system requirements for Fire protection and relevant codes. All necessary control & Power cabling required from pumps & pressure switches, sensors to their panels shall be in the scope of contractor. All cablings/ wiring shall be FRLS.

4.2 Fire Hydrant System (Internal)
The water to the Internal Hydrant system shall be fed through vertical risers located at common area or staircase.

The Building shall be equipped with a Hydrant and First aid Hose Reel System. The Hydrant Stations with Fire Hose Reel shall be provided at landing of all stairs/fire shaft and to meet the requirements as per NBC, relevant IS codes and local fire regulations.

a) Locations of Internal Fire Hydrant Stations shall be in the recessed wall openings and the same shall be coordinated with Architectural drawings. The door frame shall be made 2mm thick SS -304.

b) To reduce excess pressure, Orifice plates of suitable design shall be provided.
c) The hydrant risers shall be terminated with automatic air release valve at the highest points (on top of each wet riser) to release the trapped air in the pipe work along with necessary accessories.

d) Air vessel shall be installed in the fire pump room (connection from the common discharge header), fabricated out of at least 8 mm thick shell thickness made out of MS sheet to withstand the pressure, with dished ends and supporting legs. This shall be of 250 mm dia and 1 m high (excluding the support legs). This shall be completed with necessary flange connection to the wet riser piping and air release valve with necessary piping to meet the functional requirement of the system. The air vessel shall be of continuous welded construction and painted with red Colour. This shall be tested for twice the working pressure.

e) Each internal hydrant station shall consists of one single headed 63mm SS hydrant valve, 2nos 15m long RRL-Type – A Fire hoses, 1 no wall mounted hose reel with 30m long hose tubing, complete with shut off nozzle & clamps, 1 no GM/SS branch nozzle and 1 no fireman axe. All fixtures shall be as per list of approved makes for electrical works.

f) Test and drain line for each sprinkler riser system.

4.3 Fire Hydrant (External)

a) The External hydrants shall be provided around building. The maximum spacing between two external hydrants, Number & type of hydrant valve, hoses and branch nozzle shall be as per NBC, relevant IS codes and local fire regulations.

b) Each External hydrant station shall consist of hydrant valve along with two nos. C.P hoses and one branch nozzle housed in weatherproof MS cabinet with glass front door. All the equipment’s housed inside shall be as per list of approved makes for electrical works.

c) An isolation valve shall be provided for ease of maintenance.

d) Contractor shall provide orifice flanges fabricated from 6 mm thick stainless steel plates on the branch lines feeding different zones/ floors so as to allow required flow of water at 3.5 Kg/ sq.cm pressure. The contractor shall furnish design for these orifice flanges.

e) Fire brigade inlets for pumping water into hydrant lines shall be provided. Fire brigade inlet shall be located and arranged so that hose lines can be readily and conveniently attached to the inlets without external interference.

f) Underground piping shall be laid at least 1m below and at road crossing where heavy vehicles are expected to pass, shall be protected with RCC pipe for additional protection.

4.4 Automatic Sprinkler System

a) Automatic Wet Sprinklers & associated piping works with Flexible drops, wherever necessary in false ceiling areas, shall be provided throughout the proposed terminal building and utility buildings as per code.

b) Sprinklers system shall not be provided for the followings areas:

- Electrical switch rooms, substation, UPS/ battery room & other equipment rooms.
External Canopies

c) The sprinkler header piping shall be connected from each riser, provided in the staircases/other common areas. Each riser tapping shall be provided with separate butterfly valve along with supervisory switch, flow switch, Non Return valve, and Pressure gauge, drain & test connections.

i. The system shall be designed as per requirements in NBC, relevant IS codes and local fire regulations.

ii. Sprinkler shall be provided in bathrooms / Toilets where the area is more than 5sqmtr or as per NBC.

iii. Sprinkler protection shall be provided in chutes as lowest, highest and alternate floor levels. Mechanical protection to avoid damage due falling objects shall be provided.

iv. Sprinklers shall be provided at false ceiling level and above false ceiling (if Ceiling Void is more than 800 mm to the bottom of the slab).

v. The temperature of sprinkler shall be selected depending on the hazard classification as per relevant NBC, NFPA, UL/FM codes.

vi. Flexible (braided SS316L) sprinkler drops shall be provided where required, for connecting the drop pipes to the sprinkler heads.

vii. Upright sprinklers shall be provided in areas having no false ceiling & Pendent Sprinklers in areas having false ceiling. The sprinkler layout shall also be coordinated with false ceiling layouts in coordination with the Architect.

viii. Extended Coverage Sprinklers with required K-Factor shall be provided for all double height areas complying relevant NBC, UL/FM code and local regulations.

ix. Sprinklers shall be provided below HVAC ducts & Baggage handling system (BHS) conveyor belts, having width larger than 1200 mm one sprinkler above & one below shall be provided.

x. Rosettes shall be coordinated and match as per architectural requirements for the below ceiling sprinklers.

xi. While designing & locating the Sprinklers, obstruction of beams & other structures and services shall be considered.

xii. Ball valve of suitable size shall be provided for drain of sprinkler system at the farthest point and shall be taken to nearest drain outlet.

4.5 Portable Fire Extinguishers

i. The portable fire extinguishers to handle small fires shall be provided as per IS 2190 with references made to NFPA 10 wherever applicable. However, additional fire extinguishers shall be provided as per requirement of the local Fire Service authorities.

ii. Fire Extinguishers shall be provided in all entire public and services areas based on the coverage area & travel distance for the particular type of extinguishers and hazard
classification.

iii. Extinguishers shall be mounted inside the wall mounted Cabinets. Fire Extinguishers shall be provided in all public areas, near each exit doors, inside the recessed openings in coordination with the Architect.

iv. The capacity of the extinguishers shall be based on the hazard classification and per the provisions indicated in IS -15683.

v. Fire Extinguisher shall be installed in Passenger terminal building, ATC building for building, AHU Rooms, electrical room, UPS / battery room, IT sever Rooms, External Canopies etc. as per fire norms. Also areas in utility building like AC Plant Room, Substation, Other equipment rooms etc. shall be covered with fire extinguisher as per fire norms.

vi. Sand Buckets shall be installed in areas mentioned in subsequent paras.

5. DRAWINGS AND TECHNICAL DOCUMENTS
   The design and drawings shall include for the following besides the other necessary requirements:

a) Concept design, design basis report, detailed hydraulic calculations, P&I Diagram, riser diagram with supporting documents complete.

b) Internal & external Fire Hydrant drawings showing piping network, Fire Hose Station Locations, air valves and drain valves, all termination details etc., for all levels.

c) Automatic Fire Sprinkler System drawing showing pipe distribution with sizes and spacing, sprinkler locations, alarm valve location, drain points etc., for all levels.

d) Portable Fire Extinguisher Location for all levels.

 e) Standard details showing typical Fire Hose Station Connections, Breeching & Fire Service Inlet details, Hangers & Support details etc.

f) Design & Detail drawings for Fire Water Tank, pipe Sleeves, etc.

g) Pump room drawing showing Pump, piping & Valves arrangement, all instrumentation etc.

h) Detail design calculations with supporting documents to be submitted for approval.

i) Technical submittals for all equipments/ materials to be submitted for approval.

j) The EPC Contactor is to prepare all the necessary fabrication GFC drawings as per functional requirement and these shall be submitted to the Engineer-in-Charge in 3 sets and be approved by him before fabrication is commenced. All such drawings shall show the dimensions of all equipment and installation.

k) Further set (4 copies) of all approved shop drawings shall be supplied by the EPC
Contractor for use of the Engineer-in-Charge for execution of work.

6. SYSTEM DESCRIPTION & SPECIFICATIONS

6.1. Hydrant System Description
a) The Fire protection covers Wet Risers, Sprinklers in the entire building, Fire Hose Stations housing Hose Reels, Landing Valve, branch pipe and Hose. External Hydrant ring main along with Yard Hydrants are provided. Fire service inlet and Fire Breeching connections are also to be provided.

b) The Hydrant and Sprinkler system are automatic in action and are kept pressurized at all times.

c) The Hydrant risers are terminated with air release valves at the highest points and with drain valves at the bottom.

6.2. Sprinkler System Description
i. The automatic sprinkler system is a piped system having water under pressure all the time with sprinkler heads fixed against the outlets at appropriate places. The sprinkler heads are of fixed temperature type with a quartzoid bulb held in position by forged gunmetal yoke and a deflector. The quartzoid bulb contain liquid having high vapour pressure. Upon receiving heat, the vapour pressure inside the bulb increase rapidly and at the rated temperature, the bulb shatters and thereby opens the sprinkler head, permitting flow of water. The sprinkler piping network of each floor shall be provided with suitable size of butterfly valve with inbuilt supervisory switch, Check valve, flow switch and test and drain assembly.

ii. The sprinkler installation shall have a set of Installation Control Valve Comprising of Main Stop Valve, Alarm Valve and water Motor Gong. The Stop Valve must be right handed, i.e. to stop valve, spindle must rotate clockwise. The controlling wheel must be clearly marked showing direction in which wheel is to be turned, to close, and an indicator to show whether valve is open or shut, the location of stop valve is to be easily visible and unobstructed.

iii. The Alarm Valve must be of approved type and fixed on the main supply pipe immediately above the stop valve, and before any connection is taken off to supply any part of installation.

iv. The Water Motor Gong must be fitted as near to the alarm valve as possible and must not be located more than 6m above the valve. The water gong shall consist of a water motor which rotates at high speed. The shaft carries an arm on which a striker weight is provided and the weight strikes the gong on each revolution of the motor and produces an audible alarm.

v. The design of sprinkler Installation shall be in conformity with Sprinkler rules and regulation prescribed by IS 15105, UL/FM standards. Pressure reducing at lower floor shall be by suitable orifice flanges of 6 mm thick stainless steel so as to restrict the pressure between 3 to 5 Kg/cm² at any floor level where tapping has to be made from Main Riser. The position of orifice flange shall be immediately after tapping point and before the Isolating valve / Flow Switch. The flow switches in each zone shall be wired and connected to the Fire Alarm Panel.
vi. The entire buildings shall be sprinkled except switch rooms, sub-station, IT, equipment rooms etc. The system shall be charged by a Vertical Wet Riser which is connected to the Sprinkler Header in the Pump House. From the Header one riser shall be connected through which the Sprinkler lines of the different zones are tapped. Drain valves to be provided.

6.3. Fire Pumps, Motors, Engine and Accessories

a. Fire Pumps & motors

All the fire pumps are connected to the respective dedicated fire water tank through a common suction manifold and the discharge of each pump is connected to a common discharge manifold. The discharge manifold provides the system connections. Necessary isolation valves and check valves are provided for sectional isolation and control. Process and instrumentation devices will be provided for monitoring and control functions.

The fire pump shall be horizontally mounted single stage centrifugal split casing type and direct driven by electrical motor, as specified. The pump rating and performance shall be described in the drawings and should be as per NBC. Pump casing shall be of close-grained cast iron with bronze impeller. The shaft sleeve shall be brass or SS-410 and the trim shall be brass or bronze and the shaft shall be stainless steel. Pump shall be capable of delivering 150 % of the rated capacity at 65 % of the rated head and the no-delivery head shall not exceed 120 % of rated head. Pump casing shall withstand 1.5 times the working pressure. The pump shall be electrically driven with direct flexible coupling. In the event of a demand from the system, the main electric fire pump will automatically start at a preset pressure level and deliver the rated flow at the rated pressure to the system. In the event of failure of the main electric pump to start on demand, the standby diesel driven fire pump will start at a preset pressure level and deliver the demand. Stopping of the fire pumps will be manually only. The jockey pump will ensure that the system is maintained at the design pressure at all times.

The fire pumping system is the most critical component of the complete fire-fighting system and therefore requires be periodically operating and testing to ensure the functionality is not impaired. To facilitate this by simulation, a test line will be provided which will be tapped-off the pump discharge common header and will have a pump flow test meter with isolation valves. The discharge of the test line will be connected to the fire tank. This arrangement will provide a means of periodic running of the fire pumps in a closed loop without water wastage as well as ensure water circulation in the static fire water tank.

The flow test meter shall be sized to measure flow of 150% of pump rated capacity so that the performance characteristics of the fire pumps can be periodically tested to verify there is no deterioration in performance outputs over a period of time. Status of the fire pumps shall be monitored at the fire alarm control panel.

The electric drive motor for Electric driven fire pumps shall be squirrel cage A.C. induction type suitable for operations on 415 volts, 3 phase, 50 Hz system. The motor shall be totally enclosed fan cooled type confirming to protection class IP – 55. The class of insulation shall be ‘F’. The speed shall be 1450 / 2900 RPM or as per the OEM standards. The motor shall be of continuous duty and shall have horse power rating necessary to drive the pump at 150 percent of its rated discharge with at least 65 percent rated head.
The motor shall conform to IS 325 – 1978. The motor starter shall be automatic star Delta type confirming to relevant IS. The starter assembly shall be suitable integrated in the power and control panel for the riser system and sprinkler system.

b. Diesel Pump
   i. Diesel Engine
      The engine shall be cold starting type without the necessity of preliminary heating of the engine cylinders or combustion chamber. The engine shall be multi cylinder / vertical, 4 stroke cycle, water cooled, diesel engine, developing suitable HP at the operating speed specified to drive the diesel driven fire pump capable of delivering the required capacity and head as required. The engine shall be capable to continuous non-stop operation for 8 hours. The engine shall conform to IS 1601 / IS 10002.
   
   ii. Engine Accessories
      The engine shall be complete with the following accessories: -
      1. Dynamically balanced Fly wheel.
      2. Direct coupling for pump and coupling guard.
      3. Corrosion Resister.
      4. Air cleaner, oil bath type / Dry type.
      5. Fuel service tank support and fuel oil filter with necessary pipe work. No PVC pipe connections to be used.
      6. Electrical Starting battery (24 v) along with battery charger
      7. Exhaust silencer with necessary pipe work.
      8. Governor.
      9. Instrument panel housing all the gauges, including Tachometer, hour meter and starting switch with key. (For Manual Starting)

   iii. Cooling System
      The diesel engine shall be water cooled, the water for cooling shall be taken from discharge of fire pump (taken off prior to the pump discharge valve), directly into the engine cylinder jackets via pressure reducing device to limit the applied pressure to a safe value as specified by Engine Manufacturer.

   iv. Lubricating Oil System
      Forced feed Lubricant Oil System shall be employed for positive lubrication. Necessary Lubricant oil filter shall be provided located, suitable for convenient servicing.

   v. Starting System
      The starting system shall comprise necessary batteries (1 x 24v or 2 x 12v), 24 volts starters motor of adequate capacity and axle type gear to match with the toothed ring on the fly wheel. By metallic relay protection to protect starting motor from excessively long cranking runs suitably integrated with engine protection system shall be included within the scope of the work. The capacity of the battery shall be suitable for meeting the needs of the starting system.

      The battery capacity shall be adequate for 10 consecutive starts without recharging with cold engine under full compression. The scope shall cover all cabling, terminals, initial charging etc.

      Battery charger for charging batteries when set is not operating connected to the load side so that it will get on energized from the mains.
vi. Exhaust System & exhaust pipe
The exhaust system shall be complete with hospital silencer and silencer piping including bends and accessories. The total back pressure shall not exceed the engine manufacturer’s recommendation. The exhaust piping shall be suitable lagged. The exhaust piping shall run within the duct land terminate above roof level. The exhaust pipe shall be suitably insulated & cladded.

vii. Engine Shut Down Mechanism
This shall be auto/ manually operated and shall return automatically to the starting position after use.

viii. Governing System
The engine shall be provided with an adjustable governor to control the engine speed within 5% of its rated speed under all conditions of load up to full load. The governor shall be set to maintain rated pump speed at maximum pump load.

ix. Engine Instrument
Engine instrumentation shall include the following:
1. Lubricant oil pressure gauges.
2. Lubricant oil temperature gauges.
3. Water pressure gauges.
4. Tachometer
5. Hour meter
6. Automatic start / stop device.
7. Selector switch for automatic, testing operation.
8. The instrumentation panel shall be suitably resident mounted on the engine

x. Engine Protection Devices
Following engine protection and automatic shutdown facilities shall be provided:
1. Pipe Work: – All pipe lines with fittings and accessories required shall be provided for fuel oil, Lubricant oil and exhaust systems, copper piping of adequate sizes, shall be used for Lubricant Oil and fuel oil. MS piping will be permitted for exhaust.

2. Anti-Vibration Mounting: - Suitable vibration mounting duly approved by Engineer in charge for mounting the unit so as to minimize transmission of vibration to the structure. The isolation efficiency achievable shall be clearly indicated.

3. Battery charge: - Necessary float boost charger shall be incorporated in the control section of the power and control panel, to keep the battery under trim condition. Voltmeter and ammeter to indicate the state of charge of the batteries shall be provided.

4. Day Oil Tanks: - Day oil tanks shall be of suitable capacity and suitable for 8Hrs continuous operation and made out of minimum 3 mm thick MS sheets, duly welded and painted as per requirements. It should be attached with level indicator with signals.
compatible to computer/ BMS.

5. The day oil tank shall be equipped with an air breather, shielded level gauge, strainer and a hand hole of not less than 150 mm diameter, besides the required fuel connection and a drain plug. Primer coating with two coats of highly corrosion resistant primer shall be applied according to the seven tank process of painting. The tank shall be power coated finally. The fuel tank shall be hydrostatically tested at a pressure not less than 0.35 kg/ sq.cm. The fuel tank shall be equipped with fuel piping and valves, Overflow pipes, vent & sludge trap, drain valve, inspection and cleaning hole fill connection etc. The fuel tank shall have the calibration facility. An adequate size spill tray shall have both vertical & horizontal reinforcement with suitable size angle section.

xi. AMF Panel

The automatic mains failure control panel shall be such that to start the Diesel Pump automatically when there is failure of main supply / Emergency supply and other main fire pumps. The panel will have suitable rated bus bars, internal wiring, fuses, with suitable provision for connection incoming / outgoing / out coming loads. It will include the following accessories.

1. One set main supply voltage monitor to identify low voltage complete failure and initiate necessary signal for operation of automatic control gear.
2. 1. No. mains supply failure timer.
3. 1. No. restoration timer.
4. 1. No. control unit incorporating engine start / stop and 3 impulse starting relay and failure to start lock out.
6. 1. No. counter to indicate the number of times the set started.
7. 96 sq. mm flush mounted voltmeter with selector switch and fuses / MCB to read voltage on mains / load set.
8. 96 sq. mm flush mounted ammeter with selector switch.
9. Relay section will comprise a set of relays for followings:
   - Automatic starting of the diesel pump in event of mains voltage failing / main fire pump fails subject to interlocking as specified below a present value.
   - In the event of failure of diesel pump to start on failure of mains supply/ main fire pump subject to interlocking as specified on one attempt, two more starting impulse will be automatically given and if still the engine does not start due to some defects within 30 seconds of first starting impulse, it will get disconnected and locked out automatically and necessary audio and visual signal given.
   - In the event of failure of diesel pump due to faulty starting, the main supply contactor will get energized without any time delay on the restoration of the main supply and interlocking shall be open to main fire pumps.
   - The circuitry will make use of minimum number of relays and control wiring will be neatly provided with adequate size of copper conductor cable of suitable cross section, voltage grading and tag numbered at either end.
   - Control relays both DC and AC monitor will be of sturdy construction.
• One audio Alarm

• All control fuses will be so located as to be easily accessible for replacement.

In the manual operation the diesel pump will be started by the attendants by pressing the start push button and stopped by pressing stop push button irrespective of the conditions of the main supply. Thus with this arrangement it will be possible to exercise routine test of the diesel pump.

xii. Exhaust Pipe
Providing and fixing M.S class ‘C’ Diesel Engine exhaust pipe including all fittings & support and fiber rope protection.

c. Fire Pump Accessories
The fire pump shall be complete with the following accessories:
  o Suction and discharge eccentric reducers.
  o Suction and discharge pressure gauges 150 mm dia with gauge cocks brass piping for pressure damping.
  o Pump coupling guard.
  o Common base frame fabricated M.S. or cast iron.
  o Anti-vibration mounts.
  o Foot valves with Strainers (For negative suction) or Gate valve and strainers for positive suction.
  o Pressure switches
  o Butterfly valves and non-return valves in Suction and delivery piping.
  o Elastomeric bellows.

d. Pump Foundation
Each pumps shall be bolted and grouted to a reinforced concrete foundation (designed as per relevant IS codes/other norms) of 1:1 1 / 2:3 concrete (1 cement : 1 1 / 2 fine aggregate : 3 coarse aggregate) and cured for 7 days. Each concrete base shall include supports for pipe elbows at the suction and / or discharge. The pump foundation and supports shall be as per the pump manufacturer’s recommendation and also be got vetted either from AAI approved structural Engineers or from Govt. Institution.

Unless otherwise indicated, all equipment to be mounted on vibration isolator rubber pads and shall have a minimum, operating clearance of 40 mm between the inertia base of structural steel frame and the concrete housekeeping pad. The clearance space shall be checked by the contractor to ensure that no construction debris has been left to short-circuit or restrict the proper operation of the vibration isolation system.

e. Control Panels
   i) Unless otherwise specified in the tender specifications, the entire equipment shall be suitable for operating on 415 volts, 50 cycles, earthed neutral, 3 phase, 4 wire A.C system.
All components accessories, raw materials and finished parts used in the manufacture and assembly of switch boards, power and controls circuit wiring and earthing system shall comply with the relevant Standards and further as described in LT panel section to be followed.

ii) All equipment, cables etc. shall be adequately rated for the switch rating to suit the climatic condition experienced in the vicinity of installation and other similar installations.

iii) The contractor shall submit the fabrication drawings of the Pump Panel indicating all enclosures separately for all Pumps etc. for approval by the AAI. Drawings shall indicate cable inlets, outlets, chamber dimensions and front and side elevations. These drawings shall take into account all fuses, contactor, switches & meters etc.

The control panels shall be fitted with circuit charts mounted to the inside cover. These charts shall consist of a typed list giving the designation of each circuit and the size of the breaker required, and shall be protected by a sheet of Perspex 2 mm thick, labels shall also be attached to the barriers of breaches indicating the number of each individual circuit shown on the list.

iv) The Contactor rating shall be suitable for the rating of the Main Fire Pump, Sprinkler Pump and Jockey Pump: Contractor shall co-ordinate and supply the total panel suitable for the pumps offered by him.

v) Control wiring from pressure switches of different settings in Hydrant line, Sprinkler line, Jockey Pump, Booster Pumps, for sequence of operation shall be included to complete the system.

vi) Control code with ferrule marking shall also be made.

vii) The wiring shall be PVC insulated and copper conductor cable of 650 / 1100 volts grade (conforming to IS 694) as required from Fire Pump Board to motor. All cable / wire shall be FRLS/ FR of outer sheath.

viii) Testing
The panel shall be tested at manufacturer's works and shall be got approved by AAI before dispatch to site. The panel shall be tested again at site as directed by AAI.

6.4. Fire Fighting Accessories

a) Piping

1) Pipes of the following types (depending upon the description of item) shall be used:

   i) M.S/GI pipes conforming to IS: 1239 with up-to date amendments, ISI marked (Heavy grade) (for pipes of sizes 150 mm NB and below) suitably treated on the outside to prevent soil corrosion as per IS: 10221.

   ii) M.S/GI pipes up to 150 mm dia shall have all fitting as per IS 1239, part II (heavy grade)

   iii) M.S/GI pipes above 150 mm dia shall be as per IS: 3589 inclusive of IS marking.

2) For M.S/GI pipes up to 50 mm dia screwed jointing shall be adopted, while for pipes above 50 mm dia welded or flanged connections shall be used. Only Electro galvanized nuts/bolts shall be used.
3) Wrapping & Coating: Underground piping below ground with necessary fittings & accessories shall have protective wrapping & coating of minimum 4 mm thick layer as per IS 10221. Minimum 2 coats of anti corrosive coating shall be applied to pipes before applying wrapping material.

4) Hangers and supports shall be capable of carrying the sum total of all concurrently acting loads. They shall be designed to provide the required supporting effects and allow pipelines movements as necessary. All guides, anchors, braces, dampers, expansion joints and structural steel to be attached to the building / structure, trenches etc. shall be provided by the Contractor. Hangers and components for all piping shall be approved before fixing.

5) The piping system and components shall be capable of withstanding 150 per cent of the maximum working pressure. Pipes shall be pressure tested to hydrostatic test pressure 1.5 times the maximum working pressure (minimum 14Kg/Sq Cm). The pressure shall be maintained for a period of two hours and there shall be no drop in pressure at the end of this period. However, full system shall be pressure tested for 24hrs or as per relevant code/norms.

6) Flanged joints shall be used for connections to vessels, equipment, flanged, valves and also suitable straight lengths of pipeline lengths of pipeline of strategic points to facilitate erection and subsequent maintenance work.

7) Excavation for pipelines shall be in ground to the levels and grades as required at Site. Pipelines shall be buried to a minimum depth of 1.0 meter or as required to suit the site conditions. Pipes shall be supported on mounting pad over PCC blocks (1:2:4) of size 250 mm x 250 mm x 200 mm at intervals of 3.5 m. The bends and joints shall also be supported at both sides. Mains shall not be laid under buildings. Air release valves shall be provided in the hydrant lines at Suitable intervals.Wherever required supports for all trenches or adjoining structures with adequate timber supports shall be provided. On completion of testing and pipe protection, trenches shall be refilled with excavated earth in 15 centimeters layers and consolidated. Contractor shall dispose of all surplus earth within a lead of 500m or as directed by AAI. Safety Code for scuff & ladders IS 3696 should be followed.

8) Exposed/Above ground (AG) pipes
   a) Exposed/Above ground (AG) pipelines and fittings shall be coated with two coats of oil primer and two coats of enamel paint as per IS approved colour code. The surfaces shall be properly cleaned before applying the primer. AG pipes shall be supported at regular intervals on masonry, RCC, truss, beams, roofs, trenches etc. Air release valves shall be provided in the hydrant lines at suitable intervals.

   b) All pipes shall be adequately supported from ceiling or walls by structural clamps fabricated from M.S. structural (duly galvanized) e.g. rods, channels, angles and flats. All clamps shall be painted with one coat of primer and two coats of black enamel paint. The contractor shall provide inserts at the time of slab casting or provide suitable anchor fasteners.

   c) The pipe supports or hangers shall be designed to withstand combined weight of pipe, pipes fittings, fluid in pipe and insulation. Pipe supports shall be of steel fully
galvanized and coated with rust preventing paint and finished with two coats black enamel paint. The maximum spacing for pipes supports shall be as below:

<table>
<thead>
<tr>
<th>Pipe (MM)</th>
<th>Spacing (MTR)</th>
<th>Size of support</th>
</tr>
</thead>
<tbody>
<tr>
<td>Up to 25</td>
<td>2.0</td>
<td>6mm</td>
</tr>
<tr>
<td>32 to 65</td>
<td>2.4</td>
<td>8mm</td>
</tr>
<tr>
<td>75 to 125</td>
<td>2.7</td>
<td>10mm</td>
</tr>
<tr>
<td>150 &amp; above</td>
<td>3.0</td>
<td>12mm</td>
</tr>
</tbody>
</table>

d) Pipes supports shall be spaced at maximum interval of 1.5 mtrs, on either side of heavy fitting and valves. Wherever piping passes through walls, pipes sleeves of diameter larger than that of piping shall be provided. Pipe sleeves shall be of steel or cast iron pipe.

b) **Valves**

1. Gate valves / Butterfly valves will be used for isolation of flow in pipe lines. For sizes up to 50 mm gate valves shall be used and they shall be of the outside screw rising spindle type and shall be as per IS: 778. For sizes 80 mm and above butterfly valve shall be used. No butterfly valves to be provided in the suction side of the pumps.

2. Gate valve shall be provided with a hand wheel, position indicator, by pass valve, draining arrangement of seat valve and locking facility (as required). Gate valves shall have back setting bush to facilitate gland renewal during full open condition.

3. Non-return valves shall be cast iron wafer swing check type. An arrow mark in the direction of flow shall be marked on the body of the valve. These valves shall conform to IS: 5512. The flap shall be cast iron and flap seat ring of loaded gun metal.

4. Valves below 50 mm size shall have to be screwed ends while those of 50 mm and higher sizes shall have flanged connections. Drain lines will have valves for draining.

5. Alarm check valve: This shall be installed in the tapping point to each wet riser from the internal ring main. Alarm Check Valve shall have divided seated ring, rubber faced clapper. Water flow alarm check valve that is intended to use in sprinkler system shall be designed to automatically actuate hydraulic alarm, when there is steady flow of water in to the system that is equivalent to the discharge rate of one or more sprinklers. The alarm check valve shall be flanged type with Cast Iron body & bronze seat ring. The clapper shall be cast iron.

c) **Yard Hydrant**

Yard Hydrant valve shall be as per IS: 5290 and IS marked. The valve shall be oblique type complete with hand wheel, quick coupling connection, spring and gun metal blank cap as per IS: 5290. The hydrant shall be tapped from the 150 / 100 dia main with elbow and standpipe 80 mm dia at approx. 1-2 m above ground level.

d) **Internal Landing Valve**

The Internal landing valve shall be of gun metal / SS conforming to IS: 5290. It shall be oblique type, complete with hand wheel, quick coupling connection, spring and gun metal blank cap.
e) **Hose Reel**
The hose reel shall be directly tapped from the riser through a 20 mm dia pipe, the drum and the reel being firmly held against the wall by use of dash fasteners. The Hose Reel shall be swinging type (180 degrees) and the entire Drum, Reel etc. shall be as per IS : 884. The rubber tubing shall be of approved quality and the nozzle shall be 6mm dia shut off type.

f) **Delivery Hose**
Delivery Hose for firefighting shall be of 63mm dia, 15mtr. long RRL hose pipe with 63mm dia Male and Female Gun metal couplings duly binded with MS wire, rivets etc. conforming to IS 636 (type-A)

g) **External Hose Cabinet.**
1) Hose for Fire Brigade used inlet shall be housed in a Hose Cabinet of minimum Size of 0.9 M x 0.6Mx0.5M with glass and locking arrangement.

2) The cabinet shall be of minimum 16 SWG MS sheet and framing of MS tubular sheet with center opening glazed doors (clear glass of 5.5-mm thickness). The glass shall be firmly fixed by means of steel clips and screw.

3) The steel work shall be given primer coating, two coats of highly corrosion resistant primer, applied according to the seven tank process of painting. The cabinet shall be powder coated finally. The words “Yard Hydrant” “Hydrant” etc. shall be painted in white (or red on the glass) in 75 mm high letters. The hose box shall be lockable type. All horizontal surfaces shall be sloped adequately with water discharge holes. The final coat of paint shall have stove enameled finish.

4) A brick pedestal with brick wall complete with plaster OR MS channel frame with hydrant pipes as support shall also be constructed/ provided for supporting the hose box.

h) **Fire Brigade Inlet.**
Fire Brigade Inlet connection shall be taken directly to the Riser. It shall comprise of four instantaneous male inlets coupling with plug and steel chain. The inlet shall have a non-return valve and a sluice valve on the up to like riser. The Fire Brigade Inlet shall be complete with necessary components like special fittings of medium quality MS bends, flanged tees etc. The plug shall be brass.

Fire Brigade Inlet for Tank Filling by Fire Brigade shall be four way with gun metal instantaneous male inlet coupling connections for connection with Fire Brigade vehicle, complete with cap, chain and plug. It shall comply to the requirements in IS 904.

i) **Pressure Gauge**
The Pressure Gauge shall be constructed of die cast aluminum and stove enamel. It shall be weather proof with an IP55 enclosure. It shall be stainless steel Bourden type Pressure Gauge glycerin filled, with a scale range from 0 to 16 Kg / CM square and shall be constructed as per IS: 3624.
j) Pressure switches
   It shall be of industrial type, single pole, double throw electric pressure switching
designed for starting or stopping equipment within the pressure of the system drops or
exceeds the pre-set limits. All switches shall have ¼” BSP (F) inlet connection and
screwed cable entry for fixing cable gland. The pressure switch shall have a rating of 4-
20 kg/cm² with 0.8 to 3 kg. Differential pressure setting. Maximum working pressure
shall be 28 kg/cm² with auto reset.

k) Painting
   All Hydrant and Sprinkler pipes & fittings (above ground) shall be painted with Fire red
color paint (Shade No. 536 of IS: 5). The pipes shall be painted with one coat of Zinc
Chromate primer and after hydraulic test -two or more coats of synthetic enamel paints.

l) Branch pipe with nozzle
   63 mm dia standard, gun metal / SS branch pipe with nozzle of 20 mm nominal bore
outlet as per BIS: 903, suitable to fit with standard instantaneous type 63mm dia

m) Fire Stop Mortar
   Fire stop mortar shall be fire resistant, cement based mortar with thermal insulating
properties, providing a minimum of 2 hours fire rating & maximum 4 hours fire rating. It
shall have good adhesion properties with base materials like concrete, masonry, metal
pipes. It shall prevent passage of fire, smoke and water through fire rated wall and floor
penetrations, cladding, etc.

n) Fire Stop Collar
   Fire stop collar shall be ready to use, pre-assembled system consisting of intumescent
wrap contained within cylindrical steel sheet housing. The intumescent effect of the
wrap shall be initiated by heat and causes high expansion pressure. Fire rating shall be
a minimum of 2 hours & maximum 4 hours.

o) Orifice Plate
   Orifice plate shall be made of minimum 6 mm thick stainless steel with orifice of
required size in between flange and landing valve to reduce pressure to a working
pressure of 3.5 Kg/cm² when the pressure at the outlet of landing valve exceeds 7
Kg/cm². The item shall be complete with fixing arrangements etc.

b. Sprinkler System
   Pendant type Sprinkler Head.
   1. Sprinkler heads shall be quartzoid bulb type with bulb, valve assembly yoke and the
deflector. The sprinkler shall have approved make and type with 15 / 20 mm nominal dia
outlets.
   2. The bulb shall be made of corrosion free material strong enough to withstand any
water pressure likely to occur in the system. The bulb shall shatter when the
temperature of the surrounding air reaches to 68 degree C.
   3. The nominal bore shall be 15/20 mm dia & colour of liquid shall be Red
   4. The Sprinkler head shall be approved by UL/FM
i) Upright type Sprinkler Head
Upright sprinkler heads shall be similar to pendent type in material construction and performance but designed to throw water droplets upwards in umbrella fashion, to cool the underside of ceiling and extinguish any fire involving combustibles above false ceiling. The Sprinkler head shall be approved by UL / FM. The nominal bore shall be 15/20 mm dia and the colour of liquid shall be red.

ii) Extended Throw Side wall Sprinkler Head
These sprinkler shall be fast Response Type with Fusible Alloy melting at 68 deg C - 74 deg C. The material shall be of Gun Metal / Stainless steel. The coverage shall be (as per IS 15105) up to max. 20 M2 with forward throw up to 6M and side wise 2 M either side with spray pattern of 120 degree minimum. The fast response shall be achieved by quick heat absorbing metal fins or any other technology and the sprinkler shall be listed by UL/FM.

iii) Concealed type Sprinkler Head
The exposed part of the sprinkler shall be concealed by means of cover plate assembly which shall be mounted flush with the false ceiling. It shall be rated at 68 or 71 degree C and shall withstand pressures up to 12 Kg / cm2. The sprinkler Head shall be provided with a matching escutcheon plate. The ceiling plate shall absorb heat and transfer the heat to a fusible alloy which at rated temperature shall melt and expose the Sprinkler head to the heat below.

iv) Extended Coverage Pendant Sprinkler
This type of sprinkler shall be used in double height areas. The Sprinkler head shall be approved by UL / FM. The nominal bore dia shall be as per K factor defined by the manufacturer for quick response / extended coverage sprinkler where ever it is used above 6m. The colour of liquid shall be red.

v) Flow Switch
Flow Switch shall have a paddle made of stainless steel of the width to fit within the pipe bore. The terminal box shall be mounted over the paddle / pipe through a connecting socket. The switch shall be able to trip and make/ break contact on the operation of a single sprinkler head. The terminal box shall have connections for wiring to the Annunciation Panel. The switch shall have IP: 55 Protection. The flow Switch shall work at a minimum flow rate of 100 LPM. Further, it shall have a Retard to compensate for line leakage or intermittent flows.

vi) Inspection, test & drain valve assembly
Test and drain assembly with an integral sight glass assembly, shall be used with each sprinkler cross-main tapping for inspection, testing and draining of system. The testing assembly shall consist of smooth bore, corrosion resistant, test orifice equivalent to that of sprinkler's orifice and 25mm dia pipe connection and shall be suitable for installation in any position. It shall be with a handle control to provide positioning or test, drain and shut off. The sight glass assembly shall be unique, self-cleaning that provides a positive indication of flow even in dimly lit areas, without flashlight. The maximum service pressure shall be 12.1 bars.

vii) Flexible sprinkler drops
Corrugated stainless steel braided flexible drops made from AISI 316L with high tensile strength shall be used in architecturally sensitive areas, all suspended ceiling areas, and most congested areas, to fix sprinkler at designated place. It shall be complete with snap clamp type end brackets as Manufacturer’s product and part of flexible drops. The technical specifications shall be as follows:

1. Minimum bending radius : 178mm
2. Maximum working pressure : 200 psi (13.78 bars)
3. Test pressure : 1000 psi (68.94 bars) (Bursting)
4. Connection : Branch line-25mm NPT / 3/4" (32 mm)
5. Sprinkler : 1/2 or ¾ NPT
6. Lengths : 0.6, 0.8, 0.9,1.2,1.5 & 1.9 meters
7. Temperature Rating : 300 Deg F (148.88 DegC)

viii) Piping
For Piping the specification as laid down for Hydrant piping shall be followed.

ix) Installation Control Valve for Sprinkler
Installation Control Valve will be Diaphragm actuated and the body and cover to be C.I as per IS: 210. The seat shall be of bronze and the sealing by Rubber. The valve shall comprise of following:

Wet Pilot Actuator, Water Motor Gong, Strainer, a flow test, a drain valve. It shall have check valve, and a Drip check, alarm test valve, pressure indicator and all other components as required. Further, a retard chamber shall also be provided to compensate for water surges. The gong shall be installed at an audible place preferably outside the fire pump room /at required locations

c. Portable Fire Extinguishers
Portable fire extinguishers shall be ABC type (dry chemical type), Carbon dioxide, clean agent type and foam type etc as per the requirement. The capacities shall be worked out based on the type of hazard. These extinguishers shall be suitably distributed in the entire areas of all the concerned buildings based on the hazard classifications. These shall be placed or hanged on wall in a group on several suitable places or placed inside the extinguisher cabinet in coordination with architectural requirements. The number of extinguishers shall be calculated in accordance with NBC and IS 15683.

The portable fire extinguishers to handle small fires shall be provided as per IS 2190 with references made to NFPA 10 wherever applicable. However, additional fire extinguishers shall be provided as per requirement of the local Fire Service authorities.

Fire Extinguishers shall be provided in all entire public and services areas based on the coverage area & travel distance for the particular type of extinguishers and hazard Classification.

Extinguishers shall be mounted inside the wall mounted Cabinets. Fire Extinguishers shall be provided in all public areas, near each exit doors, inside the recessed openings in coordination with the Architect.

The capacity of the extinguishers shall be based on the hazard classification and per the provisions indicated in IS -15683.

Sand Buckets shall be installed in transformer room, near DG , outside the Substation, for External Canopies etc. as per fire norms.
Typical location for different type of fire extinguishers includes, but not limited to, the following:

- 6.0 KG, multi-purpose ABC dry chemical type fire extinguishers: All areas except electrical rooms, kitchen, generator rooms and fuel pump room.
- 4.5 KG or higher capacity CO2 fire extinguisher: Electrical Rooms.
- Clean Agent Extinguishers: Server and Data storage area.
- One Mechanical Foam extinguishers of 9 litres capacity & one ABC powder extinguishers of 6 Kgs. Capacity should be provided near the transformer.
- One Mechanical foam extinguishers of 9 litres capacity and one ABC powder extinguishers of 6 Kgs. Capacity should be provided near the diesel generator.
- One CO2 extinguishers of 2 Kgs. Capacity should be provided inside each lift machine room.
- 9L foam extinguisher, Trolley Mounted extinguishers like 25 Kg ABC extinguisher, 50 L mechanical foam extinguisher proposed in accordance with IS 2190.
- Modular fire extinguisher shall be provided in electrical rooms, AHU rooms and other rooms where sprinkler system cannot be provided.

a) All the extinguishers suggested above should be with B.I.S. markings and should be located at an easily accessible position without obstructing the normal passage and maintained periodically.

**CO2 TYPE FIRE EXTINGUISHER**

CO2 type fire extinguisher of 4.5 kgs assembled out of seamless steel cylinder (conforming to IS:7285 latest) having CCE approval and ISI mark complete with wheel type valve (conforming to IS: 3224 latest), high pressure wire braided discharge hose (minimum 1 meter length) with horn and carrying handle. The cylinder should be fully charged with CO2 Gas. All other components, design, performance, anticorrosive treatment should be as per IS: 15683 and IS: 16018 latest.

**6 KG CAPACITY DCP EXTINGUISHER**

The design, construction and testing of 6 kg DCP store pressure type extinguisher shall confirm to IS 15683 latest edition. The fire extinguisher shall be suitable for class A, B and C fires. The body of extinguisher shall be made up of seamless deep drawn MS shell.

The cylinder hydraulically tested at 35 kg/cm2 and burst pressure shall be 55 kg/cm2. The bottom of the cylinder shall be welded to the seamless cylinder body confirming to IS 15683 requirements. Neck ring shall be made up of seamless Hot rolled structural steel (IS 2062-GR A) bottom ring shall be made up of non-corrosive material having suitable dimension. Valve shall be of brass forging (IS 6912-GR FLB) having CE marking. The valve shall have the tapping for pressure gauge with NRV. The handle shall be of M.S., cold form, powder coated upper-lower lever for squeezing. The squeeze grip shall have the safety locking arrangement to avoid accidental operation. The safety pin shall be provided with seal, the valve shall also have the provision to mount the extinguisher on the wall bracket. Suitable wall bracket shall be provided along with
extinguishers. Pressure gauge: brass shell-nickel plated, water proof. The range of the pressure gauge shall be 0 to 25 bar. Siphon tube: shall be made up of aluminium.

Discharge hose: PVC nylon braided rubber or EPDM rubber, dimension- L: 500 mm, ID: 10 mm, burst pressure 50 kg/cm². The discharge hose shall be provided with SS male nipples at both ends. one end shall be fitted at the valve and another end shall be provided with HDPE nozzle. Provision shall be made for housing the discharge hose on extinguisher body.

Extinguishing media: extinguisher shall be filled with 90% UL listed mono ammonium phosphate powder. Propellant gas: Nitrogen, suitable for DCP extinguishers. fire rating of the extinguisher shall be 3A, 21B. Painting: shall be powder coated with fire red conforms to IS 2932, shade 536 of IS 5. Working temperature range: -30 deg. cent. to +55 deg. cent. operating instruction shall be displayed on extinguisher body. Working and store pressure shall mention on the stickers. It shall have BIS certified permanently engraved ISI mark on body.

Performance test: Extinguisher shall meet all performance tests as per IS 15683 (latest edition).

Hydro test and performance tests shall be witnessed by Engineer in charge as per IS 15683 latest edition.

Certificates: Vendor shall submit the following test reports and documents at the time of delivery.

• ISI certificate as per IS 15683(latest edition)
• Manufacturer test certificates
• Extinguisher details and operating manual
• Inspection report
• UL listed map powder certificate.
• Any other relevant reports/guarantee certificates etc.

CLEAN AGENT FIRE EXTINGUISHER 2 KG
Clean agent Fire Extinguisher 2 Kg capacity manufactured to IS:15683, with BIS mark , Brass forged squeeze lever discharge valve with NRV(CEEN 3 APPROVED), fitted with pressure indicating guage (CEEN3 APPROVED), direct nozzle, wall mounting bracket & screw, duly charged. Also to meet the requirements given in the latest NFPA 2001 on clean agent fire extinguishing systems in line with environmental considerations of Kyoto and Montreal Protocol & latest MOEF regulations (Ministry of Environment & Forest).

MODULAR ABC FIRE EXTINGUISHER 5KG
Modular ABC Fire Extinguisher supplied shall be as per IS 15683 with M.S. body fitted with adapter or Flange for fixing on ceiling, automatic sprinkler consisting of fusible bulb rated at 68 deg. Celsius, pressure gauge etc. and complete as required. The dry chemical powder used shall comply with IS 14609. The propellant shall be air, CO2,
nitr**rogen** or mixture of gases having maximum dew point of -55 deg. Celsius. The equipment shall be duly painted with post office red colour.

**MODULAR CLEAN AGENT FIRE EXTINGUISHER 5KG**
Modular Clean Agent Fire Extinguisher supplied shall be as per IS 15683 with M.S. body fitted with adapter or Flange for fixing on ceiling, automatic sprinkler consisting of fusible bulb rated at 68 deg. Celsius, pressure gauge etc. and complete as required. The clean agent used shall comply with IS 15493 or standard of clean agent supplied by the manufacturer. The propellant shall be air, CO2, nitrogen or mixture of gases having maximum dew point of -55 deg. Celsius. The equipment shall be duly painted with post office red colour.

4. **INSPECTION AND TESTING (Hydrant & Sprinkler System)**

1. Inspection – General
   a) All site fabricated work/material shall be subject to inspection in cleaned condition, prior to erection. At no event, site fabricated work/material shall be installed in position without inspection and approval by Engineer In Charge. The Contractor shall ensure that each stage of fabrication is carried out in compliance with the procedures specified in the IS / NBC/CPWD standards as applicable and/or specified in this document.
   
b) The contractor shall submit test certificates for all materials supplied as per category requirement mentioned in list of approved makes for electrical works.

2. Testing
   Before energizing electrically operated equipment, care shall be taken to meet the local electrical rules and regulations, earthing of the body, verifying availability of safe insulation resistance value, etc. Also confirm the motor enclosure to the level of protection required for the particular application.
   
The Contractor shall ensure that testing & commissioning of each component is carried out in compliance with the procedures specified in the IS / NBC/CPWD standards as applicable and/or specified in this document.

   a. Pumps
      i) The pumps shall be tested according to the standard recommendations of the manufacturer. The following parameters are to be recorded and plotted and submitted to the Engineer in Charge.
         a. Discharge Q
         b. Pressure P or Head H
         c. Motor voltage and current.
         d. Efficiency
      ii) The power consumption is to be computed and crosschecked with manufacturer’s data. Any abnormalities, if noted, shall be brought to the notice of the manufacturer and necessary corrective action be taken before commissioning and handing over, without any extra cost. Manufacturers test certificates shall also be submitted to Engineer in Charge for verification.
b. **Piping**
   i) All piping shall be tested by filling water, removing air locks, foreign materials, etc. and applying pressure at 1.5 times of the maximum working pressure (minimum 14 Kg/Sq cm) and see that the pressure drop is within 0.5 Kg per Sq. cm over a period of 2 hours. The testing shall be carried in sections by blocking both ends or closing the valves provided for 24 hr continuously. After completion of the installation and connecting to the mains of pumping system the installation shall once again tested and rectify breakage if any or replace the defective material, free of cost.

c. **Electrical system**
   Required tests shall be conducted as specified in internal EI package.

d. **Hydrant system**
   The entire hydrant system shall be tested in the presence of AAI to ascertain the functioning of each system, equipment, etc. as desired by AAI. The remotest hydrant hydrant shall have 3.5 kg/Sq.cm pressure during test. The contractor shall hand over the system only if it is proved that the system performs as per the specifications.

e. **Sprinklers**
   It shall be factory tested for operation characteristics and chemical tests. Necessary test results shall be submitted before supply. The contractor shall establish the discharge of the sprinkler during the testing at site.

f. **Sprinkler alarm valve**
   i) The pump shall start automatically and maintain pressure at the appropriate flow rate. The drain valve fitted above the alarm valve shall be opened and the time taken for the alarm gong to operate be noted. There shall not be a significant variation in the timing. The pressure at the “C” gauge of the alarm valve shall be noted at the full load condition of the pump and the value should match with that of the specification. The proper functions of the alarm gong associated with the alarm valve and its level of audibility shall be checked. An audibility level of 85 db above the background noise level is required. Necessary testing equipment shall be arranged by the contractor free of cost.

   ii) While conducting the tests, the water flowing through the test valve shall be equivalent to the flow through one sprinkler. It should auto start the pumps and activate the alarm motor and gong. When the test valve is closed, the water flowing through the test valve should stop.

g. **Operation of pumps**
   i) All the pumps shall be operated by both auto/Manual modes, and shall have automatic starting and stopping arrangements to maintain the system pressure.

   ii) Jockey pump shall not be in operation while the main pump is in operation. Under normal conditions, the water pressure in the hydrant lines shall be maintained at rated pressure kg/sq.cm, and the auto/Manual switch shall be in the auto mode. When the pressure drops by 0.5 kg/sq.cm, the jockey pump shall start automatically through
pressure switches arrangements and when pressure develops to rated kg/sq.cm the pump shall stop automatically. The jockey and main pumps shall not be in operation simultaneously.

iii) In case, pressure keeps on reducing and drops by 1 Kg/cm², the Jockey shall be cut off and the, the main electric fire pump shall be triggered.

iv) In the event of failure of main electric fire pump, the standby diesel engine driven pump shall start operation automatically. The main pump shall then be locked out.

v) If within a preset period the standby pump fails to start or fails to develop adequate pressure, the control system shall shut down the standby pump and lock it out and given an audiovisual indication to that effect at the control panel. Suitable interlocking of pumps shall be provided to prevent simultaneous operation of pumps.

vi) The control panel shall have status selection for each of the pumps for “automatic” as well as “manual” operation.

vii) Pumps when under “manual” status shall be operated manually through relevant push buttons.

viii) The fire pumps once started shall not be stopped automatically except for the jockey pump.

ix) The fire pumps shall be locked out for operation both for “manual” and “automatic” operations, once the low water controls operates and furnish an audio and visual alarm on the panel the audio alarm can be silenced by accepting the alarm. The visual alarm shall be individual for each equipment. It shall be flashing type and on acceptance remain steady. A reset button shall be provided for each pump for returning the pump for fire duty.

x) Over load or under voltage/no volt trip devices for main fire pump shall not be provided in the starter. LED type indication lamps to indicate the availability of power shall be provided.

xi) Once tripped the main fire pump shall remain locked out for operation irrespective of the position of its operational status selection switch. Look out indication shall be available on the panel.

xii) Return to normal operational availability shall be feasible only by manual re-set of locked out units by operation of appropriate push buttons.

xiii) When fire pumps are brought into operation an audible tone from turbine type alarm operated by water flow in the mains shall be provided to indicate the healthiness of the system. The healthy running alarm shall not be silenced till the fire pump is shut down, but the tone may be mellowed by the operation, if required.

xiv) Alarm for failure and lock out of any pump shall distinct from “healthy” alarm. Failure alarms shall be loud and can be silenced on acceptance.

xv) Repeat indication of various audio and visual indications on a slave remote panel in fire control room in building shall be available. The slave Remote panel shall have indication
lamps to show the status of:

1) Power healthy in fire pump room.
2) Jockey pump ‘ON’
3) Main pump ‘ON’

xvi) The slave Remote panel shall also have a hooter, which shall sound in case, any pump is ‘ON’. The slave Remote panel shall have a provision to reset the hooter with the help of a push button.

xvii) The contractor shall carry out necessary arrangements for supply and installation of items required like timer switches, sensors, cables, etc. and control wiring between pressure switches and panels to operate the pumps as described above. The cost for the same shall be included in the total contract value.

7. GAS BASED ROOM FLOODING SUPPRESSION SYSTEM:

7.1 GENERAL
1. All the equipment of the Fire Suppression System namely cylinders, Nozzles, and accessories for completing the Fire suppression System except piping and manifold shall be of one make only. Following authorizations shall be made available from the manufacturer.

a) Technical compliance to the specification by manufacturer.
b) Providing test reports complying the specification at the time of inspection.
c) Authorization that above system are in production and would be serviceable for at least five years from the date of tender. No obsolete product should be quoted.
d) Manufacturer must have presence in India. Manufacturer products shall have Quality system in compliance with international standard.
e) Contractor/OEM should provide initial fill and details of subsequent cylinder refilling location.
7.2 SCOPE

a) Total flooding gas suppression system for server rooms.

b) Localized panel suppression system for main distribution MV electric panels, DVOR, ILS, GP, elevator & escalator panel and for Precision air conditioning system.

c) Clean Agent Fire Suppression System to be integrated with automatic detection and Control.

d) Electrical Panel Suppression system shall be integrated with panel manufacturer design.

e) The contractor shall be responsible to complete the entire work in all respects and any other work necessary to complete the job whether specifically mentioned or not in the scope of work. In general, scope of work covers the following but not limited to:- Design, supply of all materials, installation, fabrication, testing and commissioning, puff test, performance guaranteeing of total flooding (main room + below false flooring + above false ceiling) centralized Clean Agent Fire Extinguishing System for Fire Protection of various risks in the rooms. Clean Agents to be considered are HFC227ea and FK-5-1-12 as per NFPA-2001 (latest edition) for Fire Protection of various risks.

f) The actual net volume of the risk shall be calculated based on the Architectural & Structural Drawing of the room/building by the Contractor. Contractor shall design the system to meet the minimum requirements of total flooding fire extinguishing Clean Agent system as per NFPA-2001 and having design concentration as specified at 70Deg F (21 Deg C) for the single largest risk area of the concerned room. The system design shall be total flooding and Clean Agent requirement shall correspond to the single largest risk area of concerned room/building.

g) System supplied and design calculation shall be approved by UL/FM/Vds/LPCB and TAC accredited agency. All equipments shall be approved by UL/FM/Vds/LPCB and cylinders along with cylinder valve assemblies shall be seamless and PESO/CCE approved. It shall be noted that Clean Agent system to be provided shall meet the requirements of NFPA- 2001 (2012 edition). Hence anything specified as “Mandatory” in NFPA-2001, although not specifically mentioned in this specification, shall form part of this specification.

h) The system shall be designed based on the single largest risk area of the room concerned. However, the grouping of cylinders shall be made in such a way that discharge takes place corresponding to the volume of the risk under fire. The system shall include electrically actuated automatic Clean Agent Fire Extinguishing System complete with filled up Clean Agent cylinders, cylinder rack, manifolds, pressure reducing devices, cylinder valves, directional valves, pipes, discharge nozzles, bracket supports, hangers and such other fittings as necessary for complete installation of the system, including chipping of existing RCC/ brick walls/ cutting of steel plates etc. or removal & re-fixing of false ceiling and floor of risk areas, fixing fasteners and other activities required to install the system.

i) The system shall also comprise of the different modes of operation, actuation and cancellation facility etc. with necessary local control panel as per specification. The Contractors shall have to offer 100% Clean Agent filled standby cylinders for each building (i.e. A reserve bank of Clean Agent filled cylinders with manifold,
directional valves and automatic change over to any of the two banks after actuation of main cylinders to be provided in each risk area i.e. 100% reserve.)

j) The Contractor shall consider total flooding centralised system with directional valves and offer 100% filled up standby cylinders for each building/system separately.

II. Applicable Standards and Publications
A. The design, equipment, installation, testing and maintenance of the Clean Agent Suppression System shall be in accordance with the applicable requirements set forth in the latest edition of the following codes and standards:

1. National Fire Protection Association (NFPA) Standards:
   • NFPA 2001 Clean Agent Fire Extinguishing Systems
   • NFPA 70 National Electric Code
   • NFPA 72 National Fire Alarm Code

2. Underwriters Laboratories, Inc. (UL) Publication
   • Fire Protection Equipment Directory with quarterly supplements

3. SMPV Rules, PESO/CCE (For storage cylinders)

III. Specifications:
1. The clean agent system considered for equipment protection and total flooding application shall be in compliance with the provision of Kyoto protocol.

2. The minimum criteria for the selection of the clean agent will be on the following parameters:
   a) Zero Ozone Depleting Potential
   b) Global warming Potential not exceeding one.
   c) Atmospheric lifetime not exceeding one week.

3. The clean agent considered for the suppression system must be suitable for manable occupied areas with high NOEL (No Observable adverse effect level) as compared to design concentration to ensure the high safety margin to the human who might be present in the hazard area.

4. The minimum design standard shall be as per NFPA 2001 latest edition.

5. For safety reasons the clean agent fire suppression system cylinder, valve discharge Hose, nozzle etc. must be considered of the same manufacturer to ensure proper performance as a system with UL/FM approvals. Contractor has to arrange a third party to test the performance of the complete system.

IV. Design Requirements
Design requirement shall be as given below.

a) System: The centralized system shall be designed to protect the single largest
risk area (volume wise) of all the three portions simultaneously i.e. below false floor, main room and above false ceiling. Volume below false floor, main room and above false ceiling shall be calculated based on the relevant Architectural and Structural drawings. However, the design volume shall not be less than minimum volume specified in NFPA 2001.

b) System Operation: The system shall comprise of the different modes of operation specified below with actuation and cancellation facility etc. and with necessary control panel. System operation shall be possible to operate by following means:

i. Automatically due to fire detection in the protected area.

ii. Operation of manual release push button located adjacent to protected area.

iii. By operating manual lever provided on electrical/ manual control head on pilot cylinder

iv. By push button actuation at Clean Agent control panel, in manual mode

The Clean Agent shall be discharged / actuated automatically after an adjustable time delay based on the detection signal received. The delay shall be minimum 30 seconds; however it shall be adjustable from 30 to 120 seconds. In the local control panel of Clean Agent system, there shall be one hooter, which shall operate once the gas is released. During time delay, there shall be a pre-discharge alarm (audio and visual). Hooter shall follow the alarm once the gas is discharged.

V. Gas Properties & Its Discharge Characteristics:


b) Design Concentration for type of clean agent selected shall be in accordance to approval taken from UL/ FM/ Vds/ LPCB or higher % /quantity of volume as specified by Clean Agent manufacturer for Clean Agent system. However the maximum discharge concentration shall not exceed NOAEL. System shall be designed for No Adverse Effect Level (NOEL).

c) System shall be provided with 100% connected reserve & the cylinders shall be located indoors. Automatic release shall be initiated via smoke detection system, located in cross- zone pattern (different loops). The system could be set on manual mode or auto mode. The discharge piping & nozzles shall be designed in order to allow discharge of 95% of minimum design concentration of clean agent gas as per NFPA 2001.

VI. Clean Agent Gas & Its Grouping/Distribution

The quantity of Clean Agent gas provided shall be sufficient to protect the single largest risk with 100% standby. The system for every individual risk shall have its
own distribution piping, nozzles, alarm, and actuation system, etc. Suitable combination of cylinders shall be made to cater to all the risk areas individually. Both primary and standby cylinders shall be permanently connected to the distribution piping through manifold and arranged for easy and auto changeover. Since the system is designed for the largest risk and there are several risk areas varying in size in a particular building, the system shall permit the use of required number of cylinders for any individual risk involved so that the concentration of gas in that risk area does not exceed the NOAEL specified in NFPA standards.

a) System Flow Calculations: System flow calculations shall be performed using a calculation method listed or approved by the authority having jurisdiction (i.e. UL/FM/Vds/LPCB) and TAC accredited agency. The system design shall be within the manufacturers listed limitations. Contractor shall also provide sufficient measure (like properly designed louvers etc.) facilities in the risk areas to dissipate over pressurization due to release of Clean Agent and also provide calculation in support of same for each protected area. Approval certificate of software from the UL/FM/Vds/LPCB shall be submitted.

b) Clean Agent Quantity: Minimum design concentration of Clean Agent gas shall be as per cl. No. 5.4.2 of NFPA-2001 at 70 Deg F by volume for Clean Agent fire extinguishing system based on approved listed flow calculation method. Clean Agent concentration requirement shall be computed considering the volume of the hazard as specified. The Contractor, as per NFPA-2001, shall work out the quantity of Clean Agent. However, Contractor shall quote minimum quantity of agent for the volume as given in the scope. Suitable margins of 20% for leakage etc. shall be kept over & above the calculated quantities. However in any case the minimum design concentration of Clean Agent gas shall not be less than 37.5% for IG-541 & IG-55, 7% for HFC227ea and 8.6% for NAF S-III at 70°F by volume unless otherwise specified by the agent manufacturer for clean agent fire extinguishing system based on approved/listed flow calculation method.

c) Clean Agent Storage Cylinders: The Clean Agent storage cylinders shall be designed to hold Clean Agent at ambient temperatures. Cylinder shall be of approved type and freshly imported. Minimum design level pressure of storage cylinder shall be as per NFPA-2001. The capacity of the cylinder shall be standardised for better placement & inter-changeability. The design pressure for cylinder shall be suitable for the maximum pressure developed at 130 Deg F (55 Deg C). The cylinders shall be charged to a fill density or super pressurisation (super pressurisation means the addition of a gas to fire suppression agent cylinder necessary to achieve the pressure required for proper system operation) within the range specified in the manufacturers listed manual. Contractor shall select the capacity of cylinder based on the storage
space available and for better replacement and interchangeability. The Contractor shall preferably select the capacity of cylinder keeping in view the filling ratio as per NFPA 2001. The cylinder shall be seamless, brand new (date of manufacturing of cylinders shall not be older than 1 year from the date of bid opening) never retested and month & year of manufacture shall be latest (or as specified in the requisition). Each cylinder shall have a permanent name plate, specifying the agent, tare and gross weight in addition to the pressurization level, nominal agent volume. Cylinder shall bear the mark of manufacturer, serial number, single test certificate issued by authority having jurisdiction and shall be duly approved by competent authority of the country of origin (FM/UL/Vds/LPCB/EEC) in addition to approval by PESO/CCE Nagpur, (India). Cylinders without approval will not be accepted. A reliable means of indication shall be provided to determine the pressure in refillable cylinders. PESO/CCE Approval of the cylinders is a must. Cylinder shall conform to the requirement of NFPA 2001 and shall be compatible with the engineered system being provided along with design analysis. Each cylinder shall have pressure relief valve to protect the cylinders against excess pressure conditions. Pressure gauges with isolation valves on manifold shall be provided. Automatic means such as check valve shall be provided to prevent agent loss if the system is operated when any cylinders are removed for maintenance.

d) Layout of Cylinders: Clean Agent cylinders shall be arranged in the following manner:
   i) In a battery of cylinders manifold together, leading to distribution piping and discharge nozzles for the risk to be protected, including below false floor and above false ceiling spaces, along with a reserve battery of Clean Agent filled cylinders with manifold and directional valves, including arrangement for automatic change over to any of the two banks after actuation of main cylinders to be provided in each risk area i.e. 100% reserve.
   ii) The cylinder storage racks shall be provided for main as well as for reserve cylinders.
   iii) The manifold, containers referred to above shall be securely mounted on the floor and suitably supported in a rack with provision for convenient individual servicing and content weighing according to manufactures installation manual. Such servicing or weighing shall be possible without shutting down the system. A space marked as Clean Agent space/room on the drawing will be made available to the Contractor for placing Clean Agent Cylinders and Piping Manifold. Contractor shall accommodate the storage of Gas Cylinders and Manifold Piping in the space provided and confirm the adequacy of space (along with technical bid).

e) Piping, Fittings and Discharge Nozzles
   i) Piping & Fittings:- Pipe shall be provided as per the requirements specified
NFPA- 2001. Pipe thickness calculation shall be as per ASME B31.1 power piping code. Normally welded joints shall be provided. Threaded pipes, if used, shall have threads in joints and fittings conforming to ANSI B1.20.1.

ii. Pipe fittings shall be provided as per NFPA-2001.

iii. All CS Studs, Bolts and Nuts shall be Hot Dip Galvanised as per ANSI A153 for corrosion resistance.

iv. The Pressure Reduction device shall be easily identifiable.

v. The Clean Agent piping layout shall be such that the pipes of one risk shall not pass through that of another risk.

vi. All Valves shall be approved for intended use. The Gaskets, O-Rings and other Valve material shall be compatible to the Clean Agent.

vii. The Clean Agent piping and nozzles shall have to planned clearing following facilities coming on its route, in the areas where protection is being envisaged:

- The beams and ribs which crisscross the ceiling. The Clean Agent piping shall be routed considering clearing structural beams / columns or any other facilities coming in the areas where Clean Agent system is being envisaged. All necessary civil works including taking support from Structural steel members, blast resistant RCC walls or breaking brick walls for routing the piping and making them good, shall be in the scope of work of Contractor.
- Path of AC ducts.
- Cabling in false flooring.
- Light fittings, detectors etc.

If required, the exposed piping works shall be camouflaged to match with the interior of the protected room.

f) Discharge Nozzles

Discharge nozzles shall conform to Cl.4.2.5 of NFPA 2001 and shall be of Brass and shall be FM/UL approved. Discharge nozzles used in the system shall be listed for the use intended for discharge characteristics. The selection of nozzle orifice shall be such that the discharge time required to achieve 95% of the minimum design concentration for flame extinguishment based on 20% safety factor shall not exceed the time specified in NFPA-2001 for the halocarbon/ Inert gas selected as per NFPA-2001. Each nozzle shall be permanently marked to identify the manufacturer as well as type and size of the orifice along with tag / part number, orifice code, or other suitable marking as specified by the authority having jurisdiction.

g) Painting
Painting shall be carried out as per Job Specification for Shop and Field Painting. Painting and colour scheme of pipelines, Clean Agent storage cylinders, supports etc. shall be as per shade No. 536 of IS: 5.

h) Operating Devices

i. Operating devices shall include Clean Agent releasing devices or valves, discharge controls and shut down equipment necessary for successful performance of the system.

ii. Electric Supply: The contractor will provide 240/415V +/- 10%, 50 +/- 5%, SPN/TPN power supply at a convenient point or as recommended by the OEM. Converter, if required, to convert to any other operating voltage shall be in Contractor’s scope.

iii. The automatic Clean Agent system shall be of robust design and shall not be readily rendered inoperative easily. The Clean Agent system shall be designed to function properly for the temperature range specified in NFPA-2001.

iv. The Clean Agent cylinders shall be mounted on front and firmly supported in brackets in a manner that they will not be easily subjected to mechanical, chemical or other damage, which would render the system inoperative.

v. In addition to Automatic actuation, there shall be a normal manual control for actuation, which shall be located so as to be conveniently and easily accessible at all times including the time of fire. This control shall cause the complete system to operate in its normal fashion.

vi. Manual controls shall not require a pull of more than 40 lb nor a movement of more than 14 inches to secure operation. Each remote manual control for activation shall be located not more than 4 feet above the floor.

vii. Weight of Clean Agent shall be monitored by pressure switches along with local pressure indicator for each cylinder. All local pressure indicators in a bank of cylinders (main / stand by) shall be connected in a signal loop and shall give a common indication/signal of loss of pressure in that particular bank in the Control Panel for Clean Agent system located inside Control Room. Scope of supply includes complete system, interconnecting cables and installation of all equipments and accessories.

viii. Contractor shall also provide sufficient measure (like properly designed fire rated louvers-which shall be opened during fire scenario and remains closed in normal condition etc) facilities in the risk areas to dissipate over pressurization due to release of clean agent and also provide calculation in support of the
same for each protected area.

ix. 1 no. Potential free contact shall be provided in clean agent system to generate alarm in fire alarm panel.

x. 1 no. Potential free contact shall be used in fire alarm panel for common fault in clean agent system panel.

i) Local Control Panel for Clean Agent System

The local control panel shall be free standing, floor mounted type and shall be suitable for both auto and manual operation. The panel shall be made out of minimum 16 gauge CRCA sheets. Doors and covers shall be made out of 14 gauge CRCA sheets. The panel shall be naturally ventilated, totally enclosed, dust and vermin proof, with IP-42 enclosure as a minimum. The Clean Agent system shall be actuated automatically by the signal received from the fire alarm and detection panel. Fire alarm and detection panel, after detecting the fire in the protected area/zone, shall provide an actuating signal to Clean Agent control panel, which in turn shall energise the solenoid valve to trigger the dumping operation in the respective protected area/zone. Necessary control / interlock cabling between Fire Alarm and Detection Panel and Clean Agent system panel, using multi-core 2.5 Sq.mm, Cu conductor PVC insulated flame retardant cable, shall be provided by the Contractor. The fire alarm and detection panel shall be located in suitable place/ Control Room building. The control panel shall be located inside the clean agent cylinder room or any other place as decided by AAI at the time of detailed engineering. However, control panel shall be equipped with adequate rating battery charger and VRLA battery with 24 hour back up, for efficient operation of the system during mains power failure. Control panel shall be provided with all alarms, indicators, caution/sign board and relays/control switches meeting all the requirements of NFPA-2001 and shall include but not be limited to the following:

- Two alarms and one fault indicator lamp for each zone to be protected.
- Combination of alarm silence and alarm off switch.
- Combination of fault silence and trouble lamp switches.
- Alarm test switch
- Alarm re-set switch.

The system shall have a positive warning device by sounding alarm to alert personnel of the impending discharge and also a positive indication to show that the system has actuated. Two numbers potential free contacts shall be provided for AAI’s use, one contact for indication of start of dumping operation and other contact for indication of end of dumping operation.
Alarm indicating failure of supervised devices of equipment shall give prompt and positive indication of any failure and shall be distinctive from alarm indicating operation of hazardous conditions.

All indication lamps shall be LED type with minimum size of 10 mm. Warning and instruction signs at entrance to and inside protection areas shall be provided.

A Control Box/Clean Agent Release Panel shall be provided for manual control at the exit doors of each risk area, comprising of selector switches for selection of Main/Reserve and Auto/Manual Push buttons for Clean Agent release.

Potential free contacts shall be provided from the Clean Agent Control Panel to shut off the fire dampers/louvers and Air Conditioning System.

Supervision of automatic systems shall be provided and shall include electrical supervision of the actuating device and the wiring connecting the actuation device and the detection system.

Operating instructions shall be displayed on a name plate fitted permanently on the Clean Agent skid.

Clean Agent extinguishing system shall incorporate a pre-discharge alarm with a time delay, sufficient to allow personnel evacuation prior to discharge. The delay shall be minimum 30 seconds. However it shall be adjustable from 0 to 180 seconds.

The cable trays shall be of hot dipped galvanized steel made out of Mild Steel sheets of 2.0 mm thickness for width of trays upto 60mm and 3.0 mm thickness for width of trays more than 60 mm in standard lengths (section). The size/width of the trays shall be finalized by Contractor during detail engineering based on number of cables and routing etc. Hot dip galvanizing for the cable trays shall be carried out as per IS-4759 after fabrication of trays. The amount of galvanizing shall be 66 µm / 460 g/m2. Each section of tray shall be supplied with required accessories such as connector plates, nuts, bolts, washers etc. required for connecting ends of each tray section. Fasteners / nuts, bolts, washers etc. shall be SS material. The cable trays shall be installed with proper supports using angles of proper size. All the structural supports shall be properly painted with primer and finished painting.

Solenoid valves shall be Direct acting type with SS body, Intrinsically Safe, 24V DC with insulation class F. Abort switch shall be provided outside each risk area and on the main gas release panel.
VII. **Materials of Construction**

The material of construction shall be as per this specification for the items specified. For other items, the materials of construction used in the system shall be in accordance with NFPA-2001 or as specified by the equipment manufacturer for the intended use (if the same is not specified in NFPA-2001). The material of construction shall be UL/FM/Vds/LPCB approved. The approval of the same shall be submitted at the time of bid submission.

VIII. **INSPECTION AND TESTING**

a) Approval of Installation: The complete system shall be tested (as per NFPA standards) to meet the approval of AAI. The entire Clean Agent system shall be got approved from TAC (Tariff Advisory Committee, India) accredited agency by the Clean Agent Vendor. Only listed or approved equipment and devices shall be used in the systems i.e. all equipments shall be approved by UL/FM/Vds/LPC and cylinders along with cylinder valve assemblies shall be seamless and PESO/CCE approved.

b) The approval of installation shall be subject to satisfying the requirements specified in NFPA-2001.

c) All critical equipments such as cylinders, cylinder valves, directional valves, pressure reducers, nozzles, actuation controls, pressure gauges etc. shall have approvals from UL/FM/Vds/LPC. In order to determine that the system has been properly installed and will function as specified, the following tests shall be performed:

i. A thorough visual inspection of the installed system and hazard area. The piping, operational equipment and discharge nozzles shall be inspected for proper size and location. The locations of alarms and manual emergency releases shall be confirmed. The hazard area shall be inspected closely for un-closable openings and sources of agent loss. The supplier shall furnish the composition certificate of Clean Agent satisfying the requirements of quality requirement table (Table 4.1.2(a) for Halogenated Agent and Table 4.1.2(b) for IG Agent Quality requirements etc.) of NFPA-2001. Filling certificate should be provided specifying from which original Clean Agent drum the gas has been taken and which cylinder is filled.

ii. A check of labeling of devices for proper designations and instructions. Name plate data on the storage cylinders shall adhere to specifications.

iii. A test for mechanical tightness of the piping shall be conducted as per NFPA- 2001

iv. A dump test shall be carried with clean agent gas.

IX. **Technical Data Requirements**

i. System design including computerized system flow calculations, piping and storage layout using approved listed software (UL/FM/Vds/LPCB).
Hydraulic calculation for each risk area shall be provided. The complete output shall be submitted which also shows that there is no error in calculation and discharge time is less than as specified in NFPA using seamless steel cylinders.

ii. List of Indian/ International standards to which the offered equipments conform.

iii. Catalogues/ Brochures giving technical particulars and details of operation/maintenance of the offered elements/ system.

iv. Certificates of agencies who have accorded approval for the components/elements offered.

v. Numbers and placement/ area coverage for type of nozzles used.

vi. Quantity of each type of equipment offered along with the calculations.

vii. Protected room/ area piping layouts along with the details of supporting arrangement.

viii. Quantity of Clean Agent offered for various areas as per specifications.

ix. PFD, P&ID and GA Drawing.

x. GA and dimensional drawings of the areas showing storage, piping and nozzles for various areas.

xi. Mounting/ fixing details of all the elements.

xii. Testing and inspection schedule and procedure.

xiii. Cylinder data sheets.

xiv. Other relevant data sheets.


xvi. List of drawings.

xvii. Battery and charger sizing calculations.

xviii. GA and schematic designs of Control Panel.

xix. Functional write up of control panel including battery charger.


xxi. Program user’s manual for software used for Clean Agent flow calculation.

8. GAS BASED LOCALISED PANEL FLOODING SYSTEM:

a. The scope covers supply, installation, testing and commissioning, performance guaranteeing of automatic gaseous fire extinguishing CO2/inert gas based flooding system complete suitable for electrical panels with fire detection tube, cylinder, valves, and integration with fire alarm control panel for annunciation as per specifications, drawings, codes, standards and good engineering practice etc. complete.

b. Applicable Standards Include:

<table>
<thead>
<tr>
<th>Standard</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>NFPA 12</td>
<td>Standard on Carbon Dioxide Extinguishing Systems.</td>
</tr>
<tr>
<td>NFPA 2001</td>
<td>Clean Agent Fire Extinguishing Systems</td>
</tr>
<tr>
<td>NFPA 70</td>
<td>National Electrical Code.</td>
</tr>
</tbody>
</table>
c. Scope of work
1. Direct fire extinguishing clean gas based flooding system.
2. Providing fire detection tube inside the panels for direct systems.
3. CO2/ Inert gas for flooding of the Panels as per specification having zero ODP and having a distinct odor for flooding system and suitable for human beings. Details of gas used shall be submitted with offer.
4. Wiring /Connection to local/remote fire alarm systems. (Integration with fire alarm control panel)
5. Any other item required for successful commissioning of the system.
6. Total flooding Gas suppression system for server rooms and localized panel suppression system for main distribution MV electric panels, DVOR, ILS, GP, elevator & escalator panel and for Precision air conditioning system. The suppression system consists of Polymer base tubing, CO2 / Inert gas cylinder and custom engineered valves.

d. The cylinder shall be kept near the protected area and tubing through cylinder shall be done inside the protected Panels. In case of Fire, when the flame touches the tubing and it reaches a temperature of 90-110 Deg C the tubing bursts at its hot test point (which is nearest to the most vulnerable part of the fire), thus forming a nozzle. The pneumatic mechanism then triggers the valve of the extinguisher and sprays the agent out directly in to the fire, thus dousing the fire quicker and locally.

e. Heat Sensing tube shall have the following characteristics:
   1. acts as a multi-sensor and multi extinguishing jet
   2. made of a high-tech polymer
   3. long time resistance, flexibility and temperature sensitivity
   4. when bursting at the hottest spot, it ruptures as a nozzle shape opening
   5. Shall be UL listed.

f. The actual net volume of the risk shall be calculated by the Contractor based on the GA Drawing of the electrical panel to be protected. CONTRACTOR shall design the system to meet the minimum requirements of total flooding fire extinguishing Carbondioxide system as per NFPA-12 or that of NFPA-2001.

g. System supplied and design calculation shall be approved by UL/FM/Vds/LPCB and TAC accredited agency. All equipments shall be approved by UL/FM/Vds/LPC and cylinders along with cylinder valve assemblies shall be seamless and PESO/CCE approved. It shall be noted that system to be provided shall meet the requirements of NFPA-12/NFPA 2001 (latest edition). Hence anything specified as “Mandatory” in NFPA-12/NFPA-2001, although not specifically mentioned in this specification, shall form part of this specification.

h. Approval of Installation
   i) The complete system shall be tested to meet the approval of AAI. The entire
system shall be got approved from TAC (Tariff Advisory Committee, India) accredited agency by the Vendor. Only listed or approved equipment and devices shall be used in the systems i.e. all equipments shall be approved by UL/FM/Vds/LPC and cylinders along with cylinder valve assemblies shall be seamless and PESO/CCE approved.

ii) All critical equipments such as cylinders, cylinder valves, directional valves, pressure reducers, nozzles, actuation controls, pressure gauges etc. shall have approvals from UL/FM/Vds/LPC. In order to determine that the system has been properly installed and will function as specified, the following tests shall be performed:

a. A thorough visual inspection of the installed system and hazard area. The piping, operational equipment and discharge nozzles shall be inspected for proper size and location. The locations of alarms and manual emergency releases shall be confirmed. The hazard area shall be inspected closely for un-closable openings and sources of agent loss.

b. A check of labeling of devices for proper designations and instructions. Name plate data on the storage cylinders shall adhere to specifications.

c. The cylinder along with cylinder valve assembly shall be PESO/CCE, Nagpur approved.

d. The contractor shall ensure sufficient gas pressure level in all fire extinguisher during completion of project
Part III

HVAC SYSTEM
1 SYSTEM DESCRIPTION

1.1 Introduction
The HVAC, VRV/VRF design specification for proposed Terminal Building & Control Tower is covered under this section.

The design specifications indicated are minimum guidelines to enable the contractor to carry out engineering and execute entire HVAC works to meet the indicative design/employer’s functional requirement.

1.2 Scope of Work (HVAC)
The Scope of Work related to HVAC systems comprising of design, engineering, manufacture, supply, delivery, storage, installation, balancing, testing, commissioning, coordination, interfacing, integrating, handover & training.

1.3 HVAC Plant
Water Cooled Screw Chiller, Condenser, variable secondary with constant primary pumps, condenser pumps, cooling towers, motorized butterfly valve /isolation valves, Strainer, NRV, expansion tank, air separator, auto air vent, drain, makeup water line, piping, insulation, power, VFD, Electrical panel, cabling, ventilation fans, instruments, sensors etc.

1.4 Requirement in brief for HVAC systems for Proposed Terminal Building and its allied structures are as below.

- High side equipment’s including chillers, primary and secondary pumps, hot water generators etc.
- All Low side HVAC equipment’s such as AHUs, along with dampers
- Hot water/chilled water and Condensate drain piping with insulation. Pre insulated wherever buried piping.
- Condenser water piping with strainer, butterfly valves, NRV etc. complete as per design requirements.
- Cooling towers based on design criteria.
- Air distribution system with thermal and acoustic insulation, supply, return air, fresh air.
- Grills, Diffuser & Drum louvers/Jet nozzles shall be coordinated with architectural finishes.
- Ventilation and Exhaust equipment’s and air distribution systems for non-air conditioned spaces.
- Air lock lobby with automatic sliding gates on all entry & exit gates of terminal building
- Smoke extraction system shall be provided in the building. Same shall be in accordance with NBC.
- All Electrical, Control panels, cabling & sensors associated with the HVAC work.
- Fire alarm integration with HVAC equipment’s and associated cabling as per rating.
- Associated chain pulley arrangement for removal and maintenance of HVAC equipment.
- Contractor shall also provide mandatory spares during warranty period for all equipment’s.
- Fire sealant for 2 hr rated walls for pipes and ducts crossing the wall/slab.
- Trench/plant room will have proper drain connected to nearest drain chamber.
• Water line connection shall be provided in plant room & AHU Rooms.
• Associated sensors for AHUs & Pumps integration with programmable Fire Damper.
• Testing, balancing, commissioning and handing over of manuals.
• Insulation & Aluminum cladding for pumps, pipes & all equipment in utility buildings as required.
• HVAC equipment’s shall have BMS compatibility as HVAC system shall be monitored and controlled by BMS.
• Centralized HVAC system for Terminal Building.
• VRF/VRV Air conditioning system for ATC Building.
• In addition to Centralized HVAC system, standby Air conditioning units to be provided for Conference room, VIP/Guest Room, UPS rooms, server Room, Airport manager office, APD office, etc. in Terminal Building
• Unitary AC to be provided in office spaces of - utility block / Sub-station, BMS room, medical center, etc.
• Precision Air-conditioning System with suitable standby arrangement shall be provided for Server Rooms for Passenger terminal building &ATC building, DVOR, ILS and Glide path.
• The contractor shall provide detailed Design Basis Report (DBR) based on relevant codes referred in document along with all the calculation such as cooling load, equipment selection, pressure loss, ventilation, smoke, pressurization, drawings etc.
• Self-sealing brass test points shall be provided all HVAC equipment’s at inlet and outlet Separate potable calibrated instruments to be provided.
• All motors for HVAC system shall be energy efficient (MIN IE3) type suitable for 415±10% volts incoming power supply.
• Seismic isolation of HVAC equipments shall be as per NBC norms.
• Detailed system design parameters, insulation criteria & equipment selection criteria shall be provided but not limited to.

1.5 Design Requirements Outdoor design condition
The outdoor design data for the HVAC design shall be as per the local weather data of the station.

1.6 Indoor Design Conditions
a) Indoor Design Condition will be as per standards of ASHRAE.
b) All the conditioned space shall be maintained at 23 ±1°C, RH 55±5%.
c) Heating system can be designed to maintain 19 ±1°C, RH 55±5%.

1.7 General
The Contractor shall verify the sufficiency of the size of the shaft openings, clearances in wall cavities and suspended ceilings for proper installation of grilles, diffusers, controls, insulation, conduits, cables etc. The contractor shall locate all equipment which must be serviced, operated or maintained in fully accessible positions. The exact location and size of all access panels, required for each concealed control damper, valve or other devices requiring attendance, shall be determined by the contractor. Access panel shall be standardized for each piece of equipment/device/accessory and shall be clearly marked.

1.8 Occupancy and Fresh Air
Fresh Air requirements shall be as per latest edition of ASHRAE 62.1. The co-relation of different space with ASHRAE in m3/person & fresh air requirement needs to be...
furnished with DBR in tabular format. Also note if the architect provides the occupancy with respect to ASHRAE higher no will be the basis referred for calculation.

1.9 Mechanical Ventilation

<table>
<thead>
<tr>
<th>Area</th>
<th>Type of Ventilation</th>
<th>Air Change Per Hour</th>
</tr>
</thead>
<tbody>
<tr>
<td>Toilet</td>
<td>Exhaust</td>
<td>10</td>
</tr>
<tr>
<td>HT / LT Switch room</td>
<td>Exhaust</td>
<td>20</td>
</tr>
<tr>
<td>Plumbing pumps room</td>
<td>Supply &amp; Exhaust</td>
<td>20</td>
</tr>
<tr>
<td>STP</td>
<td>Supply &amp; Exhaust</td>
<td>22 &amp; 30</td>
</tr>
<tr>
<td>Basement Ventilation</td>
<td>Supply &amp; Exhaust</td>
<td>12</td>
</tr>
<tr>
<td>Lift Well</td>
<td>Pressurization</td>
<td>As per BS5588 part 4 /NBC 2016</td>
</tr>
<tr>
<td>Staircase</td>
<td>Pressurization</td>
<td>As per BS5588 part 4 /NBC 2016</td>
</tr>
</tbody>
</table>

Noise criteria

It is recommended to maintain acoustic conditions for all the space NC(Noise criteria) / NR (Noise Rating) as per ASHRAE.

System Design parameter for selection of Air Handling Unit and its components shall be:
- Maximum face velocity across pre-filters & filters: 2.54 m/sec (500 fpm)
- Maximum face velocity across cooling coils: 2.54 m/sec (500 fpm)
- Maximum fan outlet velocity: 10.16 m/sec (1800 fpm)
- Maximum fan motor speed: 1450 RPM (Approximate)

Piping shall be sized for the following design parameters:
- Maximum velocity: 1.2 m / Sec (4 fps) for piping 50 mm & under
- Maximum velocity: 2.5 m / Sec (8.2 fps) for piping over 50 mm dia
- Maximum friction: 15 k Pa per 30 M Run (5 ft per 100 ft Run)
- Maximum flow velocity (Air conditioning system).

Design parameter for Duct design shall be:
- Maximum flow velocity in main ducts for air conditioning: 400 mtr/min
- Maximum flow velocity in Branch ducts for air conditioning: 250 mtr/min
- Maximum velocity at supply air grilles/ diffuser: 150 mtr/min
- Maximum flow velocity in ducts for ventilation in pump room, generator room, toilet exhaust & Kitchen exhaust: 1.5 times of Main ducts & branch ducts
- Maximum friction: 1 cm WG/100 m run
Ventilation Fan:
Maximum fan outlet velocity for fan upto 450 mm dia. : 550 mtr/min
Maximum fan outlet velocity for fan above 450 mm dia. : 600 mtr/min
Maximum fan speed. : 1450 RPM

Water Cooled Chilling Machine
Performance rating of the water cooled chilling machine shall be based on the following design parameters:

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temperature of chilled water entering chiller</td>
<td>55° F</td>
</tr>
<tr>
<td>Temperature of chilled water leaving chiller</td>
<td>45° F</td>
</tr>
<tr>
<td>Fouling factor for chiller in FPS unit</td>
<td>0.0005</td>
</tr>
<tr>
<td>Fouling factor for condenser in FPS unit</td>
<td>0.0010</td>
</tr>
<tr>
<td>Temperature of condenser water entering condenser</td>
<td>85° F</td>
</tr>
<tr>
<td>Temperature of condenser water leaving condenser</td>
<td>95° F</td>
</tr>
</tbody>
</table>

COP at AHRI condition (100 % load ) for chiller - 5.8 (Minimum as per ECBC)
IPLV at AHRI conditions (kW/TR) - 8.8 (As per Super ECBC)
Refrigerant (No Chlorine) - (R-427a / R-410A / R-407C R-134A / R-404a / R-514A / CFC and HCFC free refrigerant)

**Note:**

a) Condenser water In/out temperature may vary depending on location of the project.

1.10 Load synopsis

**Terminal Building**

CHILLED WATER SYSTEM

HVAC load for terminal building approx. = 1200 TR (Approx.)
Hot Water Generator = 400 TR (Approx.)

**ATC Tower Building, VRF SYSTEM**

Total HVAC load including fresh air = 210 TR(Approx.)

270 HP

**Note:** The actual loads shall be decided after detailed engineering including heat load calculations etc. done by EPC contractor.

1.11 Equipment Standby philosophy

Chillers, Hot water generators, pump sets and cooling towers and associated equipment’s shall be provided in N+1 (N working + 1 standby) configuration.

1.12 Functional Requirement

The HVAC functional requirements shall be as shown below:

- Air handling units with VFD shall comprise of supply/return air fan, cooling coil with control valve, filter complete with electrically interlocked dampers. Each air handling unit shall supply cooled and dehumidified air to conditioned space through insulated
air duct.

- Ceiling Suspended units shall be provided as required. TFA with Heat Recovery Wheel shall be considered for fresh air requirements.
- Supply air will be through air terminal devices as per throw and return will be designed accordingly.
- Thermostat shall be provided for controlling zone temperature.
- Fresh air & exhaust will be connected to external louver.

1.13 Mechanical Ventilation & Exhaust

- Utility building will be ventilated.
- All the intake/extract will have 5 meter distance maintained amongst each other to avoid short circuiting.
- UPS rooms will have exhaust system to avoid buildup of hydrogen ions.

1.14 Materials and Equipment

All materials and equipment shall conform to the relevant Indian Standards or international and shall be of the approved make and design. Makes shall conform to list of approved makes. All equipment shall operate under all conditions of load without any sound or vibration which is objectionable as per specification in the opinion of AAI. In case of rotating machinery sound or vibration noticeable outside the room in which it is installed or annoyingly noticeable inside its own room, shall be considered objectionable.

1.15 Manufacturer’s Instruction

Where the manufacturer has furnished specific instructions, relating to the material and equipment used in this project, covering points not specifically mentioned in these documents, manufacturer’s instructions shall be followed in that case.

1.16 Technical Data and Proposed Equipment

All the technical data, design basis and proposed equipment included in this document are only guidelines and these shall be assessed, verified and validated by the Contractor.

1.17 Codes and Standards

The codes, regulations and standard applicable for design of various equipment’s, selection of materials, installation, testing and commissioning are covered in this section. The international standards shall be applicable, wherever relevant national Standards/code is not available.

- National Building Code of India - 2016 (NBC)
- Relevant Bureau of Indian Standards (BIS) codes
- Indian Society of Heating, Refrigeration, and Air Conditioning Engineers (ISHRAE) Hand Book.
- American Society of Heating, Refrigeration, and Air Conditioning Engineers (ASHRAE)
- Air filters as per ASHRAE Standard 52.2 – 2007
- NFPA 92B for Standard for Smoke Management Systems in Malls, Atria, and Large Spaces
- Duct construction standard as per SMACNA
- National Electrical Manufacturers’ Association (NEMA)
• Air Conditioning and Refrigeration Institute (ARI)
• Air Diffusion Council (ADC)
• Air Movement and Control Association, Inc. (AMCA)
• American National Standards Institute (ANSI)
• American Society of Mechanical Engineers (ASME)
• American Society for Testing and Materials (ASTM)
• American Water Works Association (AWWA)
• Underwriters Laboratories, Inc. (UL)
• British Standard European Norm (BSEN)

1.18 Drawings and Technical Documents

• Contractor shall submit detailed design basis report along with supporting calculations for the entire HVAC system Electrical SLD, control diagram & control sequence.
• All HVAC load calculations shall be done using latest version of Hourly Analysis Program or software which is using heat transfer function methodology to calculate heat load.
• All the drawings shall be prepared on computer through AutoCAD System.
• Drawings shall include layouts for AHU Rooms, Fan Rooms, Ventilation fans, detailed Ducting drawings showing exact location of supports, flanges, bends, tee connections, reducers, silencers, distribution grids, volume control dampers, collars, grilles, diffusers; detailed piping drawings showing exact location and type of supports, valves, fittings etc; acoustic lining and external insulation details for ducts, pipe insulation etc; electrical panels inside/outside views, power and control wiring schematics, cable trays, supports and terminations.
• These drawings shall contain all information required to complete the Design and Execute the Works and shall contain details of construction, size, arrangement, operating clearances, performance characteristics and capacity of all items of equipment, also the details of all related items of work.
• Each item of equipment/material proposed shall be a standard catalogue product of an established manufacturer from the list of approved makes.
• Manufacturer’s drawings, catalogues, pamphlets and other documents shall be maintained in the Records Office. Each item in each set shall be properly labelled, indicating the specific services for which material or equipment is to be used, giving reference to the governing section and clause number and clearly identifying the items and the operating characteristics.
• Samples of all materials like grilles, diffusers, controls, insulation, premoulded pipe section, control wires etc. shall be maintained at site in a dedicated samples room provided by the Contractor and submitted for approval to Engineer in charge.
• All HVAC drawings shall be coordinated with all other services drawings any impact or change due to co-ordination will be absorbed by contractor.
• Final handover documents shall include O&M manual along with as built drawing.

1.19 Construction Specification

This section shall cover the construction specification for HVAC installation consisting of:
• HVAC Equipment’s
• Chilled/Hot water distribution
• Air distribution
• Insulation
The basic requirements for the system and materials are as under:

- Air Handling Units
- Ceiling Suspended units shall be provided as required.
- Chilled water piping
- Ducting
- Thermal insulation
- Acoustic lining of duct
- Acoustic lining of room
- VRF/VRV
- Unitary System
- Precision Air conditioning

2 WATER COOLED SCREW CHILLER

2.1 SCOPE OF WORK:

This chapter describes central Air-conditioning plant with AHRI certified factory assembled & tested chilling units with a COP and IPLV greater than as mentioned in para 1.9 of technical specification and using a zero ODP and low GWP refrigerant. The chilling machine shall be of approved make consisting of the following:

a) Twin/Mono screw Compressor with a pair of Helical Rotors
b) Electric Motor
c) Shell & Tube type Water Cooled Condenser
d) Shell & tube type water chiller
e) M.S. foot mounting, plate with cushy foot mounting
f) First charge of refrigerant and oil
g) Refrigerant piping & controls
h) Variable speed drive as starter
i) Microprocessor control with multiple display.
j) Water flow switch

2.2 GENERAL:

Each unit will be completely factory-assembled including evaporator, condenser, sub-cooler, oil separator, compressor(s), motor, lubrication system, micro-computer control center, and all interconnecting unit piping, wiring and accessories. The chiller performance, as complete unit shall be certified by AHRI 550/590 (latest edition)

IKW/TR should be less than or equal to 0.6037.

The unit shall have all components mounted on a sturdy powder coated MS framework fabricated out of sturdy channels and angles. The compressors and the unit as a whole shall be provided with suitable anti-vibration mounts. The vibration of the chilling machine shall not exceed a peak to peak displacement of 100 microns measured anywhere on the machine. The noise level of the machine shall not exceed 85 dB at a distance of 1m from the machine

2.3 COMPRESSOR:

The compressor will be semi hermetic/Hermetic, helical rotary twin/mono screw type. The compressor housing will be of grey iron / cast iron, optimized through finite element
analysis, precision machined to provide minimal clearance for the rotors. The compressor will have an internal oil reservoir and advanced pressure differential driven oil system to assure a constant supply of oil to the bearings at all times. A spring actuated positive seating check valve will be incorporated in the compressor housing to prevent rotor backspin during shutdown. The shaft seal will be a spring-loaded, carbon ring type with precision lapped collar cooled by low pressure oil.

Capacity control will be achieved by use of Variable speed drive and a slide valve to provide fully modulating control from 100% to 25 % of full load. The slide valve will be actuated by oil pressure, controlled by external solenoid valves through the microcomputer control center. The unit will be capable of operating with lower temperature cooling tower water during part-load operation in accordance with ARI Standard 550/590 latest edition.

2.4 MOTOR DRIVELINE:
The motor will be 2-pole, continuous duty, squirrel cage induction type, and will have a refrigerant cooled enclosure for Semi Hermetic Compressor. The 3-phase induction motor shall utilize suction gas cooling. In each phase winding shall be equipped with embedded sensors to monitor motor temperature and provide effective protection for compressor operation.

Motor full-load amperes at design conditions will not exceed motor nameplate (FLA). Motor will be designed for use with Variable speed drive / star delta/soft starter. Motor will be factory-mounted and directly connected to the compressor to provide compressor/motor alignment.

2.5 LUBRICATION SYSTEM:
An adequate supply of oil will be available to the compressor at all times. During startup and shut down, this will be achieved by oil reservoirs in the compressor During operation, oil will be delivered by positive system pressure differential. An immersion oil heater will be provided, (temperature actuated), to effectively remove refrigerant from the oil. An external, replaceable-cartridge, oil filter will be provided, along with manual isolation stop valves for ease of servicing. An oil ejector will be provided to automatically remove oil which may have migrated to the evaporator, and return it to the compressor. The oil separator will be of a horizontal design with no moving parts, and will provide effective oil separation before the refrigerant enters the heat exchangers.

2.6 EVAPORATOR:
Evaporator will be of the shell-and-tube, DX/flooded type designed for 150 psig working pressure on the refrigerant side, and will be tested at minimum 1.25 times of working pressure. Shell will be fabricated from rolled carbon steel plate with fusion welded seams; have carbon steel tube sheets, drilled and reamed to accommodate the tubes; and intermediate tube supports spaced no more than 1200 mm apart. The refrigerant side will be designed in accordance with the ASME Boiler and Pressure Vessel Code, Section VIII - Division 1 or other equivalent international standards like PED,NB or GB code. Tubes shall be high-efficiency, internally and externally enhanced type having plain copper bands at all intermediate tube supports to provide maximum tube wall thickness at the support area. Each tube will be roller expanded into the tube sheets providing a leak-proof seal, and be individually replaceable. Water velocity through the tubes will not exceed 6 FPS. The evaporator will have refrigerant relief devices to meet the requirements of the ASHRAE 15 Safety Code for Mechanical Refrigeration.
Water boxes will be removable to permit tube cleaning and replacement. Stub-out water connections having mild steel flanges will be provided. Vent and drain connections with plugs will be provided on each water box/pipe. Chiller outlet pipe shall be provided with bellow type water flow switch to prevent compressor start up till full water flow is established.

Evaporator shall be insulated with minimum 19 mm thick Nitrile Rubber to avoid condensation. Insulation has to be factory installed. Site insulation work is not accepted.

2.7 WATER COOLED CONDENSER:
Condenser will be of the shell-and-tube type, designed for 150 psig working pressure on the refrigerant side, and be tested at minimum 1.25 times of working pressure. Shell will be fabricated from rolled carbon steel plate with fusion welded seams, have carbon steel tube sheets, drilled and reamed to accommodate the tubes; and intermediate tube supports spaced no more than 1200 mm apart. A refrigerant sub-cooler will be provided for improved cycle efficiency. The refrigerant side will be designed, in accordance with the ASME Boiler and Pressure Vessel Code, Section VIII – Division 1 or other equivalent international standards like PED, NB or GB code. Tubes shall be high-efficiency, internally and externally enhanced type having plain copper bands at all intermediate tube supports to provide maximum tube wall thickness at the support area. Each tube will be roller expanded into the tube sheets providing a leak-proof seal, and be individually replaceable. Water velocity through the tubes will not exceed 6 FPS. Evaporator should have a proper mechanism to monitor liquid level i.e it should be monitored with sensors or liquid level sight glass. The condenser will have refrigerant relief devices to meet the requirements of the ASHRAE 15 Safety Code for Mechanical Refrigeration.

Water boxes will be removable to permit tube cleaning and replacement. Stub-out water connections having mild steel flanges will be provided. Vent and drain connections with plugs will be provided on each water box. Condenser outlet pipe shall be provided with bellow type water flow switch to prevent compressor start up till full water flow is established.

The shell shall have a large storage area so as to serve as a receiver / Reservoir. The condenser shall be provided with an easily accessible purge connection and a water drain.

Hydrostatic tests shall be carried out at the manufacturer’s works before the dispatch of the chiller and the manufacturers test certificate shall clearly indicate the test pressures, Pressure drop at full rated flow, condenser capacity at rated flow and delta T at clean conditions.

2.8 REFRIGERANT SYSTEM:
Refrigerant flow to the evaporator will be metered by an electric/float expansion valve controlled by the control center to accommodate varying head conditions or single/multiple fixed orifice with no moving parts. Liquid line components include a manual shut-off valve, refrigerant recovery valve, and moisture sight glass and orifice plate. Suction lines are covered with closed-cell insulation. The orifice of the refrigerant system automatically adjusts to the continuously changing pressure condition and modulates refrigerant flow to the evaporator accordingly. The condenser shell will be capable of storing the entire system refrigerant charge during servicing. Isolation from the rest of the system will be by manually operated isolation valves located at the inlet.
and outlet of the condenser. Additional valves will be provided to facilitate removal of refrigerant charge from the system.

The unit is equipped with a suction strainer to prevent any foreign debris introduced to the system during maintenance or service to be allowed into the motor housing. Motor cooled by refrigerant is protected by means of filter or strainer to protect the motor and prolong motor life.

2.9 REFRIGERANT PIPING

Design aspects of Refrigerant Piping:

1. Refrigerant piping shall be designed and installed so as to:
   a) Ensure circulation of adequate refrigerant at all loads.
   b) Ensure oil return to compressor positively and continuously.
   c) Keep pressure losses within limits, especially in suction lines.
   d) Prevent oil/liquid refrigerant from entering the compressor when the compressor is working as well as when it has stopped.
   e) Prevent trapping of oil in evaporator or suction lines, which may return to the compressor in the form of slug.

2. Hot gas lines:
   Oil shall be entrained and carried by hot gas under all load conditions likely to be encountered in normal operation.

3. Liquid Lines:
   a) Liquid lines shall be designed to ensure that flashing of liquid refrigerant does not occur by minimizing the pressure drop suitably, by avoiding long vertical risers, and appropriate sub cooling.
   b) Each liquid line shall be provided with a permanently installed refrigerant drier of throw away or rechargeable type. The drier shall be installed in a valved line.

4. Suction Lines:
   a) Oil shall be entrained and carried by the suction gas under all conditions of load likely to be encountered in normal operation.
   b) Piping shall be designed for a suitable velocity of refrigerant (similar to hot gas line) to ensure that oil will not separate from the gas and drain to the compressor in slugs.
   c) The refrigeration system shall be equipped with controls for pump down system so that the evaporator and suction line are emptied before the compressor shuts off, thus preventing liquid refrigerant and oil from entering the compressor when restarted.
   d) Refrigerant lines shall be sized to limit pressure drop between evaporator and condensing unit to less than 0.1 kg. per sq.cm. (3 psi).
   e) Isolating valve shall be provided to enable isolation of each compressor in case of multiple compressor units (as built in valves), strainer, drier and any other components as may be required for proper operation and maintenance. Isolation valves shall be provided as standard for storing the refrigerant in the condenser during servicing of compressor.
   f) Thermostatic expansion valve/float valve shall be provided in refrigerant circuit flooded system as per manufacturer’s design.

5. Material
   a) Fittings like bends, tees, sockets etc. shall be of wrought copper or forged brass and
shall be suitable for the duty involved. Flare type compression fittings of forged brass shall be allowed up to 15 mm piping size.

b) Where specified in the tender specification, mild steel may be provided for refrigeration piping, with seamless MS tubes and fittings of heavy class conforming to IS: 1139/ASTM Equivalent. All liquid lines and instruments lines shall however be of copper only.

6. Pressure Testing

After completion of the piping installation, the entire chilling unit shall be pressure tested with dry nitrogen or any other inert gas at the following pressures:

<table>
<thead>
<tr>
<th>Refrigerant</th>
<th>Test pressure (Kg./Sq. cm. (Gauge))</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>High pressure side</td>
</tr>
<tr>
<td>R - 134a</td>
<td>10</td>
</tr>
</tbody>
</table>

This test shall be carried out as follows:

a) The system shall be charged with nitrogen or inert gas to 1.0 Kg./sq.cm. gauge and all joints shall be checked for leakage with a mixture of four part water, one part liquid soap and a small amount of glycerin. Leaks shall be marked, pressure released and repairs done. Brazed joints, which leak, shall be opened and redone. These shall not be repaired by addition of brazing alloy to the joints.

b) The system shall now be charged with nitrogen or the inert gas to the pressure specified in the above table and the process of locating leaks and repairs shall be repeated.

c) Final pressure test:

   After all the leaks have been repaired, the system shall be retested with the test pressure maintained for a period of not less than 8 hours. No measurable drop in pressure should be detected after the pressure readings are adjusted for temperature changes. Pressure gauges, controls and compressors may be valved off during pressure testing.

2.10 Control Center

**General:** The chiller shall be controlled by a stand-alone microprocessor based control center. The chiller control panel shall provide control of chiller operation and monitoring of chiller sensors, actuators, relays and switches.

**Control panel:** The control panel shall include color liquid crystal display (LCD) surrounded by “soft” keys which are redefined based on the screen displayed at that time. This shall be mounted in the middle of a keypad interface and installed in a locked enclosure. The screen shall detail all operations and parameters of the chiller and its major components. Panel verbiage shall be available in other languages as an option with English always available. Data shall be displayed in either English or Metric units. Smart Freeze Point Protection shall run the chiller at 36.00°F leaving chilled water temperature, and not have nuisance trips on low water temperature. The sophisticated program and sensor shall
monitor the chiller water temperature to prevent freeze up. The panel shall display
countdown timer messages so the operator knows when functions are starting and
stopping. Every programmable point shall have a pop-up screen with the allowable ranges,
so that the chiller cannot be programmed to operate outside of its design limits.

The chiller control panel shall also provide:

1. System operating information including:
   a. return and leaving chilled water temperature
   b. return and leaving condenser water temperature
   c. evaporator and condenser saturation temperature
   d. oil pressure at compressor
   e. % full-load amps
   f. compressor discharge temperature
   g. operating hours

2. Digital programming of set points including:
   a. leaving chilled water temperature
   b. current limit %
   c. system cycling

3. Status messages indicating:
   a. system run/stop
   b. system ready to start
   c. start inhibit

4. Safety shutdowns enunciated through the display and the status bar, and consist of system
   status, system details, day, time, cause of shutdown, and type of restart required. Safety
   shutdowns include:
   a. evaporator – low pressure
   b. evaporator – transducer or leaving liquid probe
   c. condenser – transducer or temperature sensor
   d. condenser – high pressure
   e. discharge – high temperature
   f. oil – low differential pressure
   g. oil – clogged filter
   h. oil – high pressure
   i. motor – motor protection

5. Cycling shutdowns enunciated through the display and the status bar, and consists of system
   status, system details, day, time, cause of shutdown, and type of restart required.
   Cycling shutdowns include:
   a. system cycling - contacts open
   b. control panel - power failure
   c. leaving chilled liquid - low temperature
d. leaving chilled liquid – flow switch open
e. condenser – flow switch open
f. leaving chilling liquid – high temperature

6. Security access to prevent unauthorized change of set points, to allow local or remote control of the chiller. Access is through ID and password recognition, which is defined by three different levels of user competence: view, operator and service.

7. The operating program and programmed set points are stored in non-volatile memory (EPROM) to eliminate reprogramming the chiller due to AC power failure or battery discharge.

8. A numbered terminal strip for all required field interlock wiring.

9. An RS-232 port to output all system operating data, shutdown / cycling message, and a record of the last 10 cycling or safety shutdowns to a field-supplied printer. Data logs to a printer at a set programmable interval. This data can be preprogrammed to print from 1 minute to 1 day.

10. The capability to interface with a building automation system to provide:
   a. remote chiller start and stop
   b. remote leaving chiller liquid temperature adjust
   c. remote current limit set point adjust
   d. remote ready to start contacts
   e. safety shutdown contacts
   f. cycling shutdown contacts
   g. run contacts

11. Chiller Starter Panel: The chiller shall be equipped with a factory fitted Variable frequency drive. The VFD panel shall be min.IP-42 or above protection for indoor application. The VFD starter panel shall be complete with non-fused power disconnecting switch/ circuit breaker, with external lockable handles in compliance with Article 440-14 of NEC, to isolate the unit power supply for service. The panel shall have VFD, under/ over Voltage trip, single phase preventers, and all necessary relays and protections, analogue ammeter and voltmeter and as designed and Certified by the OEM of the Chiller

2.11 VERIFICATION OF CAPACITY AND EFFICIENCY
   a) Unit manufacturer shall provide a witnessed FOUR point performance test as per the latest version of AHRI-550/590-latest editions test procedures with the exception of AHRI tolerance on capacity.
   b) Chiller performance test shall be witnessed by AAI representative at the factory. Contractor to include in his price for all expenses including travel food and accommodation etc related to the visit.
   c) Factory performance test for one of chiller (One out of Four) with the proposed refrigerant at 25%, 50%, 75% and 100% load at design conditions and at constant condenser entry temperature with AHRI tolerance in a manufacturers test facility. Furnish a certified test report to confirm performance as specified.
   d) The Manufacturer should submit AHRI certified performance sheets at the above mentioned load conditions for the tender design conditions along with the bid and testing should be conducted based on the proposed design conditions mentioned in the tender.
e) Include AHRI-approved selection method in proposals for chiller performance for acceptable refrigerant. Verification of date and version of computer program shall be available with AHRI.

f) Run the performance test with clean tubes in accordance with ARI 550/590 latest edition to include the following:
   - Make a downward temperature adjustment per Section A7.3 to the design leaving evaporator water temperature to adjust from the "design fouling" to the "clean tube" condition.
   - Make an upward temperature adjustment per Section A7.3 to the design entering condenser water temperature to adjust from the "design fouling" to the "clean tube" condition.
   - Conduct the performance test with clean tubes and with temperature adjustments in (1) and (2) above without exception. Have the manufacturer clean tubes, if necessary, prior to test to obtain a test fouling factor of .0000 hour square feet F/BTU.
   - Provide factory test instrumentation per AHRI Standard 550/590-latest editions, and calibration of all instrumentation traceable to the National Institute of Standards and Technology (formerly NBS).

g) If the equipment fails to perform within allowable tolerances the manufacturer will be allowed to make necessary revisions to his equipment and retest as required. The manufacturer shall pay all expenses resulting from retesting. In the event that these revisions do not achieve submitted performance, AAI's reserves the right to reject the equipment.

h) The Owner or his representative shall be notified 14 days in advance to witness the factory performance test.

i) Submit a certified test report of all data to the AAI prior to completion of the project. Provide the factory certified test report signed by an officer of the manufacturer's company. Pre-printed certification will not be acceptable; certification shall be original.

2.12 Sound Data:
The screw chiller Sound Pressure Level (SPL), in decibels (dB), with a reference pressure of 20 micro Pascal, shall not exceed the values listed below. All ratings shall be in accordance with AHRI Standard 575-87, "Method of Measuring Machinery Sound within Equipment Rooms."

No reduction of entering condenser water or raising of leaving chilled water temperatures will be allowed in the SPL's. Making such a temperature adjustment does not represent the loudest operating condition the chiller will experience while on the job, and could mask sound problems that would otherwise occur. A minimum of 75 percent of the sound data points along the length of the machine shall be taken, and established as the minimum percentage of total possible points used to determine sound levels.

<table>
<thead>
<tr>
<th>% Load</th>
<th>dBA</th>
</tr>
</thead>
<tbody>
<tr>
<td>100</td>
<td>86</td>
</tr>
<tr>
<td>75</td>
<td>86</td>
</tr>
<tr>
<td>50</td>
<td>86</td>
</tr>
<tr>
<td>25</td>
<td>86</td>
</tr>
</tbody>
</table>

The specific chiller meets the referenced noise criteria above

2.13 WARRANTY
Provide a 5 year warranty for parts, labor and refrigeration from date of issuance of occupancy permit. Warranty to coincide with manufacturer's parts warranty. Warranty shall
be 5 years after the Defect Liability Period of 2 Years and Warranty shall be for all parts, labor and refrigeration.

2.14 INSTALLATION

The complete chilling unit shall be installed over a RCC foundation and shall be adequately isolated against transmission of vibrations to the building structure. Necessary foundation bolts, nuts, levelling screws etc. wherever required for mounting the unit shall be provided by the contractor.

2.15 FACTORY INSULATION

Factory-applied, anti-sweat insulation is attached to the cooler shell, flow chamber, tube sheets, suction connection, and (as necessary) to the auxiliary tubing. The insulation is a flexible, closed-cell nitrile, 38 mm thick, applied with vapor-proof cement.

2.16 PAINTING

The equipment shall be supplied as per manufacturer's standard finish painting.

2.17 Chiller Design Conditions

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chiller Capacity</td>
<td>400 TR</td>
</tr>
<tr>
<td>Chilled Water Leaving Temperature</td>
<td>45°F</td>
</tr>
<tr>
<td>Chilled Water Return Temperature</td>
<td>55°F</td>
</tr>
<tr>
<td>Chilled Water Flow</td>
<td>960 GPM</td>
</tr>
<tr>
<td>Evaporator Fouling Factor</td>
<td>0.0005 ft² °F hr / Btu</td>
</tr>
<tr>
<td>Condenser Water Entering Temperature</td>
<td>85°F</td>
</tr>
<tr>
<td>Condenser Water Leaking Temperature</td>
<td>95°F</td>
</tr>
<tr>
<td>Condenser Water Flow</td>
<td>1200 GPM</td>
</tr>
<tr>
<td>Condenser Fouling Factor</td>
<td>0.001 ft² °F hr / Btu</td>
</tr>
<tr>
<td>Maximum Pressure drop across condenser and Cooler</td>
<td>30 ft of wg</td>
</tr>
</tbody>
</table>

(Only two pass shells shall be accepted)

Manufacturers should submit the following computer selection sheet for chiller from their latest version of chiller selection software

- Performance sheet with 100%, 75%, 50% and 25% loads at design conditions at constant condenser water entry temperature as well as at AHRI relief temperatures.
- Performance sheet with 100% to 25% unloading at constant condenser water entry temperatures

3.0 ONLINE TUBE CLEANING SYSTEM (OLTCS)

The scope includes design, supply, installation and commissioning of 4 sets of OLTCS (one for each condenser). Online tube Cleaning system for individual chiller to be provided. Online tube Cleaning System complete with all accessories as per the requirement. The condenser online tube Cleaning System is intended to prevent formation of various forms of fouling and scaling in the condenser tubes.

Each set of OLTCS shall comprise the following:

- Two Nos. Ball Separators at Condenser CW outlet pipe (one for each pass).
b) One No. common Ball recirculation pump with drive motor for each condenser.
c) One No. common Ball collector for each condenser.
d) One No. Manual ball sorter (Bucket type sorter with sieves to manually sort out the undersized balls by shaking the sieved bucket manually) for each set of OLTCS.
e) Differential pressure measuring system shall be provided for each ball separator. DP measuring system shall comprise of DPT + DPG.
f) Instrument shall be with Remote seal/Capacitance type arrangement.
g) Stubs for DPT and DPG shall be independent.
h) Ball monitoring system comprising of an independent balls recirculation monitor and an independent balls oversize monitor.
i) Complete Pipe work, including interconnection piping, valves, distributors and injection nozzles, support installation materials shall be provided.
j) All the field instruments required shall be provided.
k) Commissioning balls and other commissioning spares has to be provided.
l) Set of mandatory spares to be provided. List to be finalized with AAI.
m) Supporting arrangement complete with foundation plates, anchor bolts, nuts, sleeves, inserts, all Installation materials, fixing bolts, clamps and other accessories etc. for complete equipment supplied under this package.

4.0 CHILLER PLANT MANAGER

4.1 General
A Chiller Plant Automation (CPA) system will be included with the chillers to provide coordinated chiller plant operation, optimize energy efficiency, equipment protection with alarms, and all other requirements of a central chilled water plant. The CPA will also serve as an essential chiller management tool for owner personnel. This specification details specific features and junctional requirements of the CPA System. In addition and priced separately, the CPA System shall be capable of controlling all central plant equipment, if so specified.

4.2 Acceptable Suppliers

The Chiller Plant Automation (CPA) system shall be furnished and installed by the chiller manufacturer.

4.3 Supplier Responsibilities

The chiller manufacturer will be responsible for CPA System hardware, sensors, installation, programming, wiring, start-up, submittal, project documentation, one year warranty, and all other provisions of this specification. The chiller manufacturer will comply with the provisions of this specification as a requirement to be an acceptable supplier of the chillers and the CPA System.
4.4 Bid Submittal

The following Bid Submittals are required for an acceptable proposal of the CPA System:

a. CPA Equipment Dimensions
b. Chiller Plant Sequence of Operation
c. CPA software description and operation
d. CPA Equipment Data Sheets
e. Monitoring and Control Points List (indication of equipment to be installed by others)
f. RS-232 C Compatibility Specification and Instructions

4.5 CPA Hardware

The CPA System must be a microprocessor based programmable controller with the capability of specific chiller plant control, chiller interface, and operator use. The CPA will be designed to operate in a NEMA-1 standard equipment room environment and must be U.L. approved.

a. Inputs
   The CPA will have inputs for accepting signals from temperature sensors, pressures sensors, flow meters, chiller power use, equipment status, etc. The CPA must be capable of using analog inputs 0 to 10 volts DC, 4 to 20mA, digital switch closure, and pulse width signals. The chiller manufacturer will be responsible for selecting the appropriate method of system inputs and monitoring. Input quantity shall all be a minimum of four (4) inputs on up to 48 inputs according to the controller specified.

b. Outputs
   The CPA will control the chiller plant using Direct Digital Control (DDC). The CPA outputs must be capable of modulating/positioning valves, chiller control vanes, pump speed, fan speed, and other devices. The CPA must be capable of both analog control 0 to 10 volts, digital switch closure rating of 24VAC, and pulse width modulation. The chiller manufacturer will be responsible for selecting the appropriate method of control. Output quantity to be minimum of nine (9) and a maximum of twenty-four (24) in a specified controller.

c. HOA – Hand/Off/Auto Switch
   All CPA outputs must have Hand-Off-Auto (HOA) switch for manual override of the system and indicating light(s) for output status.

d. Communication Data Port
   The CPA must have an RS-232 data port for communication to a printer, terminal, or PC. The data port must use standard industry ASCII communication protocol, selectable 300 to 9600 baud synchronous communication speed. RS-485 must be used for the LAN (Local Area Network) communication port.

e. Communications to Other Building Automation Systems
The CPA will have a translator capability included that will transfer all inputs, alarm conditions, safety/cycling information to the BAS. The translator shall broadcast in 0 to 10VDC signals. These signals are to be generic and not require special protocols.

1. The supplier of the BAS shall be responsible for the connections to the CPA Translator. Any special signal conditions needed by the BAS supplier are to be provided in their portion of these specifications.

2. The translator shall be capable of receiving commands from the BAS to request information on each device controlled by the CPA and to change setpoints, alarm points, on-status of the chillers, maximum demand of each chiller, and parameters as recommended by the chiller manufacturer. In no case shall the translator accept an improper command that will make the chillers operate at poor efficiencies or be subject to possible damage.

f. RS-232 Translator
The CPA will have an RS-232 Translator for equipment control interface to third party BAS via RS-232 ASCII protocol communication.

g. Communications to remote Service/Control Stations
The CPA will have the ability to communicate via a modem to a remote station. The remote station shall not require a terminal or computer to receive information. However, such terminals shall also be capable of being used if desired by the owner and included in this specification.

4.6 Operator Display and Interface

The CPA must have a display panel for human interface, on-site access to chiller plant operating data, enunciation of system alarms and messages, and changes in chiller plant control. The operator display shall be built-in. The CPA System must have the following features:

a. Keypad
   Must have twenty (20) keys allowing access to all functions of the system; access of all chiller system temperatures, pressures, flows, calculated values, and equipment status. Also, change of chiller setpoint, chiller lead/lag selection, pull-down demand limit, chiller plant operating schedule, and other parameters as recommended by the chiller manufacturer for optimize chiller plant operation.

b. Display
   The CPA System display shall be a built-in display with a two line digital display of forty (40) characters per line and must be capable of displaying system temperatures, pressures, flows, calculated values, equipment status, valve position, system alarms, and messages.

c. Other Features
   The CPA System must have an audible means to enunciate system alarms by use of a beeper or horn in conjunction with the flashing alarm indication on the display screen. A CRT must be included if specified.
4.7 Sensors and Interface Devices
The chiller manufacturer shall provide all sensors and interface devices for the CPA System. All sensors and devices shall be of the highest quality and reliability while meeting the following accuracy and specifications for proper chiller plant operation.

a. Temperature Sensors
Temperature sensors shall be platinum or nickel RTD or thermistor also must be mounted in a separable well. Temperature sensor accuracy must be less than 1% over application range and at least +/-1/4deg. F accuracy. Differential temperature sensors for chilled water temperature and load calculations must be 1deg.F accuracy. Temperature wells will be supplied by the chiller manufacturer for installation by others. However, sensor wells on the chiller unit must be factory mounted. If not factory mounted, chiller supplier will insure the added installation charges.

b. Other Sensors and Devices
Water pressure sensors, chiller kW/amp sensors, and refrigerant pressure sensors shall be 1% accuracy over the application range. All sensor mounts and fittings will be supplied by the chiller manufacturer and installed in the factory. System input sensors that are mounted in the field shall have piping installed by others.

Water valves and operators will be supplied by others unless otherwise noted which then will be electric or pneumatic and interfaced with the CPA System. The chiller manufacturer will approve valve operator vendors per specification. The mechanical contractor will install all valves in the piping as shown on drawings.

c. Auxiliary Panels
The chiller manufacturer will provide any auxiliary panels for interface devices, where needed.

d. Chiller Control Panel Compatibility
The CPA System and interface devices shall tie into the chiller control panel without override to its operating control and safety integrity and shall be installed by the chiller manufacturer unless otherwise noted. In the event of CPA panel failure, the microprocessor on the chiller unit shall provide English read-out and shall be completely capable of controlling itself at the last command set point issued by the CPA System.

4.8 CPA Software
The CPA System must have operating system software with specific features, capabilities for proper chiller plant control and future AAI requirements. The CPA software will be preprogrammed with provisions for AAI programmability plus custom control features to match all requirements. Canned programs without total flexibility for customer needs are not acceptable.

a. Control Algorithms
The CPA must be capable of P, PI, and PID (Proportional-Integral-Denotative) control for chilled water temperature control, and condenser by-pass valve control, cooling tower fan control, chiller loading/unloading control, pump control, and other control algorithms. Set point, offsets, and rate factors must be adjustable for fine-tuning and chiller plant control stability.
b. Decision Logic
The CPA must be able to make logic control decisions for intelligent chiller plant control decisions based on various operating conditions. The software must be able to perform comparisons, if then, greater than, less than, equal to, and similar logic decisions.

c. Equation Processor
The CPA software must incorporate a means to do mathematical equations for calculating chiller plant variables and chiller operator information. Totalizing the date is also an essential requirement.

d. Clock/Calendar
The CPA software and control algorithms must incorporate an uninterruptable real time clock capable of time of day, month, year, and day of week.

e. English Commands and Messages
The CPA software must use English commands for system programming and operator commands. The software must also be capable of displaying/printing messages, alarms based on chiller plant operating conditions, and operator input in English.

f. Security Access
The CPA software must have at least three (3) levels of password security to allow access to information only, limited chiller plant control changes, and CPA reprogramming respectively.

g. Historical Data
The CPA software must be capable of accumulating historical data and equipment logs. The CPA must have sufficient memory to store at least 48 hours of chiller logs and weekly chiller plant management reports.

h. Other Software Features
The CPA must be capable of interfacing to a smart modem, be capable of auto-answer, and auto-dial for remote access, and shall have voice communication capabilities on-board the unit.

i. Graphing
The CPA must be capable of graphing the relationship of 3 inputs. This capability must be provided and demonstrated at start-up and at acceptance of the system.

j. Translation of Information
The CPA must be capable of including the software necessary to perform the functions of the translator described in this specification.

4.9 Sequence of Operation
The CPA System will be programmed for specific sequences of operation to provide chiller plant operating efficiency by the use of automatic equipment operation, equipment protection, translation of data, and alarms. The chiller manufacturer will provide appropriate control application for AAI chilled water plant and must include the following:
a. **Adaptive Start/Stop**

The CPA will minimize equipment energy use and automatically adjust chiller-pump-tower start/stop schedule(s) by outdoor air temperature, zone space temperature, chilled water temperature, and historical cooling load inertia/reaction time. Chilled water pumps, condenser pumps, tower, and chillers will be controlled separately for optimum start time and stop time. The CPA will determine if water temperature can be reduced from a level reached during idle times before starting chiller compressor. The CPA will determine if water temperature is suitable for shutdown of chiller compressor in advance of actual un-occupancy time. In no case will a single contractor be allowed to shut everything down simultaneously.

b. **Chiller Sequencing/Selection**

Lead/Lag chiller selection will be determined and can be rearranged upon AAI selection. The CPA will automatically forecast cooling load requirement/trend and automatically select optimum equipment combination based on historical energy efficiency, load requirements, chiller-pump-tower kW, and chiller-ready-to-run. The customer may alternatively select optimize/equal chiller run time. Chilled water and condenser water valve(s) will be opened/closed based on chiller selection. The CPA shall be capable of controlling any chiller configuration. Owner shall be able to start chillers at one location or shall be able to select automatic start. Any chiller commanded to start but not doing so will be a designated alarm. Operator will be alerted to start the next most optimum chiller by chiller number location.

c. **Optimum Chiller Load Distribution**

The CPA will automatically load individual chillers based on energy efficiency and optimum equipment combination. The CPA will also reset leaving chilled water temperatures on individual chiller(s) to optimize chiller load distribution while maintaining chilled water supply/return set point mode. Any parallel chiller that is in circulation but does not have water circulating, the evaporator will be in alarm.

d. **Chilled Water Reset/Condenser Water Reset**

The chiller(s) leaving chilled water will be automatically reset/adjusted based on one of the following (customer selectable) methods:

1) constant chilled water supply temperature (i.e. 45°F) for individual chiller or common supply;

2) constant return water temperature control (i.e. 55°F); and,

3) chilled water reset based on outdoor temperature or outdoor humidity. Minimum and maximum reset limits are customer defined.

The condenser water supplied to the chiller shall be lowered as much as to within 5°F of the leaving chilled temperature to reduce lift and provide maximum savings. Chillers that cannot operate with such low condenser temperatures shall be outfitted with a condenser water valve provided by the chiller manufacturer. Associated installation costs shall be the responsibility of the chiller manufacturer.

e. **Low Load Control**

An individual chiller will not be allowed to operate below a selectable operating point (i.e. 30% load) unless only one chiller is required for the cooling load. For cooling load below 25%, the CPA will select to cycle the chiller to maximize energy efficiency or
select continuous operation based on cooling load inertia/reaction time and historical data.

f. Auto Start after Power Failure
   In the event of a power failure, all equipment will remain off for a select period. Equipment will then be sequentially started to minimize kW peak demand.

g. Auto Start of Standby Chiller
   If a chiller or its auxiliary equipment fails to start or shuts down on safety failure, a standby chiller and its associated auxiliaries will be started.

h. Failure Alarms
   The CPA shall recognize and enunciate chiller, pump, and fan failure by means of positive proof feedback and/or safety failure circuit. An alarm message will be displayed and beeper/horn sounded.

i. Pull-Down Demand Limiting
   Upon start-up, the chiller is gradually loaded to a selectable kW limit for a selectable period of time prior to allowing full loading.

j. Cooling Tower Control
   Cooling tower by-pass valve is modulated to maintain minimum condenser water supply temperature of 55°F. This temperature is adjusted in accordance with outside conditions up to 85°F. Cooling tower fans are automatically cycled based on chiller operation. For optimize energy efficiency, cooling tower fan ON/OFF and fan speed is automatically selected based on fan kW rating and incremental chiller kW change.

k. Pump Sequencing and Control
   Pumps are started prior to chiller start-up and are sequenced based on chiller operation and cooling load requirement. Pump shut-down is based on same. Pump speed is controlled by pump pressure on secondary pumps equipped with variable speed control.

l. Total Chiller Plant Optimization
   The CPA sums cooling tower fan’s kW, pump’s kW, chiller’s kW, and automatically selects and operates equipment for maximum energy efficiency based on load forecast, historical efficiency, and optimum equipment combination.

4.10 Alarms and Messages
   The CPA System must be capable of displaying chiller plant alarms and messages. Minimum requirements include chiller failure alarms, pump failure alarms, tower fan failure alarms, high/low temperature alarms, high/low alarms for all inputs, high/low alarms for all calculated variables (i.e. chiller efficiency), and CPA System diagnostics.

4.11 Reports and Chiller Logs
   The system must be capable of accumulating and displaying chiller plant data, historical chiller logs, and reports. Minimum report requirements include chiller historical kWh use, heating/cooling degree-days, chiller run times, lead/lag selection, historical cooling load, BTUH/Ton-hrs, number of chiller failures, most recent chiller alarm, cooling tower run times, pump run times, free cooling run times, and total chiller plant (est.) power use. Minimum chiller log requirements include all chiller plant
operating temperatures, pressures, chiller kW, pump, tower and chiller operating status, and total system (est.) energy use. All logs must be available for a previous 48 hours, in 2-hour increments.

4.12 BAS Compatibility

The CPA must be capable of interface with a Building Automation System (BAS) through Translator or communication link. The chiller manufacturer will provide interface instructions prior to bid so that all work by others can be identified.

4.13 PC Compatibility

The CPA must be capable of ASCII communication to a PC through an RS-232 direct connection or telephone line. The chiller supplier must submit interface instructions and a list of PC software (proprietary or third party) capable of interface of chiller, communication, display of chiller data, reports, and alarms.

4.14 Wiring and Pneumatics

Wiring

The chiller manufacturer shall provide all labor, material, and install all control wiring for all sensors, control devices, equipment interfaces, and electrical power to the CPA System. All wiring will be in accord with local and national Electrical Codes which also must be properly labeled.

All wiring must be installed in EMT conduit.

Pneumatics

Where pneumatic control is required, the chiller manufacturer will provide all material and labor used to install pneumatic piping, interface devices to the CPA System, and equipment/devices that are to be installed.

Pneumatic air compressor and air source supplied by others.

4.15 Project Drawing and Documentation

Project drawings must be submitted after installation and completion of the CPA System. The chiller manufacturer will provide three (3) copies of the following:

a. As-built wiring diagrams
b. As-built pneumatic diagrams
c. Installed bill of Material
d. Sequence of Operation
e. CPA System Operation’s Manual

4.16 Training

The chiller manufacturer will provide one (1) day of on-site operator instruction to designated customer personnel. Training will include routine operation, use of optimize chiller plant operation, controller maintenance, and use of chiller energy management features. The CPA supplier must also offer, at the Owner’s expense, a three (3) day factory training course.

4.17 System Warranty

After project completion, the chiller manufacturer will provide one (1) year of CPA service with total responsibility for warranty including hardware, sensors, wiring, labor, and software. The chiller manufacturer will provide a minimum of two (2) routine
inspections by a qualified Service Technician who will inspect, adjust, and verify proper CPA System operation.

The chiller manufacturer will provide software support, including a back-up copy of software programming and will provide minor software changes as deemed necessary by the chiller manufacturer to assure proper system operation.

The chiller manufacturer shall provide a price for a three (3) year CPA Service Agreement at bid time. The selection of this option is totally up to the Owner and may not be exercised at bid time. Pricing is, however, required as part of the bid package.

4.18 System Future

The CPA System shall be expandable into a Building Automation System. Although not a requirement of this section of the specification, supplier must demonstrate that the system is fully expandable from the central plant up to a building wide system using standard components manufactured by the chiller supplier. The components are to be fully distributive and totally stand-alone modules as previously described.

4.19 Typical CPA Points List

**Inputs:**
- Leaving Chilled Water Temperature
- Entering Chilled Water Temperature
- Evaporator Pressure
- Condenser Pressure
- Entering Condenser Water Temperature
- Tower Fan Control (individual fans)
- Leaving Condenser Water Temperature Amperage
- Chilled Water Set point that the micro panel is controlling to Reset Range
- the micro panel is set to Current Limit Set point that the micro panel is actually controlling to Evaporation Saturation Temperature
- Condenser Saturation Temperature
- Purge Unit Air Solenoid
- Purge Unit Oil Solenoid
- Oil Pump
- Chiller Water Pump Contact

**Outputs:**
- Chiller ON/OFF
- Current Limit Set point
- Leaving Chilled Water Set point
- Pump Control (individual pumps) Chilled Water
- Oil Pressure Pump Control (individual pumps)
- Cond. Water
## CPM DATA POINT SUMMARY

<table>
<thead>
<tr>
<th>Sr. No</th>
<th>Description</th>
<th>Qty</th>
<th>Total Points</th>
<th>Required signal</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Chiller Plant (Water Cooled Chiller)</td>
<td>4</td>
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</tr>
<tr>
<td>1</td>
<td>Chiller On/Off command</td>
<td></td>
<td>4</td>
<td>NO/NC Potential free contact to Chiller Microprocessor</td>
</tr>
<tr>
<td>2</td>
<td>Chiller Run status</td>
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<td>4</td>
<td>NO/NC Potential free contact from Chiller Microprocessor</td>
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<tr>
<td>3</td>
<td>Chiller Fault/Alarm status</td>
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<td>NO/NC Potential free Contact from Chiller Microprocessor</td>
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<td>4</td>
<td>Chiller CHW Temperature Reset Set point</td>
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<td>4</td>
<td>0-10VDC or 4-20mA to chiller microprocessor</td>
</tr>
<tr>
<td>5</td>
<td>Chiller Current Limit Set point</td>
<td></td>
<td>4</td>
<td>0-10VDC or 4-20mA to chiller microprocessor</td>
</tr>
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<td>6</td>
<td>Chiller inlet isolation valve Open/Closed command</td>
<td></td>
<td>4</td>
<td>NO/NC Relay Command to Valve</td>
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<td>4</td>
<td>NO/NC Potential free contact from Valve</td>
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<td>CW inlet isolation valve Open/Closed status</td>
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<td>NO/NC Potential free contact from Valve</td>
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<td>10</td>
<td>Common CHW supply header temperature</td>
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<td>12</td>
<td>Flow transmitter</td>
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<td>0-10 VDC or 4-20mA from Flow Meter</td>
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<td>Supply/return header Bypass valve cmd</td>
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<td>Outside Air Temp/Humidity</td>
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<tr>
<td>C</td>
<td>Primary Chilled Water Pumps (PCHP)</td>
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<td>DO</td>
<td>AI</td>
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<tr>
<td>---</td>
<td>----------------------------------</td>
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</tr>
<tr>
<td>1</td>
<td>Pump Auto/Manual status</td>
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<td>Pump On/Off command</td>
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</tr>
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<td>3</td>
<td>Pump run status</td>
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<td>4</td>
<td>Pump trip status</td>
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</tr>
<tr>
<td>5</td>
<td>Pump VFD control</td>
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<td>6</td>
<td>Pump VFD feedback</td>
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<th>AO</th>
<th>SW</th>
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<td>Pump VFD feedback</td>
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<td>1 Fan Auto/Manual status</td>
<td>2 Fan On/Off Command</td>
<td>3 Fan Run status</td>
<td>4 Fan Trip status</td>
<td>5 CT inlet/outlet Isolation valve Open command</td>
<td>6 CT inlet/outlet Isolation valve Open/close status</td>
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<td>E</td>
<td>Cooling Tower (CT)</td>
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<td>AO</td>
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<td>Fan On/Off Command</td>
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<td>Fan Run status</td>
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<td>Fan Trip status</td>
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5.0 HYDRONIC PUMPS

5.1 Scope:
This specification covers the design, materials of construction, features, performance and testing of the long coupled End suction pumps. Pump shall be suitable for the purpose they are intended.

5.2 Codes and Standards:
The design, material, construction, manufacture, inspection, testing and performance of end suction pumps shall comply with all currently applicable statutes, regulations and safety codes in the locality where the Equipment will be installed. The Equipment supplied complies with the latest applicable Indian, American or equivalent Standards. Other National Standards are acceptable, if they are established to be equal or superior to the listed standards.

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5.3 General:
The pumps shall be flexible coupled with spacer, single stage, centrifugal, foot mounted volute type radial split casing, end suction with back-pull out design. Hence, the rotating unit can be removed and serviced without disconnecting suction, discharge piping and
electrical motor. The pump, electric motor, base frame, coupling and coupling guard shall be factory assembled at the pump manufacturer’s facility. Installation instructions shall be included with pump at time of shipment. The pump manufacturer shall have complete unit responsibility. The pump shall be selected in such a manner that pump efficiency is greater than 70%.

5.4 Features of Construction:

5.4.1 Pump Casing:

Pump casing shall be of robust construction with integrally-cast pedestal support feet in order to transmit pipe load to the base and foundation. Liquid passages in the casing shall be smooth finish to ensure high efficiency.

Pump casing shall be capable of withstanding 1.5 times the design pressure.

Pump casing shall be EN-GJL-250 Grey Cast Iron according to BS EN 1561: 1997 and capable of withstanding to the maximum pressure developed by the pump.

Flange dimensions are in accordance with EN 1092-2. Pump casing shall be fitted with bronze wear ring. Pump casing shall have tapped and plugged holes for priming and draining.

5.4.2 Impeller:

The impeller shall be lead free cast bronze enclosed type with smooth surface finish for minimum frictional loss. This ensures high efficiency. Impeller shall be keyed to the shaft and secured by impeller lock nut. All impellers are dynamically balanced to ISO 1940-1: Grade G6.3. The thrust balancing can be of balancing holes or back vanes. The direction of rotation of the impeller is clockwise when viewed from the motor.

5.4.3 Shaft:

Shaft shall be martensitic stainless steels according to AISI 420, ground and polished to final dimensions and be adequately sized to withstand all stresses, hydraulic loads, vibrations and torques coming in during operation. Shaft shall be designed in such a way that first critical speed will be at least 25% away from the maximum rotating speed. Shaft run-out shall be limited at the seal face and at the impeller to 0.05 mm. Shaft shall be provided with Mechanical seal as default fitment to provide the leak free operation.

5.4.4 Wear Rings:

A renewable type bronze wearing ring shall be provided in the pump casing to maintain close running clearance and to minimize leakage and recirculation losses.

5.4.5 Mechanical Seals:

The liquid cavity shall be sealed off at the pump shaft by an internally-flushed mechanical seal with carbon seal seat and Silicon carbide seal ring, suitable for continuous operation at 221 Deg F (105 Deg C). The mechanical shaft seal has dimensions according to EN 12756.

5.4.6 Bearings:

Antifriction ball bearings shall be of standard type and shall meet minimum L-10 rating life up to 50000 hrs. These shall be factory filled lubrication. Bearing of the pump shall be effectively sealed to prevent loss of lubricant or entry of dust or water.
5.4.7 Coupling:
Pumps shall be provided with flexible type, center drop-out (Spacer) design coupler, capable of absorbing torsional vibration, shall be employed between the pump and motor. Coupling guard shall be bolted to the base plate shall be furnished for all coupled pumps and it shall be rigid and free of vibration.

5.4.8 Motors:
Motor shall be a horizontal, foot mounted, totally enclosed fan-cooled, standard squirrel cage induction motors with main dimensions according to IEC standards. Electrical tolerances are to IEC 60034. Motor shall be energy efficient type(MIN IE3). Motor shall be to with IP 55 enclosure. The class of insulation shall be F with temperature rise limited to Class B. Motor shall be suitable for operation on a 415 V (± 10% variation), 50Hz ± 5%, 3phase, or 240V-1phase AC supply. Motor shall be suitable for both DOL and / or STAR/DETA /VFD starting as the case may be. Pump and motor shall be factory aligned, and shall be realigned by the contractor as per factory recommendations after installation.

5.4.9 Base Plates:
Base plate shall be of fabricated steel and securely welded cross members. Grouting area shall be fully open. The combined pump and motor base plate shall be sufficiently stiff as to limit the susceptibility of vibration. The base plate should be provided with lifting lugs.

5.4.10 Name plates:
Each pump shall be provided with a name plate indicating the following details:
1. Pump type designation
2. Pump Model
3. Rated flow
4. Rated head
5. Pressure rating/max temperature
6. Rated speed

5.4.11 Working pressure:
Maximum allowable working pressure (MAWP) for all the pressure containing parts shall in no case be less than the maximum discharge pressure produced by the pump at shut off (including tolerances), at the max suction pressure, for the maximum impeller diameter and the maximum continuous speed.

Note: MAWP shall not be less than 10 kg/cm² for pumps with DN150 flanges & 16 kg/cm² for pumps with DN32 to DN250 flanges. Pump shall be rated for minimum of 10bar working pressure.

5.4.12 Vibration:
The pump(s) vibration limits shall conform to Hydraulic Institute ANSI/HI 1.1-1.5- 1994; section 1.4.6.1.1 or ISO 10816 for recommend acceptable unfiltered field vibration limits (as measured per HI 1.4.6.5.2) for pumps with rolling contact bearings.
5.4.13 Sound Level:
Sound pressure level of the pump driver shall be max 82 dbA* measured at 1.8m
distance from pump for the duty points.(* Note: Based on the motor kW and speed
according to ISO 3743)

5.4.14 Painting:
The equipment shall be thoroughly cleaned and greased. All rust sharp edges and
scales shall be removed. All external and exposed cast iron parts of pumps have an
epoxy-based coating made in a cathodic electro-deposition (CED) process which is
high-quality dip-painting process and which would prevent rusting and corrosion. The
coupling and shaft shall not be painted.

5.5 PUMP & MOTOR SELECTION:
The pump(s) selected shall conform to EN 733 standards for Preferred Operating
Region (POR) unless otherwise approved by the engineer. The pumps shall be factory
manufactured, assembled and hydrostatically tested as
per Hydraulic Institute standards in an ISO 9001 approved facility. Motor should be of
variable frequency drive compatible. Motor should be selected as non-over-loading
type.

Note: The motor nameplate rating for pumps under parallel operation shall not be less
than the max BKW indicated on the pump data sheet (the power at the END of the curve
for the rated impeller) or shall have the specified margin as per this clause whichever is
greater. The pump motors shall also be suitable for Start-up under open discharge valve
condition.

5.6 Inspection & Testing of Various Items:
Before effecting delivery of the equipment, following inspections and tests as per
relevant IS standards shall be carried out.

For Pumps:
a) Hydrostatic Testing
b) Performance Test (Single point / Duty point)
c) Dynamic balancing for pump impeller.

5.7 Drawings:
The following drawings shall be submitted by the EPC Contractor.
1. Dimensional drawing of pump and motor (Suction and discharge connections and
   foundation details shall also be indicated).
2. Performance curves (capacity vs. total head, efficiency, NPSH and KW
   requirement) ranging from zero to maximum capacity.
3. Technical Data sheet for Pumps

5.8 VARIABLE SPEED PUMPING SYSTEM:
Variable speed pumping system should provide stable and predictable flow rate over a
wide variation of head pressure dedicated for HVAC application including the following:-
a) Shall incorporate a starter to keep starting current within full load current of the motor.
b) Shall conform to ISO 9001.
c) Shall be CE marked for compliance with both LV & EMC directives.
d) Shall have built-in chokes (harmonic filters) both on positive and negative rails of DC link of frequency converter (FC) for harmonic suppressions.
e) Shall provide full motor rated BHP without any de-ration at all speeds (0 to 100%).
f) The frequency converter (F.C.) shall convert Local voltage V +/- 10%, 3 phase, 50 Hz, utility power supply to an adjustable output voltage and frequency. The FC must be capable of delivering full true RMS output voltage to the motor equal to the mains input voltage to FC at full load and speed and should not cause any de-ration of the motor.
g) The voltage to frequency ratio shall be automatically decided by the FC based on the torque requirements of centrifugal pump. It should not be set a constant V/F ratio, to prevent damage to connected equipment and to optimize energy usage.
h) The FC shall work in conjunction with any standard design squirrel cage induction motor and shall not require the motor to be de-rated or cause the motor temperature to rise above the class ‘B’ rise expected on normal mains operation. The motor shall not require an external blower even at slow speed running. Full motor load (kW’s) and torque shall be available throughout class B temperature rise and certification provided.
i) Full output torque shall be maintained in the ambient conditions of + 45°C and 95% RH without any de-rating.
j) The control system shall include as a minimum, the programmable logic pump controller, adjustable frequency drive(s) and remote sensor/transmitters as required by the design. Provide additional items as specified or as required to properly execute the sequence of operation.
k) The variable speed pump logic controller, adjustable frequency drives(s), AFD by pass and remote sensor/transmitter(s) shall be individual components.
l) Pump logic controller, adjustable frequency drives, sensor/transmitters and related equipment shall be installed by the HVAC Contractor.
m) Line voltage power wiring shall be installed by the electrical contractor as shown on the field connection drawings and wiring diagrams supplied with the pumping package.

n) Low voltage (24 VDC and 115 VAC) wiring shall be installed by the controls contractor as shown on the field connection drawings and wiring diagrams supplied with the pumping package.
o) Enclosure shall be of min. IP-42 along with suitable panel and ventilation system.
p) F.C. (Frequency Converter) supplier shall be able to provide on request, a detailed harmonics analysis to evaluate the anticipated THD (Total Harmonic Distortion)

5.8.1 COMPONENTS:

5.8.1.1 Pump Logic Controller:

1. The pump logic controller assembly shall be listed by and bear the label of Underwriter’s Laboratory, Inc. (UL). The controller shall be specifically designed for variable speed pumping application.
2. The controller shall function to proven programs that safeguard against damaging hydraulic conditions including:
   - Motor overload
   - Pump flow surges
   - Hunting
   - End of Curve
   - System over Pressure

3. Multi Pump Controller shall be capable of receiving multiple analog input signals from one differential pressure transmitters as indicated in the design. Multi Pump Controller will then select the analogue signal that has deviated most from its set point. The selected signal will then be used as the process input value for the hydraulic stabilization function. Multi Pump Controller shall be capable of controlling up to six pumps in parallel.

4. Multi Pump Controller shall be capable of accepting an additional analog input signal from a flow sensor. This input shall be used for the end of curve protection. Instantaneous Flow value should be displayed in the front page. Cumulative Flow data’s should be logged into Multi pump controller.

5. Multi Pump Controller shall be capable of accepting 7 different set points activated through either clock program or individual digital inputs.

6. Multi Pump Controller shall be capable of accepting additional analog input as external set point influential signal to vary the primary analog input signal. This external set point influential signal shall be user selectable from various types of signals like ambient temperature signal or like.

7. Multi Pump Controller shall have program function to accept the pump curve data for optimizing the system performance in terms of energy consumption for the pump being controlled.

8. Multi Pump Controller shall be self-prompting and all alarm messages shall be displayed in plain English. The operator panel shall have the following features:
   - Multi fault memory and recall of last 24 faults with time stamping
   - Red fault light with related alarm message on default screen with graphical representation of the fault.
   - Soft touch membrane keypad switches

9. Multi Pump Controller shall have a display screen size of minimum 320 pixels X 240 pixels VGA display with backlight. Current status of settings and measured values are to be displayed in the default screen.

10. Multi Pump Controller shall have an installation wizard to enable the user to configure the system with minimum assistance.

11. Multi Pump Controller shall have minimum 2 level password protection to safeguard the settings against unwanted / unauthorized changes.

12. Display should have menu driven function for the operation easiness.

13. Multi Pump Controller shall be capable of performing the following pressure boosting function:
Low suction pressure cut out to protect the pumps against operating with insufficient suction pressure.

High system pressure cut-out to protect the piping system against high-pressure conditions.

14. The following communication features shall be provided to the BMS
   - Remote start/stop of the Variable Speed Pumping System through potential free contact from BMS
   - Individual pump start/stop/trip status from VSPS through potential free contact to BMS
   - Failure of any system component
   - Process variable
   - AFD speed
   - Individual analogue input
   - Individual pump/VFD on/off status
   - System percent reference
   - System start/stop command
   - System operating mode
   - Individual pump kW consumption
   - Individual pump operating hours
   - Individual pump running speed in Hz/percentage reference
   - System flow, when optional flow sensor is provided

15. Multi Pump Controller shall have on board Ethernet port for connecting the VSPS to BMS. If given static IP address, Multi Pump Controller should be accessible over Intranet or Internet.

16. The pump logic controller shall be housed in a min. IP-42 enclosure.
   - Adjustable Frequency Drive:
     a) The variable frequency drive(s) shall be pulse width modulation (PWM) type, microprocessor controlled design.
     b) VFD, including all factory-installed options, is tested to UL standard 508. VFD shall also meet C-UL and be CE marked and built to ISO 9001:2000 standards.
     c) VFD shall comply EMC directives as per IEC 61800-3:2004, category C1 with 50 meter motor cable (for power less than or equal to 90 KW) & category C2 with 50 meter motor cable (for power more than 90 KW).
     d) VFD shall be housed in min. IP-42 enclosures for indoor applications. Wall mounted/VFDs with plastic enclosures shall not be acceptable.

17. VFD shall employ an advanced sine wave approximation and voltage vector control to allow operation at rated motor shaft output speed with no derating. This voltage vector control shall minimize harmonics to the motor to increase motor efficiency and life. Power factor shall be near unity regardless of speed or load.

18. VFD shall have balanced DC link chokes to minimize power line harmonics. VFDs without a DC link choke shall provide a 3% impedance line reactor.
19. Automatic motor adaptation (AMA) algorithm shall be available in the VFD. This feature shall allow for automatic adaptation of drive to meet the characteristics of the motor to have increased efficiency leading to additional energy savings. AMA feature should be able to configure without disconnecting the motor from the VFD.

20. Output power switching shall be done without interlocks or damage to VFD.

21. The following user adjustable parameters shall be provided in the VFD:
   a) Acceleration time
   b) Deceleration time
   c) Minimum frequency
   d) Maximum frequency

22. VFD shall be compatible for BACNET/IP protocol as standard.

23. VFD shall have Automatic Energy Optimization (AEO) function. This feature shall reduce voltages when the drive is lightly loaded to provide a 3% to 10% additional energy savings.

24. VFD shall be suitable for elevations to 1000 meters above sea level without derating. Maximum operating ambient temperature shall not be less than 40 Deg Celsius. VFD shall be suitable for operation in environments up to 95% non-condensing relative humidity.

25. VFD shall be capable of displaying the following data in plain English via 40character alphanumeric display:
   (a) Frequency
   (b) Voltage
   (c) Current
   (d) Kw Per Hour consumption
   (e) Running hours
   (f) Run mode(Remote/local)
   (g) Active power
   (h) RPM

26. VFD(s) shall be warranted for a period of 12 months

5.8.2 Differential Pressure Transmitters

Differential pressure transmitters shall be field mounted and shall transmit an isolated 4-20mA DC signal indicative of process variable to the pump logic controller via standard three wire 24 DC system with Emission/Immunity confirming to EN61000-6-2/3.

Unit shall have stainless steel wetted parts with two 7/16" process connections. It shall be protected against radio frequency interference and shall have water tight, IP 55 electrical enclosure. Sensor should be capable of withstand a burst pressure of 25 bar. Accuracy shall be within 2.5% BFSL (Best Fit Straight Line).

5.8.3 Sequence of operation

a) The system shall consist of Multi Pump Controller, multiple pump/VFD sets, with manual and automatic alternation and pump staging.

b) The pumping system shall start upon the start command from the BMS when the Multi Pump Controller is configured in “Remote” mode.

c) If the Multi Pump Controller is configured in “Local” mode, the system is started via the “Control Unit” at the panel and the pumping system shall operate...
automatically.

d) Differential pressure transmitters shall be provided as indicated in the design.
e) Each DPT shall send a 4-20 mA signal to the pump logic controller, indicative of the field condition.
f) Multi Pump Controller shall compare each DPT signal against the set point and consider the most deviated signal for engineering the VFD/Pumps speed.
g) Multi Pump Controller shall continuously scan the DPT signals and compare with the set point to control the most deviated zone.
h) If the actual process variable (PV) is not met by the lead pump, Multi Pump Controller shall initiate a timed sequence to bring in a lag pump into operation.
i) The lag pumps shall accelerate in tandem with the lead pump decelerating until both the pumps settle at same speed to meet the set point. (Process Variable PV = Set Point SP).
j) Further if the Process Variable (PV) changes, both the pump(s) speed should change together.
k) During normal running sequence, Multi Pump Controller should attempt to destage pumps so that optimum number of pumps is always running in terms of energy consumption.
l) In the event of lead pump/VFD fault, Multi Pump Controller automatically initiates a timed sequence to start the standby pump/VFD set in the variable speed mode. The standby variable speed pump shall be controlled by the Multi Pump Controller.
m) VFD fault indication shall be continuously displayed on the display screen graphically until the fault is rectified and the controller has been manually reset.
n) In the event of failure of zone differential pressure transmitter, its process variable signal shall be removed from the scan/compare sequence. Alternative zone differential pressure transmitter if available, shall remain in the scan/compare sequence.
o) Upon differential pressure transmitter failure a plain English warning message shall be displayed on the Control Unit of Multi Pump Controller screen with a fault code.
p) In the event of failure to receive all zone differential pressure transmitter signals, a user selectable number of VFD/Pump sets shall run at a user adjustable speed. Same shall be reset upon correction of the zone failure.

6 COOLING TOWERS

6.1 SCOPE

The scope of this section comprises the design, supply, erection, testing and commissioning of cooling towers in accordance with requirements.

6.2 TYPE

Cooling Towers shall be induced draft type in accordance with requirements.
6.3 INDUCTED DRAFT COOLING TOWER
Cooling Towers shall be suitable for outdoor use. Tower shall be vertical, induced draft, counter/cross flow type. FRP / GRP construction, in rectangular / square profile, complete with fan, motor, diffusion deck spray section, eliminators, steel supports, and equipment as per design requirements.

6.4 Capacity
The cooling tower capacities shall be as per design and requirement. All cooling towers shall be certified by CTI (Cooling Tower Institute).

6.5 Side Casing
This shall be made out of FRP / GRP (Glass reinforced polystyrene) construction with smooth surface on both sides for minimum resistance to air flow. It shall have sufficient structural strength to adequately withstand high wind velocities and vibration. The casing may be installed in the reinforced cement concrete basin identified in drawings, as required. The cooling tower shall not be less than 75 cm above the ground / floor level. The tower supporting structure shall be made out of hot dipped galvanized tubular frame. Air intake shall be all along the sides so that tower can be installed quite independent of prevailing wind direction. Anodized aluminum or PVC louvers integrated with fill and backed up by galvanized bird screen shall be provided at air intake. Sufficient clearance between casing and adjoining structures shall be provided to enable servicing and periodic cleaning. The fan guard shall be as per standard and designed to prevent contact between fan and human finger.

6.6 Cold Water Basin
Cold water basin shall be a deep sump of FRP on which cooling tower super structure shall be supported as per requirements. Basin fittings shall include the following:
   i. Bottom outlet.
   ii. Screened suction assembly.
   iii. Drain connected to the side / underside of basin with valve.
   iv. Overflow connected to the side of basin.
   v. Built-in bleed off attached to inlet header discharging through polyethylene tube into overflow pipe.
   vi. Ball type automatic make up water valve.
   vii. Quick fill connected to the side of basin.
   viii. Equalizing connection and balancing valve for multiple Cooling Towers.

6.7 Distribution System
Hot water distribution system shall comprise of header and branch arms system with flow balancing system or open pan gravity flow system. No overflow or splash of water shall be allowed at design flow rates.

6.8 Filling
Fillings shall be made of corrosion proof and rigid PVC film in honey comb design and arranged in square / rectangular form. Thickness of PVC fills shall not be less than 0.2mm. Fill sheets shall be suspended from H.D.G steel structural tubing supported from the lower structure & shall be elevated above the floor of the cold water basin to facilitate cleaning and easy replacement. They shall be arranged in such a manner to ensure negligible resistance to air flow and to eliminate back water spots and prevent
fouling through scales that may form. In order to reduce carry-over losses through entrainment of moisture drops in air stream, PVC drift eliminator shall be installed.

6.9 Mechanical Equipment
The tower shall be provided with low speed fan running through gear reducer or direct driven fan speed shall not exceed 720 RPM. Fan shall be of the propeller type light-weight rotor fitted with multiple aero foil blades. The entire fan assembly shall be statically and dynamically balanced. Fan shall be driven by 415±10% volts, 3 phase,50 Hz, AC supply, and energy efficient (MIN IE3) motor totally-enclosed, fan-cooled, weather-proof construction (IP55), designed and selected to operate in humid air stream. Fan shall be protected by a fan guard and bird screen of galvanized steel construction to prevent birds from nesting during idling period & shall be easily accessible for inspection and maintenance. The guarding shall be as per standards. A service ladder of Aluminum / stainless steel shall also be provided for greater convenience. The mechanical equipment assembly shall be adequately supported on a rugged steel base welded to tubular support assuring vibration-free support. Fan guard and bird screen (of galvanized steel construction) shall be provided to prevent birds from nesting during idling periods. Gear-reducer shall be of spiral bevel type.

G.S.S canopy shall be provided over the fan motor for protection against rain water. Care shall be taken that fan air is not restricted. Motor terminal box shall be made water tight.

6.10 Sound
Sound Level: To maintain the quality of the local environment, the maximum sound pressure levels (dB) from the cooling tower operating at full fan speed shall not exceed 85 DB in free field condition

6.11 PERFORMANCE DATA
Complete performance ratings and power consumption at varying loads and outdoor wet bulb temperatures, shall be submitted and verified at the time of testing and commissioning of the installation.

6.12 TESTING
Capacity of the cooling tower shall be computed from the measurements of water flow, incoming / outgoing water temperatures and ambient air wet bulb temperature using accurately calibrated mercury-in-glass thermometers. Computed ratings shall conform to the specified capacities and quoted ratings. Power consumption for cooling towers shall be computed from measurements of incoming voltage and input current.

A detailed performance test shall be carried out for cooling tower in the monsoon season in presence of Engineer in-charge.

7 EXPANSION TANK PRESSURIZATION UNIT WITH VACUUM DE-GASSER
a) Expansion, pressurization and Vacuum Degassing of the chilled water system to be provided by an integrated unit comprises of pressurized expansion tank, pressurization unit with stainless steel cylinder for effectively removing of dissolved gas by vacuum degassing function c/w state of the art digital controller.

b) The Expansion tank & pressurization unit shall be sized appropriate to the static height, total system volume, maximum ambient temperature, maximum allowable system pressure and safety relief valve settings and glycol content (%) if required.
c) The expansion tank shall be fitted with a replaceable high quality butyl rubber bladder in accordance with DIN 4807-3, Nitrogen gas filling for longer maintenance of pre-pressure.
d) The pressurized expansion tank shall be cylindrical, in accordance with Pressure Equipment Directive 2014/68/EU. Tanks from (100 - 1000 liters): in accordance with EN13831 & from 1200 - 8000 liters: in accordance with AD2000.
e) Pressurization unit shall be manufactured and designed in accordance with European Pressure Equipment Directive PED 2014/68/EC and Machinery Directive 95/16/EC.
f) The expansion tank shall have Red (RAL 3002) epoxy powder coating.
g) Tank shall be Suitable for addition of glycol-based anti-freeze up to 50%.
h) Tank shall be delivered with pressure gauge.
i) Maximum continual working temperature of the bladder shall be 70 °C (158 °F), and tank shall be Suitable for systems with a flow temperature of 120 °C.
j) The Pressurization unit shall have two pumps duty standby housed in a steel cabinet with vacuum degassing cylinder of Stainless steel for removal of dissolved gas c/w break tank of polypropylene with AB Air gap fluid cat 5, float valve, over flow connection, pressure sensor, solenoid valve, isolation Valve, NRV, Drain Valve, flood protection in the event of a serious leak, MODBUS Communication protocol/ BACnet communication protocol (optional).
k) The system shall have Individual controllers for pressurization as well as vacuum degassing function. Bright LED displays scrolling messages including pump operation and alarm mode, digital pressure set points with adjustable differential, and security password protection, High and low pressure alarm setting shall be selectable by the user. The Vacuum degassing function and pressurization function shall be programmable according to system requirement,
l) In case of any fault, controller shall display the fault code and generate the alarm.
m) Auto resetting low water detection.
n) The product shall be installed according to the manufacturer's instructions using manufacturer's approved components.
o) The unit required for this system shall be complete in all respect with pumps, control panel, pressure transmitter, control cables, piping, supports, clamps etc.
p) The unit shall comprise break tank with lid, water connections with isolating valve and float valve, centrifugal pumps (duty/standby) with continuously rated single phase motor, pressure switch, pressure reducing valve with gauges and interconnecting pipework and valves, all mounted on to a mild steel base plate.
q) A water meter shall be provided to monitor the quantity of water being added to the system during operation.

8 AIR SEPARATOR
The combined Air & Dirt Separator unit allows it not just to remove free and dissolved air but also dirt particles of up to 10 microns without any change to the designed Pressure drop. The special design of the tube is at the heart of the unique combined action of the separator. Dirt particles of all sizes should sink to the bottom of the unit and collect in the dirt chamber, whilst the air bubbles rise and collect in the air chamber. The dirt can be flushed out while the system is in full operation through the drain valve. The air should release via the automatic air vent. The medium used to de-aerate and remove dirt shall be manufactured of Steel Tube & copper wire & Tin. The large collector at the bottom should ensure that flushing is only required now and then. The automatic air vent should be guaranteed not to leak and cannot be closed.
There should be a special constructed air chamber to protect the valve mechanism from
dirt. Sufficient volume to take care of pressure fluctuations. Air Separation via centrifugal
force is not acceptable Large capacity collection chamber should reduce the need for
frequent draining. A drain valve is installed at the bottom of the tube for flushing out the dirt.
All connections, fittings and heads shall be of carbon steel. The Design and manufacturing
of the unit should be in accordance with 97/23/EC. The unique tube element should cause
a local change of the flow in the steel housing, from turbulent to laminar. Because of this,
micro bubbles of air are removed from the fluid and dirt particles will sink down. The micro
bubbles are collected in the air chamber and released to the environment by means of an
automatic air vent. The dirt particles are collected at the bottom of the separator and can be
released manually during operation. A good flow-through of the piping should be
guaranteed.

9 AIR HANDLING UNITS

9.1 Scope:
The scope of work under this heading shall cover design, supply, erection, testing,
commissioning of air handling unit as per specification.

9.2 Double Skin Air handling Units with VFD

9.2.1 CASING

The housing/ casing of the air handling unit shall be of double skin construction. The
housing shall be so made that it can be delivered at site in total/ semi knock down
conditions depending upon the construction. The framework shall be of extruded
aluminium hollow sections. All the members shall be assembled through mechanical
joints to make a sturdy and strong framework for various sections.

Double skin panels shall be made of 0.8mm pre-plasticized / pre coated Galvanized
sheet steel minimum 60g/sqm and 0.8mm galvanized sheet inside with insulation of 25
mm thick CFC free PUF injected insulation of 40 kg/m³ density (min.) with K factor not
exceeding 0.04w/sqm°C.

The panels shall be bolted /screwed to the framework with soft rubber gasket in between
to make the joints airtight. Suitable doors with powder coated hinges and latches shall
be provided for access to various panels for maintenance

The Fan and the motor arrangement shall be mounted on to the common framework.
The entire housing i.e. The Air Handling Unit shall be mounted on GI Base channel
framework. Drain pan shall be constructed of 18 gauge SS sheet with PUF injected
insulation. The pan shall have necessary slope to facilitate for fast removal of
condensate. The coil shall be mounted on the rollers in order to facilitate easy removal
of the coil from the drain pan for cleaning.

AHU panels shall be factory fitted with pressure ports for DPT installation. The number
and size of these shall be confirmed in the AHU technical approval stage. In case
opening is to be made in AHU panel, the same shall be with C-channel all around to
prevent entry of PUF into air stream. The channels shall be cut at 45 degrees at the
corners to avoid overlap. Material for the channel shall be same as that of internal skin
of AHU.
Rubber grommets shall be provided at all entry points into AHU such as coil connection, cable entry etc. The same shall be double lip tight fitting to prevent air leakage.

All access doors shall be outward opening. For doors provided downstream of the fan, especially in high static AHUs, additional clamps shall be provided along periphery of door to maintain constant pressure and ensure proper sealing.

Water resistance marine light with power cabling shall be included. Micro switch with wiring for Door shall be provided such that fan motor shall stop upon opening the door.

9.2.2 Thermal Break Profile
AHU with mixing box having return air ducted shall be provided with thermal break profile as per design. Also these AHU’s shall be provided with 45mm ± 2mm thick panel. Panels and thermal break profiles for all AHUs shall be designed and assembled in such a way that there shall not be any condensation on AHU with conditions of 35 deg C and 92% RH (AHU surrounding conditions) at designed operating conditions inside the AHU.

9.2.3 Damper
Dampers shall be opposed blade type. Blades shall be made of double skinned aerofoil aluminium sections with integral gasket and assembled within a rigid extruded aluminium alloy frame. All linkages and supporting spindles shall be made of aluminium or nylon, turning in teflon bushes. Manual dampers shall be provided with a bakelite knob for locking the damper blades in position. Linkages shall be extended wherever specified for motorized operation. Damper frames shall be sectionalized to minimize blade warping. Air leakage through dampers when in the closed position shall not exceed 1.5% of the maximum design air volume flow rate at the maximum design air total pressure.

9.2.4 Motor and Drive
Fan motors shall be energy efficient min. IE-3 and shall be 415±10% volts, 50 Hz, three phase, totally enclosed fan-cooled class F, with IP-55 protection. Motors shall be especially designed for quiet operation and motor speed shall not exceed 1440 rpm for forward curved fan and 2900 rpm for backward curved fan. Drive to fan shall be provided through belt-drive arrangement. Belts shall be of the oil-resistant type. The fan motor shall be suitable for VFD operation.

9.2.5 Fan
Fan shall be AMCA certified (For Fan Efficiency Grade, Air and Sound performance) DIDW type centrifugal forward/backward curved (for belt driven package) and plug fans for direct driven package. The fan housing, impeller shall be fabricated from GI sheet. Fan impeller shall be mounted on a solid steel shaft statically and dynamically balanced. Shaft shall be supported to the housing with angle iron frame and pillow block heavy duty ball bearing. Fan housing shall be made of die-formed side sheets with streamlined inlets and guide vanes to ensure smooth air- flow into the fans. Fan housing and TEFC Fan motor in IP-55 Construction shall be mounted within the fan section on a common extruded Aluminum base mounted inside the air handling unit on anti-vibration mounts. The fan outlet shall be connected with casing with the help of fire retardant canvass.

9.2.6 Cooling Coils
Chilled water coils shall have 12.7mm(1/2") to 15 mm(5/8") dia (O.D) tubes minimum 27SWG (0.4 mm) thick with sine wave aluminum fins firmly bonded to copper tubes assembled in stainless steel frame. Face and surface areas shall be such as to ensure rated capacity from each unit and such that the air velocity across the coil shall not exceed 150 meters per minute (500fpm). The coil shall be pitched in the unit casing for proper drainage. The coil shall have copper header with chilled water supply & return connections protruding out of AHU casing by minimum 150 mm and fitted with dielectric coupling or adapter for connection with MS pipes. Each coil shall be factory-tested at 21 kg per sq. cm air pressure under water. Tube shall be hydraulically / mechanically expanded for minimum thermal contact resistance with fins. Fin spacing shall be 11 to 13 fins per inch (4 - 5 fins per cm). Water pressure drop in coil shall not exceed 10 PSIG(0.70 kg/cm.sq.).

Coils shall be provided with mechanical means to purge air from the coil during commissioning by means of a purge valve or nipple. To prevent splashing, discharge from the same shall be routed to the condensate drain pan by means of flexible PVC tubing of suitable diameter. Purge valve / nipple shall be accessible externally or by removal of blanking panel.

All AHU’s shall be provided with minimum 6 Row Cooling Coils. Heating coil may be provided if required as per design. Heating coil shall be 2 row deep and shall be of same construction as defined above.

In case AHU has multiple coil stacked one above another, intermediate drain tray of SS 304 (18 gauge) shall be provided so that upper level of coil drains into this drain tray. Copper / SS 304 piping shall be provided from this drain tray upto main bottom tray.

Computerized cooling coil selection output shall be submitted.

9.2.7 Variable frequency drive
VFDs shall be suitable for continuous operation at full load in max ambient temperature of 47 deg C. The frequency converter shall not be a general purpose product, but a dedicated HVAC engineered design. The VFD shall be tested to appropriate UL. The VFD shall be CE marked and conform to the European Union Electro Magnetic Compatibility directive. The VFD shall be programmable to control and integrated with AHU pressure Sensors. Hence this will have additional I/O ports.

9.2.8 FILTER SECTION

9.2.9 PRE-FILTER
Each unit shall be provided with a 50 mm thick factory assembled filter section containing washable synthetic type air filters having anodized aluminium frame. The media shall be supported with High Density polyethylene (HDPE) mesh on one side and aluminium mesh on the other side. Filter banks shall be easily accessible and designed for easy withdrawal and replacement of filter cells. Filter bank framework shall be fully sealed and constructed from GSS. The efficiency of the filters shall be 90% down to particle size of 10 microns (MERV-8) in AHU’s, & HRW units in return air stream) as per IS 7613, and ASHRAE 52.1. Filters face velocity shall not exceed 500 Feet per Minute. Filters shall fit so as to prevent by-pass.
9.2.10 FILTERS - CODES AND STANDARDS

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9.2.11 FILTER ASSEMBLY

The housing shall be made from extruded aluminium sections. All joints shall be sealed airtight and shall be made free of all burrs and sharp edges.

The filter loading mechanism shall be sliding type or front loading type. The locking mechanism shall be a spring loaded, toggle type mechanism with a bolt and throughst assembly which shall throughst the filter evenly against the sealing flange of the housing when it is installed.

9.2.12 Isolators

Vibration isolators shall be provided to all air handling units. The fan and motor framework shall be isolated from the AHU framework by means of spring type vibration isolators. The AHU shall be mounted on 6 inch high PCC block suitable for weight of the AHU. The platform shall be 6 inch bigger than the AHU frame size from all sides. The framework of the AHU and the P.C.C. block shall be isolated by means of neoprene mats of size 150mmx150mm in two layers with 16g G.S.S. sheet sandwiched in between.

9.2.13 Fresh Air Intakes

Exhaust/Fresh air louvers of 80 mm thick high performance (55% free area) drainable fixed louver type Aluminium frame and blades. Mullions to be sliding interlock type with integral internal drain. Jamb and mullion drains to be open on front face in order to direct water away from inside of louver. Blades to be one piece extrusions with gutters design to catch and direct water to jamb and mullion drains.

Fastners to be of aluminium. Louvers to have framed 13 mm mesh removable mill finish aluminium bird screens.

Powder coated fresh air louvers constructed out of extruded aluminium duly anodized (20 microns and above) complete with bird screen, filters and damper shall be provided in the clear openings in masonry walls for fresh air of the air handling units. Louvers, filters, damper, and fresh air duct shall be provided for various air handling units. Fresh air dampers shall be of the interlocking opposite blade louver type. Blades shall be made of not less than 16 gauge aluminium sheet, edges covered with felt to provide airtight closure, and shall be rattle-free. Dampers shall be equipped with brass / nylon bushes and bush bearings. Filters shall be similar to those earlier specified for air handling units. All hardware shall be corrosion resistant brass or Stainless steel.

9.2.14 Accessories

Each air handling unit shall be provided with manual air vent at high point in the cooling coil and drain plug in the bottom of the coil. In addition, the following accessories may be required at air handling units, their detailed specifications are given in individual sections.

- Insulated butterfly valves, balancing valves, ‘Y’ strainer, union & condensate drain
piping with ‘U’ trap up to sump or floor drain in air handling unit room, as described in section “Piping”.

b. Instrument as specified.
c. Minimum 2 Nos nameplates (1 in etched metal and other plastic) mounted onto AHU panel with suitable water-resistant adhesive along with relevant warning stickers on various panels. The nameplate shall give all relevant details including fan model selected, motor KW, Air quantity and total static pressure.

9.2.15 Painting
Shop coats of paint that have become marred during shipment or erection shall be cleaned off with mineral spirits, wire brushed and spot primed over the affected areas, then coated with paint to match the finish over the adjoining shop painted surface.

9.2.16 NOISE CONTROL
Air Handling Units shall be selected for the lowest operating noise level of the equipment. Fan performance rating, power consumption, and sound power data with operating points clearly indicated shall be submitted by the tenders along with technical submittals for approval and verified at the time of testing and commissioning of the installation. The sound level within the AHU room shall be less than 75 dB at a distance of 1 meter from AHU.

9.2.17 CONNECTIONS
Piping installation requirements are specified in other section. The Drawings indicate the general arrangement of piping, valves, fittings, and specialties. The following are specific connection requirements:

- Arrange piping installations adjacent to units to allow unit servicing and maintenance.
- Connect piping to air-handling units with flanges enabling easy removal of the coil.
- Connect condensate drain pans using 50 mm (2-0 inch) minimum, insulated G.I. pipe and extend to nearest floor drain. Construct deep trap (depth as per detail) at connection to drain pan and install cleanouts at changes in direction.
- Duct installations and connections are specified in other sections. Make final duct connections with flexible connections.
- Electrical Connections:

The following requirements apply:

- Electrical power wiring is specified in section Electrical.
- Temperature control wiring and interlock wiring is specified in Section “Electrical Control systems.”
- Grounding: Connect unit components to ground in accordance with the Indian Electrical Code.

9.2.18 ADJUSTING, CLEANING, AND PROTECTING
- Adjust water coil flow, with control valves to full coil flow, to indicate lpm (gpm).
- Adjust damper linkages for proper damper operation.
- Clean unit cabinet interiors to remove foreign material and construction dirt and dust.
- Vacuum clean fan wheel, fan cabinet, and coils entering air face.
9.2.19 COMMISSIONING:

Final Checks before start-up- Perform the following operations and checks before start-up:

- Remove shipping, blocking and bracing.
- Verify unit is secure on mounting and supporting devices, connections for piping, ductwork and electrical are complete. Verify proper overload protection is installed in motors, starters, and disconnects.
- Perform cleaning and adjusting specified in this Section.
- Lubricate bearings and other moving parts with factory recommended lubricants.
- Set outside-air / supply air dampers to minimum outside-air setting.
- Comb coil fins for parallel orientation.
- Install temporary throw away filters for initial run and finally install clean filters.
- Verify manual and automatic volume control, and fire dampers in connected ductwork system are in the full-open position.
- Disable automatic temperature control operators.
- Starting procedures for central-station air-handling units:
  - Energize motor, verify proper operation of motor, drive system, and fan wheel. Adjust fan to indicate RPM.
  - Replace fan and motor couplings as required to achieve design conditions.
  - Measure and record motor electrical values for voltage and ampere.
  - Shut down and reconnect automatic temperature control operators.

9.2.20 TESTING

Cooling capacity of various Air handling units shall be computed from the measurements of air flow and dry and wet bulb temperatures of air entering and leaving the coil. Flow measurements shall be by a calibrated rotating vane anemometer and temperature measurements by accurately calibrated mercury-in-glass thermometers. Computed ratings shall conform to the specified capacities and quoted ratings. Power consumption shall be computed from measurements of incoming voltage and input current, whereas, noise level at various locations within the conditioned spaces shall be measured by a sound pressure level meter.

9.3 DOUBLE SKIN CEILING SUSPENDED DUCTABLE UNIT

Ductable units will be in double skin construction made out of Aluminium extruded section and 25 mm thick double skin panels with thermos-break profile. Ductable Units shall consist of fan section, coil section, Pre-filter section and will have the construction as described below.

9.3.1 Unit Casing

The framework of the casing will be in extruded Aluminium construction having 15 to 18 micron thick anodized finished. Double skin panels will be fabricated out of best GI 22G Powder coated sheet on outer side and plain GI 24G Sheet on inner side. Polyurethane of density not less than 36 Kg. /Cu. M. will sandwiched between inner and outer sheet. The panels will be fixed on Al. Extruded section in such a manner that fixing screw head
does not project on outer face on the panel. The screw hole on panel be blocked with Nylon sleeve with cap. The insulation shall be 25 mm thick. The screw cavity on will be blocked with nylon sleeve with cap. Drain tray will be fabricated out of SS sheet thickness not less than 18 G. The tray will have sufficient depth and proper size drain connection. The tray will be insulated from with nitrile rubber foam sheet having not less than 20mm. Filter section will have rigid construction filter fabricated out of GI sheet to house required filters. The filters will be in flange construction having GI casing. Suitable panel of section will be provided with hole for entry with required arrangement to cover sharp edge GI sheet. If required, a proper box cover will be provided on cable entry. A provision for earthing will be on mainframe near the cable entry hole. Inspection doors at required location will be with elegant design hinges made out die Aluminium alloy. Two or more number of hinges door will be provided depending upon the size the door to provide required rigidity to the panel. One or more number of door handles be provided with can type tightening. The handle and can will be made out of filled having galvanized iron spindle. The door for blower section will be at such a location that the motor and package and fan bearing can be assessed for maintenance. An additional guard made out GI wire mesh of required strength will be at inner side of blower section door. A limit switch / door switch electrical terminal will be provided to the door inter locking with fan. An inspection glass fitting having the element on both side of the panel with common gasket sleeve between two elements will provided on blower section inspection door to inspection of drive package in running without opening the inspection door. The doors of the sections accommodating will be of sufficient size to take care of removal. All nut bolts, sheet metal screws, fasteners will Zinc / Nickel-plated having resistance against.

9.3.2 Cooling Coils
The cooling coils shall be fabricated out of tube having OD not less than 10 mm and fins spaced @ 12 fins / inch. Aluminium & copper tubes will have foam bond provided hydraulic expansion method at the high pressure yield point. The capacity of the coils shall as required. All CSU’s shall be provided with a minimum of 6 Row deep Cooling Coil and a minimum of 2 row deep hot water coil. TFA shall be provided with 8 row deep cooling coil. The Coils & Fittings are suitable for 20kg/cm² Pressure. Fan scrolls shall be fitted with die formed side streamlined inlet and to ensure smooth into the fan. Computerized cooling coil selection output shall be submitted. Coil rating shall be as per latest ARI requirements.

9.3.3 Filters
Pre-filters shall be HDPE washable types with 2" with filtration level of 10 micron and of 90%. The pre-filter section will be on suction side of the filters.

9.3.4 Fan motors Three Phase:
Fan motors shall be sq. cage, and T.E.F.C. induction type, together with starters. Fan motor shall be energy efficient min. IE-3 or as specified. The motors shall be capable of high initial starting torque requirement of fans & suitable for VFD application where ever specified.
Single Phase:
Fan motors shall be lug mounted, PSC type. The motor shall be capable of high initial starting requirement of fans.

For Motors above 5 KW, Motors shall run on VFD mode as well S/D connection and DOL up to 5 KW. Motors shall be connected to an electrical panel consisting of starters, isolators, ELCB, etc. The CSU Starter panel shall be provided with sufficient potential free contacts and relays for enabling Remote on and off from AC plant control Room.

9.4 ISOLATORS
Vibration isolators shall be provided with all air handling units. Vibration isolators shall be cushion foot mounting type. Minimum vibration isolation efficiency shall be 90% and certificate of vibration isolator shall be provided by Contractor.

9.5 FRESH AIR DAMPER
Extruded aluminum construction duly anodized (20 microns and above) fresh air louvers with bird screen and dampers shall be provided in the clear openings in masonry walls of the air handling unit rooms having at least one external wall. Louvers, damper, pre-filters and ducts shall be provided as required. Fresh air dampers shall be of the interlocking, opposed-blade louver type. Blades shall be made of extruded aluminum construction and shall be rattle-free. Dampers shall be similar to those specified in “Air Distribution”. Fresh air fans and fresh air intakes shall be as per the requirements.

9.6 PAINTING
Shop coats of paint that have become marred during shipment or erection shall be cleaned off with mineral spirits, wire brushed and spot primed over the affected areas, then coated with paint to match the finish over the adjoining shop painted surface.

9.7 PERFORMANCE DATA
Air handling unit shall be selected for the lowest operating noise level. Fan performance rating and power consumption data, with operating points clearly indicated shall be submitted and verified at the time of testing and commissioning of the installation.

9.8 TESTING
Cooling capacity of various air handling unit models be computed from the measurements of air flow and dry and wet bulb temperatures of air entering and leaving the coil. Flow measurements shall be by an anemometer and temperature measurements by accurately calibrated mercury-in-glass thermometers. Computed results shall conform to the specified capacities and quoted ratings. Power consumption shall be computed from measurements of incoming voltage and input current.

10 TREATED FRESH AIR HANDLING UNITS
The scope of this section comprises of the design, supply of double-skin “Dedicated Outdoor Air Systems” (DOAS) conforming to the specifications below.

The manufacturer or their principals shall have at least 5 years of designing and manufacturing experience directly in the product i.e. energy recovery devices, with a two tier, two air stream unit.
The unit hereafter is referred to as Heat Recovery Wheel(HRW).
10.1 TYPE
The DOAS units shall be two stream units in double skin construction, comprising of supply air section, return air section and Heat Recovery Section. The supply air section shall include the following sections as per requirements. Fresh Air Inlet Damper, G3 prefilter, Cooling Coil Section, Inspection Section, Sensible Heat Recovery Wheel, Fan section comprising Supply Air fan and motor. The Return Air section shall include the following sections : Return Air inlet damper, G3 prefilter, Fan section comprising of Exhaust Fan with motor. Option shall be available for Digital Air Flow Measurement, Pressure Transmitter and Filter Cleaning Alarm as per requirements.

10.2 CAPACITY
The HRW units shall be of such capacities and static pressures as required.

10.3 CASING
The units shall be made of extruded Aluminium hollow profile frames. The profile box size shall be of minimum 30 mm for capacities upto 22000 CMH, such that it provides the required mechanical strength and rigidity. The unit should be devoid of any welded construction and should be of cabinet type. All the frames should be assembled using pressure die cast aluminum joints/corners to make a self-supporting frame. The Casing leakage shall be in accordance with relevant standard. The panels shall be of double skin construction with both inner and outer steel sheets being minimum 0.8mm thick pre coated & plasticized. 25 mm thick fire retardant glass insulation shall be sandwiched between the sheets. The fibre glass density shall be 48 kg/m3. The Inspection and access panels shall be hinged type. The hinges shall be casted, powder coated Zinc alloy. Flushed Locks and Handles shall be of galvanized steel. Other panels will be screwed on to the frame with sealant and soft rubber gasket thus making the joints air tight . All screws used for panel fixing shall be covered with PVC caps. Special hollow gaskets and seals shall be used on inspection doors and to create separation between the airstreams to ensure negligible air leakage and mixing The entire casing shall be mounted on electro galvanized channel frame work with level screws. Condensate drain pan shall be fabricated from 18 G GSS/SS construction.

10.4 SUPPLY AIR SECTION
The supply air section shall comprise of the following:

FAN SECTION
The fan shall be centrifugal backward curved, double inlet double width type. The impeller and the fan casing shall be made of hot galvanized sheet steel. The impeller shall be mounted on a solid shaft supported to housing with angle iron frame and pillow block heavy duty ball bearing. The impeller shall be statically and dynamically balanced. The fan shall be selected such that unit noise level is less than 85db. Fan housing and motor shall be mounted on a common galvanized steel or aluminum block base which can be drawn out from side for ease of maintenance. A quarter pin lock arrangement between the slide and guide pin lock arrangement between Fan and TFA outlet should be provided.

MOTOR AND DRIVE
Fan motor shall be energy efficient and suitable for 415 ± 10% volts, 50 Hz, 3 phase squirrel cage, totally enclosed fan cooled with IP – 55 protection. Motor shall be designed for quiet operation . Drive shall be provided through belt – drive arrangement. Belts will be of oil resistant type.
FILTER SECTION
The filter section shall be normally designed for deep folded disposable synthetic pre-filters for Class EU4. The filter elements shall be mounted on rails and shall be easily pulled out for replacement. The rails shall be provided with efficient gaskets to minimize the risk of leakage.

DAMPER SECTION
Damper section shall contain a built in damper of aluminum profile with leakage class III. The damper blades shall be connected with plastic gear wheels with a gasket of silicon rubber to produce tightness between the blades.

COOLING COIL SECTION WITH COIL
The cooling coil section shall be available in two options as below, and shall be selected based on the requirement's.
   i. Up to 8 row deep - long
   ii. Up to 4 row deep – short
The cooling coil section shall be suitable for chilled water type. Drain pan made out of 18g high grade SS shall be provided. The Coils & Fittings are suitable for 20kg/cm²Pressure.

INSPECTION SECTION
The Inspection section shall be for inspection of other functional sections. It shall be available in two options; long and short version and shall be selected as per requirement's.

10.5 RETURN AIR SECTION
The return air section shall comprise of above sections. The specification for this section shall remain same as defined.

The Desiccant : The desiccant should be water molecule selective and non-migratory. The desiccant should be molecular sieve, so as to keep the cross contamination to absolute minimum and also ensure the exclusion of contaminants from the air streams, while transferring the water vapour molecules. The desiccant, of sufficient mass which should not be less than 5 kg per 1000 cfm of air, should be coated with non-masking porous binder adhesive on the aluminum substrate so as to allow quick and easy uptake and release of water vapour. A confirmation has to be provided by manufacturer of wheel to this effect. A matrix with desiccants impregnated in nonmetallic substrates, such as synthetic fiber, glass fiber, etc. will not be accepted. The rotor/wheel matrix shall have equal sensible and latent recovery. The weight of desiccant coating and the mass of aluminum foil shall be in a ratio so as to ensure equal recovery of both sensible and latent heat over the operating range. Accordingly, a rotor matrix which has an etched or oxidized surface to make a desiccant on a metal foil and results in insufficient latent recovery and hence unequal recovery, or a rotor matrix made from desiccant integrated in a synthetic fiber matrix which result in insufficient sensible recovery, high rotation speed, and unequal recovery, will not be accepted.

Rotor : With optimum heat and mass through matrix formed by desiccant, of sufficient mass, coated on an aluminum foil, the rotor should rotate at lower than 20 to 25 RPM, thereby also ensuring long life of belts and reduced wear and tear of seals. The rotor shall be made of alternate flat and corrugated aluminum foil of uniform width. The rotor honeycomb matrix foil should be so wound and adhered as to make a structurally very strong and rigid media which shall not get cracked, deformed etc. due to change of
temperature or humidity. The rotor having a diameter up to 2800 mm shall have spokes to reinforce the matrix. From 2000mm diameter upwards, the option of a special wing structure, to prevent the rotors from wobbling or deforming due to the successive pressure differentials, will be available. The substrate shall not be made from any material which is combustible or supports combustion like synthetic fibrous media. Sectioned wheels, with pie segments, capable of being assembled in the field, shall be available as an option, above 2000 mm in diameter.

The surface of the wheel/rotor should be highly polished to ensure that the vertical runout does not exceed +1 mm for every 1 meter diameter, thereby ensuring, negligible leakage, if labyrinth non-contact seals are provided, and minimal drag, if contact wiper seals are provided. The radial runout also shall not exceed +1 mm for every 1 meter diameter, thereby minimizing the leakage/drag on the radial seals, and minimize the fluctuation in the tension of the drive belt. The number of wraps (of alternative corrugated and flat foil) for every inch of rotor radii shall be very consistent so as to ensure uniform air flow and performance over the entire face in the air stream. Flute height and pitch will be consistent to a very tight tolerance to ensure uniform pressure drop and uniform airflows across the rotor face. The rotor shall be a non-clogging aluminum media, having a multitude of narrow aluminum foil channels, thus ensuring a laminar flow, and will allow particles up to 800 microns to pass through it. The media shall be cleanable with compressed air, or low pressure steam or light detergent, without degrading the latent recovery.

The Cassette / casing:
The recovery wheel cassette/casing shall be manufactured from tubular structure to provide a self-supporting rigid structure, complete with access panels, purge sector, rotor, bearings, seals, drive mechanism complete with belt.

The rotor/wheel should have a field adjustable purge mechanism to provide definite separation of airflow minimizing the carryover of bacteria, dust and other pollutants, from the exhaust air to the supply air. It shall be possible, with proper adjustment, to limit cross contamination to less than 0.04% of that of the exhaust air concentration. The face and radial seals shall be four (4) pass non-contact labyrinth seals for effective sealing between the two air streams, and also for a minimum wear and tear ensuring infinite life of the seals.

10.6 Heat Recovery Wheel:
The heat recovery section shall include Heat recovery wheels and shall have minimum recovery of 75% of total heat. ie. Both Sensible and Latent heat (each being minimum 75%) The wheel shall be made of pure aluminum foil coated with molecular sieve desiccant with pore diameter of 3 Å. The cross contamination between the two air streams shall be nil and leakage shall be less than 0.04%. The vertical and radial run of the wheel shall be less than 1mm per meter of diameter. The wheels shall have non-contact labyrinth seals for effective sealing between the two air streams.

The substrate of the wheel matrix should be only of pure aluminum foil so as to allow quick and efficient uptake of thermal energy, sufficient mass for optimum heat transfer, maximum sensible heat recovery at a relatively low rotational speed of 20 – 25 rpm.

The desiccant should be of Ecosorb 340 type which combines the selectivity of 3Å desiccant for the 2.8Å water molecule and has a higher diffusivity of the 4Å molecular sieves so as to ensure the exclusion of contaminants in the air stream.
while transferring only water vapour molecules resulting in selective and fast latent recovery.

The desiccant of sufficient mass should be coated with non-masking porous binder adhesive on the aluminum substrate so as to allow quick and easy uptake and release of water vapour. A matrix of desiccants impregnated in non-metallic substrate shall not be used.

The weight of the desiccant coating and the mass of the aluminum foil shall be in a ratio so as to allow equal recovery of both sensible and latent heat over the operating range.

The rotor shall be made of alternate flat and corrugated aluminum foil of uniform width. The rotor honeycomb matrix foil should be so wound and adhered as to make a structurally very strong and rigid media which shall not get cracked, deformed etc. due to change of temperature or humidity. The rotor shall rotate at lower than 20 – 25 rpm thereby also ensuring long life of belts and reduced wear and tear of seals. Rotor having a diameter greater than 2000 mm shall have special reinforcements in the form of spokes or shall be of sectionalized construction with pie segments to prevent the wobbling and deforming of the wheels.

The recovery wheel casing shall be manufactured from tubular structure to provide a self-supporting rigid structure complete with access panels purge sector rotor, bearings, seals, drive mechanism complete with belt.

The rotor wheel shall have a field adjustable purge mechanism to provide definite separation of airflow minimizing the carryover of bacteria, dust, and other pollutants from the exhaust air to the supply air. It shall be possible with proper adjustment to limit the cross contamination to less than 0.04% of the exhaust air concentration. The face and radial labyrinth seals shall be four pass non-contact labyrinth seals for effective sealing between the two air streams, and also for a minimum wear and tear ensuring infinite life of the seals.

11 HOT WATER GENERATOR

11.1 Scope
This section sets out the general requirements in respect of shell type hot water generators as per ASME Standards.

11.2 Shell Type Hot Water Generator
The hot water generator shall be vertical / horizontal, shell type, designed, constructed and tested for the specified water flow rates and temperatures.

11.3 Material Design and Construction
The shell of the generator shall be made 10 mm thick boiler quality steel sheet and dish of 12mm thick sheet steel with electric fusion welded seams. The shell be designed for 60 degrees centigrade of water circulation, unless specified otherwise. The shell with insulation, shall be mounted inside a cabinet of iron frame with 16SWG mild sheet steel covers held with locks / bolts and hinges. The cabinet shall be provided with sufficient louvers and rat proofing to ensure ventilation of heater terminals of boiler. Boiler shell shall be installed above the finished floor on iron frame. The iron frame shall be provided with lifting lugs and pedestals.
11.4 Heaters

Electric heaters shall be provided in banks of equal capacity distributed on three power phases. Heaters shall be mounted within seamless incoloy sheathed electrically resistant U-tubes. The heaters shall be easily removable externally, without opening terminal plate or disturbing other components. The heater mounting socket shall be made leak proof. Heaters shall be suitable for 415 ± 10% volts, 50 Hz, three phase AC supply and shall be in direct contact with water contained in shell.

Connections and Accessories

The hot water generator shall be provided with following accessories.

a) Inter locking of electric panel cover with incoming switch / limit switch.
b) Flow switch, automatic alarm for low water level and reset type high temperature switch with respective indication lights.
c) Drain point with Gun Metal valve.
d) Descaling Gun Metal valve.
e) Automatic air vent and automatic high temperature pressure relief valve.
f) Step control thermostat for individual heater bank and master safety thermostat of fixed setting.
g) Flanges for water pipe connections.

11.5 Pressure Testing

The shell shall be tested in the factory upto two times the working pressure or 21 Kg/Sq.Cm. gauge, whichever is higher.

11.6 Insulation

The shell shall be insulated with two layers of 50 mm thick resin bonded fibreglass Insulation /Equivalent insulation covered with 26 SWG aluminium cladding.

11.7 Electric Control Cabinet

The electric control cabinet shall be made as detailed in electrical panels and mounted directly on main frame. All controls and terminals shall be factory wired and tested. The control cabinet shall consist of following major controls of rated capacities:

a) Incoming MCCB.
b) ON-OFF toggle switch for individual banks.
c) Contactors with HRC fuses for individual heaters.
d) Indicating lights for ON status for individual banks.
e) Fault indicating lights.
f) Alarm with manual reset.
g) Thermostats and Master thermostat.
h) Cabling and control wiring.
i) Three phase ammeter and voltmeter with selector switches.
j) Control cabinet shall be BMS compatible
k) The panel shall be open able only after switching off the incoming power supply.
11.8 Painting
The external surface of the shell shall be cleaned, de-rusted and applied with three coats of primer. The hot water generator shall be factory finished with durable epoxy paint on outside. Shop coats of paints that have become marred during shipment / erection shall be Cleaned off with mineral spirits, then coated with enamel paint to match the finish over the adjoining shop painted surface. The electrical panel shall be provided with powder coated paint finish of matching colour with hot water generator.

12 FANS

12.1 SCOPE
The scope of this section comprises the design, supply, erection, testing and commissioning of centrifugal, in-line, axial flow, propeller and roof extraction type fans conforming to these Specifications and in accordance with the requirements.

12.2 TYPE
Centrifugal, in-line propeller fans and roof mounted units shall be of the type as indicated on Drawings and identified as required.

12.3 CAPACITY
The air-moving capacity of fans shall be as per requirements.

12.4 CENTRIFUGAL FAN
Centrifugal fan shall be DIDW / SISW Class I construction arrangement 3 (i.e. bearings on both the sides) for DIDW / SISW fans complete with, squirrel-cage induction motor, V-belt drive, belt guard and vibration isolators, direction of discharge / rotation, and motor position shall be as per the Approved-for-Construction shop drawings.

a. Fans shall be centrifugal, backward / forward inclined blades. Fan casing shall be made of galvanized steel sheet. Fan wheels shall be made of galvanized steel, grease lubricated bearings. Fan wheels and pulleys shall be individually tested and precision balanced dynamically.

b. Motors shall be mounted inside the AHU casing and be totally enclosed, fan cooled, to be class F insulation. Motors shall drive heavy duty V-belt, constant pitch.

c. Both fan and motors assemblies shall be mounted on a deep section aluminum alloy or galvanized steel (depending on size) base frame.

d. Bearings: shall be of the sleeve / ball-bearing type mounted directly on the fan housing. Bearings shall be designed especially for quiet operation and shall be of the self-aligning, oil / grease pack pillow block type.

e. Motor : Fan motor shall be energy efficient min. IE-3 or as specified and suitable for 415±10% volts, 50 Hz, 3 phase AC power supply, squirrel-cage, totally enclosed, fan-cooled motor, provided with class F insulation, Motor shall be designed especially for quiet operation and motor speed shall not exceed 1500 rpm. The fan and motor combination selected for the particular required performance shall be of the most efficient (smallest horse power), so that sound level is lowest.

f. Drive to fan shall be provided through belt with adjustable motor sheave and a standard belt guard to meet standard for avoiding contact between human finger and blades. Belts shall be of the oil-resistant type.

g. Vibration Isolation : MS base shall be provided for both fan and motor, built as an integral part, and shall be mounted on a cushy foot vibration isolators as shown in approved-for-construction shop drawings.
f. Centrifugal fans for smoke extract application shall have external belt drive and motor and fan casing shall be internally rated for for 250°C for 2 Hrs. Fan shall confirm to standard 211 and 311. Fan must be tested in accordance with ANSI/ AMCA standard 210-99 and AMCA standard 300-96 in an AMCA accredited laboratory. Fans shall be certified to bear the AMCA label for air and sound performance.

125 AXIAL FLOW FAN

Fan shall be complete with motor, motor mount, direct driven and vibration isolation type, suspension arrangement as per approved for construction shop drawings.

a. Casing: shall be constructed of galvanized sheet steel. Fan casing, motor mount and straightening vane shall be of welded/bolted steel construction. Motor mounting plate shall be of structural steel thickness as per OEM Standard and suitable to handle the weight of the motor and propeller, machined to receive motor flange.

Casing shall have flanged connection on both ends for ducted applications. Fan casing are with internal punched inlet and outlet flanges to prevent air leakage, for size upto 1250 mm dia and shall be constructed of rolled steel with a continuous seam weld. Support brackets for ceiling suspension shall be welded/bolted to the casing for connection to hanger bolts. Straightening vanes shall be aerodynamically designed for maximum efficiency by converting velocity pressure to static pressure potential and minimizing turbulence. Casing shall be bonderized, primed (minimum of 2 coats of rust free primer) and finish coated with enamel paint or powder coated after phosphating process as prescribed in CE / UL.

b. Rotor: hub and blades shall be cast aluminum alloy Blades shall be die-formed aerofoil shaped for maximum efficiency and shall vary in twist and width from hub to tip to effect equal air distribution along the blade length. Rotor shall be statically and dynamically balanced. Extended grease leads for external lubrication shall be provided for fans, if required. Taper lock bushing shall be used to mount the propeller to the motor shaft. The impeller and fan casing shall be carefully matched and shall have precise running tolerances for maximum performance and operating efficiency.

c. Motor: shall be energy efficient min. IE-3 or as specified, squirrel-cage, totally-enclosed, fan cooled, standard frame, constant speed, continuous duty, single winding, suitable for 415±10% volts, 50 Hz, 3 phase AC power supply, provided with class ‘H’ insulation. The speed of fan shall be as per manufactures standard. Motor shall be specially designed for quiet operation. Fan total efficiency should not be less than 70%, noise level should not be more than 85 dB @ 3 m distance when measured in hemispherical reverberant room conditions for fans running in Emergency Mode and 75 dBA @ 3 m distance when measured in Hemispherical Reverberant room conditions for fans running in case of Normal Mode. Motor conduit box shall be mounted on exterior of fan casing, and lead wires from the motor to the conduit box shall be protected from the air stream by enclosing in a flexible metal conduit/ vanes / tubes.

d. Drive to fan shall be direct driven.

e. Vibration Isolation: The assembly of fan and motor shall be suspended from the slab by vibration isolation suspension of rubber-in-shear type in accordance with BS EN 12103-3-2002.

f. Accessories: The following accessories shall be provided with all fans:

i. Outlet cone for static pressure regain.
ii. Inlet cone.

g. Fan silencers may be provided whether or same is required to control noise. Fans shall be factory assembled and shipped with all accessories. Axial Flow Fan shall be **AMCA certified for Air and Sound performance** in accordance to AMCA 210 and AMCA 300. Fan shall be suitable for both indoor and outdoor application with all accessories. Entire fan model & AMCA Seal shall appear in technical submittal of fan.

**FAN SELECTION**

a) Fan efficiency of 60 % or more is only for the guidance on air performance however the fan should be selected for lowest electric power consumption at an operating point. The specific fan power must be minimum.

b) The outlet velocity must be kept below 15 m/s for normal temperature and 18 m/s for high temperature fans to ensure system stability, reduce pressure losses, possible vibration in the ducts and better attenuation.

**FAN INSPECTION**

Before dispatch of fans at site, the performance of any one fan will be tested at operating conditions in AMCA certified laboratory for the claimed efficiency, air performance and sound levels using AMCA standards.

**126 PROPELLER FAN**

Propeller fan shall be direct-driven, three or four blade type, mounted on a steel mounting plate with orifice ring.

a. Mounting Plate shall be of galvanized steel sheet construction, square with streamlined venturi inlet (reversed for supply applications) coated with baked enamel paint. Mounting plate shall be of standard size, constructed of 12 to 16 gauge sheet steel depending upon the fan size. Orifice ring shall be correctly formed by spinning or stamping to provide easy passage of air without turbulence and to direct the air stream.

b. Fan Blades shall be constructed of aluminum or steel. Fan hub shall be of heavy welded steel construction with blades bolted to the hub. Fan blades and hub assembly shall be statically and dynamically balanced at the manufacturer’s work.

c. Shaft shall be of steel, accurately ground and shall be of ample size for the load transmitted and shall not pass through first critical speed through the full range of specified fan speeds.

d. Motor shall be standard (easily replaceable) permanent split capacitor or shaded pole for small sizes, totally enclosed with pre-lubricated sleeve or ball bearings, designed for quiet operation with a maximum speed of 1000 rpm for fans 31 cm dia and smaller and 1500 rpm for fans 31 cm dia and smaller. Motors for larger fans shall be suitable for 415±10% volts, 50 Hz 3 phase power supply.

e. Accessories: The following accessories shall be provided with propeller fans:

i) Wire guard on inlet side and bird screen at the outlet as per standard to avoid contact between finger and moving part.

ii) Fixed or gravity louvers built into a steel frame at the outlet.
127 AXIAL FLOW FAN (FOR FIRE, SMOKE AND HEAT EXHAUST)

Fan shall be suitable for mounting in duct or wall / floor / slab as required. Fan shall be complete with motor, motor mount, direct driven and vibration isolation type, suspension arrangement as per approved for construction shop drawings.

a. The ventilation fan Unit shall be configured and arranged as detailed on the drawings and as per requirement. Equipment shall be suitable for High Temperature application and manufactured from heavy gauge sheet steel or pre galvanized steel sheet and shall withstand 300 degree for 2 hour. The casing shall be fitted with an external IP65 rating terminal box and shall be bonderized, primed (minimum of 2 coats of rust free primer)and finish coated with enamel paint or powder coated after phosphating process as prescribed in CE- or hot dip/ pre galvanized with minimum of 225 GSM zinc coating.

b. The fan impeller and motor shall be direct drive with high efficiency min. IE-3 motors or as specified, flange mounted with IP55 enclosures. Motors shall be pre-wired to an external electrical terminal box through weatherproof flexible conduit/ vanes/tube. Fan Total Efficiency should not be less than 60%, noise level should not be more than 90 dB @ 3 m distance when measured in hemispherical reverberant room conditions.

c. Motor conduit box shall be mounted on exterior of fan casing, and lead wires from the motor to the conduit box shall be protected from the air stream by enclosing in a flexible metal conduit/vanes. All the High temperature Fans should either be EN-12101-3 2015 for a minimum of 300 Deg C for a minimum of 2 Hrs and should be CE labeled.

d. The unit shall be suitable for operating in smoke reservoir and non-smoke reservoir applications.

e. The unit shall be supplied with all necessary ancillaries as recommended by the manufacturer and in accordance with the specification.

f. The unit will be provided complete with matching flanges, flexible connections, anti-vibration mounts and all other necessary components to complete the installation and shall be in accordance with the manufacturer’s specification.

g. Axial Flow Fan shall be AMCA certified for Air and Sound performance in accordance to AMCA 210 and AMCA 300. Fan shall be suitable for both indoor and outdoor application with all accessories.

h. All high temperature fans to be used for fire application shall bear the certification /listing of UL/CE (in addition of being AMCA certified for Sound and Air Performance) conforming to CE/UL “Power Ventilator for smoke exhaust” or EN12101-3-2015 smoke and heat control system specification for powered smoke and heat exhaust ventilator.

FAN INSPECTION

Before dispatch of fans at site, the performance of any one fan of AAI choice will be tested at operating conditions in AMCA certified laboratory for the claimed efficiency, air performance and sound levels using.

128 SINGLE SKIN FAN SECTION FOR FRESH AIR & EXHAUST

Fan section casing shall be made of galvanized steel. The casing shall be made of galvanized sheet of mm thick and powder coated. The specification for the casing, motor, drive and fan shall be similar as that specified for double skin air handling unit.

The fan outlet shall be connected to the casing with the help of fire retardant flexible canvas. Opening for access door and gaps between sections shall be provided with the neoprene rubber gasket fixed in extruded sections.
In case of exhaust application, the outlet of fan shall have aluminum louvers with bird screen.

In case of fresh air application, fan inlet shall have fresh air aluminum louvers with bird screen as well as removable washable and synthetic filters made of five layers of media (total 50 mm thick) with aluminum frame.

In case of lift & staircase pressurization application, inlet of fan shall have fresh air aluminum louvers with bird screen.

**12.9 DOUBLE SKIN FAN SECTION FOR FRESH AIR & EXHAUST**

Double skinned panels shall be 50 mm thick made of galvanized steel, pressure injected in between by injection moulding machine with foam insulation (density 38 kg/m$^3$) shall be fixed to 1.5 mm thick aluminum alloy twin box section structural framework with stainless steel screws. Outer sheet of panels shall be made of galvanized pre plasticized sheet of 22 SWG thick, and inner sheet of 22 SWG thick plain G.I. Sheet.

The fan outlet shall be connected to the casing with the help of fire retardant flexible canvas. Opening for access door and gaps between sections shall be provided with the neoprene rubber gasket fixed in extruded sections.

In case of exhaust application, the outlet of fan shall have aluminum louvers with bird screen.

In case of fresh air application, fan inlet shall have fresh air aluminum louvers with bird screen as well as removable washable and synthetic filters made of five layers of media (total 50 mm thick) with aluminum frame.

In case of lift & staircase pressurization application, inlet of fan shall have fresh air aluminum louvers with bird screen.

**12.10 IN-Line Fans**

Duct mounted supply, exhaust or return fans shall be of centrifugal /direct driven in-line type. The fan housing shall be of the square / Circular design constructed of heavy gauge galvanized steel and shall include square / Circular duct mounting collars.

Fan construction shall include two removable access panels located perpendicular to the motor mounting panel. The access panels must be of sufficient size to permit easy access to all interior components.

The fan wheel shall be centrifugal backward inclined, constructed of steel and shall include a wheel cone carefully matched to the inlet cone for precise running tolerances. Wheels shall be statically and dynamically balanced. Motors shall be heavy duty ball bearing type, carefully matched to the fan load and furnished at the specified voltage, phase and enclosure. Motors and drives shall be mounted out of the airstream.

Precision ground and polished fan shafts shall be mounted in permanently sealed, lubricated pillow block ball bearings. Bearings shall be selected for a minimum (L10) life in excess of 100,000 hours at maximum catalogued operating speed.
All fans shall be tested as per AMCA Certified Ratings Seal for both sound and air performance and one fan performance must be witnessed in AMCA certified test bed.

12.11 ROOF MOUNTED FAN

Roof mounted fan shall be a centrifugal fans, direct driven with EC fans, complete with motor drive, and housing suitable for outdoor application as per requirement and specifications.

a) **Housing:** Fan housing shall be constructed of heavy gauge sea water resistant aluminum includes exterior housing, curb cap, wind band, and motor compartment housing and shall have a rigid internal support structure. Curb cap base to be fully welded to wind band to ensure a leak proof construction. Tack welding, bolting, and caulking are not acceptable. Drive frame assemblies shall be constructed of heavy gauge steel and mounted on vibration isolators. Breather tube shall be provided to allow entry of fresh air for motor cooling and shall be suitable to allow electrical wiring to be run through it. The entire assembly shall be suitable for outdoor applications and raised from the roof terrace sufficiently to prevent down-flow of rain water accumulated on the terrace.

b) **Fans:** Fan shall be backwardly inclined centrifugal wheel and shall be designed for maximum efficiency, minimum turbulence and quiet operation. Fan shall be statically and dynamically balanced.

c) **Motor & Drive Package:** Motor shall be high efficiency with a minimum of min. IE-3 efficiency level and shall be made to IEC design. Motors are heavy duty ball bearing type to match with the fan load and furnished at the specific voltage and phase and shall be mounted on vibration isolators, out of the airstream. There should be a provision to draw fresh air into the motor compartment through an area free of discharge contaminants for the motor cooling. It should be easily accessible for maintenance.

d) **Backdraft Damper:** To be provided as per requirement’s or as specified, roof-mounted fan shall be equipped with a rattle-free backdraft damper to prevent air from re-entering the fan when fan is not in operation, thus sealing completely in closed position. Damper shall be chatter proof under all conditions.

e) **Vibration Isolation:** The motor and fan assembly shall be isolated from the base with vibration isolators. Vibration isolators shall be Double studded or pedestal style true isolators with no metal to metal contact. Each Vibration isolators shall be sized to match the weight of each fan.

f) The fan should have confirmation to EU standards and declaration in this regard must be furnished by the manufacturer.

g) The smoke extract roof fans should be suitable to operate suitably for 120 degree for continuous operations and must be credited as per EN 12103-2002.

12.12 JET FANS

Ductless Demand control ventilation (DDCV) shall comprise of -

1) Jet Fans
2) Main Supply & Exhaust Fans
3) CO Sensors
4) Control Panel with Programmable logic control
5) CFD analysis.
6) System commissioning and handing over

The basement ventilation system should be adequate to maintain concentration of toxic gases within safe limits as per NBC 2016 /ASHRAE i.e. within 35 ppm for 1 hr. exposure with a maximum of 25 ppm for 8 hrs exposure or 6 ACPH & 12 ACPH in case of smoke.
The entire basement must be divided into smoke control zones with zoning as per NBC 2016.

The jet fans should have aerodynamic radial impeller (centrifugal impeller) for maximum thrust with low noise. The low profile, high velocity centrifugal induction fan should generate thrust of 50/85/100 N, appropriate size of jet fan may be selected based upon space available and ceiling height requirement as per local legislation. The outlet deflector and the spread of induction fan should cover maximum floor areas so that fewer units are required than with conventional impulse units which lowers cabling costs, installation, and maintenance and ceiling coverage.

- Compact casing for thin ceiling height
- Motor F300 for 300°C/120min. or standard temperature
- Tested & Certified according to EN 12101-3:2015

Centrifugal jet fan must be strategically located in the entire basement avoid stagnation zones. The velocity throw profile of the jet fan must be submitted for the approval.

**CFD Analysis.**

CFD (Computer Fluid Dynamics) is in a simplified version, a dynamic simulation of the behavior/development of smoke, air speed, visibility and others, inside the car park with given certain condition. The software used for simulation shall be recognized by ASHRAE handbook. "Large Eddy Simulation (LES) turbulence model based numerical simulation shall be conducted for simulating smoke spread. K-epsilon turbulence model based numerical simulation shall be conducted for evaluating indoor air quality. The simulation shall be conducted by qualified engineer having specialized experience of at least 50 projects in basement ventilation. The simulation results shall match the safety and air quality requirements as mentioned in relevant ASHRAE/NBC/AS 1668 standard.

**CO Sensor**

CO is colourless, odourless fatal gas which can only be detected using a precise sensor. CO gas must be diluted to acceptable level as per NBC 2016. The CO gas detector shall use electrochemical for sensing CO as a sensing method for sensing CO. The CO sensor shall have L.C. display indicating the ppm level. The detection range of the CO gas detector shall be from 0 to 250 ppm. The CO gas detector shall have high sensitivity and reliability. The CO gas detector shall require the power supply of 24VAC or DC (12~36V). The output signal of CO gas detector shall be on Modbus and 2-10 volts DC or 4 to 20 m Amps and relay output. The housing material of CO sensor is Flame retarded according to UL94-V1. The CO gas detector shall be CE approved.

The operating temperature of the CO gas detector shall be -10 to 50degree Celsius.

**Controls**

In addition to electrical panel and control specifications. In basement ventilation, the jet fans must be wired in zig-zag configuration with fire resistant cabling of suitable size. The fan must be interlocked with exhaust fan. Each smoke control zone should have an independent sub panel connected to mechanical ventilation panel and if any panel/sub panel is located in open and public areas it must have tamper proof construction to avoid mishandling and accidental operation.

**System commissioning and handing over**

The final detail design of the systems shall be undertaken by the specialist fan supplier to ensure there is the correct air movement both for normal carbon monoxide (CO) removal and also for smoke extract in the event of a fire. The analysis shall include a 3-D computational fluid dynamic (CFD) analysis for the entire car park area to validate the design requirements.
Full fan selection data and control regimes shall also be verified by the specialist fan supplier and incorporated into

PERFORMANCE DATA

All fans shall be selected for the lowest operating noise level. Capacity ratings, power consumption, with operating points clearly indicated, shall be submitted and verified at the time of testing and commissioning of the installation.

TESTING

Capacity of all fans shall be measured by an anemometer. Measured air flow capacities shall conform to the specified capacities and quoted ratings. Power consumption shall be computed from measurements of incoming voltage and input current.

13 SCRUBBER (DRY TYPE)

13.1 GENERAL

The kitchen scrubber shall be complete in all respects and shall generally comply with the following specifications given below:

13.2 ELECTROSTATIC SECTION:

Electrostatic precipitation technology based dry type air cleaner to remove Oil, Smoke & fumes from the Kitchen exhaust air.

13.3 CONSTRUCTION:

13.3.1 BLOWER SECTION:

The blower section shall be constructed out of 16G GI sheet in folded construction and shall include Centrifugal backward curved DIDW fan wheel of totally GI construction with inlet cones and shall be complete with individual motor and drive and shall be mounted C Channel frame and Cushy Foot or Spring Mounts. The fan shall have a capacity not less than the one specified in the catalogues and shall be constructed and rated based on delivery against the rated static pressure with the media and filters in place. The fan will be of riveted construction and made with GI sheet of required thickness. The fan wheel will be of the multi-blade type and mounted on two self-aligning pillow block bearings of the requisite size. The fan shall be run with the help of groove drives as per the recommendation of the drive supplier. The blower housing will of the Pittsburgh joint construction and the drive will be provided by a motor of adequate capacity. The motor plate will be constructed out of 6mm MS or heavier metal with slotted holes, which permit belt adjustment in both the direction. The outlet velocity of the blowers will be kept low.

13.3.2 FILTER SECTION:

All sections will include 5 layer 30 micron aluminium wire mesh filters of 50 mm thickness including the mounting channels in SS 304 1.6mm GI for ease of removal and renewal of filter cells. The filters to be designed at 2.5 m/s to give 90% efficiency down to 30 microns.

13.3.3 CABINET FANS

The construction of the cabinet fans shall be identical with that of the air washer unit except that the cabinet fans will not have filters and humidifiers.

Ionizer: Stainless steel spiked ionizers to create high voltage DC field.
Collector Plate: aluminum collector plates which should be alternatively charged positive & negative with large collecting area with 14” deep cell, to work as magnet for charged smoke & oil particles. Average efficiency of 90-95% in single pass as per ASHRAE test method. Electrostatic Precipitator should be able to charge particles from 0.01 micron to 10 micron through solid state power supply. Collector cell should be of permanent type and slide out facility for easy removal for cleaning.

13.4 POWER SUPPLY:
Power supplies shall be 100% solid state UL Listed and operate on 230 VAC, 50 Hz, 1 Phase input and provide a dual high voltage output of (+) 12 to 13 KVDC for the ionizer and (+) 6.0 to 6.5 KVDC for the collector. Module of capacity above 3000 CFM shall be equipped with Pulse width modulating (PWM) to maintain the specified collection efficiency by maintaining a constant charge in the event of Low/High Voltage from source thus ensuring that the unit functionality is not affected with these voltage fluctuations. Power Consumption should not be more that 50 watts per cell.

System should be fitted with interlock switch for safety.

The system should be able connected to a fan section to achieve airflow of 500 FPM across the air cleaner and should be interlocked with the fan to prevent dry run of the units.

14 PIPING, VALVES & ACCESSORIES:
14.1 SCOPE
The scope of this section comprises the supply and laying of pipes, pipe fittings and valves, testing and balancing of all water and refrigerant piping required for the complete installation. All pipes inclusive of fittings and valves shall follow the applicable Indian Standards. All pipes, valves, fittings shall be minimum PN16 rating.

14.2 Pipe Sizing

<table>
<thead>
<tr>
<th>Chapel water pipe sizing for pipes up to 50 mm dia</th>
<th>Water Velocity not to exceed (1.22 m/s) P.D not to exceed 4m / 100m</th>
</tr>
</thead>
<tbody>
<tr>
<td>For Pipes above 50mm dia and up to 200mm dia</td>
<td>P.D. not to exceed 4m / 100m, velocity not to exceed 2.4 m/s.</td>
</tr>
<tr>
<td>For pipe sizes above 200 mm dia</td>
<td>P.D. not to exceed 4m / 100m, Maximum velocity = 3.0 m/s.</td>
</tr>
<tr>
<td>For Headers</td>
<td>P.D. not to exceed 4m / 100m, In the velocity range = (1.8 – 2.4) m/s.</td>
</tr>
</tbody>
</table>

Coil Connection Pipes to be sized for full flow rate of respective coils.

14.3 MATERIAL
CHILLED AND CONDENSER WATER PIPING
All chilled water and condenser water pipes and fittings shall be of MS class ‘C’ (heavy class) confirming to BIS 1239 for pipe size up to 150 mm dia shall be of MS tube and for pipe size 200mm dia and above shall be as per BIS 3589 having minimum 6mm thickness. All jointing in the pipe system shall generally be by welding, unless mentioned otherwise, or
directed at site. All welding shall be done by qualified welders and shall strictly conform to Indian Standards code of procedure for manual metallic welding of Mild steel as per BIS 823. Welders brought to site shall submit the recent test certificate issued by competent agency conducting welding tests.

Condenser & Chilled water line must have quick filling connection arrangement at plant room 40 mm size with full way valve & a drain line too of the same size.

All pipes and their steel supports shall be thoroughly cleaned and given one primary coat of red oxide paint before being installed. All chilled water piping will rest on Pipes support with Rubber Insert seated on MS angles / channel approved by AAI and securely fastened with U strap. All welded piping shall be subjected to the approval at site.

Fittings shall be malleable casting of pressure rating suitable for the piping system. Fittings used on welded piping shall be of the weldable type. The ends of pipe lengths to be welded shall be cut square by saw or cutter and the edges leveled to form a 'V' groove before welding. Under no circumstance, shall the edges be formed by gas cutting. The welded joint shall be painted externally with a coat of red-oxide primer.

Tee-off connections shall be through equal or reducing tees. Drilling and tapping of the walls of the main pipe shall not be resorted to and will not be allowed.

For circumferential joints between pipe lengths/pieces 200 mm dia and larger, welding rings shall be provided.

All welded piping (particularly piping above false ceiling) shall be subject to the approval of AAI, before the work is closed.

Flanges shall be of slip on raised face type. The supply of flanges shall also include supply of bolts and nuts and suitable asbestos/fiber rubber insertion gaskets (minimum 3mm thick).

14.4 FITTINGS
All fittings shall be of MS class 'C' (Heavy class). Butt weld fittings shall conform to BS 4504 PN 16 and Flanges to BS 10 Table E unless otherwise indicated, in the specifications. Screwed fittings shall be malleable iron banded, black heart type to BS 143 with BS 21 taper internal and external pipe threads. Joints shall be made with jointing compound and best quality hemp.

All bends shall be ready made of heavy duty, wrought steel of appropriate class.

14.5 PRE-INSULATED PIPES AND FITTINGS
General
Pre-insulated pipe shall be provided complete with factory made bends and tees as required. The pipes shall be installed in complete accordance with the manufactures recommendations.

The pre-insulated pipes shall consist of a High Density Poly Ethylene (HDPE) internal carrier pipe insulated with rigid polyurethane foam and protected externally by an impact resisting outer pipes of high density polyethylene. During manufacture the carrier pipe, the polyurethane foam, and the outer casing shall be securely bonded together. The insulation and outer cover shall have sufficient compressive and shear strength to resist any long term underground loadings.

14.6 SERVICE PIPE
All chilled water and condenser water pipes and fittings shall be of MS class ‘C’ (heavy class) confirming to BIS 1239 for pipe size up to 150 mm dia shall be of MS tube and for pipe size 200mm dia and above shall be as per BIS 3589 having minimum 6mm thickness.

The condenser water piping shall be with minimum 1.2mm thickness FRP coated MS "C" class Heavy duty pipes laid between cooling tower pumps, condenser shells and cooling tower complete with all fittings and accessories like Bends, Tees, reducers, supports, clamps, etc., pipes shall be applied with bituminous primer and painted to color codes.

**14.7 INSULATION**

The service pipe insulation shall be polyurethane foam with 36 kg/cu m minimum density, 90% minimum closed cell content, minimum compressive strength of 40 psi and thermal conductivity of 0.14 Btu-in/hr./ft/°F. The insulation shall completely fill the annular space between the service pipe and jacket and shall be bonded to both, the service pipe & jacket.

The insulation shall be provided to the minimum thickness specified below:

<table>
<thead>
<tr>
<th>Diameter of MS pipe (mm)</th>
<th>Minimum Insulation thickness (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>500</td>
<td>80</td>
</tr>
<tr>
<td>350</td>
<td>50</td>
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<tr>
<td>300</td>
<td>50</td>
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<tr>
<td>250</td>
<td>50</td>
</tr>
<tr>
<td>200</td>
<td>50</td>
</tr>
<tr>
<td>150</td>
<td>50</td>
</tr>
</tbody>
</table>

**INSULATION JACKET**

The outer protective insulation jacket shall be seamless, extruded, black, UV resistant, high-density polyethylene (HDPE). The HDPE pipes should be of PE 80 grade PN 2.5 pressure rating.

**Insulation Process:**
Use HDPE as per specs given above

The pre-insulated pipes must be manufactured using High pressure PUF injection machines. The outer jacket & the carrier pipe must be held concentric using special chucks. Vent holes must be drilled to ensure expiration of air. The necessary quantity of Polyol & ISO must be mixed at high speed & injected into the void. The quantity of PUF injected for each pipe must be kept as a verifiable record to ensure that the required density & thickness of insulation is maintained.

**14.8 GROOVED PIPE JOINTING SYSTEM**

All grooved components (including couplings, fittings, valves and accessories) to be supplied by one manufacturer. Grooving tools shall be of the same manufacturer as the grooved components.

**Grooved Mechanical Couplings for Joining Carbon Steel Pipe**

1. Grooved Mechanical Couplings: Manufactured in two housing segments for all
coupling sizes (3/4" (DN20) through 24" (DN600)) of cast ductile iron, conforming to ASTM A-536, Grade 65-45-12. Gaskets shall be pressure-responsive synthetic rubber, grade to suit the intended service, conforming to ASTM D-2000. Mechanical Coupling bolts shall be zinc plated (ASTM B-633) heat treated carbon steel track head conforming to ASTM A-449 and ASTM A-183.

2. Rigid Type: Coupling housings with offsetting, angle-pattern bolt pads shall be used to provide system rigidity and support and hanging in accordance with ANSI B31.1, B31.9, and NFPA 13. Rigid couplings shall require visual pad-to-pad verification of complete installation.

a. Flexible Type: Use in locations where vibration attenuation and stress relief are required. Flexible couplings may be used in lieu of flexible connectors at equipment connections. Three Couplings shall be placed in close proximity to the vibration source.

3. Flange Adapters: For use with grooved end pipe and fittings, for mating to ANSI Class 150 flanges.

4. Grooved couplings shall meet the requirements of ASTM F-1476.

5. Gasket: Synthetic rubber, wide width, conforming to steel pipe outside diameter and coupling housing, manufactured of elastomers as designated in ASTM D-2000.

Grooved End Fittings:

Fittings shall be cast of ductile iron with flow equal to standard pattern conforming to ASTM A-536, Grade 65-45-12, forged steel conforming to ASTM A-234, Grade WPB 0.375" wall (9.33 mm wall), or fabricated from Std. Wt. Carbon Steel pipe conforming to ASTM A-53, Type F, E or S, Grade B. Fittings provided with an alkyd enamel finish or hot dip galvanized to ASTM A-153. Zinc electroplated fittings and couplings conform to ASTM B633.

1. Grooved Hole-Cut Branch Outlets:

a. Bolted Branch Outlet: Branch reductions on 2"(DN50) through 8"(DN200) header piping. Bolted branch outlets shall be manufactured from ductile iron conforming to ASTM A-536, Grade 65-45-12, with synthetic rubber gasket, and heat treated carbon steel zinc plated bolts and nuts conforming to physical properties of ASTM A-183.

b. Strapless Outlet: 1/2"(DN15) or 3/4"(DN20) NPT outlet on 4" (DN100) and larger header sizes rated for 300 PSI (2065 kPa).

c. Strapless Thermometer Outlet: To accommodate industrial glass bulb thermometers with standard 1-1/4"-18 NEF 2B extra fine thread and 6" (152mm) nominal bulb length on 4" (DN100) and larger header sizes rated for 300 PSI (2065 kPa).

Installation:

1. Pipe ends shall be clean free from indentations, projections and roll marks in the area from pipe end to groove for proper gasket sealing.

2. The gasket style and elastomeric material (grade) shall be verified as suitable for the intended service as specified.

3. Couplings installation shall be complete when visual metal-to-metal contact is reached.

Training:

1. A factory trained representative (direct employee) shall provide on-site training for contractor's field personnel in the use of grooving tools, application of groove, and product installation.
Application:
1. A representative shall periodically visit the job site and review installation. Contractor shall remove and replace any improperly installed products.
2. Grooved mechanical pipe couplings, fittings, valves and other grooved components may be used as an option to welding, threading or flanged methods.
3. Grooved end products manufacturer to be ISO-9001 certified.

**14.9 DRAIN WATER SERVICES**

All condensate drain water pipes and fittings shall be of CPVC. The pipes shall be round and shall be supplied in straight lengths with socketed ends. The internal and external surfaces of pipes shall be smooth, clean, and free from grooving and other defects. The ends shall be cleanly cut and square with the axis of the pipe. The pipes shall be designed by external diameter and shall conform to IS: 13592. The pipes shall be of Class-III; 6 Kg/cm² pressure rating. Drain pipes shall be insulated using closed cell elastomeric Nitrile Rubber of suitable thickness with treated woven glass cloth laminated on one side.

**14.10 DELIVERY, STORAGE AND HANDLING OF PIPES AND FITTING**

1. Provide factory applied plastic end caps on each length of pipe and tube. Maintain end caps through shipping, storage and handling as required to prevent pipe-end damage and eliminate dirt and moisture from inside of pipe and tube.
2. Where possible, store pipe and tube inside and protected from weather. Where necessary to store outside, elevate above grade and enclose with durable, or by packaging with durable, water proof wrapping.
3. Protect flanges and fittings from moisture and dirt by inside storage and enclosure, or by packaging with durable, water proof wrapping.

**14.11 ALUMINIUM CLADDING**

Aluminium cladding shall be tight formed to fit tightly over the outer circumference of the insulation with longitudinal overlaps of not less than 40mm and the outer part of the overlap shall be secured with self-tapping screws or rivets of the appropriate type at centers of not more than 150mm. All longitudinal joints shall be hidden from view as far as possible.

Circumferential overlaps to be not less than 40mm and secured with self-tapping screws or rivets of the appropriate type, not less than four, equally spaced. One circumferential joint should be left free at maximum interval of 6 meters to allow for expansion and contractions.

All joints shall be so arranged as to shed liquids and shall be sealed with suitable gun applied water resistant sealant.

All bends and fittings shall be covered with matching aluminium sheet cladding tailored to fit the application but using specially segmented purpose made pieces or mitered bends where applicable.

All insulation termination points shall be trimmed with compatible aluminium coiled end capping pieces secured over the aluminium cladding with closed head pop rivets.
All aluminium metal works shall be pre-formed and correctly installed and manufactured to ensure a smooth, clean, uniform installation free from sharp and dangerous edges.

Aluminium cladding shall be with minimum 0.7mm thick plain aluminium sheets, silicon sealant, necessary rivets and SS toggle clips.

14.12 VALVES

14.12.1 Isolating Valves: Butterfly Valves, Globe Valves

Globe Valves – 50mm to 300mm
Body & Bonnet shall be of Cast Iron [GG-25], wedge / disc shall be of Cast Iron [GG-25] with SS overlay to PN16. Rising Stem outside screw and yoke type, stem shall be stainless steel, gland packing and gasket shall be Graphite, and Hand wheel in Cast Iron, Raised Faced Flanged ends to BS4504 PN16. Internal and external epoxy coating to 100 microns. Pressure/temperature rating: 16 bar for -10 to 120°C

Hydro Static Pressure: Body: 24 bar Seat: 17.6 Bar

Gate Valves
All gate valves, up to and including 50 mm dia. Shall be of gun metal screwed type, conforming to class 1 of IS:778/Equivalent BS Standards.

Butterfly valves – 65 mm to 150mm
Wafer-type, Semi-lugged, pinless design, Butterfly valve shall be Cast Iron [GG-25] body Construction, Ductile Iron Disc and Stainless Steel [SS410] shaft, EPDM liner, Confirms to BS5155, Bushing shall be Teflon and O Ring shall be NBR. Aluminium Lever operated with 10 lockable positions, suitable for installation between PN16 flanges. Internal and external epoxy coating to 200 microns.

Pressure/temperature rating: 16 bar for -10 to 110°C. Hydro Static Pressure: Body: 24 bar Seat: 17.6 Bar

Butterfly valves – 200mm to 600mm
Wafer-type, Semi/Fully-lugged Type, Butterfly valve with Cast Iron body Construction, Ductile Iron Disc and Stainless Steel [SS410] shaft. EPDM liner, Confirms to BS5155, O Ring shall be EPDM/NBR. Cast Iron Gear operated suitable for installation between PN16 Flanges.

Pressure/temperature rating: 16 bar for -10 to 110°C Hydro Static Pressure: Body: 24 bar Seat: 17.6 Bar

14.12.2 Manual Balancing Valves/Double Regulating Valves

All balancing valves of up to and including 50 mm dia. Shall be in gun metal screwed type construction. The valves of 65 mm dia. and above shall be in cast iron flanged end construction.

Manual Balancing Valves / Double Regulating Valves – 15mm to 50mm
Body of Bronze [BS 1400LG2]. Stem, disc and bonnet of DZR Brass, Y-pattern, variable orifice type, ABS Knob, EPDM O ring, Teflon Seat Ring, Hand Wheel embraces a Vernier scale for accurate setting and enables the disc to be locked in the
set position, threaded ends to BS21 [BSPP] PN25 rated Pressure/ temperature ratting: 25 bar for -10 to 120°C
Hydro Static Pressure: Body: 37.5 bar Seat: 27.5 Bar

Manual Balancing Valves / Double Regulating Valves – 65mm to 300mm
Y-pattern, Variable orifice type conforming to BS5152. Body, bonnet in Cast Iron [GG 25] with SS Stem. Disc 65mm to 200mm Cast Iron with EPDM coated, 250 & 300 SS with EPDM ring. Hand Wheel shall be Ductile Iron having a Vernier scale for accurate setting and enables the disc to be locked in the set position. End connections to be flanged to BS4504 PN16.
Pressure/ temperature ratting: 16 bar for -10 to 120°C Hydro Static Pressure: Body: 24 bar Seat: 17.6 Bar

Manual Balancing Valves / Double Regulating Valves –300mm and Above
These shall be a combination of Butterfly Valve as per section 1.8 and Metering Station/Orifice Plate. Metering station shall be of Cast Iron or SS material with 2 test points for measurement of flow.
The valves shall be complete with pressure test points.

14.12.3 Strainers
Strainer – 15mm to 50mm
Y Type Strainers, Body and cover to be of bronze body with Stainless steel screen of 0.8mm perforations, Gasket shall be PTFE, End connections to be threaded to BS21 [BSPP].
Pressure/Temperature rating: 16 bar Hydro Static Pressure: Body: 24 bar

Strainer – 65mm to 300mm
Y Type Strainers, Body and cover to be of Cast Iron [GG 25] with Stainless steel screens of 1.5mm perforations. End connections to be flanged to BS4504 PN16. Drilling on the bolted cover, with drain plug connection, Internal and external epoxy coating required to 100 microns. Pressure/Temperature rating: 16 bar Hydro Static Pressure: Body: 24 bar

Strainer – 350mm to 600mm
Y Type Strainers, Body and cover to be of Ductile Iron [GG 40] with Stainless steel screens of 3mm perforations. End connections to be flanged to BS4504 PN16. Drilling on the bolted cover, with drain plug connection. Internal and external epoxy coating required to 100 microns.
Pressure/Temperature rating: 16 bar for -10 to 120°C. Hydro Static Pressure: Body: 24 bar

14.12.4 Check Valves
Check Valves – 15mm to 50mm
Body, cover, disc and seat shall be of bronze body, Swing pattern type to BS 5154 PN16 series B. Screwed in cover with BS21 [BSPP] threaded ends. Valves should be suitable for mounting in both horizontal and vertical pipe (with flow upwards).
Pressure/Temperature rating: 16 bar for -10 to 100°C. Hydro Static Pressure: Body: 24 bar Seat: 17.6 Bar

Check Valves – 50mm to 300mm – Dual Plate Wafer Type
Body shall be Cast Iron Body with Bronze [BS 1400LG2] disc, Stainless steel stem and spring with NBR seat rings. Dual plate Wafer type pattern to PN16. Valves should be suitable for mounting in Horizontal and Vertical pipes.

Pressure/Temperature rating: 16 bar for 90°C. Hydro Static Pressure: Body: 24 bar Seat: 17.6 Bar

14.12.5 Two way type Pressure Independent Balancing cum Modulating flow control valve with digital thermostat
PN 16 Rating,
DN 15 to DN 32 Brass Body Ext. Threaded DN 40 & DN 50 Cast Iron Body, Ext. Threaded
DN 65 to DN 100 Cast Iron body, Flanged Ends Connection

Duly mounted with a BMS compatible Modulating actuator IP54 Type suitable for 24V AC for AHU / FCU as per specification.

SPECIFICATIONS
The Self-balancing flow control valves that are pressure independent, two-way, modulating to accept Input signals from the control system. Each Air Handling Unit / Ceiling suspended Units etc. shall be provided with 2-Way Pressure Independent Balancing cum Control Valve with Integrated in a single Body with Globe Type in Construction. Valves should be provided with Spring Return Function Actuators Only.

Regarding Control - Valve should be equipped with electronic modulating actuator which can accept either “4(0)-20 mA / 2(0)-10 V DC signals. Operating voltage for actuator shall be 24V AC. Delta P controller should ensure 100% valve authority at all loads (part load Actuator shall be able to work against maximum closing pressure of 6 Bar at full load) with feedback signal to Control system.

Balancing each valve should have step less adjustable maximum flow limitation as per the designed flow rate of coils. Balancing should be done only in valve not in actuator so that at any given condition of failure balancing is not lost and easily accessible. All Valve actuator are microprocessor based with self-calibrating feature. Valve should be of linear control characteristics with steeples characteristics.

GENERAL SPECIFICATIONS
Pressure Independent Balancing Cum Control Valve Shall be Provided/Installed at each Outlet of Cooling Coil Unit., AHU & FCU.

a. Pressure Controller Device should maintain the Pressure irrespective of Fluctuation with the help of Diaphragm self-adjusting type and should not be in contact with each other.
b. Control valve shall accurately control the flow, with help of Modulating Actuator
c. Valve actuator housing shall be rated to IP 54. Control/Dip Switch Setting should be easy to Manual Access to avoid Manual Contact too directly with Integrated IC Circuit of the system.
d. Flow regulation unit shall consist of stainless steel Material 316.
e. All Valve Sizes should have a Testing Port Device for verifying accuracy of flow performance with respective of Differential Pressure.
f. Valve should be Globe Type in Construction and not with cylinder type cartridge. Globe construction valves are accepted as the most accurate characteristics valves. (I.e. they very closely follow the graphs made for valve opening and flow characteristics.)
g. The Valve + Actuator must have ability to undertake both Logarithmic Control Characteristics and Linear Control Characteristics. This ensures compatibility for both Water/Air and Water/Water Heat Exchange.
h. Only Liner characteristics should not be acceptable as with this valve + actuator characteristic, the resultant energy characteristic will not remain linear and this shall lead to improper control leading to overflow/underflow phenomenon.
i. Balancing & Control: Balancing should be accomplished by the Diaphragm and Control should be taken care by Actuator receiving signals from Room Thermostats or BMS.
j. Actuator should not play a part in balancing process. This will ensure that even an operational issue in the actuator will not lead to loss of Balancing. Valve Actuator housing shall made of non-Corrosive Material.

14.12.6 Two way Modulating Valves
All the chilled water coils having flow greater than 8 gpm may have cast iron body modulating valves on the AHU coil return line (if required). These valves shall be with the magnetic actuators or Motorized and modulating type. All these AHU control valves to have integral hand wheel for manual override purposes. The manufacturer's logo should be embossed on the valve body. PWM actuators for FCU applications shall be offered.

Valves below 50mm shall be screwed type complete with union coupling supplied by the valve supplier. Valves equal and above 65mm shall be flange type PN 16. All valves shall be suitable for working water pressure of 10 bar.

All the chilled water coils having flow equal or less than 8 gpm shall have red brass body valves with a separate magnetic actuator with linear characteristics. The valve should be spring return type with manual override. The actuator shall be IP 40 to IEC 529. The valve shall be suitable for working the water pressure of 10 bar.

14.12.7 Flexible Bellows
Rubber Bellow – 15mm to 50mm

Bellows to be of Reinforced Neoprene Rubber, twin sphere. End connections shall be of Steel Electro Galvanized union type to BS21 [BSPP]. Control/Tie rods to be used as recommended by Manufacturer.

Pressure/Temperature rating: 10 bar at 60°C. Hydro Static Pressure: Body: 15 bar

Rubber Bellow – 65mm to 600mm

Bellows to be of Reinforced Neoprene Rubber, single sphere. Single piece floating flanged end connections, electro galvanized to BS4504 PN16. Control/Tie rods to be used as recommended by Manufacturer.

Pressure/Temperature rating: 16 bar at 40°C. Hydro Static Pressure: Body: 24 bar
14.12.8 Test Points – 15mm
Body shall be of brass material, self-closing type, and suitable for measuring flow on manual balancing valves.

14.12.9 Drain cocks – 15mm
Drain cocks to be of forged brass(nickel plated) construction, ball type with hose union, cap and chain arrangement, NBR O Ring, PTFE seat, Aluminium Lever operated with threaded end connections to BS21 [BSPP].
Pressure Rating: 25 Bar

14.12.10 Automatic Air Vents – 15 to 25mm
Body and cover shall be of Brass, and Float shall be of Polypropylene material. Float and lever in anti-corrosion resin, Gasket shall be EPDM and an Integral Brass check valve, and connections to be threaded to BS21 [BSPP].
Pressure Rating: 12 Bar

14.12.11 Flanges – 50mm - 600mm
Flanges shall be made of Carbon steel material raised face, serrated finish to BS4504 PN16 as per DIN 2543 standard, Slip On type.
Pressure Rating: 16 Bar
Flanges may be tack welded into position, but all final welding shall be done with joints dismounted, 3mm thick gaskets shall be used with all flanged joints, the gaskets shall be fiber reinforced rubber as approved by the Engineer-in-charge. Flanges shall be used as follows: Counter flanges for equipment having flanged connections. Flanged pairs shall be used on all such equipment, which may require to be isolated or removed for service (E.G. pumps, Refrigeration machines, air handling units etc.) All threaded valves shall be provided with nipples and flanged pairs on both sides to permit flange connections, for removal of valves from main lines for repair/replacement.

14.13 INSTRUMENTS AND ACCESSORIES

14.13.1 Thermometers / Temperature Gauges
Thermometer shall be Glass Stem-type V shape with Aluminums casing, gold colored anodized, clear figures by means of black marking; scale range in °C. Brass insert shall be ½” BSPP male threaded ends, removable from casing.
Glass Insert shall be capillary tube of prismatic solid glass with clear black scale marking, blue spirit filling on white background, flexible mounted glass tube by rubber rings.
Scale range: -30 to +50°C or 0 to 120°C

14.13.2 Pressure Gauges
Bourdon tube type with Black muffled steel casing of 150mm diameter. Copper alloy bourdon tube with brass bottom connections of ½” BSPP male threads, Operating temperature of -20 to 60°C with 1% accuracy.
Pressure gauges to be fitted with gauge cocks and siphons for easy reading directly on installations.
Scale range: 0 to 16 bar

14.13.3 Gauge Cock – 15mm
Brass gauge cocks shall be with quarter-turn levers. Gauge Cocks to have threaded connections to BS21 [BSPP].
Pressure Rating: 25 Bar

14.13.4 Siphon – 15mm
Siphons to be of the U-type made of Steel with black varnish finish. Siphons shall be of threaded connections to BS21 [BSPP].
Pressure Rating: 25 Bar

14.13.5 Differential Pressure switch for pipe work
These shall be used to measure pressure differential across suction and discharge of pumps. The range shall be as specified in the data sheet. Switch shall be ON with increase in differential. Housing for these shall be weather proof with IP 55 protection. The pressure switch shall be capable of withstanding a hydraulic test pressure of 1.5 times the working pressure. The set point shall fall in 40-70% of the scale range and shall have differentials adjustable over 10%-30% of the scale range. The switches shall be provided with site adjustable scale and with 2 NO/NC contacts.

14.14 PIPING INSTALLATIONS
Tender drawings indicate schematically the size and location of pipes. The contractor, on the award of the work, shall prepare detailed working drawings, showing the cross-section, longitudinal sections, details of fittings, locations of isolating and control valves, drain and air auto vent valves, and all pipe supports. Contractor must keep in view the specific openings in buildings and other structures through which pipes are designed to pass.

Piping shall be properly supported on, or suspended from, stands, clamps, and hangers as specified and as required. The contractor shall adequately design all the brackets, saddles, anchors, clamps and hangers, and be responsible for their structural sufficiency.

Pipe supports shall be of steel, adjustable for height and primer coated with rust preventive paint and finish coated black. Where pipe and clamps are of dissimilar materials, a gasket shall be provided in between spacing of pipe supports shall not exceed the following:

<table>
<thead>
<tr>
<th>Pipe Size</th>
<th>Rod Diameter (mm)</th>
<th>Base Support</th>
</tr>
</thead>
<tbody>
<tr>
<td>Upto 65mm</td>
<td>10</td>
<td>40 x 40 x 6 thk. Angle</td>
</tr>
<tr>
<td>75 to 125mm</td>
<td>10</td>
<td>50 x 50 x 6 thk. Angle</td>
</tr>
<tr>
<td>150 mm to 200 mm</td>
<td>15</td>
<td>ISMC 75</td>
</tr>
<tr>
<td>250 mm</td>
<td>20</td>
<td>ISMC 100 *</td>
</tr>
<tr>
<td>300 mm</td>
<td>22</td>
<td>ISMC 150 *</td>
</tr>
</tbody>
</table>
Vertical risers shall be parallel to walls and column lines and shall be straight and plumb. Risers passing from floor to floor shall be supported at each floor by clamps or collars attached to pipe and with a 15mm thick rubber pad or any resilient material. Where pipes pass through the terrace floor, suitable flashing shall be provided to prevent water leakage. Risers shall have a suitable clean out at the lowest point and air vent at the highest point.

Pipe sleeves, 50mm larger diameter than pipes, shall be provided wherever pipes pass through walls and slabs, and annular space filled with fiberglass and finished with retainer rings.

Insulated piping shall be supported in such a manner as not to put undue pressure on the insulation. 14 gage metal sheet shall be provided between the insulation and the clamp, saddle or roller, extending at least 15cm on both sides of the clamp, saddles or roller.

All pipe work shall be carried out in a workman like manner, causing minimum disturbance to the existing services, buildings, rods and structure. The entire piping work shall be organized, in consultation with other agencies work, so that laying of pipe supports, pipe and pressure testing for each area shall be carried out in one stretch.

Cut-outs in the floor slab for installing the various pipes are indicated in the drawings. Contractor shall carefully examine the cut-outs provided and clearly point out where ever the cut-outs shown in the drawings, do not meet with the requirements.

The contractor shall make sure that the clamps, brackets, clamps saddles and hangers provided for pipe supports are adequate. Piping layout shall take due care for expansion and contraction in pipes, and include expansion Loop where required.

All pipes shall be accurately cut to the required sizes in accordance with IS 554 and burrs removed before laying. Open ends of the piping shall be closed as the pipe is installed to avoid entrance of foreign matter. Where reducers are to be made in horizontal runs, eccentric reducers shall be used for the piping to drain freely. In vertical pipes, concentric reducers shall be used.

Flanged inspection pieces 1.5 meters long, with bolted flanges on both ends, shall be provided no more than 30 meters centers wherever shown in approved for construction to facilitate future cleaning of all welded pipes.
Auto/Manual air vent valves shall be provided at all specified points in the piping system for air venting. All valves shall be of 20mm/15mm pipe size, provided with drain connection & non-return valve for ease of maintenance.

Discharge from the air valves shall be piped through an equal sized mild steel or galvanized steel pipe to the nearest drain or sump. All pipes shall be pitched towards drain points.

Pressure gauges with gun metal gate valves as specified, shall be provided at the suction and discharge of chilled water/condenser water pumps supply and return at air handling units, at chillers and at condensers, as per the requirement. Care shall be taken to protect pressure gages during pressure testing.

14.15 TESTING & BALANCING
All piping shall be tested to hydrostatic test pressure of at least two and half times the maximum operating pressure, but not less than 10 Kg per sq.cm. Gauge for a period of not less than 24 hours. All leaks and defects in joints revealed during the testing shall be rectified to the satisfaction of the AAI. Piping repaired subsequent to the above pressure shall be retested in the same manner. Piping may be tested in sections and such sections shall be securely capped.

Piping repaired subsequent to the above pressure test shall be re-tested in the same manner.

System may be tested in sections and such sections shall be securely capped, then retested for entire system.

The contractor shall give sufficient notice to all other agencies at site, of his intention to test a section or sections of piping and all testing shall be witnessed and recorded by Owner's site representative.

The Contractor shall make sure that proper noiseless circulation of fluid is achieved through all coils and other heat exchange equipment in the system concerned. In case of improper circulations, the contractor shall rectify the defective connections. He shall bear all expenses for carrying out the above rectifications. He shall bear all expenses for carrying out the above rectifications, including the tearing up and re-finishing of floors and walls as required.

The contractor shall provide all materials, tools, equipment, instruments, services and labour required to perform the test and to remove water resulting from cleaning and after testing.

After completion of the installation, all water system shall be adjusted and balanced to deliver the water quantities as specified, quoted or as directed, to individual air handling units and fan coil units cooling coil.

Water circuit shall be adjusted by balancing cocks provided for balancing; these shall be permanently marked after balancing is completed so that they can be restored to their correct positions, if disturbed.

Complete certified balancing report shall be submitted for evaluation and approval. Upon approval, four copies of the balancing report shall be submitted with complete drawings and documents.
Exposed Pipes & insulation surface/cladding shall be provided the approved colour along with name & arrows marked distinctly in service areas.

All underground piping shall be laid normally in trenches as shown in the drawings. Wherever valves are to be located, pipes shall be suitably dipped, if required so that valves do not project above the ground level. Bends/elbows shall not be used either for dipping the piping upstream of the valve or for raising it downstream thereof; further, when piping is dipped or raised, the slope shall nowhere be steeper than 1 to 5.

Overhead piping shall be supported on walls/columns appropriately with brackets or hung from ceiling/roof slabs and rolled steel sections of the roof structure with MS suspension rods, hangers, cradles, etc. Suspenders shall be fastened to the roof/ceiling slab with Anchor grip bolts; similarly, Anchor grip bolts where required - shall be used for fixing wall brackets also. The contractor shall design adequately all brackets, saddles, clamps, hangers, etc., and be responsible for structural safety and integrity. Further, while providing the supports, care shall be taken to ensure freedom from vibration.

All supporting arrangements, including necessary suspenders, brackets, rods, bolts and nuts, etc., and all civil work related thereto - including drilling of holes for fixing grip bolts and any chipping and finishing, shall be included within the scope of the work of the contractor.

All supports in the plant rooms, near cooling towers etc. shall be given two coats of black paint.

Pipe sleeves 50 mm (2 ins.) larger in diameter shall be provided whenever pipes pass through walls or structures and the annular space shall be filled with felt and finished with retaining rings to isolate any vibrations from being transmitted to walls/structures.

Drains shall be provided at all low points in the piping system and shall be of the following sizes:

<table>
<thead>
<tr>
<th>Main Pipe(in mm)</th>
<th>Drain Pipe(in mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Upto 300 mm</td>
<td>25 mm</td>
</tr>
<tr>
<td>Above 300 mm</td>
<td>50 mm</td>
</tr>
</tbody>
</table>

Drain shall be provided with gate valves of equal size but with rising spindle. Piping shall be pitched towards drain points.

Suitable vibration elimination fittings shall be provided at the inlet and outlet of pumps, chillers and condensers.

Install manual air vents at high points in piping, at heat-transfer coils, and elsewhere as required for system air venting.

Install piping from air separator, or air purge to expansion tank with a 2 percent upward slope toward tank.

Install in-line air separators in pump suction. Install drain valve on air separators 25mm dia. and larger.
Install bypass chemical feeders in each hydronic system where indicated, in upright position with top of funnel not more than 1200 mm above the floor. Install feeder in minimum 20 bypass line, from main with full-size, full-port, ball valve in the main between bypass connections. Install DN 20 pipe from chemical feeder drain, to nearest equipment drain and include a full-size, full-port, ball valve.

Support tank from floor or structure above with sufficient strength to carry weight of tank, piping connections, fittings, plus tank full of water. Do not overload building components and structural members.

14.16 WELDING - IN ACCORDANCE TO THE ASME SECTION IX GENERAL REQUIREMENTS

This paragraph covers the welding of systems. Deviations from applicable codes, approved procedures and approved shop drawings shall not be permitted. Materials or components with welds made off site shall not be accepted if the welding does not conform to the requirements of this specification. Develop and qualify procedures for welding metals included in the work. Certification testing shall be performed by an approved independent testing laboratory. Bear costs of such testing.

Certified welders, previously certified by test, may be accepted for the work without recertification provided that all of the following conditions are fulfilled:

a. Submit copies of welder certification test records in accordance with this Division.

b. Testing was performed by an independent testing laboratory.

c. The welding procedures and welders are certified in accordance with the "ASME Section IX and base materials, filler materials, electrodes, equipment, and processes conform to the applicable requirements of this specification.

d. Certification has been within a one (1) year period from the start of the project.

Filler metals, electrodes, fluxes and other welding materials shall be delivered to the site in manufacturers' original packages and stored in a dry space until used. Packages shall be properly labeled and designed to give maximum protection from moisture and to assure safe handling. Submit welding certificates for review. Each welder assigned to work covered by this specification shall be certified by performance tests using equipment, positions, procedures, base metals, and electrodes or bare filler wires. Before assigning welders to the work, provide AAI with their names, together with certification that each individual is certified as specified. No welding work shall start prior to submissions. The certification shall state the type of welding and positions for which each is certified, the code and procedure under which each is certified, date certified, and the firm and individual certifying the certified tests. Each welder shall be assigned an identifying number, letter, or symbol that shall be used to identify his welds. A list of the welders' names and symbol for each shall be submitted. To identify welds, either written records indicating the location of welds made by each welder shall be submitted, or each welder shall apply his mark adjacent to his weld using an approved rubber stamp or felt-tipped marker with permanent, weatherproof ink or other approved methods that do not deform the metal. For seam welds, identification marks shall be placed adjacent to the welds at 3 foot intervals. Identification by die stamps or electric etchers shall be confined to the weld reinforcing crown, preferably in the finished crater.

Welding materials as per ASME Section IX

A. Welding materials shall comply with the "ASME section IX Welding equipment,
electrodes, welding wire, and fluxes shall be capable of producing satisfactory welds when used by a certified welder using qualified welding procedures.

Welding Procedures In accordance to the ASME Section IX

A. Perform welding in accordance with qualified procedures using certified welders. Welding shall not be done when the quality of the completed weld could be impaired by the prevailing working or weather conditions. Welding of hangers, supports, and plates to structural members shall conform to AWS specifications.

B. Field bevels and shop bevels shall be by mechanical means. Beveling shall conform to ANSI B31.1 and AWS B3.0.

C. Replace and re-inspect defective welds. Repairing defective welds by adding weld material over the defect or by peening shall not be permitted. Welders responsible for defective welds must be re-certified.

D. Store electrodes in a dry heated area; keep free of moisture and dampness during fabrication operations. Discard electrodes that have lost part of their coating.

Cleaning of Piping and Equipment

a. After piping is erected, all piping systems shall be cleaned of all mill and welding scale, oil, corrosion, and construction debris by a pipe cleaning specialist. Systems shall be flushed clean and filled ready for service, immediately after cleaning. Do not operate pumps or equipment, until mill scale and debris has been removed from the respective system, and the system has been flushed.

b. Flush supply pipe system forward (normal direction of low) to pump suctions and to chillers. Provide large (temporary) blow-offs or drains in system low points, at pumps, at chillers, and open ends high to admit air. Fill system to open high ends and then open low drains for flushing action on return and on supplies. Prevent mill scale and debris from entering coils, tanks, equipment, and control valves. Provide temporary strainers in all systems located at pump suctions, control valves and other places as indicated ruing cleaning operations. Temporary strainers shall have 2.5 mesh perforations and shall be removed after system is flushed, after which the permanent strainers shall be installed. Isolate or adequately protect all equipment and parts which would be susceptible to damage due to foreign materials during the cleaning process.

c. Entire non-potable piping system and related equipment shall be cleaned by forced high velocity circulation of a solution of non-corrosive chemical cleaner and non-foaming detergent, followed by a continuous flush with clear, clean domestic water until residual alkalinity of the water leaving the system is 300 ppm or less. Pumps shall not be operated until system is clean.

d. Automatic device which can become clogged during the cleaning process shall be disconnected and shall not be connected permanently until the cleaning process is complete.

e. All strainers, automatic valves, pump seals, vents, etc., and other parts shall be cleaned.

15 AIR DISTRIBUTION SYSTEM

15.1 GENERAL

The scope of this section comprises supply fabrication, installation and testing of all sheet metal /aluminum ducts, supply, installation, testing and balancing of all grilles, registers
and diffusers. All to be in accordance with these specifications and the general arrangement shown on the Drawings. All ducting shall be factory fabricated from coil stock and the contractor shall establish a workshop at site where L shaped duct sections will be closed pneumatically / electrically before they are taken up for installation.

Duct work shall mean all ducts, casings, dampers, access doors, joints, vanes, stiffeners, hangers, splitters and supports etc.

15.2 CODES AND STANDARDS
The design, materials, construction features, manufacturer, inspection, testing and performance of air distribution system shall comply with all currently applicable statues, regulations, codes and standards in the locality where the system is to be installed. Nothing in this specification shall be construed to relieve the Contractor of this responsibility.

In particular, the air distribution system shall conform to the latest edition of following standards.

| IS 277 | Galvanized Steel Sheet (Plain and corrugated). |
| SMACNA | HVAC Duct construction standards – Metal and Flexible |
| SMACNA | HVAC Air duct leakage test manual |
| SMACNA | HVAC systems – Testing, adjusting and balancing. UL 181 Factory – Made Air ducts and connectors. |
| UL 555 | Fire Dampers. |
| ASHRAE 70 | Method of testing for rating the performance of Air Outlets and inlets. |

15.3 DUCT MATERIALS
RAW MATERIALS

Zinc coating shall be conforming to IS 277-2003 and Lock Forming Quality prime material along with mill test certificates. In addition, if deemed necessary, samples of raw material, selected at random by AAI representative shall be tested for thickness and zinc coating at contractor's expense at AAI Approved Laboratories. Grade of zinc coating shall be 180 GSM(min.)

<table>
<thead>
<tr>
<th>Sl No</th>
<th>Thickness</th>
<th>Grade of Zinc Coating</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.63 to 1.0mm (both inclusive)</td>
<td>180 GSM</td>
</tr>
<tr>
<td>2</td>
<td>Above 1.0 m</td>
<td>180 GSM</td>
</tr>
</tbody>
</table>

GSM: 180 grains per square meter.

CONSTRUCTION FEATURES of rectangular Ducts
All ducts shall be factory fabricated from galvanized steel of the following thickness, duct section length of 1.2 m (4ft) as indicated below:
For Ducts with External Static Pressure up to 500 Pa (ESP up to 50mm wg)
Larger side of Duct in mm | Type of Transverse Joints | Type of Reinforcement
--- | --- | ---
Up to 750 | Proprietary flange / TDF | As per SMACNA
751 to 1500 | Proprietary flange / TDF | As per SMACNA
1501 to 2250 | Proprietary flange / TDF | As per SMACNA
2250 and above | Proprietary flange / TDF | As per SMACNA

For Factory fabricated ducts (for all sizes), the transverse joint shall be Proprietary flange / TDF flange only. C&S and C&SS type flanges are not acceptable for any size of ducting.

a. Longitudinal seams shall be Pittsburgh lock type at corners. Longitudinal joints shall not be provided for rectangular ducting at locations other than corners, except where larger side of duct exceeds 2500mm. Longitudinal joints of ducting having side larger than 2500mm other than corner shall be grooved or standing seam.

b. Flanges used for transverse joints shall be of Proprietary flange / TDF type only and joined with each other with Galvanised Steel (GS) bolts, washers and nuts at the corners. GI cleats shall be used to hold the flanges together along the periphery of the flanges. The spacing between two cleats shall not exceed 300mm.

C. For transverse joints, neoprene gasket (3mm uncompressed thickness and width equal to flange face) adhered to the flange face shall be used. The bolt holes in gasket shall be the same as bolt diameter and shall be punched prior to insertion of gaskets. In joints, the bolt does not go through the gaskets.

15.4 DUCT SUPPORTS AND HANGERS

a. Rectangular Ducts shall rest on supporting GI Slotted channel (16G for ducts upto 750mm width and 12G for ducts between 751 and 2400mm, for higher sizes suitable MS painted angles shall be used with prior approval) and this supporting slotted channel shall be suspended from two full threaded GI rods fixed to concrete ceiling by suitable sized anchor fastener.

Supporting details shall be as given below.

<table>
<thead>
<tr>
<th>Larger Side of Duct mm</th>
<th>Vertical Rod Diameter mm</th>
<th>Maximum Spacing Between Supports mm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Upto 900</td>
<td>10</td>
<td>2400</td>
</tr>
<tr>
<td>901 to 1500</td>
<td>10</td>
<td>2400</td>
</tr>
<tr>
<td>1501 to 2400</td>
<td>10</td>
<td>2400</td>
</tr>
<tr>
<td>2401 and above</td>
<td>12</td>
<td>2000</td>
</tr>
</tbody>
</table>
In addition to the above, additional supports shall be provided near bends, elbows, tees or other special fittings. Additional supports are also to be provided in locations where dampers are provided in the ducting.

b. Zinc coated anchor fasteners or embedded plates shall be provided for upper attachments to the building. Anchor fasteners shall be provided by Contractor. Embedded plates shall be provided by Contractor. Contractor shall provide duct supports from angle cleats welded to the embedded plates. Anchor fasteners shall be loaded to maximum 20% of the maximum rated capacity specified by the manufacturer. Site Engineer shall approve all anchor fasteners used for supporting duct.

b. In case of insulated duct, anchor fasteners shall be selected based on actual total load.

d. Rectangular risers should be supported by angles or channels secured to the sides of the ducts with bolts, sheet metal screws or blind rivets. Risers shall be supported minimum at every 2m intervals.

TRANSFORMATION
Duct transformation shall be used to change the shape of duct and shall be made for easy and noiseless flow of air. Maximum slope of transformation shall be 1:4.

BENDS, OFFSETS and BRANCH CONNECTIONS
All bends, offsets and branch connections shall be made for smooth and noise less flow of air and minimum pressure drop. In case of full radius elbow, optimum ratio of centre line radius of elbow to duct dimension of 1.25 shall be considered. However, due to space constraint shorter radius constraint shorter radius elbow or square elbow with guide vanes may be provided. Contractor shall furnish the details of guide vanes i.e. number of vanes, location etc. in the drawing. The flow of air to the branch duct shall be regulated by a splitter damper or volume control damper.

SPLITTER DAMPERS
Splitter dampers shall be fabricated of minimum 18G GSS and shall be of robust construction. The position of splitter damper shall be adjusted by use of the splitter rod.

15.5 INSTALLATION PRACTICE
All ducts shall be installed generally as per tender drawings, and in strict accordance with approved shop drawings to be prepared by the Contractor:

a) The Contractor shall provide and neatly erect all sheet metal work as may be required to carry out the intent of these Specifications and Drawings. The work shall meet with the approval of AAI representative in all its parts and details.

b) All necessary allowances and provisions shall be made by the Contractor for beams, pipes, or other obstructions in the building, whether or not the same are shown on the drawings. Where necessary to avoid beams or other structural work, plumbing or other pipes, and conduits, the ducts shall be transformed, divided or curved to one side (the required area being maintained) all as per the site requirements.

c) If a duct cannot be run as shown on the drawings, the contractor shall install the duct between the required points by any path available in accordance with other services and as per approval of AAI representative.

d) Ducting over furred ceiling shall be supported from the slab above, or from beams after obtaining approval of AAI representative. In no case shall any duct be supported from false ceiling hangers or be permitted to rest on false ceiling. All metal work in dead or furred down spaces shall be erected in time to occasion no delay to other contractors work in the building.

e) Where ducts pass through brick or masonry openings, it shall be provided with 25mm thick TF quality expanded polystyrene around the duct and totally covered with fire barrier mortar for complete sealing.
f) All ducts shall be totally free from vibration under all conditions of operation. Whenever ductwork is connected to fans, air handling units or blower coil units that may cause vibration in the ducts, ducts shall be provided with a flexible connection, located at the unit discharge. Flexible connections shall be constructed of fire retarding flexible heavy canvas sleeve at least 10cm long securely bonded and bolted on both sides. Sleeve shall be made smooth and the connecting ductwork rigidly held by independent supports on both sides of the flexible connection. The flexible connection shall be suitable for pressure at the point of installation.

g) Duct shall not rest on false ceiling and shall be in level from bottom. Taper pieces shall taper from top.

15.6 RAW MATERIALS FOR SPIRAL DUCT

Zinc coating shall be conforming to IS 277-2003 and Lock Forming Quality prime material along with mill test certificates. In addition, if deemed necessary, samples of raw material, selected at random by AAI representative shall be tested for thickness and zinc coating at contractor's expense at AAI Approved Laboratories.

All round spiral duct and fittings shall be manufactured from G-120 galvanized steel, conforming to ASTM and SMACNA standards.

Branch connections in medium pressure systems shall be conical for 90 degree taps, and straight for 45 degrees. Seams and tap connections shall be tack welded and sealed with mastic for use up to 4” w.g., or solid welded for use to 10” w.g.

Standard connections are slip fit with couplings with Spiral mate (by Ductmate Industries) or equivalent shall be provided.

Spiral ducts shall be powder coated with colour of AAI's choice.

15.7 DAMPERS

a. Dampers: All duct dampers shall be opposed blade louver dampers of robust 16G GSS construction and tight fitting. The design, method of handling and control shall be suitable for the location and service required.

b. Dampers shall be provided with suitable links levers and quadrants as required for their proper operation. Control or setting device shall be made robust, easily operable and accessible through suitable access door in the duct. Every damper shall have an indicating device clearly showing the damper position at all times.

c. Dampers shall be placed in ducts at every branch supply or return air duct connection, whether or not indicated on the Drawings, for the proper volume control and balancing of the air distribution system.

d. Pressure relief dampers: Pressure relief dampers shall be constructed with 18G Aluminum construction with parallel blade construction. Leaf shall be 100% air tight upon closure. Leaf shall be loaded with spring pressure of stiffness (k value) corresponding to set point pressure.

e. Non return damper (Back draft damper): Non return damper shall be constructed out of
16G GSS. Blades shall ensure 100% air leak proof performance on closure. Design shall ensure that no rattling noise is produced at design duty.

f. Round VCD

Standard Construction:
Casing:
GI sheet steel Casing with 180 gsm coating as per standard 22Gauge for diameter up to 350mm & 20G for diameter more than 350mm. Frame is a spot weld construction with swaging at both ends to suit ductwork connections.
Blade:
GI steel sheet, single skin blades, 1.2mm (18G) thick, for sizes up to 500mm diameter. GI steel sheet, single skin blades, 1.5mm (16G) thick, for sizes above 500mm diameter.
Bearings:
Brass bush and Nylon / PVC bush is standard supply. Sintered Bronze oil impregnated bushes are optional.
Axles:
Blades are coupled with Linkage and Frame with Zinc plated spindles, Square or Round. Spindles are either welded or riveted as per specification.
Quadrant:
Manual operation, locking type quadrant made of GI steel with full “open” and “close” markings. Quadrant handle and drive axle are coupled to allow opening/closing of VCD at any position.
Gasket:
Black foam gasket at the blade tips to prevent air leakage in “shut off” position.

15.8 FLEXIBLE DUCT CONNECTION:
The Flexible Connection should be made of TF quality fire retardant double canvas or imported fabric of fiberglass weave having silicone rubber coating, as per the requirement. Flexible connections shall be air tight & water proof and withstand high temperature application, nonflammable type and does not support combustion. There shall be extruded Angle aluminum frame at both ends for connection.

15.9 FIRE & SMOKE DAMPERS FUSIBLE LINK
a. Whenever a supply/return duct crosses from one fire zone to another, it shall be provided with approved fire damper of at least 1½ hour fire rating as per UL555/1995 tested by CBRI. This shall be curtain type fire damper.

b. Fire damper blades shall be one piece folded high strength 16 gage galvanised steel construction. In normal position, these blades shall be gathered and stacked at the frame head providing maximum air passage and preventing passing air currents from creating noise or chatter. The blades shall be held in position through fusible link of temp 700 C. The HVAC contractor shall supply UL classified Fire Dampers meeting or exceeding the specifications. Fire Dampers shall be furnished and installed as per requirements. Fire Dampers shall have a fire rating of 1.5/3 Hrs. as per requirement, in accordance with latest edition of UL555. Each Fire damper shall be AMCA licensed and shall bear the AMCA seal for air performance.

Damper shall be equipped with UL labelled Fusible Link with Temperature setting 165 or 212deg. F. Fire dampers shall have been tested to close under dynamic air flow conditions
with pressure up to 1000 pa and velocities up to 10.2 m/sec. Fire damper shall be approved for Horizontal or vertical installation as may be required by the location shown in the drawings.

Damper Frame shall be a roll formed structural hat channel, reinforced at corners, formed from a single piece of 1.6mm galvanized steel. Damper blades shall be roll formed 3-v groove (1.6mm thick) or aerofoil shaped in case of 3 Hrs. fire rating (equivalent to 2.3mm thickness strength) roll formed using 0.8mm thick single piece of galvanized sheet. Bearings shall be of stainless steel fitted in an extruded hole in the damper frame. All galvanized steel used shall be with minimum 180GSM Zinc coating bigger size Dampers shall be supplied in multiple modules of sizes not exceeding in dimensions of certified module jack shafted together.

Fire damper shall be equipped with an electric limit switch to indicate open and close position of the damper blades.

Fire Damper shall be installed in wall or floor opening using galvanized steel sleeve of minimum 435mm length of sheet thickness as per SMACNA and as per Installation instruction of Manufacturer.

c. In case of fire, the intrinsic energy of the folded blades shall be utilized to close the opening. The thorough of the suddenly released tension shall instantly drive the blades down and keep it down without the use of springs, weights or other devices subject to failure.

d. Fire damper sleeves and access doors shall be provided within the duct in accordance with the manufacturer’s recommendation.

e. The contractor shall also furnish to the Owner, the necessary additional fusible links (spares), as recommended by the manufacturer, at the time of commissioning of the installation.

MOTORISED COMBINED SMOKE & FIRE DAMPERS - SPRING RETURN TYPE

a) All supply air Ducts in AHU room crossing shall be provided with approved make fire and smoke dampers of at least 120 minutes fire rating certified by CBRI, Roorkee as per UL555:1973.

b) The fire damper blades & outer frame shall be formed of 1.6 mm galvanised steel sheet. The damper blade shall be pivoted on both ends using chrome plated spindles in self-lubricating bushes. Stop seals shall be provided on top & bottom of the damper housing made of 16G Galvanised steel sheet. For preventing smoke leakage side seals will be provided. In normal operating conditions damper blade shall be held in open position with the help of a 24 V operated electric actuators thereby providing maximum air passage without creating any noise or chatter.

c) The damper shall be actuated through electric actuator. The actuator shall be energised with the help of a signal from smoke detector installed in AHU Room / R. A. Duct. The fire damper shall close due to temp. Rise in S. A. Ducts through the electric temp. Sensor which is factory set at 165 °F.

d) Each motorized smoke cum fire damper shall have its own panel which will incorporate necessary circuit required to step down voltage available from UPS or emergency power supply to show status of the damper (open or close), to allow remote testing of damper, indication in event of damper closure due to signal from smoke sensor / temp. Sensor & reset button. Additional terminal will be provided to have audio cum video signal in Central Control Room.
e) Damper actuator shall be such that it should close the damper in the event of power failure automatically and open in the same in case of Power being restored.

f) The fire Damper shall be mounted in fire rated wall with a duct sleeve 450 MM long. The sleeve shall be factory fitted on fire damper. The joints at sleeve end shall be slip on type. Minimum thickness of GI Sheet shall be 18G.

g) The damper shall be installed in accordance with the installation method recommended by the manufacturer.

h) Hinged access doors of suitable size complete with air tight gaskets shall be provided in all fire dampers & plenums.

15.10 AIR TERMINAL DEVICES

SUPPLY AND RETURN AIR DIFFUSERS:
Supply and return air diffusers shall be as per the requirement. The supply air diffuser shall be provided with removable key operative volume control dampers. Aluminum supply and return air diffusers shall be powder coated with color of AAI's choice, or shall be anodized aluminum.

Supply/return air linear diffuser shall be Aluminium diffusers shall be powder coated & made from extruded aluminium section, square, rectangular, or round diffusers with flush fixed pattern or adjustable flow pattern. Aluminum diffusers shall be square or rectangular in shape. Diffusers for different spaces shall be selected in consultation with the AAI/Architect. Supply air diffusers may be equipped with fixed air-distribution grids, removable key-operated volume control dampers, and anti-smudge rings as per the requirement.

LINEAR SUPPLY AIR/RETURN AIR GRILLES:
These shall be extruded aluminum construction with fixed horizontal bars at 15 Deg inclination and flanges on both sides. The thickness of fixed bar louvers shall be at least 5.5mm & angle shall be 20mm/30mm inside. The grilles shall be suitable for concealed fixing. Volume control damper of aluminum construction with black anodized finish shall be provided in SA duct collars.

LINEAR SLOT DIFFUSER.
Liner diffuser shall be powder coated extruded aluminum construction multi slot type with air pattern control provided in each slot. Supply air diffuser shall be provided with hit & miss damper in each slot of the supply air diffuser. Plenum shall be provided for each supply air diffuser and Spigot damper for insulated flexible ducts with accessories as required etc. shall be provided as part of diffuser and no separate payment shall be made for plenum and spigot damper.

The Material of Grilles shall be as follows:
All grilles shall be selected in consultation with the AAI/Architect. Different spaces shall require horizontal or vertical face bars, and different width of margin frames.

All grilles shall have a soft, continuous neoprene gasket between the periphery of the registers and the surface on which it has to be mounted. The effective area of the registers shall not be less than 85 percent.
Grilles shall be of adjustable pattern as each grille bar shall be pivotable to provide pattern with 0 to 90 Deg horizontal arc and up to 30 Deg deflection up or down. Bars shall hold deflection settings under all conditions of velocity and pressure. Extruded aluminum grilles shall have fixed bars.

Bars longer than 45cm shall be reinforced by set-back vertical members of approved thickness.

The material thickness of grills, diffuser, and damper shall be as follows:

<table>
<thead>
<tr>
<th>Grille Type</th>
<th>Material</th>
<th>Gauge</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diffuser</td>
<td>Aluminum</td>
<td>18</td>
</tr>
<tr>
<td>Louvers</td>
<td>18</td>
<td></td>
</tr>
<tr>
<td>Grills</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Frame</td>
<td>18</td>
<td></td>
</tr>
<tr>
<td>Louvers</td>
<td>24</td>
<td></td>
</tr>
<tr>
<td>Volume Control Damper</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Frame</td>
<td>18</td>
<td></td>
</tr>
<tr>
<td>Louver</td>
<td>24</td>
<td></td>
</tr>
</tbody>
</table>

JET DIFFUSER
Jet Diffuser shall be constructed of aluminum spinnings supported on a studding and spacer assembly. The core may be rotated through 180 Deg to expose either a straight or diffused core assembly. The Jet Diffusers shall have reversible and rotatable core design which allows the air jet to be adjusted for both pattern and deflection. Units may be mounted individually or in banks in bulkhead arrangements or directly into stub ducts. Jet Diffusers to handle high air volume which should be simple & effective air diffusion for large spaces. Jet Diffuser to have reversible core to product long throw jet or short throw diffuser patterns, jet may be deflected off axis by up to 15 deg. Core should project in steps for uniform air diffusion for larger space.

DRUM JET DIFFUSER
Drum Jet Diffuser shall be constructed of aluminum extrusions and should come complete with brush strips to provide a low friction, airtight seal. Standard installation is screw fixing through the face flange. Drum Jet diffuser should be high capacity unit specifically designed to handle high air volume where a long throw is required. The drum jet diffuser is fully adjustable to provide a full jet spread and directional control. The face of drum jet should have adjustable up to 30 Deg up & down to have better air diffusion & also the inner core should have guiding vanes which should be fully adjustable to better air distribution in the system.

FRESH AIR INTAKE AND EXTRACT LOUVRES:
All the louvers shall be rain protection type and shall be fabricated from extruded aluminum. The bottom louver shall be provided with extended lip to prevent rain water seepage inside duct/room. The louvers shall additionally be provided with heavy duty expanded metal (aluminum -alloy) bird screen from within.

TESTING & BALANCING:
After the installation of the entire air distribution system is completed in all respects, all ducts shall be tested for air leaks before painting the interiors of conditioned spaces air distribution system shall be allowed to run continuously for 2 hours for driving away any dust & foreign material logged within ducts during installation.
15.11 Sound Attenuators

Attenuators shall be installed in ducts in accordance with requirements. Noise levels within conditioned spaces shall be not greater than those set out in schedule below:

**Noise Level Design Criteria**

<table>
<thead>
<tr>
<th>Space</th>
<th>MAXIMUM NOISE CONTROL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Public Areas</td>
<td>NC 40 – NC 45</td>
</tr>
<tr>
<td>Offices/ Administrative area, Public Toilets</td>
<td>NC 40</td>
</tr>
<tr>
<td>Restaurants</td>
<td>NC 35 - NC 45</td>
</tr>
<tr>
<td>Corridors/ Lobbies</td>
<td>NC 35 - NC 45</td>
</tr>
</tbody>
</table>

- Attenuators shall be of steel construction with casings out of minimum 22 G galvanized steel. Acoustic fill shall be inert, non-hygroscopic, vermin proof, fibre glass of required density adequately protected against corrosion and covered with 26 gauge perforated aluminium sheet. Attenuators shall be supplied complete with flanges.
- Acoustic performance of the attenuators (net insertion loss) shall meet or exceed the values listed below:

<table>
<thead>
<tr>
<th>OCTAVE BAND Centre FREQUENCY HZ</th>
<th>63</th>
<th>125</th>
<th>250</th>
<th>500</th>
<th>2K</th>
<th>4K</th>
<th>8K</th>
</tr>
</thead>
<tbody>
<tr>
<td>Insertion loss dB 900 mm long attenuators</td>
<td>2</td>
<td>7</td>
<td>12</td>
<td>19</td>
<td>23</td>
<td>18</td>
<td>11</td>
</tr>
<tr>
<td>Insertion loss dB 1500 mm long attenuators</td>
<td>6</td>
<td>10</td>
<td>18</td>
<td>30</td>
<td>34</td>
<td>23</td>
<td>14</td>
</tr>
</tbody>
</table>

- The pressure drop values of the silencers shall be indicated for each duty.
- Manufacturers shall submit a test certificate for acoustic and aerodynamic performance of the attenuators. Attenuators shall be tested in accordance with ACMA test methods/BS 4718 and insertion loss and self-generated noise for each octave band and pressure drop shall be stated in the schedule.

15.12 Noise Attenuators

Attenuators if required shall be of steel construction with casings out of minimum 22G galvanized steel. Acoustic fill shall be inert, non-hygroscopic, vermin proof, fiber glass of
required density adequately protected against corrosion and covered with 26 gauge perforated aluminium sheet. Calculation needs to be provided to justify the db level attained.

15.13 FIRE RATED DUCTWORK

Ducting for kitchen exhaust & fire evacuation shall be fire rated as per following specifications.

a. All fire rated ductwork constructed for mechanical or dual ventilation / smoke extract systems and kitchen exhaust shall be fabricated from Lock Forming Quality grade prime Galvanized Steel Sheet, constructed to enhanced SMACNA American/DW144 European standard to either low, medium or high velocity/ pressure.

b. Test requirement of fire rated ductwork should be tested to BS476: Part 24 [1987] and ISO 6944 providing required fire rating for Stability and Integrity.

c. Stability: the ability of a duct, ductwork & the support system to remain intact & fulfill their intended function for a specified period of time, when tested to the requirements of BS476: Part 24 and ISO 6944.

d. Integrity: the ability of a duct or ductwork to remain free of cracks, holes or openings outside the compartment in which the fire is present for a specified period of time, when tested to the requirements of BS476 Part 24 ISO 6944.

e. Insulation: the ability of a duct or ductwork to maintain its separating function without developing temperatures on its external surface outside the compartment in which the fire is present, which exceeds, (i) 140°C as an average value above ambient & or, (ii) 180°C as maximum value above ambient at any point, when tested for a specified period of time to the requirements of BS476: Part 24 ISO 6944.

f. It’s important that the fire rated ductwork has a smooth internal surface in order to minimize the pressure loss within the fire rated ductwork system thereby reduce the power requirements.

g. All fire rated ducts for Smoke Extract Duct shall have Stability / Integrity and Insulation for smoke temperatures up to 300°C upto 2.0 hrs. restriction of the duct due to twisting or buckling after the fire test shall not cause 25% or more reduction in cross sectional area proven by certification from an independent test house.

h. Each duct shall have fire rated coating. Fire rated coating compound used for construction of fire rated ductwork shall be protected with minimum 0.7mm to 1mm nominal thickness tested to properties as per the requirements of BS 476: 6 & 7, including non-combustibility Class O and fire propagation - Class 1 surface spread of flame & materials in accordance with Building Regulations.

i. Fire duct to be tested / assessed to BS 476: Part 24 for all sizes up to 25 meters x 3 meters cross-sectional area and fully certified to vertical and horizontal plane.

j. Fire rated duct fabricated to Method 3 of BS 5588: Part 9, factory produced. The coating compound shall be applied either offsite or onsite on the ground, dried and
cured.

k. Fire duct expansion under fire conditions shall not exceed following.

- at 430°C an expansion of 0.006106mm per mm
- at 600°C an expansion of 0.00852mm per mm
- at 1100°C an expansion of 0.01562mm per mm.

15.14 BRAIDED (WIRE) ROPE SUPPORT

Braided (Wire) Hangers shall be used to suspend static mechanical, electrical and HVAC services.
Braided (Wire) Rope Hangers shall consist of a pre-formed wire rope sling with either a ferruled loop, permanently fixed threaded M8 stud, or permanently fixed nipple end with toggle, at one end or hook or eyelet or any other end fixture type or size as per manufacturers recommendation. The end fixings and the wire must be of the same manufacturer. The system is secured and tensioned with a wire rope Hanger self-locking grip at the other end.

Only wire and/or supports supplied and/or approved, shall be used with the system.

a. Braided (Wire) Rope Hangers have been independently tested by Lloyds Register, APAVE, TUV, UL, CSA and SMACNA, approved by ULC and CSA and comply with the requirements of DW/144 and BSRIA – wire Rope Suspension systems. Wire rope is manufactured to BSEN 12385: 2002.

b. The contractor shall select the correct specification of wire Hanger to use for supporting each particular service from table 1 below. Each size is designated with a maximum safe working load limit.

The correct specification of Braided (Wire) Rope Hanger required is determined using the following formula.

Weight per meter of object suspended (kg) X distance between suspension points (m) = weight loading per Braided (Wire) Rope Hanger suspension point (kg).

The contractor shall select the correct length of Braided (Wire) Rope required to support the service. Lengths from 1-10m lengths. No in-line joints should be made in the rope.

16 Insulation

16.1 SCOPE

The scope of this section comprises the supply and application of insulation conforming to these specifications. The insulation material shall be Closed Cell Elastomeric Nitrile Rubber Foam Insulation.

16.2 MATERIAL

Thermal insulation material for Duct & Pipe insulation shall be Closed Cell Nitrile Rubber insulation. Thermal conductivity as per DIN EN 12667 / EN ISO8497 of the insulation material shall not exceed 0.038 W/mK or 0.212 BTU / (Hr-ft2-oF/inch) at an average temperature of 30°C. Density of the nitrile rubber shall be 40-60 Kg/m3. The product shall have temperature range of -40°C to +105°C as per EN 14706, EN 14707 and EN 14304. The insulation material shall be fire rated for Class 0 as per BS 476 Part 6: 1989 for fire propagation test and for Class 1 as per BS 476 Part 7, 1987 for surface spread of flame test. The material also pass UL 94 Test for Vertical Burning and Horizontal Burning and
FM Approved. Water vapour permeability shall be not less than 0.024 per inch (2.48 x 10^-13 Kg/m.s.Pa i.e. µ<7000: Water vapour diffusion resistance) as per EN 12086 & EN13469.

For Non-Exposed Ducts, the Nitrile Rubber insulation shall be with factory laminated embossed aluminium foil of minimum 60 micron thickness having weight of 193 gsm as per EN ISO 2286-2.

For Exposed Ducts the Nitrile Rubber insulation shall be with factory laminated with 3-layered non-metallic composite cladding of minimum 230 micron thickness of metallic appearance with aluminium as an intermediate layer and tested for UV resistance as per EN ISO 4892-2 Method A.

For Chilled Water / Hot Water piping insulation, nitrile rubber insulation shall be additionally cladded with a 3-layered non-metallic composite cladding of minimum 350 micron thickness having total weight of ≥ 500g/m2, of metallic appearance with aluminum as an intermediate layer and tested for UV resistance as per EN ISO 4892-2 Method A. The Class shall be tested for Class 0 Fire performance as per BS 476 Part 7 & 6 having a flammability index ≤ 5 as per AS1530.2. The cladding material is to be applied with 30 – 50mm overlap to be fixed with plastic rivets and finished with a silver self-adhesive tape. All bends, T-Sections and end caps shall be cladded with thermoformed fittings for pipes of up to 80mm dia.

For Condensate Drain Piping, the insulation material shall be factory laminated with chemically treated glass cloth of 7mill /0.18mm thickness and tested for UV Resistance as per EN ISO 4892-2 Method A.

The Material shall comply to BS 6853 for smoke toxicity values. The material shall comply to CFC / HCFC free material as per US EPA 5021A-2003. The material shall be Lead, mercury and asbestos free and should have zero Global Warming Potential and Ozone depleting Potential. Thermal conductivity of insulation material shall not be effected by aging as per DIN 52616 standard.

Insulation shall be in tube form for pipe nb dia upto 80mm and above 80mm sheets shall be used for piping.

Thickness of the insulation shall be as specified for the individual application. Each lot of insulation material delivered at site shall be accompanied with manufacturer’s test certificate for density and thickness. Samples of insulation material from each lot delivered at site may be selected by Owner’s site representative and gotten tested for thermal conductivity and density at Contractor’s cost. Adhesive used for sealing the insulation shall be rubber based contact adhesive in a blend of solvents free from benzene, non-flammable and with low VOC content (maximum 850 gm/l as per IGBC guide lines) strictly as per manufacturer’s recommendations.

Ducting insulation thickness shall be as per table below.

<table>
<thead>
<tr>
<th>Ducting position</th>
<th>Thickness</th>
</tr>
</thead>
<tbody>
<tr>
<td>SA duct in RA path</td>
<td>13 mm</td>
</tr>
<tr>
<td>Ducted return air system</td>
<td>SA duct:</td>
</tr>
<tr>
<td></td>
<td>19 mm</td>
</tr>
<tr>
<td></td>
<td>RA duct:</td>
</tr>
<tr>
<td></td>
<td>13 mm</td>
</tr>
<tr>
<td>Both SA &amp; RA exposed</td>
<td>Both 25 mm</td>
</tr>
</tbody>
</table>
16.3 DUCT INSULATION

External thermal insulation shall be provided as follows:

The thickness of insulation material shall be as per design/manufacturer standard. Following procedure shall be adhered to:

Duct surfaces shall be cleaned to remove all grease, oil, dirt, etc. prior to carrying out insulation work. Measurement of surface dimensions shall be taken properly to cut closed cell insulation to size with sufficient allowance in dimension. Cutting of insulation sheets shall be done with adjustable blade to make 90° cut in thickness of sheet. Hacksaw or blades are not acceptable tools for cutting the insulation.

Material shall be fitted under compression and no stretching of material shall be permitted. All longitudinal and transverse joints shall be sealed by providing 50 mm wide Self Adhesive aluminum tapes / silver tapes as per the insulation material finish as per manufacturer recommendations. The insulation installers shall be certified by manufacturer.

Direct contact between Duct and hanger shall be avoided. Hangers shall pass outside the Duct Support. Insulation Manufacturer shall supply duct supports having PET foam as load taking member embedded in flexible elastomeric foam nitrile rubber sheet with outer metal face having aluminium metal) so that the insulation material is joint with insulation material on both side of pipe support for Nitrile and the weight of pipe is transferred to the PET saddle.

16.4 PIPING INSULATION

All chilled water, refrigerant, and condensate drain piping shall be insulated in the manner specified herein. Before applying insulation, all pipe shall be brushed and cleaned. All MS pipes shall be provided with a coat of zinc chromate primer. Thermal insulation shall be applied as follows or as specified.

Chilled Water Piping Insulation thickness shall be as follows; For Insulation on Piping outside the Plant Room:

<table>
<thead>
<tr>
<th>Pipe nominal bore</th>
<th>Thickness</th>
</tr>
</thead>
<tbody>
<tr>
<td>Upto 80 mm NB Dia</td>
<td>25 mm</td>
</tr>
<tr>
<td>Above 80 mm NB Dia</td>
<td>32 mm</td>
</tr>
</tbody>
</table>

For Insulation on Piping inside the Plant Room:

<table>
<thead>
<tr>
<th>Pipe nominal bore</th>
<th>Thickness</th>
</tr>
</thead>
<tbody>
<tr>
<td>Upto 25 mm NB Dia</td>
<td>32 m</td>
</tr>
<tr>
<td>Above 25 mm upto 50 mm NB Dia</td>
<td>38 m</td>
</tr>
<tr>
<td>Above 50 mm upto 125 mm NB Dia</td>
<td>44 m</td>
</tr>
<tr>
<td>Above 125 mm NB Dia</td>
<td>50 m</td>
</tr>
</tbody>
</table>
Condensate Drain Piping Insulation thickness shall be as follows:

<table>
<thead>
<tr>
<th>Pipe nominal bore</th>
<th>Thickness</th>
</tr>
</thead>
<tbody>
<tr>
<td>Condensate drain piping upto 50mmNB Dia Pipes</td>
<td>9 mm</td>
</tr>
<tr>
<td>Condensate drain piping above 50mm NB Dia Pipes</td>
<td>13 mm</td>
</tr>
</tbody>
</table>

Insulating material in tube form (minimum upto 80 dia pipes) shall be sleeved on the pipes. On piping, slit opened tube from insulating material shall be placed over the pipe and adhesive shall be applied as suggested by the manufacturer. Adhesive must be allowed to tack dry and then press surface firmly together starting from butt end and working towards center. Wherever flat sheets shall be used it shall be with self-adhesive and cut out in correct dimension using correct tools. Scissors or Hacksaw-blade shall not be allowed. All longitudinal and transverse joints shall be sealed by providing 50 mm wide self adhesive silver tapes as per manufacturer recommendations. The adhesive shall be strictly as recommended by the manufacturer. The insulation shall be continuous over the entire run of piping, fittings and valves. All valves, fittings, joints, strainers etc. in chilled water piping shall be insulated to the same thickness as specified for the main run of piping and application shall be same as above. Valves bonnet, yokes and spindles shall be insulated in such a manner as not to cause damage to insulation when the valve is used or serviced. Direct contact between pipe and hanger shall be avoided. Hangers shall pass outside the saddle. Insulation Manufacturer shall supply PUF saddles with pre-laminated insulation sheet of both side (PUF saddle sandwich between nitrile insulation material on both side with outer metal shell made of aluminium) so that the insulation material is joint with insulation material on both side of pipe support for Nitrile and the weight of pipe is transferred to the PUF saddle in the center.

The non-metallic cladding material is to be applied with 30 – 50mm overlap to be fixed with plastic rivets and finished with a silver self-adhesive tape. All bends, T-Sections and end caps shall be clad with thermoformed fittings for pipes of upto 80mm dia. For higher dia pipes, the cladding sheet is to be cut in required shape and applied on insulation material. Manufacturer’s installation manual shall be submitted and followed for full compliance. All insulation work shall be carried out by skilled workmen specially trained and certified by manufacturer in this kind of work. All insulated pipes shall be labeled (S.R. or R.R.) and provided with 300 mm wide band of paint along circumference at every 1200 mm for colour coding. Direction of fluid shall also be marked. Un-insulated MS pipes shall be painted throughout and direction of fluid marked. All painting shall be as per relevant BIS codes.

16.5 DUCT/AHU ROOM ACOUSTIC LINING

Duct Acoustic Lining - Open Cell Nitrile Rubber

Duct acoustic lining material shall be Nitrile Rubber open cell foam. Thermal conductivity of the insulation material shall not exceed 0.047 W/moK at an average temperature of 20°C. Density of the nitrile rubber shall be 140 – 180 Kg/m3. The material should withstand maximum surface temperature of +85°C and minimum surface temperature of -20°C. The material should conform to Class 1 rating for surface spread of Flame in accordance to BS 476 Part 7 & HBF, HF 1 & HF 2 in accordance to UL 94, 1996. Insulation should have antimicrobial product protection, and should pass Fungi Resistance as per DIN EN ISO 846 Method A for fungal resistance and Method C for bacteria resistance.
The insulation should pass Air Erosion Resistance Test in accordance to ASTM Standard C 1071-05 (section 12.7). Thickness of the material shall be 12 mm thick specified for the individual application and with noise absorption proprieties (NRC ≥ 0.55 for 15mm Thick) as per IS: 8225 / ISO 354 / ASTM423C. The insulation should be installed as per manufacturer’s recommendation.

**Acoustic Lining of Mechanical Rooms-Open Cell Nitrile Rubber**

Air handling unit rooms shall be provided with acoustic lining. Material shall be processed from Nitrile rubber open cell foam. The material should be fiber free. The density of the same shall be 140-180 Kg/m³. The material should have thermal conductivity not exceeding 0.047 W/Mk at an average temperature of 20° C. The maximum surface temperature of material shall withstand is 85° C and minimum temp shall be -20° C. Thickness shall be as specified. The material should conform to class 1 rating for surface spread of flame as per BS 476 Part 7 & HBF, HF 1 & FH 2 in accordance with UL 94, 1996. Thickness, if not specified, shall be considered as 20mm specified for the individual application and with noise absorption proprieties (NRC ≥ 0.60) as per IS: 8225 / ISO 354 / ASTM423C.

Insulation should have antimicrobial product protection, and should pass Fungi Resistance as per DIN EN ISO 846 Method A for fungal resistance and Method C for bacteria resistance. The insulation should pass Air Erosion Resistance Test in accordance to ASTM Standard C 1071-05 (section 12.7).

Surface shall be cleaned and two coats of adhesive recommended by the manufacturer should be applied on the walls. The foam sheets should be cut to required size and a layer of adhesive should also be applied to it. When it is tack dry it is stuck to the walls / ceiling. All longitudinal and transfer joint shall be covered with 22 gauge 50 mm wide GI strip with screws. Acoustic lining of walls shall be terminated approximately 15 cm above the finished floor to prevent damage to insulation due to accidental water-logging in plant/AHU rooms.

**16.6 PUMP INSULATION**

Chilled water pump shall be insulated to the same thickness as the pipe to which they are connected and application shall be same as above. Care shall be taken to apply insulation in a manner as to allow the dismantling of pumps without damaging the insulation.

**16.7 SHELL INSULATION**

The chiller shells shall be factory insulated in accordance with the manufacturer’s standards.

**16.8 COLD WATER AND EXPANSION TANK INSULATION**

Cold water tank, and chilled water expansion tank shall be insulated as per manufacturer’s standard.

**16.9 Sound Attenuators**

Attenuators shall be installed in ducts in accordance with requirements. Noise levels within conditioned spaces shall be not greater than those set out in schedule below:
a. Noise Level Design Criteria

<table>
<thead>
<tr>
<th>Space</th>
<th>MAXIMUM NOISE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Public Areas</td>
<td>NC 40 – NC 45</td>
</tr>
<tr>
<td>Offices/ Administrative area,</td>
<td>NC 40</td>
</tr>
<tr>
<td>Public Toilets</td>
<td>NC 40</td>
</tr>
<tr>
<td>Restaurants</td>
<td>NC 35 - NC 45</td>
</tr>
<tr>
<td>Corridors/ Lobbies</td>
<td>NC 35 - NC 45</td>
</tr>
</tbody>
</table>

b. Attenuators shall be of steel construction with casings out of minimum 22 G galvanized steel. Acoustic fill shall be inert, non-hygrosopic, vermin proof, fiber glass of required density adequately protected against corrosion and covered with 26 gauge perforated aluminium sheet. Attenuators shall be supplied complete with flanges.

c. Acoustic performance of the attenuators (net insertion loss) shall meet or exceed the values listed below:

<table>
<thead>
<tr>
<th>OCTAVEBAN DCENTRE FREQUENCY HZ</th>
<th>63</th>
<th>125</th>
<th>250</th>
<th>500</th>
<th>1K</th>
<th>2K</th>
<th>4K</th>
<th>8K</th>
</tr>
</thead>
<tbody>
<tr>
<td>Insertion loss dB 900 mm long attenuators</td>
<td>2</td>
<td>7</td>
<td>12</td>
<td>19</td>
<td>23</td>
<td>23</td>
<td>18</td>
<td>11</td>
</tr>
<tr>
<td>Insertion loss dB 1500 mm long attenuators</td>
<td>6</td>
<td>10</td>
<td>18</td>
<td>30</td>
<td>42</td>
<td>34</td>
<td>23</td>
<td>14</td>
</tr>
</tbody>
</table>

d. The pressure drop values of the silencers shall be indicated for each duty.
e. Manufacturers shall submit a test certificate for acoustic and aerodynamic performance of the attenuators. Attenuators shall be tested in accordance with ACMA test methods/BS 4718 and insertion loss and self-generated noise for each octave band and pressure drop shall be stated in the schedule.

17 **VRF SYSTEM**

17.1 **GENERAL DESCRIPTION**

This scope under general conditions together with the tender drawings, covers the manufacture, assembly, testing, packing, transport, loading and unloading, handling of equipment at site, erection, testing and commissioning into service, carrying out all the acceptance tests and handing over the VRV/VRF HVAC system for control tower and
sectionalized areas as per requirement. All works shall be done in co-ordination with other service works and according to site conditions. VRF system shall be suitable for both heating and cooling application.

All Variable Refrigerant Flow Air Conditioners shall be fully Factory assembled, wired, piped and tested. The System shall comprise of Air Cooled Outdoor Units, and a multiple type and capacity Indoor units connected by common Refrigerant Piping with necessary Y joints as required, Central Master Controller, necessary Power and Control Cabling. The VRF system should essentially consist of the following:

The VRF System shall provide trouble free operations, and provide flexibility in operation of Indoor Units in conjunction with the outdoor units so that areas/zones can be operated independently and the outdoor unit works at optimum efficiency at the partial operation. It shall be possible to switch on any of the Indoor Units that require Cooling. The capacity of Indoor and Outdoor Units shall be matched, using a DC inverter based system. The System shall be capable of automatic operation even with varying Outdoor and Indoor requirements and make use of low Outdoor Temperatures to achieve lower Power Consumption. All Systems shall be modular in nature, and easily up gradable / inter connectable for larger capacities. Units shall have hermetically sealed Scroll/Rotary compressors to ensure high EER. Modular System shall incorporate all required controls for parallel operation of Compressors, Condensers, Fans, and Indoor Units as well as Refrigerant liquid control. All Systems shall be designed for proper oil return to Compressor System, along with the distribution of oil to individual Compressors.

17.2 STANDARDS & CODES

The design, manufacture and performance of equipment shall comply with all currently applicable statutory regulations and safety codes in the locality where the equipment will be installed. The equipment shall also conform to the requirement of the latest editions of applicable IS Standards. Entire VRF system shall comply with the relevant ASHRAE 90.1 energy efficiency standards. The contractor shall refer the relevant sections of this specification for equipment standards and codes. Nothing in this specification shall be construed to relieve the contractor of his responsibility.

Minimum efficiency requirements for Variable-Refrigerant Flow Air Conditioners shall be as per following table:

<table>
<thead>
<tr>
<th>Equipment Type</th>
<th>Size Category</th>
<th>Minimum Efficiency</th>
</tr>
</thead>
<tbody>
<tr>
<td>VRF air conditioners, Air cooled</td>
<td>&lt; 65,000 Btu/h</td>
<td>13.0 SEER</td>
</tr>
<tr>
<td></td>
<td>≥ 65,000 Btu/h and &lt;135,000 Btu/h</td>
<td>11.2 EER 13.1 IEER</td>
</tr>
<tr>
<td></td>
<td>≥ 135,000 Btu/h and &lt; 240,000 Btu/h</td>
<td>11.0 EER 12.9 IEER</td>
</tr>
<tr>
<td></td>
<td>≥ 240,000 Btu/h</td>
<td>10.0 EER 11.6 IEER</td>
</tr>
</tbody>
</table>
The minimum efficiency requirements of VRF system shall be as per the table or as per ARI 550/590 latest edition whichever is of higher energy performance.

17.3 SYSTEM DESCRIPTION
The variable Refrigerant Flow (VRF) System should be air cooled, similar to split type air conditioning system consisting of singular condensing unit connected to multiple indoor units, each having the capability of individual set point control & the Condensing unit should incorporate multiple scroll/rotary/screw/inverter compressors to obtain approx. 10% to 100% capacity control. The indoor units should be provided with Cordless Remote Control as a standard accessory. Suitable starter panel, power & control cabling to cater the functional and operational requirement of multiple ODU combination shall be under the scope of Contractor.

The VRF system shall have Micro Processor. The entire VRF system shall be possible to control from a single PC with the suitable software to control & monitor the following features:

a. Temperature of air in the room / area served by any indoor unit.
b. Indication of number of indoor units and outdoor units working.
c. On / off of individual indoor units.
d. It shall be possible to change the setting of temperature of indoor units.
e. To start / stop any indoor unit at preset times and it shall be possible to change the time settings.
f. The microprocessor / PC software shall be compatible with the BMS for auto operation / control.

17.4 AMBIENT CONDITIONS
To be capable of operating within a wide range of ambient temperatures. The Condensing units should be capable to provide cooling within an ambient range of (-5 Deg. C to 45 Deg. C DB). The regulation in Refrigerant flow is to be achieved by Scroll/rotary inverter Compressors head pressure control (by varying fan speeds) & hot gas bypass connection etc.

17.5 REFRIGERANT
The Entire Condensing unit and Evaporating unit should be factory assembled and tested. The units should come with an initial charge of refrigerant R410a/R407c or equivalent of CFC free from the factory. Any additional required refrigerant shall be added at site free of cost and loss of refrigerant due to defect of equipment or workmanship shall also be filled up free of cost even during the guarantee period.

17.6 REFRIGERANT PIPING DISTANCE LIMITS
To be capable of refrigerant piping runs up to 150m between the condensing unit and indoor units with 50m level difference without any oil traps or double risers. The oil Equalizing line should be inside the Condensing unit, to avoid 'inverted' oil traps at site. The level difference between indoor units connected to the same refrigerant circuit can be extended to 15m.

17.7 REFRIGERANT PIPEWORK
The scope of Refrigerant Piping work shall include Design, Supply, installation, testing and commissioning all interconnecting pipe work between the condensing unit & indoor units. Use refrigerant quality seamless copper tubes with brazed connections and the appropriate Distribution joints and headers. The piping should be routed at site in such
a manner, that brazed joints in the Refrigeration Piping are kept to a minimum. Refrigerant pipe works shall comply with the relevant ASHRAE 15 standards. All the refrigerant pipes are to be tested for its conformation to relevant IS.

17.8 JOINT ORIENTATION
Install the proprietary Distribution refrigeration pipe joints and headers in an appropriate orientation to enable correct distribution of refrigerant. The Distribution joints shall be factory insulated with pre-formed sections of expanded Polystyrene / equivalent.

17.9 CLEANLINESS OF PIPING
All pipe work must be kept clean and free from contamination to prevent breakdown of the system. Seal all pipe ends and keep sealed until immediately prior to making a joint.

17.10 PRESSURE TESTING
After complete installation of refrigerant, pipe work shall be pre-pressure tested and repaired if necessary and further pressure tested to hold 1.5 times of working pressure for a minimum 24 hours with dry nitrogen prior to insulating the joints. After satisfactory testing, the refrigerant pipe shall be evacuated and dehydrated to (- 755 MM HG) and hold for twelve hours depending on the pipe length.

17.11 ADDITIONAL CHARGE
Additional refrigerant charge weight must be calculated based on the actual length of the refrigerant pipe work. The refrigerant charging process must be carried out with an appropriate charging station and under supervision of Engineer-in-charge.

17.12 PIPING
Piping shall be refrigerant grade hard copper piping as required. Pipe joining shall be done using special fittings. Refrigerant joints supplied by VRV/VRF manufacturer shall be provided where required. Piping jointing shall be of the brazed type. The piping shall be tested at 30kg/cm².

The indoor and outdoor units shall be connected with refrigerant piping. All piping connections for the units should be performed inside the unit. The refrigerant piping should be insulated with antimicrobial properties nitrile rubber insulation of suitable thick round closed cell elastomeric insulation finished. Brazing shall be carried out to the requirements of relevant code of practice using silver soldered brazing rods. Compression fittings will not be accepted on refrigerant pipe work. After insulation of the complete piping the same shall be tested with nitrogen at 450 psi pressure. After successful pressure testing of the pipe work the same shall be vacuumed and vacuum shall be maintained for 12 hours, vacuum shall be achieved using a vacuum pump. The vacuum shall be broken by refrigerant. This exercise shall be carried out twice before the AAI or Authorized representative, before charging the refrigerant in the circuit. All connections of refrigerant piping shall be in high grade copper of refrigeration quality.

17.13 FIXING PIPE WORK
Fix and support pipe work at a minimum of 2.5 meter centers on suitable GI cable tray/saddling arrangement as per AAI or Authorized representative requirement. Cover the exposed Refrigerant pipes on the terrace with openable GI Cable trays / walk able platform.
17.14 INDOOR UNITS
This section deals with supply, erection, testing and commissioning of Various Type of Indoor Units confirming to general specification and suitable for the duty selected. Each indoor unit shall have the capability to cool or heat independently as per the requirements of the zone. The type, capacity and size of indoor units shall be as per requirements.

17.15 GENERAL
Indoor units shall have electronic control valve to control refrigerant flow rate respond to load variations of the room.

a. The address of the indoor unit shall be set automatically in case of individual and group control

b. In case of centralized control, it shall be set by liquid crystal remote controller. The fan shall be dual suction, aerodynamically designed turbo, multi blade type, statically & dynamically balanced to ensure low noise and vibration free operation of the system. The fan shall be direct driven type, mounted directly on motor shaft having supported from housing.

c. The cooling coil shall be made out of seamless copper tubes and have continuous aluminum fins. The fins shall be spaced by collars forming an integral part. The tubes shall be staggered in the direction of airflow. The tubes shall be hydraulically/mechanically expanded for minimum thermal contact resistance with fins. Each coils shall be factory tested at 21kg/sq.m air pressure under water.

d. Unit shall have cleanable type filter fixed to an integrally moulded plastic frame. The filter shall be slide away type and neatly inserted.

e. Each indoor unit shall have computerized PID control for maintaining design room temperature. Each unit shall be provided with microprocessor thermostat for cooling or cooling and heating.

f. Each unit shall be with wired LCD type remote controller. The remote controller shall memorize the latest malfunction code for easy maintenance. The controller shall have self-diagnostic features for easy and quick maintenance and service. The controller shall be able to change fan speed and angle of swing flap individually as per requirement.

17.16 Specifications of Indoor units
17.16.1 Cassette type indoor units

a) These units shall be installed between the bottom of finished slab & top of false ceiling.

b) Unit shall have provision of connecting fresh air without any special chamber & without increasing the total height of the unit (320 mm maximum).

c) The unit must have in built drain pump, suitable for vertical lift of 750 mm

d) Unit must be insulated with sound absorbing thermal insulation material, Polyurethane foam. The sound pressure level of unit at the highest operating level shall not exceed 46 dB (A).

e) The unit must have drain pump kit. The drain pump must be suitable to lift drain 700 mm (Min.) from the bottom of the unit.

17.16.2 Concealed duct type units

f) These units shall be ceiling suspended with suitable supports to take care of operating weight of the unit, without causing any excessive vibration & noise.

g) The cold air supplied by these units will be supplied to the area to be air conditioned, through duct system specified in the tender.
h) Each indoor unit must have electronic expansion valve operated by microprocessor thermostat based temperature control to deliver cooling/heating as per the heat load of the room.

i) The Sound Pressure level of unit at the highest operating level shall not exceed 50 dB (A), at a vertical distance of 1.5 m below the units with duct connected to the unit.

j) The unit must have provision of adding drain pump kit if required & specified. The drain pump must be suitable to lift drain to 700 mm (Min.) from the bottom of the unit.

17.16.3 Wall Mounted Units
(a) Wall mounted units must be compact & stylish design that does not detract from the décor of the room.
(b) Each indoor unit must have electronic expansion valve operated by microprocessor thermostat based temperature control to deliver cooling/heating as per the heat load of the room.
(c) The unit must have provision of adding drain pump kit if required & specified. The drain pump must be suitable to lift drain to 700 mm (Min.) from the bottom of the unit.
(d) The sound pressure level of unit at the highest operating level shall not exceed 46 dB(A).
(e) Refrigerant control in the indoor unit shall be through Electronic Expansion Valve.

17.16.4 TFA Units
Fresh air Treatments Unit shall be suitable for VRV/VRF type of Unit. Fresh air unit to be connected to the VRV/VRF condensing unit & it shall be heat pump type to provide cooling in summer & heating in winter. This unit shall be capable of handling outside air temperature 4 degree to 46 degree. The unit shall include pre-filter, fan section & DX-coil section. The housing of unit shall be light weight powder coated galvanized steel.

17.17 REFRIGERANT COIL
The Refrigerant Coil shall be made of aluminum fins and copper tubes of dia.12.5mm or 16mm OD. The minimum no. of fins / cm for cooling coils shall be 4.72. The bonding of aluminum fins with copper should be done hydraulically. The tube thickness shall be as per manufacturer standard the cooling coil should be tested for leaks at a hydraulic pressure of at least 10 Kg / sq.cm. For a minimum period of 3 hours at works. The velocity across face should be limited to 152 metre / minute. In case of chilled water coils the design should be such to limit water velocity to maximum of 2.5 m / sec.

17.18 FILTERS
Each unit shall be provided with a factory assembled filter section containing washable synthetic type air filters having extruded aluminum frame having filtration capacity of 10 micron particle size with an efficiency of 90% efficiency. Filters shall fit so as to prevent by pass. Holding frames shall be provided for installing a number of filters cells in banks. These cells shall be held within the frames by sliding the cells between guiding channels. Face velocity across filters shall not exceed 152 MPM.

17.19 ELECTRONIC EXPANSION VALVE
Each indoor unit shall be fitted with an electronic expansion valve which controls the refrigerant flow in response to the load variations in the room. The electronic expansion valve is to be controlled via a computerized control sensing the return air temperature,
refrigerant inlet and outlet temperatures. During the cooling operation the electronic expansion valve controls the refrigerant superheat degree at the evaporator.

17.20 INDOOR UNIT FANS
Direct driven multi-blade type blower statically and dynamically balanced to ensure low noise and vibration free operation. The fan shall be mounted directly on motor shaft having supported from housing. The fan shall be direct driven type. The noise level shall not exceed 50 dBA.

17.21 COOLING COILS
To be direct expansion constructed from copper tubes expanded into Aluminium fins to form a rigid mechanical bond. The tubes shall be staggered in the direction of airflow. The fins shall be uniformly bonded to the tubes by mechanical expansion of the tubes. The coils shall be tested against leaks.

17.22 SUPPLY AIR DISCHARGE LOUVERS
The indoor units shall be provided with auto swing of the supply air louvers for cassette type indoor units. The louvers should be capable of providing continuous swing operation or to be fixed in any direction required.

17.23 UNIT CONTROL BOARD
It shall include in the indoor unit a printed circuit board complete with, address switches for a variety of operation controls, emergency operation switch and fault / operation indication LED's. The fan motors shall be thermally protected.

17.24 UNIT CASING
The indoor unit casing (ceiling mounted units) to be fully insulated and sealed to prevent condensation.

17.25 CONDENSATE DRAIN
The Drain connection of each indoor unit to the main Header should be of Min.25mm dia. The header pipe should be of 32mm dia. The drain pipe should be of CPVC, whereas the connection of the indoor unit to the CPVC pipe shall be with flexible braided pipe. The drain piping should be insulated with 9 mm thick tubular Nitrile Rubber Elastomeric insulation supported on suitable size GI cable tray and the cassette type units shall be provided with condensate drain water pump, it should lift the water to the drain headers automatically trap shall be considered as part of drain piping.

17.26 UNIT CONTROL
In case of individual and group control, set the addresses of each indoor unit to minimize commissioning time. In case of centralized control, set the addresses by the remote controller.

17.27 CONDENSING UNITS
To be fully weatherproofed, factory assembled and pre-wired with all necessary electronic and refrigerant controls. Construct the casing from mild steel panels coated with a baked enamel finish and powder coatings. The condenser coil fins shall be provided with a corrosion resistant finish. Each modular inverter outdoor shall be with DC driven compressor.

   a) The outdoor unit shall have inverter compressors and if one inverter compressor
malfunctions, other continues to provide emergency operation smoothly till repair is affected.

b) It should also be provided with duty cycling for multiple inverter compressor switching starting sequence for better stability and prolonging equipment life.

c) The unit shall be provided with its own microprocessor control panel.

d) The outdoor units should have anti-corrosive base plate for easy mounting of unit.

e) The machine must have a sub cool feature to use coil surface more effectively through proper circuit/bridge so that it prevents the flushing of refrigerant from long piping due to this effect thereby achieving energy savings.

f) In case the supplier propose to supply multiple modular outdoor unit each modular unit shall have inverter compressor. It is also required that failure of a particular compressor/unit shall not affect the function of the entire system.

The condensing unit shall be designed to operate safely when connected to multiple indoor units.

17.28 MODULAR DESIGN

Allow for side by side installation by the modular design of the condensing units.

17.29 FAN MOTOR SPEED CONTROL

The outdoor unit should be fitted with low noise, aero spiral design fan with aero fitting grille for spiral discharge airflow to reduce pressure loss and should be fitted with DC fan motor inverter type for better efficiency. The condensing unit fan motors to have at least two speed operations to maintain constant head pressure control in all ambient temperatures and modes of operation.

17.30 COMPRESSORS

The compressor shall be highly efficient Rotary/Scroll type and capable of inverter control. The scroll/rotary inverter type compressors shall be with electronic controls, capable of loading and unloading to follow the variations on cooling loads, using the latest axial compliant sealing technology. The microprocessor panel should incorporate control for precise monitoring of status of the system. The electromagnetic interference & conversion losses shall be minimized. It shall change the speed in accordance to the variation in cooling or heating load requirement.

17.31 REFRIGERANT CIRCUIT

The refrigeration circuit shall be completed for the condensing units with refrigeration compressors, motors, fans, condenser coils, electronic expansion valve, solenoid valves, 4 way refrigerant valve, distribution headers, capillaries, filters, shut down valves, service ports, receivers and accumulators and all other components which are essential for safe and satisfactory operation.

17.32 SAFETY DEVICES

Provide the following safety devices as a part of the outdoor unit. High pressure switch, fuses, crank case heater, fusible plug, over current protector.

17.33 OIL RECOVERY

Equip the unit with an oil recovery system to ensure stable operation for systems with long refrigerant piping.

17.34 CONTROL
Use computerized control to maintain a correct form of temperature. For the indoor units incorporate an on/off switch, fan speed selector, thermostat setting and liquid crystal display which indicates temperature setting. Operational mode, malfunction codes etc.

17.35 INDOOR UNIT CONTROL
Accomplish by the use of individual controllers for each indoor unit.

17.36 FAULT DIAGNOSIS
The system shall be equipped with a diagnostic function for quick and easy maintenance and service.

17.37 NOISE LEVEL
The contractor shall ensure that systems provided shall not cause or exceed following noise levels:
(a) 1 m away from outdoor units - 70 dBA
(b) 1 m away from indoor units - 50 dBA
Contractor should clearly state any special treatment if necessary to achieve above noise levels.

17.38 VIBRATION LEVELS
The contractor shall ensure that systems shall not cause or exceed the vibration levels and they shall be within limits as per standards.

17.39 Y JOINTS
All the refrigerant joints shall be proprietary in nature from the main VRV/VRF supplier. It should have one inlet and two outlet connections, both for suction and liquid line of respective size of the refrigerant piping along with its insulation. The refrigerant joint should be designed and supplied by the supplier of VRV/VRF indoor and outdoor unit manufacturer.

17.40 CENTRAL CONTROLLER
Following functions shall be possible;
(a) Control all the indoor units and outdoor units
(b) Zone control
(c) Malfunction code display
(d) All the functions available with wired remote controller
(e) It should be possible to wire the remote to 1000 m
Centralized intelligent Touch Controller (Master Central Controller)

A multifunctional compact centralized controller shall be provided with the system.

The Graphic Controller must act as an advanced air-conditioning management system to give complete control of VRV air-conditioning Equipment, it should have ease of use for the user through its touch screen, icon display and colour LCD display. It shall be able to control indoor units with the following functions:-
(a) Starting/stopping of Air-conditioners as a zone or group or individual unit
(b) Temperature setting for each indoor unit or zone.
(c) Switching between temperature controls modes, switching of fan speed and direction of airflow, enabling/disabling of individual remote controller operation.
(d) Monitoring of operation status such as operation mode and temperature setting of individual indoor units, maintenance information and troubleshooting information.
e) Display of air-conditioning operation history.

f) Daily management automation through yearly schedule function with possibility of various schedules.

The controller shall have wide screen user friendly colour LCD display and can be wired by a non-polar 2 wire transmission cable to distance of 1 km. away from indoor unit.

NOTE: System shall be compatible with BACNET/MODBUS protocol for BMS interfacing and shall be provided with necessary converter/ integrator as required as part of VRF system.

18 DX UNITS

18.1 AIR COOLED SPLIT AC/ CASSETTE UNIT Hi-wall split indoor unit

Indoor unit shall remove moisture at least 1.5 liters/hour. The unit shall adjust its performance automatically depending on the room temperature and heat generated. It shall have 24 hour programmable on/off timer. The unit shall work on dry mode to remove extra moisture in high humid situation. The unit shall have features like sleep mode, in built time delay, auto restart after power interruption, memory back up to retain setting even after power interruption, oscillating louvers etc.

Each Indoor unit shall be complete with cooling coil, Fan. Filter and control accessories. It shall have electronic control valve which control refrigerant flow rate in respond to load variations of the room. The fan shall be of the dual suction multi blade type and statically and dynamically balanced to ensure low noise and vibration free operation. Indoor unit shall be fitted with high purity filtration to eliminate dust, odour of all indoor smells and shall trap fine dust and smoke particles to ensure healthy indoor air quality.

Compressor

All compressors shall be hermetically sealed rotary/ scroll type of suitable capacities. Compressor shall be suitable for R410a/407c refrigerant. The compressor shall be electrically interlocked with indoor and outdoor fan motors, HP/LP cutouts and thermostat in the evaporator. The compressor shall be housed inside the Condenser.

Condenser (Air cooled)

The coils shall be made of copper hydraulically bonded with aluminium fins. The tubes shall have a minimum of 9.5 mm outer diameter, firmly bonded with aluminium fins spaced at 12-14 fins/inch. The air velocity across the face of the coil shall not exceed 200 m/min. The coils shall be designed for a maximum working pressure of 35 kg/sq.cm. The condenser coil shall be protected on the open end by a wire mesh duly powder coated/plastic coated.

Evaporator coil

The coils shall be made of copper tubes hydraulically bonded with aluminium fins. The coils shall be hydrophilic in nature. The tubes shall have a minimum of 9.5 mm outer diameter, firmly bonded with aluminium fins spaced at 12-14 fins/inch. The air velocity across the face of the coil shall not exceed 170 m/min. The coils shall be designed for a maximum working pressure of 35 kg/sq.cm. The circuit should include a thermostatic expansion valve/capillary tube, distributor, liquid strainer, suction line shut off valve and liquid line shut off valve.

Condenser motor

The condenser motor shall be of IP-55 rating.
CEILING MOUNTED CASSETTE UNITS:
The units shall be ceiling mounted type. The housing of the unit shall be of powder coated galvanized steel and shall include pre filter, fan section, coil section, etc. The body shall be light in weight and shall be able to suspend from four corners. The fan shall be aerodynamically designed diffuser turbo fan type. The fan shall be mounted directly on motor shaft having supported from housing. The fan shaft shall be statically and dynamically balanced. The fan shall be direct driven type. The cooling coil shall be of seamless copper tubes, and shall have continuous aluminium fins. The tubes shall be staggered in the direction of airflow. The fins shall be uniformly bonded to the tubes by mechanical expansion of the tubes. The coils shall be tested against leaks. Unit shall have filter cleanable type of resin net (with mold resistant) fixed to an integrally molded plastic frame. The filter should be slid away type but neatly inserted. All visible Units shall have an external attractive panel for supply and return air. Ceiling Mounted Cassette Unit shall have four way supply air grilles on sides and return air grille in center. Each unit shall have high lift drain pump, fresh air intake provision and low gas level detection system. Each unit shall have an electronic expansion valve which control refrigerant flow rate in respond to load variations of room. Each unit shall also have a pressure sensor. The computerized PID control shall be used to maintain a correct room temperature. Each unit shall be provided with microprocessor thermostat for cooling &heating. Each unit shall be with wired remote controller LCD type. The LCD remote controller shall memorize the latest malfunction code for easy maintenance.

CONTROL
Computerized PID control shall be used to maintain a correct room temperature. Unit shall be equipped with a self-diagnosis for easy and quick maintenance and service. The LCD (Liquid Crystal Display) remote controller shall memorize the latest malfunction code for easy maintenance. Remote control (Cordless) shall be provided with one On/Off timer, selecting fan speed (Three speeds), angle of swing flap and setting up of temperature.

Compressor
All compressors shall be hermetically sealed scroll type of suitable capacities. Compressor shall be suitable for R22/R410a/R407c refrigerant. The compressor shall be electrically interlocked with indoor and outdoor fan motors, HP/LP cutouts and thermostat in the evaporator. The compressor shall be housed inside the Condenser.

Condenser (Air cooled)
The coils shall be made of copper hydraulically bonded with aluminium fins. The tubes shall have a minimum of 9.5 mm outer diameter, firmly bonded with aluminium fins spaced at 12-14 fins/inch. The air velocity across the face of the coil shall not exceed 200 m/min. The coils shall be designed for a maximum working pressure of 35 kg/sq.cm. The condenser coil shall be protected on the open end by a wire mesh duty powder coated/plastic coated.

Evaporator coil
The coils shall be made of copper hydraulically bonded with aluminium fins. The coils shall be hydrophobic in nature. The tubes shall have a minimum of 9.5 mm outer diameter, firmly bonded with aluminium fins spaced at 12-14 fins/inch. The air velocity across the face of the coil shall not exceed 170 m/min. The coils shall be designed for a maximum working pressure of 35 kg/sq.cm. The circuit should include a thermostatic expansion valve/capillary tube, distributor, liquid strainer, suction line shut off valve and liquid line shut off valve.
Condenser motor
The condenser motor shall be of IP-55 rating.

18.2 Refrigeration piping and accessories

Soft drawn copper shall be used in piping with brass fittings wherever required. Brazing shall be with silver copper phosphorous alloy. Horizontal lines shall have a grading of at least 1:250 away from the compressor and towards condenser to prevent gravity draining of oil to compressor. Liquid lines shall be sized to ensure that flashing of liquid refrigerant does not occur. The circuit should include a thermostatic expansion valve, distributors, liquid strainer, de-hydrator and liquid lines shut off valve and suction line shut off valve.

All refrigerant pipes shall be insulated with flexible elastomeric closed cell insulation having a built-in Vapour barrier. It shall be of pre-formed tubes of appropriate thickness.

Insulation must have a thermal conductivity of less than or equal to 0.034 W/(m.K) at 0°C and less than or equal to 0.036 W/(m.K) at 20°C when measured according to ASTM C 177, ASTM C 518 or EN ISO 8497. Insulation must have a Moisture Resistance Factor of μ greater than or equal to 7,000 according to DIN 52615 or less than or equal to 0.02 per inch according to ASTM E96 Procedure A., flame spread not over 25 and smoke development not over 50. Insulation must have an operational temperature range of -50°C to +105°C (tubes). All refrigerant piping shall have minimum 19mm thick insulation. All drain piping shall have minimum 9mm thick insulation.

Leaks shall be tested with nitrogen gas and soap solution at a minimum pressure of 21 kg/sq.cm. After all leaks have been repaired, system shall be tested with nitrogen gas at a test pressure maintained for a period of not less than 24 hours. No measurable drop in pressure should be detected after the pressure readings are adjusted for temperature changes. After satisfactory completion of the pressure test, the system shall be evacuated to reduce the pressure to 0.1 Kg/Sq.cm. for a period of 6 hours and vacuum broken. A vacuum pump connected to the refrigeration system shall be used to create the vacuum and the installed compressor shall not be used to create the purpose. The system shall again be evacuated and a vacuum of 0.01 Kg/Sq.cm maintain for 24 hours before charging with correct quantity of refrigerant and oil. The system shall be operated for 12 hours and then again tested for leaks.

Drain Piping
Drain pipe shall be of suitable dia UPVC pipes. All Split units shall be provided with independent drain lines. The drain shall be taken to the drain main line. All drain pipe shall be insulated with 12mm thick insulation of closed cell elastomeric nitrile rubber with density not less than 80kg/m³ finished with an 8 Oz canvas cloth covering adhered between two coats of fungicidal protective coating suitably supported on trays, clamps etc.

Fan
Fan section including wheel and housing shall be of heavy gauge steel/aluminium. Fans shall be centrifugal, forward curved multi-blade type. Fan housing shall have inlets and guide vanes for smooth air flow. Fans shall be complete with drive motor. The fans should be statically and dynamically balanced. The fan motor should be resilient mounted. The fan should deliver a static pressure of 20 mm.

Filters
All evaporator units shall be provided with air filters capable for filtration up to 20 microns. The filters shall be of washable synthetic fibre type.
Control Panel
All units shall have independent electrical control panels housing contactors, overload relays, voltage cutouts, time delays, interlocks, strip connectors, indication lamps, and control fuse. All these have to be housed inside the Outdoor unit of each circuit.

Thermostat
The indoor blower motor shall have 3 speeds and indoor units noise shall not exceed 41/38/35 dBA. The unit shall be provided with cordless remote microprocessor control.

Installation
Adequate vibration isolation using rubber/neoprene pads/vibration springs in order to reduce transmission of vibrations to the floor shall be provided for all condensing units.

Testing
Split units after installation shall be tested for its conformity to specifications. Units shall also be tested for the rated capacity and power consumption.

Electric Motor
The electric motor driving the compressor shall be as per manufacturer’s standard for this compressor and motor shall be suitable for operation on A.C. supply. The motor shall be continuous duty rated for the application. The motor shall be selected such a way that the motor rating is for actual requirement. The motor shall be provided with suitable bearing to take care of loads/throughst. Necessary lubricators shall be provided to enable the bearings to be correctly greased as required. The Contractor shall also calculate KW/TR.

18.3 AIR COOLED DUCTABLE SPLIT AIR CONDITIONING UNIT
Air-cooled Condensing Units
Air-cooled Condensing Units with casting construction made of galvanized sheet metal, zinc phosphatized with stowing enamel finish. All compressors shall be hermetically sealed scroll type/ Semi-hermetic compressors of reciprocating type must have built-in suction gas cooled motor with control system allowing safe and long-life operation of suitable capacities. Compressor shall be suitable for R410a/R407c refrigerant.

Condensing units must be equipped with oil strainer, sight glass, replaceable core type filter drier, shutoff valves and liquid solenoid valve. Condenser coils shall be especially coated for corrosion protection (heresite coating or equipment). Each compressor must be mounted on spring vibration isolators within the base frame. In addition to this, condensing units shall be mounted on vibration isolation pads of minimum 50 mm thickness.

All components must be protected from weather, heat, sand-storms, salt bearing air, etc. Units must be completed with refrigerant piping as connection between the condensing units and the air handling unit. Each condensing unit shall have its own HP, LP and oil pressure gauges with isolating valves. Control panels shall have all necessary safety and control devices for automatic operation. Compressors and fan motors have to be equipped with single phase preventer/power failure relay.

The compressors of these condensing units shall have special guarantee of five years from the contractual completion date and complete compressor have to be replaced if found defective during this guarantee period.
Air Handling Units
Air handling units shall consist of double skin casting construction with minimum 25mm panel insulation, hinged access panels, vertical / horizontal supply and return connections(factory built), high efficiency bag filters, washable metallic pre-filter and all necessary safety and control devices for automatic operation. The airflow shall be performed by means of low noise fans.

The castings shall include the evaporator of copper tubes and copper fins, the expansion valve, all piping and insulation. The copper units and copper fins shall be tin plated or blygold coated against corrosion.

Condensing Units and air handling units, for any system, shall be from same make.

Electrical Requirements
The unit shall operate on a 415 V / 3 Ph /50 Hz or 240 V / 1 Ph /50 Hz power supply as applicable. All electrical wiring shall enter the unit cabinet at a single point. Starter panel shall be provided with sufficient potential free contacts and relays for enabling Remote on and off from CIAL AC plant control Room.

Operating Characteristics
The unit shall be capable of operating at an ambient temperature of 52 degree Celsius. Unless stated otherwise, unit performance shall be rated at an ambient temperature of 52 degree Celsius dry bulb temperature.

19 PRECISION AIR CONDITIONING (HYBRID TYPE)

The scope includes design, supply, installation, testing & commissioning of Precision air conditioning unit. Technical requirement of Precision Air Conditioning are:

Precision air conditioning unit shall be hybrid type suitable for both chilled water and DX system. It shall be complete with all controls, indoor and outside units, with Direct driven Motors and Backward curved blowers, scroll compressors (Fixed speed/invertor driven compressor), flat slab type evaporator coil for full frontal access, Electronic/Thermostatic expansion valve, EU2 filters, outdoor fan speed controller, in-built sequential controller, complete installation and commissioning for server room.

All auxiliary works like ducting, inlet and drain piping, piping between indoor and outdoor, valve packages, cabling, acoustic and thermal insulation (Duct and floor for server room), volume control dampers, supply and returns air grills, stands for indoor and outdoor units with related civil works etc. as per the site requirements.

Automatic monitoring and control of cooling, heating, humidification, dehumidification, air-filtration, etc. should be installed.

The PAC solution shall support N+1 configuration These equipment should be compliant to the following:
Cabinet conforming to Class 1 BS 476 Part 6&7 standards.
Humidifier should have an adjustable capacity control ranging from 40%-100%. Immersed electrode and Bottle type humidifier. Visual and audible alarm indication Clock card for real-time logging of events and alarms. Humidity, Ventilation, Air Conditioning (HVAC)

Air conditioning for direct expansion air conditioning should be with condensers located outside the building.

Criteria in determination of the air conditioner placement should be its effectiveness in addressing the current planned load, and their adaptability to change in configuration.

Consider the air flow patterns of the hardware being installed. Take care units are not laid out in a fashion that exhausts air from one unit into the intake of the next.

Optimal temperature range for system reliability and operator comfort levels should be between 22 deg C ± 1

For safe data processing operations ambient relative humidity should be between 50+/- 5% RH.

Server room requires precision air conditioning with a sensitivity of ± 1.5 C and ± 5% RH or closer.

Ideally a Server Hall cooling system should have sensible ratio of 1: 1, most precision systems have between 90% to 100% sensible cooling.

To deliver the air to the areas in need of air conditioning, the sub floor pressure differential should be maintained at an optimal level of 2 mm wg.

Server Hall should be isolated from contaminants. Inside server Hall airborne dusts, gases and vapours should be maintained in the defined limits to minimize their potential impact on the hardware

Server Hall should be free from water ingress Microprocessor controller Panel
The display panel should be located on the front of the unit with LCD display for monitoring and alarm indication. The panel should be used for:

Status detection (whether on or off) Temperature controller
Humidity controller
The panel should make an audio visual alarm in case of:
Power failure Fan overload
Humidifier power fault Humidifier control fault Heater fault
Airflow failure Change filter Control circuit trip
Return air temperature / RH out of range Supply air temperature out of range Return air humidity sensor alarm
Return air temp. Sensor alarm Data Error
Service alarm Electric heater alarm Microprocessor fault Humidifier flood Water leakage alarm Smoke alarm
Other functions of the control panel:
Self-diagnostic functionality
An automatic changeover for duty / standby unit based on time interval setting and any failure of duty unit.
An automatic restart function with sequence start program to prevent power surge during start-up on multi-system installation.
Comprehensive event storage system by date and time of occurrence. Simply user-friendly operating guidance.
Standard BMS connectivity through RS485 (or) optional remote monitoring of the Precision AC unit using desktop PC with SNMP interface.
Note: Contractor has to include control panel with necessary breakers, starters, timers, contactors, relays, indication lamps and all other accessories as required complete. (i.e. accessories required to take electrical power from single point power supply.)
### Variable Frequency Drive Guide Specification for HVAC

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<tr>
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<th>Requirement</th>
<th>Details</th>
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<tbody>
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<td>1</td>
<td>Product type</td>
<td>Dedicated HVAC Engineered design.</td>
</tr>
<tr>
<td>2</td>
<td>Manufacturer</td>
<td>Shall have minimum 10 years’ experience in design and manufacturing VFDs.</td>
</tr>
<tr>
<td>3</td>
<td>Certification</td>
<td>UL</td>
</tr>
<tr>
<td>4</td>
<td>VFD panels</td>
<td>CPRI Certified. Panel shall be made out of 2mm thick powder coated CRCA sheet.</td>
</tr>
</tbody>
</table>

#### VFD Design requirements:

<table>
<thead>
<tr>
<th></th>
<th>Requirement</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.1</td>
<td>Voltage variations</td>
<td>380-480 V ± 10%</td>
</tr>
<tr>
<td>4.2</td>
<td>Nominal supply frequency</td>
<td>50 / 60 Hz ± 5%</td>
</tr>
<tr>
<td>4.3</td>
<td>True Power Factor (λ)</td>
<td>≥ 0.9 at nominal rated load</td>
</tr>
<tr>
<td>4.4</td>
<td>Displacement P.F. (cos φ)</td>
<td>&gt; 0.98</td>
</tr>
<tr>
<td>4.5</td>
<td>Short circuit current rating</td>
<td>100 kA RMS</td>
</tr>
<tr>
<td>4.6</td>
<td>Harmonic current control</td>
<td>5% non-saturating dual reactors on both rails of DC bus. VFDs without saturating (nonlinear) DC reactors to provide additional 3% AC chokes, if required. Additional harmonic filters are to be added to bring down the value of harmonics.</td>
</tr>
<tr>
<td>4.7</td>
<td>EMC Compliance (for emission and immunity)</td>
<td>a) For powers ≤90 kW : Shall comply with requirements of IEC 61800-3 : 2004, Category C1 (50m)</td>
</tr>
<tr>
<td>4.8</td>
<td>VFD rated continuous output current</td>
<td>Meet or exceed the normal rated currents of standard IEC induction motors</td>
</tr>
<tr>
<td>4.9</td>
<td>Torque mode</td>
<td>Variable torque. Not programmable in constant torque mode for variable torque fan and pump applications</td>
</tr>
<tr>
<td></td>
<td>Torque ratings</td>
<td>Function</td>
</tr>
<tr>
<td>---</td>
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</tr>
<tr>
<td>4.10</td>
<td>a) Starting torque: 120% for 0.5 seconds&lt;br&gt;b) Overload torque: 110% for 1 minute</td>
<td></td>
</tr>
<tr>
<td>4.11</td>
<td>Cable type</td>
<td>To allow for SWA (Single Wire Armour) cable &amp; MICS (Mineral Insulated Copper Sheath) cable in the motor circuit.</td>
</tr>
<tr>
<td>4.12</td>
<td>V/f ratio</td>
<td>Dynamically varying; fixed V/f curves not acceptable</td>
</tr>
<tr>
<td>4.13</td>
<td>Energy optimization function</td>
<td>Automatic energy optimization algorithm which continuously adjusts the applied voltage based on load and speed.</td>
</tr>
<tr>
<td>4.14</td>
<td>Motor tuning function</td>
<td>Automatic, without having to decouple the load and motor.</td>
</tr>
<tr>
<td>4.15</td>
<td>Signal Isolation</td>
<td>Galvanic Isolation between power and control circuitry</td>
</tr>
<tr>
<td>4.16</td>
<td>System response time</td>
<td>&lt; 2 ms</td>
</tr>
<tr>
<td>4.17</td>
<td>Ramp time</td>
<td>Programmable from 1 to 3,600 seconds</td>
</tr>
</tbody>
</table>

5 Service Conditions:

<table>
<thead>
<tr>
<th></th>
<th>Ambience with full VFD rated output current:</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>5.1</td>
<td>a) For powers ≤ 90 kW: 40 °C without derating&lt;br&gt;b) For powers &gt; 90 kW: 40 °C without derating</td>
<td></td>
</tr>
<tr>
<td>5.2</td>
<td>Relative Humidity</td>
<td>0 to 95%. non condensing</td>
</tr>
<tr>
<td>5.3</td>
<td>Max. altitude above sea level</td>
<td>Up to 1000m without derating</td>
</tr>
<tr>
<td>5.4</td>
<td>AC line voltage variation</td>
<td>± 10% of nominal with full output</td>
</tr>
<tr>
<td>5.5</td>
<td>VFD enclosure protection</td>
<td>IP 55(or)IP 66 integrated with mains disconnect switch</td>
</tr>
<tr>
<td>5.6</td>
<td>Aggressive environment</td>
<td>Class 3C2</td>
</tr>
<tr>
<td>5.7</td>
<td>Vibration</td>
<td>1.0 g</td>
</tr>
</tbody>
</table>

6 Protective features:
<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>6.1</strong></td>
<td>Motor overload protection</td>
<td>Class 20 I^2t electronic motor overload protection with automatic compensation for changes in motor speed.</td>
</tr>
<tr>
<td><strong>6.2</strong></td>
<td>Protective functions</td>
<td>Against input transients, loss of AC line phase, output short circuit, output ground fault, over voltage, under voltage, VFD over temperature and motor over temperature.</td>
</tr>
<tr>
<td><strong>6.3</strong></td>
<td>Function at input phase loss</td>
<td>Auto derate and warning. Should cause no damage to VFD</td>
</tr>
<tr>
<td><strong>6.4</strong></td>
<td>Function at over temperature</td>
<td>Automatically reduce carrier frequency or auto derate.</td>
</tr>
<tr>
<td><strong>6.5</strong></td>
<td>Function at over load</td>
<td>Automatically reduce output current to a pre-programmed value</td>
</tr>
<tr>
<td><strong>6.6</strong></td>
<td>Alarm log</td>
<td>Record last 10 alarms with description of alarm, date &amp; time.</td>
</tr>
<tr>
<td><strong>6.7</strong></td>
<td>Dry pump detection</td>
<td>Automatically detect and trip during a dry running situation or no flow condition, when used in pumping application.</td>
</tr>
<tr>
<td><strong>6.8</strong></td>
<td>End of curve protection</td>
<td>Detect and display a warning or trip when encountering an end of curve situation, when used in pumping application.</td>
</tr>
<tr>
<td><strong>7</strong></td>
<td>Interface Features:</td>
<td></td>
</tr>
<tr>
<td><strong>7.1</strong></td>
<td>Customer interface</td>
<td>Identical interface for full range of VFDs in a project.</td>
</tr>
<tr>
<td><strong>7.2</strong></td>
<td>Display type</td>
<td>Graphical, alphanumeric, 6 line, back lit</td>
</tr>
<tr>
<td><strong>7.3</strong></td>
<td>Auto – Manual operation</td>
<td>Control panel to have inbuilt Hand – Off – Auto Keys</td>
</tr>
<tr>
<td><strong>7.4</strong></td>
<td>Programming assistance key</td>
<td>Key for displaying on-line context sensitive assistance for programming and troubleshooting.</td>
</tr>
<tr>
<td><strong>7.5</strong></td>
<td>Protection against unauthorized access</td>
<td>2 level password protection for read &amp; write to prevent unauthorized access.</td>
</tr>
<tr>
<td></td>
<td>Parameter up load / down load</td>
<td>Control panel with program up load / down load function and also size / rating independent parameters.</td>
</tr>
<tr>
<td>---</td>
<td>--------------------------------</td>
<td>----------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>7.9</td>
<td>Languages supported</td>
<td>English</td>
</tr>
<tr>
<td>7.10</td>
<td>Indicating lamps</td>
<td>Red FAULT light, yellow WARNING light and a green POWER-ON light.</td>
</tr>
<tr>
<td>8</td>
<td>HVAC Features :</td>
<td></td>
</tr>
<tr>
<td>8.1</td>
<td>Quick set up menu</td>
<td>Menu with factory preset typical HVAC parameters</td>
</tr>
<tr>
<td>8.2</td>
<td>HVAC application menus</td>
<td>Fan, Pump, and Compressor menus specifically designed to facilitate start-up of these applications.</td>
</tr>
<tr>
<td>8.3</td>
<td>Speed control using 2 feedback signals</td>
<td>A two-feedback PID controller to control the speed of the VFD.</td>
</tr>
<tr>
<td>8.4</td>
<td>2 – zone control</td>
<td>Sum, difference, average, compare to common set point or compare to individual set point and select min. or max. deviating signal</td>
</tr>
<tr>
<td>8.5</td>
<td>Square root function of feedback signal</td>
<td>Calculate the square root of any / all individual feedback signals so that a pressure sensor can be used to measure air flow</td>
</tr>
<tr>
<td>8.6</td>
<td>PI programming</td>
<td>Auto tuning PI controller to facilitate faster commissioning</td>
</tr>
<tr>
<td>8.7</td>
<td>Installation of pressure sensor near to output of pump.</td>
<td>Actively adjust its set point based on flow, to facilitate such installation</td>
</tr>
<tr>
<td>8.9</td>
<td>Independent PID controllers</td>
<td>Three nos. additional PID controllers to control damper and valve positioners in the system and to provide set point reset</td>
</tr>
<tr>
<td>8.10</td>
<td>Floating point control interface</td>
<td>To increase/decrease speed in response to contact closures.</td>
</tr>
<tr>
<td>8.11</td>
<td>Meter displays</td>
<td>5 simultaneous meter displays on LCP</td>
</tr>
<tr>
<td>8.12</td>
<td>Display of feedback signals and set points</td>
<td>Display all connected feedback signals and its set points, in their own Engg. units (e.g.: bar / °C etc.)</td>
</tr>
<tr>
<td>8.13</td>
<td>Sleep mode</td>
<td>Programmable and be able to stop the VFD in the following situations: a) Output frequency drops below set “sleep” level for a specified time, b) External contact commands that the VFD go into Sleep Mode, or c) Detects a no-flow situation.</td>
</tr>
<tr>
<td>-------</td>
<td>-------------</td>
<td>-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>8.14</td>
<td>Run permissive circuit</td>
<td>Receive a “system ready” signal before starting and also be capable of initiating an output “run request” signal to the external equipment.</td>
</tr>
<tr>
<td>8.15</td>
<td>Loss of load detection</td>
<td>Monitor a broken belt / loose coupling and indicate via key pad warning, relay output or serial communication. This function shall be based on torque and shall have a proof timer.</td>
</tr>
<tr>
<td>8.16</td>
<td>Real time clock</td>
<td>Integral feature and shall be capable of: a) Display current date &amp; time on control panel b) Start / stop, change speed depending on time c) Time stamp all faults d) Program maintenance reminders based on time</td>
</tr>
<tr>
<td>8.17</td>
<td>Energy log</td>
<td>Function to monitor energy consumption pattern over programmable hours, days &amp; weeks</td>
</tr>
<tr>
<td>8.18</td>
<td>Load profile</td>
<td>Store a load profile to assist in analyzing system demand and energy consumption</td>
</tr>
<tr>
<td>8.19</td>
<td>Sequential logic controller</td>
<td>To perform logic functions which has logic operators, comparators and timer functions.</td>
</tr>
<tr>
<td>8.20</td>
<td>Cascade controller for multiple motors</td>
<td>To control one variable speed motor and 2 fixed speed motors. Software to have full functionality and not just on / off.</td>
</tr>
<tr>
<td>8.21</td>
<td>Automatic restart</td>
<td>To automatically restart on receiving power after a power failure.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
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<tr>
<td>---</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>8.22</td>
<td>Adjustable ramp time</td>
<td>To avoid nuisance tripping, automatically adjust the ramp times.</td>
</tr>
<tr>
<td>8.23</td>
<td>Catching a spinning fan</td>
<td>To have a flying start function to effectively control an already spinning fan – in both forward and reverse direction</td>
</tr>
<tr>
<td>8.24</td>
<td>Programmable current limit</td>
<td>Programmable for site / application requirement. Shall be able to program for trip after an adjustable time.</td>
</tr>
<tr>
<td>8.25</td>
<td>Start Delay</td>
<td>A programmable start delay shall be provided.</td>
</tr>
</tbody>
</table>
| 8.26 | Critical frequency lock out | a) Semi-automatic setting of lock out range.  
b) 4 such lock out ranges to be provided |

### Inputs and Outputs

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>9.1</td>
<td>Digital inputs</td>
<td>At least 4 programmable digital inputs</td>
</tr>
<tr>
<td>9.2</td>
<td>Digital outputs</td>
<td>At least 2 programmable digital outputs</td>
</tr>
<tr>
<td>9.3</td>
<td>Relay outputs</td>
<td>At least 2 programmable relay outputs (Form C 240 V AC, 2 A) with adjustable on/off delays.</td>
</tr>
<tr>
<td>9.4</td>
<td>Analog inputs</td>
<td>At least 2 programmable analog inputs, independently selectable for Voltage (0-10V DC) or Current (4-20mA) inputs</td>
</tr>
<tr>
<td>9.5</td>
<td>Display of analog signal</td>
<td>The Local Control Panel to display each analog signal in its Engg. units for trouble shooting &amp; setup.</td>
</tr>
<tr>
<td>9.7</td>
<td>Optional I/O modules</td>
<td>Possible to order additional I/Os including DI's, DO's, RO's, AI, AOs and Ni 1000 / Pt 1000 inputs.</td>
</tr>
<tr>
<td>9.8</td>
<td>Serial com interface for AI/DO</td>
<td>Capable of reading the status of all analog and digital inputs of the VFD through serial bus communications</td>
</tr>
<tr>
<td>9.9</td>
<td>Serial com interface for AO/DO</td>
<td>Capable to command all digital and analog outputs (including options) through the serial communication bus</td>
</tr>
<tr>
<td>Section</td>
<td>Description</td>
<td></td>
</tr>
<tr>
<td>---------</td>
<td>-------------</td>
<td></td>
</tr>
<tr>
<td>9.10</td>
<td>Fire over ride mode</td>
<td>On receipt of a digital fire input, override all other local or remote commands, ignore most normal safety circuits including motor overload, display FIREMODE, select forward or reverse operation and speed source or preset speed.</td>
</tr>
<tr>
<td>10</td>
<td>Serial Communications</td>
<td></td>
</tr>
<tr>
<td>10.1</td>
<td>Serial Com Port</td>
<td>EIA-485 (RS 485)</td>
</tr>
<tr>
<td>10.2</td>
<td>Standard serial com protocols</td>
<td>Modbus RTU, Johnson Controls Metasys N2, BACNET MS/TP</td>
</tr>
<tr>
<td>10.3</td>
<td>Optional protocols to be made available, if required</td>
<td>Lon works, Profibus, Device net</td>
</tr>
<tr>
<td>10.4</td>
<td>Connection to Personal Computer</td>
<td>Using USB port</td>
</tr>
<tr>
<td>10.5</td>
<td>Communication in case of power failure to VFD</td>
<td>Facility to provide optional 24 V DC back up power interface for keeping the controls section powered to keep communication to BMS. To be provided.</td>
</tr>
<tr>
<td>11</td>
<td>AHU Control with VFD</td>
<td></td>
</tr>
</tbody>
</table>
| 11.1    | For AHU control applications the VFD shall be supplied with the following configuration | a. VFD in IP 55(or)IP 66 enclosure, suitable for field mounting without electrical panel  
b. Control of chilled water valve in closed loop with analog input for controlling parameter (supply air temperature), internal set point for controlling parameter, analog output (0-20 mA) to chilled water valve  
c. Control of AHU speed in closed loop with analogue input for controlling parameter (Return air temperature for constant volume AHUs and Duct pressure for VAV AHUs) and internal set point for controlling parameter  
d. If a CO2 sensor or IAQ sensor is provided, the VFD shall accept the signal from the same and pass it to |
the BMS for monitoring or controlling action. If a motorised / modulating fresh air damper is provided, the VFD should control the fresh air damper in closed loop based on the input sensor signal.

e. If a humidifier is provided, the VFD shall controller the humidifier in closed loop with analogue input and internal set point for controlling parameter and analogue output to the humidifier.

f. It shall be possible to control the speed of the VFD and additional three no’s external HVAC devices (like chilled water valve, hot water valve, fresh air damper etc.) directly by the VFD only.

In case of connectivity with BMS system, the VFD shall be provided with external 24 V DC capability to continue uninterrupted communication to the BMS, in case of a power failure.

21 ELECTRICAL INSTALLATION
As per Electrical System specification.

22 INSPECTION, TESTING AND COMMISSIONING

22.1 GENERAL
The contractor must perform all inspection and tests of the system as a whole and of components individually as required, under the supervision of the Engineer-in-charge in accordance with the provisions of the applicable ASHRAE / ARI standards or approved equal and as per load requirements.

22.2 Air-conditioning System Testing
Complete Air conditioning system shall be tested for all areas for continuous 72 hrs. in summer, winter & monsoon. The system equipment’s shall be tested as given below:
22.3 SCREW TYPE WATER CHILLING MACHINE

22.3.1 WITNESS TEST

Prior to shipment, chilling machines shall be subjected to inspection and witness of performance tests by AAI representative to verify various performance parameters as confirmed by contractor by submitting computers prints earlier, before factory acceptance test (FAT). Performance test shall be carried out on one machine with VFD randomly selected as per procedure laid down by ARI 550/590 and as per design specified parameter, at 100%, 75%, 50% and 25% loading.

Fouling factor simulation for condenser and evaporator shall be done as per ARI-550/590-Incremental temperature difference (to be calculated based on Normative appendix-C of ARI-550/590) on account of designed fouling factors shall be added in condenser water entering temperature and shall be subtracted for leaving chilled water temperature.

Chiller shall produce design refrigeration capacity and guaranteed power consumption at these corrected set of entering condenser water and leaving chilled water temperature. Outside tube surface area (for condenser and flooded evaporators) being input for ARI mathematical model for fouling, shall be submitted to the Engineer-in-charge after award of work before inspection call.

22.3.2 IPLV VALUE OF CHILLERS

The chillers offered shall be energy efficient. To evaluate the performance of chillers offered, the Contractor shall provide the IPLV value of the offer model after award of work to engineer-in-charge.

The IPLV value shall be verified during the performance test at manufacturer’s factory.

23.4 PUMPS

Pump performance shall be computed from the pump curves provided by manufacturer. All pumps shall be tested as per relevant BIS codes. Type test certificate for similar item done. If not, one of the items offered is to be type tested

23.5 COOLING TOWERS

Capacity of the cooling tower shall be computed from the measurements of water flow, incoming/outgoing water temperatures and ambient air wet bulb temperature using accurately calibrated thermometers. Computed ratings shall conform to the specified capacities and quoted ratings. Power consumption for cooling towers shall be computed from measurements of incoming voltage and input current.

A detailed performance test shall be carried out for cooling tower in the monsoon season in presence of Engineer in-charge or his authorized representative.

23.6 AIR HANDLING UNITS

Cooling capacity of various air handling unit models be computed from the measurements of air flow and dry and wet bulb temperatures of air entering and leaving the coil. Flow measurements shall be by an anemometer and temperature measurements by accurately calibrated thermometers. Computed results shall conform
to the specified capacities and quoted ratings. Power consumption shall be computed from measurements of incoming voltage and input current.

23.7 PIPING

a) During construction, the contractor shall properly cap all lines, so as to prevent the entry of sand, dirt, etc. Each system of piping shall be flushed thoroughly after completion (for the purpose of removing dirt, grit, sand etc. from the piping and fittings) for as long a time as is required to thoroughly clean the system.

b) All piping shall be tested to hydrostatic test pressure of at least one and half times the maximum operating pressure, but not less than 10 kg per sq. cm gage for a period of not less than 24 hours. All leaks and defects in joints revealed during the testing shall be rectified, retested and got approved by engineer in charge. Test shall be done before application of insulation.

c) Piping repaired subsequent to the above pressure test shall be re-tested in the same manner.

d) Piping may be tested in sections and such sections shall be securely capped, then re-tested for the entire system.

e) The Contractor shall give sufficient notice to all other agencies at site, of his intention to test a section or sections of piping and all testing shall be witnessed and recorded by Owner’s site representative.

f) The contractors shall provide temporary pipe connections to initially by-pass condenser/chiller and circulate water through condenser/chilled water pipe lines for minimum 8 hours. Water should be drained out from the lowest point. The temporary lines shall be removed and blanked with dead flanges. Pot strainers and Y strainers shall be cleaned and fresh water filled in the circuits.

g) The Contractor shall make sure that proper noiseless circulation of fluid is achieved through all coils and other heat exchange equipment in the system concerned. If proper circulation is not achieved due to air bound connection, the Contractor shall rectify the defective connections. He shall bear all expenses for carrying out the above rectifications including the tearing up and re-finishing of floors and walls if required.

h) After the piping has been installed, tested and run for at least three days of eight hours each, all insulated exposed piping in plant room shall be given two finish coats of approved colour, conforming to relevant BIS Codes. The direction of flow of fluid in the pipes shall be visibly marked with identifying arrows.

i) After testing, all systems shall be chemically cleaned. After cleaning, the pipe work should be rinsed multiples times until the system is neutral. Before handover AAI site representative shall be provided with certificate of cleaning of pipe systems, signed by the contractor.

j) The Contractor shall provide all materials, tools, equipment, instruments, services and labour required to perform the test and to remove water resulting from cleaning and after testing.

23.8 BALANCING

After completion of the installation, all water system shall be adjusted and balanced to deliver the water quantities as specified, quoted, or as directed. All balancing valves/automatic balancing cum control valves shall be set for full flow condition during balancing procedure. Each water circuit shall be adjusted through
valves provided for this purpose; these shall be permanently marked after balancing is completed, so that they can be restored to their correct positions, if disturbed. Complete certified balancing report shall be submitted for evaluation and approval by Engineer-in-charge. Upon approval, four copies of the balancing report shall be submitted with the as-built drawings and completion documents.

23.9 AIR DISTRIBUTION
After the installation of the entire air distribution system is completed in all respects, all ducts shall be tested for air leaks by visual inspection. The entire air distribution system shall be balanced using an anemometer. Measured air quantities at fan discharge, at various outlets and return air shall be identical to or less/excess than 5 percent in excess of those specified. Branch duct adjustments shall be permanently marked after air balancing is completed so that these can be restored to their correct position if disturbed at any time. Complete air balance report shall be submitted for scrutiny and approval, and four copies of the approved balance report shall be provided with completion documents.

23.10 ELECTRICAL EQUIPMENT
a) All electrical equipment shall be cleaned and adjusted on site before application of power.

b) Wire and cable continuity tests.

c) Insulation resistance tests, phase to phase and phase to earth, on all circuits and equipment, using a 500 volt IR tester. The IR tester reading shall be not less than one meg. ohm.

d) Earth resistance between conduit system and earth must not exceed half (1/2) Ohm.

e) Operating tests on all protective relays to prove their correct operation before engineering the main equipment.

f) Operating tests on all starters, circuit breakers, etc.

24 FINAL INSPECTION
After completion of the entire installation as per specification in all respects, the AC contractor shall demonstrate trouble free running of the AC equipment’s and installation for a period of minimum 120 hours of running as detailed as follows.

RUNNING IN PERIOD & DATE OF ACCEPTANCE

a) After the installation work has been completed by the contractor, he will conduct tests and make adjustments as may be necessary to satisfy himself that the plant including low side equipments is capable of continuous running. Thereafter he will offer to the department a running—in period of 7 days subject to a minimum aggregate of 120 hrs at his cost (except electricity and raw water). The duty cycle of the plant during this running in period shall be same as that specified in the tender documents. In case of multiple compressor installations, all the compressors should be run by rotation. The plant will be operated and log of all parameters will be maintained during this period. The contractor will be free to carry out necessary adjustments etc. during this period without stopping the plant. Record of inside conditions will be made during this period to check the same are as per NIT
requirements. The plant will be said to have successfully completed the running–in period. After this the plant will be made available for beneficial use. After the plant has operated without any major break down/ trouble and inside conditions are maintained as per NIT requirements for the above specified running in period, it shall be taken over by the department subject to guarantee clause. This date of taking over of plant after trouble free operation during the running in period shall be the date of acceptance.

b) Any loss of refrigerant or oil during the running in period shall be made good by the contractor free of charge.

a) Capacity test of the chilling unit and other major equipments shall be carried out as and when conditions become stabilized as per details given under CPWD Specifications.

b) Seasonal testing may be carried out as and when outside condition become suitable.

c) After the trial run, the HVAC contractor shall offer the plant for the seasonal tests, namely test for summer, winter and monsoon season. The completion date for the system shall be treated from the date when the second seasonal test shall be executed successfully.

25 IDENTIFICATION OF SERVICES

25.1 Scope
The scope of this section comprises of identification of services for each piece of equipment

25.2 Valve Labels and Charts
Each valve shall be provided with a label indicating the service being controlled, together with a reference number corresponding with that shown on the Valve Charts and ‘as fitted’ drawings. The labels shall be made from 3 ply (black / white/ black) Traffolyte material showing white letters and figures on a black background. Labels to be tied to each valve with chromium plated linked chain.

A wall mounted, glass covered plan to the approval of the Architect / Engineer shall be provided and displayed in each plant room showing the plant layout with pipe work, valve diagram and valve schedule indicating size, service, duty, etc.

25.3 Identification of Services
Pipe work and duct work shall be identified by colour bands 150 mm. wide or colour triangles of at least 150 mm. / side. The bands of triangles shall be applied at termination points, junctions, entries and exits of plant rooms, walls and ducts, and control points to readily identify the service, but spacing shall not exceed 4.0 metres.

25.4 Pipe Work Services
For pipe work services and its insulation the colors of the bands shall comply with IS Codes

25.5 Duct Work Services
For Duct work services and its insulation the colors of the triangles shall comply with BS.1710 : 1971. The size of the symbol will depend on the size of the duct and the viewing distance but the minimum size should not be less than 150 mm. length per side. One apex of the triangle shall point in the direction of airflow.
<table>
<thead>
<tr>
<th>Services</th>
<th>Colour</th>
<th>BS.4800 Colour Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conditioned Air</td>
<td>Red and Blue</td>
<td>04 E 53 / 18 E 53</td>
</tr>
<tr>
<td>Ward Air</td>
<td>Yellow</td>
<td>10 E 53</td>
</tr>
<tr>
<td>Fresh Air</td>
<td>Green</td>
<td>14 E 53</td>
</tr>
<tr>
<td>Exhaust / Extract / Recirculated Air</td>
<td>Grey</td>
<td>AA 0 09</td>
</tr>
<tr>
<td>Foul Air</td>
<td>Brown</td>
<td>06 C 39</td>
</tr>
<tr>
<td>Dual Duct System Hot Supply Air</td>
<td>Red</td>
<td>04 E 53</td>
</tr>
<tr>
<td>Cold Supply Air</td>
<td>Blue</td>
<td>18 E 53</td>
</tr>
</tbody>
</table>

In addition to the colour triangles specified above all duct work shall be legibly marked with black or white letters to indicate the type of service, identified as follows:

Supply Air
Return Air
Fresh Air
Exhaust Air

The colour banding and triangles shall be manufactured from self-adhesive cellulose tape, laminated with a layer of transparent ethyl cellulose tape.

26 GUARANTEE & DEFECTS LIABILITY PERIOD

The contractor shall guarantee that all equipments shall be free from any defects, defective materials and/or bad workmanship and that the equipment shall operate satisfactorily and their performance and efficiencies of the equipment shall not be less than the guaranteed values. The guarantee shall be valid for a period of 24 (Twenty-four) months after successful completion of second seasonal test and “final taking over”. Any equipment or parts found defective shall be replaced free of all costs by the contractor. This period shall be known as the Defects Liability Period and shall be reckoned from the date the Engineer certifies and plant is taken over as laid down in clause “Taking over of Plant” hereinafter. The services of the contractors personnel, if requisitioned during this period for such work, shall be made available free of all costs to the AAI.

27 TEST ON COMPLETION

Tests on completion shall mean such tests as are prescribed in the specifications or have been mutually agreed to between the contractor and the department to be made before the plant is taken over. In case tests are not possible due to climatic conditions at the time of completion, the contractor shall be bound to carry out tests as prescribed thereafter at any time subsequent to the date of completion. The defect liability period will start only after all the tests have been successfully completed.
28 **TAKING OVER OF PLANTS**
Provisional takeover of the plant shall be made only after successful run of the HVAC system round the clock for seven days after commissioning. However, final take over shall be after successful conducting of summer and monsoon seasonal tests, whichever is later.

29 **LIST OF STANDARDS CODES**

<table>
<thead>
<tr>
<th>BIS</th>
<th>Code</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>554 - 1985 (Reaffirmed 1996)</td>
<td></td>
<td>Dimensions for pipe threads where pressure tight joints are required on the threads.</td>
</tr>
<tr>
<td>694 - 1990 (Reaffirmed 1994)</td>
<td></td>
<td>PVC insulated (HD) electric cables for working voltage up to and including 1100 volts.</td>
</tr>
<tr>
<td>780 - 1984</td>
<td></td>
<td>Sluice valves for water works purposes.</td>
</tr>
<tr>
<td>1239 (Part - I) - 1990</td>
<td></td>
<td>Mild steel tube</td>
</tr>
<tr>
<td>1239 (Part - II) - 1992</td>
<td></td>
<td>Mild steel Tubular and other wrought steel pipe fittings.</td>
</tr>
<tr>
<td>1255 - 1983</td>
<td></td>
<td>Code of Practice for installation and maintenance of Power Cables up to and including 33 KV rating (Second Revision)</td>
</tr>
<tr>
<td>1554 - 1988 (Part – I)</td>
<td></td>
<td>PVC insulated (Heavy Duty) electric cables for working voltages up to and including 1100 volts. BIS</td>
</tr>
<tr>
<td>1897 – 1983 (Reaffirmed 1991)</td>
<td></td>
<td>Copper bus bar / strip for electrical purposes</td>
</tr>
<tr>
<td>2379 - 1990</td>
<td></td>
<td>Colour code for the identification of pipelines.</td>
</tr>
<tr>
<td>2551 - 1982</td>
<td></td>
<td>Danger notice plate</td>
</tr>
<tr>
<td>4894 - 1987</td>
<td></td>
<td>Centrifugal Fan.</td>
</tr>
</tbody>
</table>
BIS : 5312 (Part-I) - 1984
(Reaffirmed 1990) Swing - check type reflux Non
return valves for water works.
BIS : 5576 & 11353-1985 Marking and identification of conductors
BIS : 8623 – 1993 Low voltage switchgear and control gear
Assemblies (Requirement for type / partly
return valves for water works)
type tested assemblies)
BIS : 8623 – 1993 (Part - II) Bus Bar trunking system
BIS : 8828 - 1996 Circuit Breakers for over current protection
for household and similar installation.
BIS : 9537 - 1981(Part II) Rigid Steel Conduits for electrical wiring
BIS : 13947-1993 (Part-I) General rules for low voltage switch gears
and control gears.
BIS : 13947 - 1993 (Part-III) Switches, dis connectors and fuse for low
voltage switch gear and control gear.
BIS : 13947 -1993 (Part-IV) Low voltage switch gear and control gear
for contractors and motor starters.
BIS : EN:779 – 1993 Filters

ASHRAE Hand Books American Society of Heating Refrigeration
& Air-conditioning. Refrigeration 2014
Systems & Equipment 2008.ASHRAE
Indoor air quality Standard 62.12013.

National Building Code of India Pollution Control Board

ANSI American National Standards Institute
NEMA National Electrical Manufacturers Association
UL Underwriters Laboratories Inc.
ETL Electrical Testing Laboratories
CSA Canadian Standards Association
NEC National Electrical Code
ISO International Standards Organization
IEC International Electrochemical Commission
Part IV

BUILDING MANAGEMENT SYSTEM
1.0 SCOPE

The Building Management System (BMS) to be provided shall perform the following general functions:

i. HVAC Management and Control
ii. Monitoring and Control of Controllers, Remote Devices and Programmable Logic Controllers
iii. Operator Interface
iv. Video display integration
v. Data collection, Historization, Alarm Management & Trending
vi. Report Generation
vii. Network Integration
viii. Data exchange and integration with a diverse range of other computing and facilities systems using industry standard techniques.

The scope of BMS here is for HVAC applications only. It should be expanded type to connect it with other building services in future. The BMS software and supervising should have the capability to expand the system at least up to 50% of the present capability.

1.1.0 SYSTEM ARCHITECTURE

The system offered shall be completely modular in structure and freely expandable at any stage with 3 level architecture.

i) The Management Level
ii) The Automation Level
iii) The Field Level

Each level of the system shall operate independently of the next level up. The system shall fully be consistent with the latest industry standards, operating on Windows 10 or Windows NT or latest edition, allowing the user to make full use of the features provided with these operating systems. To provide maximum flexibility and to respond to changes in the building use, the system offered shall support the use of BACnet, LON, Profibus and Ethernet TCP/IP communication technologies. All plant and equipment requiring control and/or monitoring functions shall be fitted with all necessary interfacing equipment readable by the BMS network.
1.1.1 The Management Level

The management level and operation of the plant shall include process visualization, data analysis, and exchange of data. At the management level, it shall be possible for communication to flow in all directions, across networks and via direct connections. The management level of the system shall consist of one and shall be capable of handling more management station PCs and the associated software modules.

1.1.2 The Automation Level

The level at which the actual processing takes place based on the logic written on the DDC. The processes are carried out at the DDC controllers for stand-alone control of all plant.

1.1.3 The Field Level

Individual room controllers for autonomous room – by – room comfort control, based on application specific logic written on the controllers.

1.2.0 INTERFACE AND INTEGRATION

1.2.1 Maintenance Management

a. Integrated
The system shall provide an integrated Maintenance Management function. The Maintenance Management function shall use specified breakdown alarms, equipment run hours or analog values from the BMS.

b. Third Party
The system shall be capable of integrating with external maintenance systems such as MS Excel, MS Access. This integration shall consist of transferring specified breakdown alarms and equipment run hours from the BMS to the external maintenance system.

1.3.0 DIGITAL CONTROLLERS

1.3.1 General

Digital Control Processors / Direct Digital Controller (DDC) shall be as per design requirement with capacity to accommodate input/ output (I/O) points required for the application plus spare points specified. Each DDC will be a truly standalone controller with its own Input-Output capacity, control logic capability, time programming and energy management capabilities. All field equipment including the sensing element (inputs) and control elements (outputs) would be wired to the
It shall be possible to hook up a DDC to a Portable Operator Terminal (POT) to enable monitoring and control of the DDC. DDC shall be designed for complex DDC and energy management applications, true peer-to-peer communications with other DDC and with the Central Operator Stations. The DDC will be networked on a truly distributed intelligence concept where each DDC shall be a self-sustained intelligent device capable of all its functionality's without dependence on other devices.

1.3.2 DDC Hardware:

i. Digital Control Processors (DDC) shall be 16 bit or latest microprocessor types with Electrical Erasable Program Read Only Memory (EEPROM) based Operating System (OS) and shall use EEPROM or flash memory for all data file and control programs (DDC Programs) and using RAM only for operating data.

ii. Each DDC shall have Nickel cadmium Lithium battery to support complete operation of the RAM for upto 30 days in the event of a power failure to the DDC. A low battery voltage status will generate an alarm condition.

iii. DDC shall have internal real-time clocks with 30-day battery backup power. All time-based controls (time scheduling, integrations and other real-time based controls) shall be performed with this real-time resident clock. Clock synchronization of the DDC on the whole bus will be automatic DDC using clocks generated by software or timers for clocking shall not be accepted.

iv. The battery backup power shall support the real-time clock. Upon power restoration all clocks shall synchronize automatically.

v. The DDC's shall be capable of supporting 8 to 48 I/Os preferably in a combination of 8 AI (Analog input), 2 DI (Digital input), 4 AO (Analog output), 2 DO (Digital output) with minimum of 10% spares of each type per DDC.

vi. The DDC would be dedicated standalone in nature and would be placed near the instrument they are controlling to reduce the installation and wiring cost.

vii. Analogue input support of the following minimum types shall be provided:
- 0/4-20mA
- 0-10 volts
- 0-5 volts
- 0/2-10 volts
- Resistance signals (Pt3000, Pt1000, Pt100, Ni1000)

viii. Digital Inputs type shall be, but not limited to the following types:
- Normally open discrete contacts
- Normally closed discrete contacts

1.3.3 DDC POT functionality shall be as follows:

i) There will be an electrical socket/port in every DDC for accessing the data points and real time information via a portable plug-in type Portable Operator Terminal (POT).
a) The POT shall not have any EEPROM and shall not require any programming.
b) The POT will plug into the DDC for its power and data. The POT which are not plugged in to the DDC but are hard wired from the Interface unit, PC station or any other device shall not be acceptable.
ii) The connection of the POT to a controller shall not affect normal operation of the controller or the bus communication in any way.
iii) The connection of the POT to any controller on a bus shall provide display access to all controllers on the bus. Each DDC shall have provision for plugging of the POT.
iv) It shall be possible for the POT to be connected to any controller on the bus to view and control any point on any other controller on the bus under password protected menus. POTs in which only a predefined number & set of points are available shall not be accepted.
v) A failure of any DDC on the bus, Interface unit or Central PC station or any other device of the system shall not affect the operation of the POT. Systems in which the POT is connected to only a single interface master port and hard wired to other controllers are not acceptable.
vi) Use of a POT at DDC shall allow the user to display software information and via password control, modify DDC software.
ii) All displays on the POT shall be in English language text and data points shall have customized descriptions as per application requirement.
iii) The POT shall be equipped with a multiple lines (with minimum of 4 lines of 20 characters each) backlit alphanumeric LCD display and a control keypad. The keypad would include Command keys, data entry keys and cursor control keys.
ix) Access shall be through self-prompting menus with cursor controls for moving through the menus. Menu selection would be with arrow key controls for moving to next/previous menu and to step forward backward within a menu.

1.4.0 FIELD DEVICES

1.4.1 Electronic Data Inputs and Outputs

Input/output sensors and devices shall be matched to the requirements of the respective connected controller panel for accurate, noise-free signal input/output. Control input response shall be high sensitivity and matched to the loop gain requirements for precise and responsive control.

1.4.1.1 Temperature Sensors

Temperature sensors shall be Resistance Temperature Detector types of Pt3000, Pt1000, Pt100 or Ni1000. These shall be two wire type sensors and shall conform to following:

i) Space temperature sensors shall be wall/surface mounted and shall be provided with blank commercial type looking covers
ii) Duct temperature sensors shall be rigid stem or averaging type as specified and shall be suitable for duct installation

iii) Immersion temperature sensors shall be provided with matching Stainless steel thermo-well of lengths as specified.

iv) Outdoor air temperature sensors shall have weatherproof enclosures and shall be directly wall/surface mounted

v) Outside air, return air, discharge air, return air, space and well sensors shall have + 0.55 degrees C accuracy between 0 degree and 100 degree C.

1.4.1.2 Relative Humidity Sensors:

i) Relative humidity sensors shall be capacitance type with an effective sensing range of 10% to 90%.

ii) Accuracy shall be +/-5% or better

iii) Duct mounted humidity sensors shall be provided with a sampling chamber. Wall mounted sensors shall be provided with covers identical to temperature sensors. Sensor housing shall plug into the base such that the same can be easily removed without disturbing the wiring.

1.4.1.3 Differential and Static Pressure Switches

A. Differential pressure switches-air:

i) They shall have field adjustable set-point capability for the specified range.

ii) They shall provide a built-in switching differential at the set-point over the specified range.

iii) Switches shall be piped to fan discharge except where fans operate at less than 25mm WC (water column), they shall be piped across the fan.

iv) Maximum pressure rating shall be at least 300 mm WC.

v) The electrical contacts shall provide dry contacts as specified and shall be rated for at least 300V A pilot duty @ 240V AC

B) Differential pressure switches-water:

i) Switches shall be adjustable differential pressure type as specified in the sequence of operation or data point summary.

ii) Devices shall be 10 kg/sq.cm rated except chilled water flow switches shall be provided with totally sealed vapor tight switch enclosure on 20 kg/sq.cm body.

iii) Differential pressure switches shall have valved manifold for servicing.

iv) The electrical contacts shall provide dry contacts as specified and shall be rated for at least 300V A pilot duty @ 240V AC.

1.4.1.4 Differential Pressure Sensors

A) Air Flow / Pressure sensors

i) Air flow and duct static pressure analog sensors shall be highly accurate suitable for the low pressures to be encountered, be selected for approximately 50% over range, and have a 4 to 20 ma/ 0-10 VDC output.
ii) Air flow measuring station sensors shall be with valve lines for testing and calibration, and shall have adjustments for zero and span.

B) Water flow Sensors

i) Water flow analog sensors shall be provided complete with flow element and shall be an all solid state precision industrial type with stainless-steel body, maximum error of not more than 0.5% of span.

ii) Sensor shall be rated for 17 kg/sq.cm minimum and installed in strict accordance to the manufacturer’s instructions complete with three valve manifold for calibration and maintenance.

1.4.1.5 Water Hardness Analysers

i) The water hardness analyzer shall be on-line conductivity type and shall provide analog output proportional to specified range.

ii) Control relays and analog output transducers shall be compatible with controller output signals. Relays shall be suitable for the loads encountered. Analog output transducers shall be designed for precision closed loop control with pneumatic repeatability error no greater than 2%.

1.4.1.6 Level Measurement

A) Level Switches

i) Level switches shall be directly vessel mounted type either top mounted or side mounted as required.

ii) These shall be float type unless specified. Process connection shall be flanged. Wetted parts shall be made of stainless steel (SS316).

B) Level Sensors

i) Level sensors shall be capacitance probe type.

ii) It shall be possible to mount the transmitter unit integral to the probe on the vessel or field mounted away from the probe

iii) Unless specified probe insulation shall be of PTFE and probe rod material SS316

iv) Process connection shall be flanged or BSP connections as specified.

1.4.2 Automatic Control Valves

i) Automatic control valves upto 50mm and smaller shall be screwed type, and valves of 65 mm and larger shall be flanged type.

ii) Valves shall be ANSI-rated to withstand the pressures and temperatures encountered. Valves shall have stainless-steel stems and spring loaded Teflon packaging with replaceable discs.

iii) All modulating straight-through water valves shall be provided with equal percentage contoured throttling plugs. All three-way valves shall be provided with linear throttling plugs such that the total flow through the valve shall remain constant regardless of the valve’s position.

iv) Valves shall be sized as specified for a pressure drop equal to the coil they serve but not to exceed 0.2 kg/ sq.cm.
v) All modulating step valves shall have linear characteristic for 90% of the closing stroke and equal-percentage for the final 10%. Valves shall be sized for 0.68kg/sq.cm entering steam and 0.2 kg/sq.cm pressure drop through valves.

vi) All automatic control valves shall be actuated by a directly coupled proportional electric actuator. Eccentric linkages are not acceptable.

1.4.3 Electric Actuators for Valves and Dampers

i) Unless specified, the electric actuator shall accept proportional input signal of 0/2-10VDC or 0/4-20mA. Unless specified actuators shall provide modulating control. Actuators shall be powered 24VAC or 240VAC as specified.

ii) The actuators shall be designed to deliver the required torque and have close off pressure ratings as required by the specified process data.

iii) The actuator shall incorporate magnetic coupling to ensure torque limitation which shall be independent of voltage supply.

iv) Unless specified, in case of power failure the actuator shaft position will remain stay-put at the last position just before power off.

v) It shall be possible to replace the actuator / remove the actuator / dismantle it from the valve body without having to remove the valve body.

vi) The actuator shall have a built in electronic switch to enable switchover of direct / reverse action of valve/damper. It shall be possible to change the direct/reverse action of valve without having to remove the actuator from valve body or change linkage assemblies.
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TS – 08
FACADE DESIGN
1.0 SCOPE OF WORKS:

The scope of work includes complete Design, Engineering, Fabrication, Supply, installation including testing of materials & performance, Quality control, Transport, Storage, Protection, final clean & handover, guaranties, & maintenance up to the defects liability period for the all façade products listed on Annexure : 01 (List of products)

A. Proposed system drawing details for following façade elements along with the engineering calculations in line with the tender drawings and specification requirement.

B. Proper site survey report prior to grid module finalization and shop drawing preparation.

C. Shop drawings, Engineering calculations, Structural STAAD, FEM analysis for all products and components to the satisfaction of the approving authority.

D. QA / QC procedures.

E. Installation methodology.

F. Detailed project schedule.

G. All material approval plans & Design submission plan.

H. Bracket layout marking and fixing with use of TOTAL STATION & level instruments by qualified surveyor.

I. Cast in channel load test, Anchor bolt pull out test at site before starting of bracket fixation.

J. All Aluminum trims & flashing covers to inside and outside of the building to seal the façade and the building structure.

K. All stainless steel anchor bolts, fasteners and structural washers.

L. Aluminum alloy brackets with serrations and serrated washers in chromate finish or MS Hot dip Galvanized brackets

M. Glazing materials, Silicon gaskets, EPDM gaskets, setting blocks, backer rod, sealants, spacer tapes, and related other materials.

N. Fire stop and smoke seal to all floor levels sealing with the building interface.

O. All metal separators in nylon and GI shims.
a. Protection tapes of 70-80 microns for glass, ACP, Solid Aluminum, Perforated Aluminum system till hand over stage.
b. All access equipments including gondolas, floor cranes, scaffoldings, hoisting and staging.
P. All material testing and processing test reports.
Q. Material certification for Green Building rating.
R. Fire rating certification
S. Performance mock-up tests at laboratory condition and onsite tests. (As per Annexure No: 03)
T. On site visual mock ups for architectural approval for all products.
U. Completion of snag list to the satisfaction of AAI/PMC.
V. Complete water wash and clean one time the façade before final hand over.
W. As built drawings.
X. All process test reports, material test certificates and product guaranties and warranties.
Y. Operation and maintenance manuals.
Z. Design and performance guaranties.
AA. Thermal performance calculation on overall Facade as per ECBC norms

1.1 Defined Terms

a) The term ‘shall’ is used to denote a mandatory requirement.
b) The term ‘should’ is used to denote a desirable requirement which is not mandatory.
c) The term ‘will’ is used to denote information given for guidance only.
d) The terms ‘Accepted’ and ‘Acceptance’ are used to denote acceptance by AAI/PMC under the contract of the Contractor’s submission.
e) The terms ‘Endorsed’ and ‘Endorsement’ are used to denote Endorsement by AAI/PMC under the Main Contract of the Contractor’s submission.
f) The term “Contractor” is used to denote the contractor under this contract who provides the all facade related works which deemed to be part of the design and build contract

2.0 STANDARDS:
All Design, Material and Workmanship shall comply with the following minimum standards:

2.1 GENERAL

- NBC 2016 : National Building Code of India (Bureau of Indian Standards)
- IS 875 (Part 1) 2015 : Code of Practice for Design Loads (other than Earth Quake) for buildings & Structures – Dead Loads
- IS 875 (Part 2) 2015 : Code of Practice for Design Loads (other than Earth Quake) for buildings & Structures – Imposed Loads
- IS 875 (Part 3) 2015 : Code of Practice for Design Loads (other than Earth Quake) for buildings & Structures – Wind Loads
- IS 875 (Part 5) 2015 : Code of Practice for Design Loads (other than Earth Quake) for buildings & Structures – Special Loads & Load combinations
- IS 1893 (Part 1) 2016 : Criteria for Earthquake Resistant Design of Structure
- IS 2016 : Specification for Plain washers
- IS 3139 : Dimensions for screw threads for bolts & nuts
- IS 3757 : Specification of High Strength Structural Bolts
- IS 4000 : High Strength Bolts in Steel Structures – Code of Practice
- IS 6610 : Specification for Heavy Washers for Steel Structures
- IS 3139 : Dimensions for screw threads for bolts and nuts (dia range M42 to M150) [covered in IS 4218: Part 5]
- IS 2016 : Specification of Plain Washers
- IS 4000 : Code of practice for high strength bolts in steel structures
- IS 6610 : Specification for Heavy Washers for Steel Structures
• BS 4190 : ISO Metric Black Hexagon Bolts, Screws and Nut specification

• BS 6105 : Specification for Corrosion-resistant Stainless Steel Fasteners

• BS 5750 : Quality Systems

• CWCT (Centre for Window & Cladding Technology) Guidelines for Thermal Insulation, Vapour control Layer & Fabrication

• ADCA : Aluminum Standards and Data-Wrought Products

2.2 ALUMINUM

• IS 8147 : Code of Practice for Use of Aluminum Alloys in structures

• BS EN 12020 : Part 2 – Tolerance on dimensions & form Aluminum & Aluminum alloys – Extruded Precision profiles in Alloys EN AW 6060 & EN AW 6063

• BS EN 12373-1 : Specification for Anodised Aluminum

• BS 1474 : Specification for Wrought Aluminum & Aluminum Alloys for general Engineering Purposes: Bars, Extruded Round Tubes & sections

• BS 3019 : Specification for TIG welding of Aluminum, Magnesium and their alloys

• BS 3571 : Specification for MIG welding of Aluminum & Aluminum Alloys

• BS 8118 : Structural use of aluminum. Code of practice for design

• BS 1470 : Specification for wrought Aluminum and Aluminum alloys for general engineering purposes: plate, sheet and strip

• BS EN 485 : Aluminum and Aluminum alloys. Sheet, strip and plate. Mechanical properties

• BS EN 515 : Aluminum and Aluminum alloys. Wrought products. Temper designations

• AS/NZS 1664 : Aluminum Structure code

2.3 FINISH

• AAMA 2604 : Voluntary Specification, Performance requirements and test procedures for High Performance Organic coatings on Aluminum Extrusions & Panels

• AAMA 2605 : Voluntary Specification, Performance requirements and test procedures for Superior Performing Organic coatings on Aluminum Extrusions & Panels

• BS 3987 : Specification for anodic oxidation coatings on wrought aluminum for external architectural applications

• BS 1615 : Specification for anodic oxidation coatings on Aluminum & its Alloys

• BS 6161: Methods of test for anodic oxidation coatings on aluminum and its alloys.

• BS 4842 : Specification for liquid organic coatings for application to Aluminum alloy extrusions, sheet and preformed sections for external architectural purposes, and for the finish on aluminum alloy extrusions, sheet and preformed sections coated with liquid organic coatings

• BS 6496 : Specification for powder organic coatings for application and stoving to aluminum alloy extrusions, sheet and preformed sections for external architectural purposes, and for the finish on aluminum alloy extrusions, sheet and preformed sections coated with powder organic coatings

• BS 6497 : Specification for powder organic coatings for application and stoving to hot-dip galvanized hot-rolled steel sections and preformed steel sheet for windows and associated external architectural purposes, and for the finish on galvanized steel sections and preformed sheet coated with powder organic coating

• BS 2569 : Specifications for Sprayed Metal Coatings

• BSEN 10143 : Continuously Hot Dip Metal Coated Steel Sheet and Strip. Tolerances on Dimension and Shape.

• BS 4190 : Specification for ISO Metric Black Hexagon Bolts, Screws and Nuts.

• BS 6338 : Specifications for Chromate Conversion Coatings on Electroplated Zinc and Cadmium Coatings.

• BS 5411 : Method of Test for Metallic and Related Coatings.

• BS 5493 : Code of Practice for Protective Coating of Iron and Steel Structures against Corrosion

• ASTM D523 : Test Method for Specular Gloss

• ASTM D4214 : Test Method for Evaluating Degree of Chalking of Exterior Paint Films

• ASTM D714 : Test Method for Evaluating Degree of Bubbling of Paints

• ASTM D968 : Test Method for Abrasion Resistance of Organic Coatings by the Falling Abrasive Tester

• ASTM D1654 : Method for Evaluation of Painted or Coated Specimens Subjected to Corrosive Environments

• ASTM D2244 : Method for Instrumental Evaluation of Colour Differences of Opaque Materials

• ASTM D2247 : Method for Testing Coated Metal Specimens at 100% Relative Humidity

• ASTM D3363 : Test Method for Film Hardness by Pencil

• ASTM G23 : Recommended Practice for Operating Light and Water Resistant Exposure Apparatus (Carbon Arc Type) for Exposure of Non-Metallic Materials.

• BS 1706 : Method for Specifying Electroplated Coatings of Zinc and Cadmium on Iron and Steel AMD 6731, May 1991 (Gr O).

• CP 3012 : Code of Practice for Cleaning and Preparation of Metal Surfaces
2.4 STEEL / WELDING

- IS 800 - 2007: Code of Practice for General Construction in steel
- IS 2062: Hot rolled Low, Medium and High Tensile Structural steel.
- IS 801: Code of Practice for use of Cold-Formed Light Gauge Steel Structural Members in general Building Construction.
- IS 806: Code of Practice for use of Steel Tubes in General Building Construction.
- IS 811: Specification for cold formed Light Gauge Structural Steel Sections.
- IS 816: Code of Practice for use of Metal Arc Welding for General Construction in Mild Steel
- IS 1161: Steel Tubes for Structural Purposes - Specification
- IS 1477: Code of Practice for Painting of Ferrous Metals in Buildings & Allied Finishes
- IS 7215: Tolerances for fabrication of steel structure
- IS 12843: Tolerance for erection of steel structure
- ASTM A743: Stainless Steel Castings
- ASTM A744: Stainless Steel Castings
- BS 4870: Specification for approval testing of welding procedures. Specification for automatic fusion welding of metallic materials, including welding operator approval
- BS 4871: Specification for approval testing of welders working to approved welding procedures. Fusion welding of steel
- BS EN 729-1: Quality requirements for Welding. Fusion welding of metallic materials, guidelines for selection & use
• BS 729: Specification for Hot Dip Galvanized Coatings on Iron and Steel Articles
• BS 2989: Specification for continuously hot-dip zinc coated and iron-zinc alloy coated steel
  of structural qualities: wide strip, sheet/plate and slit wide strip

• BS 5950: Structural use of steelwork in building. Specification for materials, fabrication and
  erection

• BS 1449.2: Specification of stainless & Heat-Resisting steel Plate, Sheet and Strip

• BS EN 10029: Hot-rolled steel plates 3 mm thick or above. Tolerances on dimensions and
  shape

• BS 3100 Steel Castings for General Engineering Purposes

• BS 2994: Specification for Cold Rolled Steel Sections

• BS EN 288: Specification and Approval of Welding Procedures for Metallic Materials

• BS 3019: TIG Welding

• BS 3571: MIG Welding

• BS EN 287: Approval Testing of Welders for Fusion Welding

• BS 7475: Specification for Fusion Welding of Austenitic Stainless Steel

• BS 7613: Specification for Hot Rolled Quenched and Tempered Weldable Structural Steel
  Plates

• BS 7668: Specification for Weldable Structural Steels. Hot Finished Structural Hollow
  Sections in Weather Resistant Steel

• BS EN 10113: Hot-Rolled Products in Weldable Fine Grain Structural Steel

• AWS C5.4: Recommended Practices for Stud Welding

2.5 GLASS

• BS 952: Glass for Glazing. Classification
- BS EN 410: Glass in building. Determination of luminous and solar characteristics of glazing

- BS EN 572: Glass in building. Basic soda lime silicate glass products

- BS EN 1863: Glass in building. Heat strengthened soda lime silicate glass

- BS EN 1279: Glass in Buildings


- AS/NZS 1288: Glass in buildings. Selection & Installation

- BS 6262: Code of Practice for glazing for buildings

- ASTM C1036: Standard Specification of Flat Glass


- ASTM C1172: Standard Specification for Laminated Architectural Flat Glass

- ASTM 1300: Standard Practice for determining Load Resistance of Glass in Buildings

- ASTM C1376: Standard Specification for Pyrolytic & Vacuum Deposition Coating on Flat Glass

- BS 6206: Specification for Impact Performance Requirements for Flat Safety Glass and Safety Plastics for Use in Building

- BS 6375: Performance of Windows

- CP 153: Code of Practice for Windows and Roof-Lights (British Standard)

2.6 GASKET

- BS 4255-1: Rubber used in preformed gaskets for weather exclusion from buildings. Specification for non-cellular gaskets
• BS 4255 -2: Specification for Performed Rubber gaskets for weather exclusion from Buildings. Cellular gaskets

• ASTM C509 : Standard Specification for Elastomeric Cellular Preformed Gasket and Sealing Material


2.7 SEALANTS

• BS 6213: Selection of Construction Sealants. Guide

• BS 5889 : Specification of one part Gun Grade Silicon Based Sealants

• ASTM D412 : Standard test method for vulcanized rubber & thermoplastic elastomers tension

• ASTM C 794 : Standard Test Method for Adhesion in Peel of Elastomeric Joint Sealants

• ASTM D 897 : Tensile testing of adhesive bonds

• ASTM C 1184 : Standard Specification for Structural Silicone Sealants

• ASTM C 920 : Standard Specification for Elastomeric Joint Sealants

• ASTM C 509: Standard Specification for Elastomeric Cellular Preformed Gasket and Sealing Material

• ASTM C510: Standard test method for staining & color change of single or multi component joint sealants.

• ASTM C962: Standard guide for use of elastomeric joint sealants

• ASTM D2203: Standard test method for staining of caulking compounds & sealants


• AAMA CW 13: Structural Sealant Glazing Systems guide.

• FGMA: Sealants Manual

• TT-S-0227E: Sealing Compound Elastomeric Type, Multi-Component (US Federal Interim Specification Board).

• BS 4254: Specification for Two-Part Polysulphide Based Sealants

• BS 5215: Specification for One-Part Gun Grade Polysulphide Based Sealants

2.8 DESIGN

• BS 6399.1: Code of Practice for Dead and Imposed Loads

• BS 6399.2 Code of Practice for Wind Loads

• BS 5588 Fire Precautions in Design, Construction and Use of Building

• BS 5588 Part 3: 1983 Code of Practice for Office Buildings

• BS 5750 Quality Systems
• BS 7543 Guide to the Durability of Buildings and Building Elements, Products and Components

2.9 INSTALLATION

• AS 2047 : Windows in buildings – Selection & Installation

• BS 5974 : Code of practice for the planning, design, setting up and use of temporary suspended access equipment

• BS 6037: Code of practice for the planning, design, installation and use of permanently installed access equipment. Suspended access equipment

2.10 SAND STONE

• BE EN 1926 : Compression
  • BS EN 13161: Flexural Strength
  • BS EN 13364: 2002 : Breaking Load at Dowel Hole
  • BS EN 13755 : Water Absorption Stone

• BS EN 1936 : Density

• BS EN 1936 : Porosity

• BS EN 1936 : Saturation Coefficient

• BS EN 12370 : Salt Crystallisation

• EN 13161 : Test method for Flexural Strength.

• EN 13364 : Test method for Resistance to Fixing

• EN 12371 : Test method for Frost Resistance

• EN 12524 : Test method for Water Vapour Permability
• EN 14066 : Test method for Thermal Shock Resistance
• EN 1936 : Test method for Apparent Density

2.11 PERFORMANCE TESTING

• ASTM E283 : Standard Test Method for Determining Rate of Air Leakage Through Exterior Windows, Curtain Walls, and Doors Under Specified Pressure Differences Across the Specimen

• ASTM E331 : Standard Test Method for Water Penetration of Exterior Windows, Skylights, Doors, and Curtain Walls by Uniform Static Air Pressure Difference


• AAMA 501.1 : Standard Test Method For Water Penetration Of Windows, Curtain Walls And Doors Using Dynamic Pressure

• AAMA 501.4 : Recommended static testing method for evaluating curtain wall & storefront systems subjected to seismic & wind induced interstory drift

• AAMA 501.2 : Quality assurance & Diagnostic Water leakage field check of Installed storefronts, curtain walls , and sloped glazing systems


• AS/NZS 4284 : Testing of Building Facades

• ISO/IEC 17025:2005 : General Requirements for the competence of testing and calibration laboratories

• ASTM E547 : Test Method for Water Penetration of Exterior Windows, Curtain Walls and Doors by Cyclic Static Air Pressure Differential.

2.12 In the event of an overlap between difference standards, the most stringent standard shall be considered.
2.13 No substitution of above codes shall be accepted unless with prior written acceptance & endorsement.

2.14 PURPOSE OF TENDER DOCUMENTS

• The Drawings & specification enclosed with the TENDER DOCUMENT are indicative only and show the overall dimensions and other limiting dimensions for the building envelope and its relationship with adjoining components.

• The Contractor shall be responsible for achieving the construction of the contract works while conforming to the Specifications and obtain approvals from the Regulatory Authority.

• The Contractor shall allow for the development of the design and no variation to the contract will be allowed for any modification of his initial design which may be necessary after testing in order to satisfy the requirements of this Specification.

2.15 VERIFICATION OF DESIGN AND SIZES

• All works shown or inferred from the Specifications and Drawings are intended to be the design criteria for the contract works.

• The detailed design development of the contract works shall be submitted by the Contractor for Acceptance and Endorsement.

• The Contractor shall be responsible for taking exact measurements at site prior to fabrication and installation of the contract works. He shall verify all measurements in consultation with AAI/PMC.

• The Contractor shall allow for any additional supports on framework where required so as to ensure the stability and capability of the installed contract works to withstand all specified loads under normal usage encountered during the service life of the works.

3.0 DESIGN / PERFORMANCE CRITERIA

3.1 The service life of the building envelope shall be not less than 50 years.
3.2 Design Wind Load shall be 260 Kg / m² (Except Ground Floor glazing) in line with the IS 875 Part III. The system shall pass at 1.5 times the design pressure without any failure of components.

3.3 System shall be transfer their own self weight & other associated dead loads to the main building structure

3.4 Deflection limits of Mullion / Transom supporting the glass under Wind Load: L / 175 or 19mm whichever less

3.5 Deflection limits of Mullion / Transom (Windows or doors for residential purpose) supporting the glass under Wind Load: L / 150 as per AS 1288 : 2006

3.6 Deflection limits of Transom supporting the glass under dead Load: L / 300 or 3mm whichever is less

3.7 Deflection limits of monolithic glass under Wind Load: L / 60 or 20mm Max (L = Shorter span) – (For the purpose of glass selection, design wind pressure is assumed to be of duration 3 second wind gust.) , whichever is less

3.8 Deflection limits of Insulated glass unit under Wind Load: L / 90 or 20mm Max (L = Shorter span) - (For the purpose of glass selection, design wind pressure is assumed to be of duration 3 second wind gust.)

3.9 Deflection limits of ACP & Aluminum Sheet at center of panel- L/60 or 20mm max. (L is Shorter Span)

3.10 Deflection limit (Aluminum Louvers) of the Structural frames and stiffening rib members – span / 175

3.11 The allowable Design stresses in the glass shall be as follows.

i. Tempered Single Glass Panel : 50Mpa
ii. Tempered Double Glass Panel : 43Mpa
iii. Heat Strengthened Single glass panel : 22Mpa
iv. Heat Strengthened Double glass panel : 19Mpa
v. Heat Strengthened laminated glass panel : 24Mpa
3.12 The permanent deformation of Aluminum structural member shall not exceed L/1000.
No failure of glass, components or bracket displacement or And Bolt failure at 1.5 times design wind load.

3.13 The surface compression and edge compression stresses in glass:

- Heat strengthened glass shall have
  - Surface compression of 24.14 MPa to 68.94 MPa
  - Edge compression of 37.93 MPa to 66.87 MPa.

- Toughened glass shall have
  - Surface compression not less than 68.94 MPa.
  - Edge compression not less than 66.87 MPa.

3.14 The Contractor shall design all components of the building envelope system, including supporting structural steel frame work, anchorage, fixings, adhesives and structural adhesives, to carry all temporary and permanent design loads, individually and in combination without causing failure, including failure which may be due to one or more over-stresses, including cracking, bowing, distortion and looseness, lack of rigidity, dislodgement by wind or seismic forces, excessive deflection or defects which would cause damage to adjacent or applied work by others.

3.15 Prepare and submit full structural analysis in the form of computations and shop drawings. The Contractor shall co-ordinate with AAI/PMC as required to obtain additional information on base structure conditions. Materials and components shall be engineered to accommodate all loading conditions.

3.16 Strength, stiffness and sizes of components and fixings shall be adequate for all conditions and requirements.

3.17 Dead Loads shall be computed by summing up the total self-weight of all the elements of the building envelope incorporated in the assembly, including fixtures and accessories.

3.18 Design supporting corbels, brackets and cast-in anchors to carry 2x the self weight without causing overstress or slipping of anchors.
3.19 The total self weight (un-factored) shall be used in combination with wind load and live load in the design of all members.

3.20 Live Loads: Shall design the building envelope systems to carry the following loads in combination with full dead and wind loads (see below for load combinations):

3.20.1 A downward point loading (100mm x 100mm) of 1.15kN on all horizontal surfaces including projecting features, sills and canopies (indoor or outdoor).

3.20.2 A line loading of 0.70kN/m acting either downward or outward on all window sills.

3.20.3 A uniformly distributed minimum loading of 0.75kPa on all roofs and canopies.

3.21 These live loading requirements do not need to be superimposed with each other.

3.22 Live loading for canopies shall be taken as 0.75kPa + allowance for any BMU access loading.

3.23 WIND LOADS

3.23.1 The building envelope shall be designed for wind loads in accordance with the requirements and standards as defined by the Indian Standards. The wind load requirements therein shall be satisfied taking into account height effects and a basic wind speed of 47m/s. Furthermore, the following requirements shall serve as a minimum for this project. The Contractor may increase these values as they deem appropriate. The Contractor shall be solely responsible for determining appropriate load values. The building envelope and its anchorage shall be designed to withstand wind pressures of not less than the following: Designed Wind Pressure = 260 Kg/m²

3.23.2 The wind pressure is calculated based on the data furnished below and other provisions laid in IS: 875 (Part 3) - 2014.

3.23.3 Corner condition occurs from edge corner of the building to a distance of 20% of the dimension of the longest side of the building, or 25% of the dimension of the shortest side of the building, whichever is greater.
3.23.4 The above cladding pressures do not take account of loading to plant areas and the like with dominant openings, canopies and other projecting features. To calculate wind loads on these areas, local pressure factors according to BS 6399, and AS1170 (Part 2) shall be applied to the wind loads specified above.

3.24 BMU LOADS
Co-ordinate with BMU Supplier and obtain details of proposed equipment, monorails, suspension points, sockets operation live loads and directions of action. Install all required restraint fixings, brackets, supports and the like and allowable tolerances for the operation of the equipment. BMU loads are not required to be superimposed with live loads. Verify all loads with BMU Supplier.

3.25 SEISMIC LOADS
- The building envelope shall be designed for seismic loads in accordance with the requirements and standards as defined by the applicable Indian Standards.
- The loading due to earthquake is assessed based on the provisions of IS: 1893-2016 (Part 1)
- Seismic zone (considered) = V (Manipur)
- Seismic Zone factor, Z = 0.16
- R-Response reduction factor =5.0
- Sa/g – average response acceleration coefficient
- Design horizontal seismic coefficient (Ah) = (Z*I* Sa) / (2*R*g) = (0.16 * 1.0 * Sa) / (2*5.0*g)
- Design seismic base shear, VB = Ah * W,
  \( (Ah = \text{Design horizontal seismic coefficient} \ W = \text{seismic weight of building}) \)

3.26 LOAD COMBINATIONS

- Design building envelope supporting structural steel framework, brackets and cast-in anchors to carry the applied loads without causing overstress or slipping of anchors. The total self-weight shall be used in combination with wind load and live load in the design of all members, IS 800 - 2007 : Code of Practice for General Construction in steel.

3.27 OTHER LOADS
Design the building envelope for additional loads applied to it, as follows:

- Design Load Reduction for Cladding to Features, Canopies and Blanked-off Walls: Single sealed panel systems to drained cavities with solid backup walls shall not be designed to incorporate wind load reduction principles based on (partial) pressure equalization.

- Temporary and Construction Loads: Design the building envelope systems to allow for all handling and installation loads without causing overstress, permanent deflection or warping.
No permanent deforming of panels, channel legs and the like during installation to enable panels to fit into place will be accepted.

3.28 LOAD SHARING

• Where two sections of different materials about each other, submit full load sharing computations based on the relative stiffness of each section.

• Composite Sections: Generally, use of composite sections shall not be allowed. However, in situations where composite sections are required and Accepted by AAI/PMC, the Contractor shall submit full computations based on applied loads, as well as thermal expansion induced stresses. In assessing stresses in the composite sections, particular care shall be applied in determining end conditions.

3.29 THERMAL STRESSES

• Design Temperature Range: The Contractor shall design the building envelope based on a surface material temperature range from 0 to +75 degrees C. Prepare and submit full analysis of all components and/or assemblies and indicate all design movements on the shop drawings.

• Movements within Building Envelope Systems due to Thermal Loads: Provide for all thermal movement to take place freely in the plane of the building envelope systems without causing harmful buckling, failure of joint seals, undue stress on fasteners and glass or other detrimental effects. No component or system shall be stressed or subject to induced loading as a result of thermal movement. Full movement allowances including assembly and installation tolerances shall be incorporated into all junction/components at each expansion joint or assembly. Any deviation from the above stated requirements for thermal design, shall require analysis and computations which fully allow for the following issues:

  a) Meteorological records indicating daily and seasonal maximum and minimum temperatures, wind, and other relevant weather effects.
  b) Solar radiant heat loads and any effects of conduction and convection.
  c) Shading, including shading from parts of this building and from adjacent buildings.
  d) Reflection, including reflection from parts of this building and from adjacent buildings.
  e) Orientation and colour.
  f) Resultant "service" temperature of building envelope system components.

3.30 BUILDING MOVEMENTS

• Design building envelope systems to provide for deflections, displacements and other movements within the building envelope system, and between the building envelope system
and the base building (including fire stop and smoke flashing connections). Include movements caused by ambient temperature changes, wind loads, dead loads, live loads, seismic loads and shrinkage. The Contractor’s design shall include moveable joints to accommodate the full range of movement requirements including manufacturing tolerances, site tolerances, thermal movement, lateral movement, floor sag, beam sag, live load deflection and column settlement.

- Allowance for movement shall be in addition to allowance for building tolerances.

- Joints shall accommodate the worst possible combination of effects to prevent loads of any kind being transferred from the building into the building envelope system, excessive movements of any joints or failure of weather seals.

- Prepare and submit full analysis and complete details of proposed design movement allowances based on the base structure information contained in the Specifications.

- Indicate movement limits and required clearances on shop drawings.

- Accommodate movements within the design movement allowances indicated on the Accepted shop drawings, silently and without failure of the system, permanent deformation, reduction of performance, visible movement at any joint, or other detrimental effects including:
  
  - Application of stresses or induced loads to any component or system, including structural elements, fixings, glass or face panels.
  - Damage to any component or system, including structural elements, fixings, glass or face panels.
  - Failure of joint seals.
• Design movement joint and select sealant products to accommodate all required expansion and contraction within joint tolerances indicated on the Accepted shop drawings and within the sealant movement limits recommended by the sealant manufacturer under loaded and unloaded conditions.

• All movement allowances shall be consistent and applied across all junctions and/or components for each expansion joint system or assembly.

• The contractor shall regularly assess and take into consideration the effect of ongoing base building movements on building envelope set-out.

3.30.1 BASE BUILDING MOVEMENTS DUE TO LATERAL DISPLACEMENT OF BUILDINGS:
Design building envelope system so that no structural element, joint or weather seal failure occurs for lateral movements between successive floors. Allow for a minimum of +/-8mm of horizontal racking for each 4m of height.

3.30.2 LONG-TERM BUILDING MOVEMENTS
The base structure will continue to undergo displacement during the life of the building due to variation in live load and creep of the concrete structural elements.

Design the building envelope system to accommodate the absolute relative vertical deflections and horizontal movements that may occur due to panel rotations due to the following displacements occurring between successive floors:

- Differential column and core shortening.
- Beam or slab edge displacement.
- Axial Shortening of edge beams.
- Floor-to-floor drift of the building.
- Make allowance for long term axial shortening of edge beams: 0.4 mm per 1 metre length.
Make allowance generally for differential live load deflection of edge beams or slabs: +/- 16mm.

3.30.3 Movement Joint between Floors: The Unitized / Semi-unitized Curtain wall is designed to accommodate differential floor movements and thermal expansion without inducing any stresses in the curtain wall system or creating any noise. This is to be achieved by either providing a stack joint at the sill, or by providing sliding joints and flexible seals to the cassette frames and back pans at the split mullion.

3.31 Identification of Cladding and Glazing Panels

- The Contractor shall provide a complete numbering system and schedule for all cladding and glazing panel units. Each panel shall be individually numbered in such a way that the manufactured history can be traced. Provide a permanent concealed marking system. Submit details for review and Acceptance.
- Identify the location of each individual panel on shop drawings and as-built drawings.
- Before the panels are delivered to the Site, provide suitable marks or identification for each panel for showing its correct location and orientation when installed.
- Identification labels on glass shall be made on a non-marking adhesive tape fixed to the glass. No tape shall be put onto the reflective coating side of a glass panel.

3.32 Dimensional Stability

- All work carried out by the Contractor shall have adequate dimensional stability to function properly and prevent damage to adjacent or applied work by other contractors.
- Design shall allow for the following:
  - Expansion and contraction
  - Building movement
  - Dimensional changes due to weather change

3.33 Visual Requirements
• Profiles: The Contractor shall design building envelope components so that sizes, profiles, dimensions and style satisfy the Performance Specifications. The Drawings included in the contract are to be used as a guideline. Indicate variations on the shop drawings. The Contractor shall not commence production of extruded aluminum sections until all profiles have been Accepted and Endorsed.

• Applied finishes: The design of the components, selection and application of finishes, and installation procedures shall ensure a high standard of applied finish protection during construction. The Contractor shall develop and implement procedures to eliminate scratches, marks and blemishes to finished surfaces during constructions. Indicate procedures in the installation procedures.

• Flatness and alignment: The design of the components, fabrication and installation procedures shall ensure a high standard of flatness, joint and edge straightness, and alignment of mating surfaces of joinery. Close attention shall be given to cutting and cut edge treatment procedures, stiffening and the tightening of fixings and fastenings which may cause distortion or warping.

• Exposed sealant: Indicate all sealants and gaskets on shop drawings. Indicate the anticipated service life and method of replacement for all sealant and gasket components. No exposed sealants of any type, structural, weather smoke or otherwise shall be permitted in any of the finished external works which will be exposed to public view unless specifically indicated in the contract Drawings or subsequent Instructions by AAI/PMC. In the event that internal sealants are required as a remedial measure to alleviate a leaking building envelope, the Contractor shall be held liable for compromising the aesthetic integrity of the finished building envelope.
3.34 Maintenance Requirement

- General: Provide design of the building envelope systems to allow for all BMU/cherry picker loads which may occur.

- Retaining pins for the BMU are to be provided by the BMU Contractor to the curtain wall assembly factory, and are to be fixed to the curtain wall system by the Contractor.

- Damage: Horizontal or near horizontal surfaces, which form part of the building envelope systems such as copings, beam encasements, ledges, or the like, shall be designed to carry human live loads from maintenance personnel.

- Self-cleaning: The design of all components for the contract works shall be such that their configuration shall facilitate the self-cleaning of the various systems. Inclined drainage surfaces and flashings, properly designed drip grooves and self-cleaning joint design are examples of this requirement.

- Panel replacement method: The Contractor shall design and install the building envelope systems to allow for the future replacement of any individual panel. The Contractor shall submit details and procedures for replacing individual damaged items as part of the shop drawings.

3.35 Base Building Tolerances

- The building envelope shall be designed to accommodate the primary structure construction tolerances.
- Unless otherwise noted elsewhere, the maximum construction tolerances shall be taken as follows:
  - Plan position of the building edge: +/- 25 mm
  - Level of slab surface and slab soffit: +/- 25 mm
  - Deviation in plan over 20M height < 50 mm
3.36 Fabrication Tolerances

- Tolerances at joints and junction details shall take precedence over tolerances of panels and major components.

- Tolerances generally shall be:
  - Joint width: +/- 1 mm.
  - Length and width of major components: +/- 0.5 mm.
  - Diagonals of major components: +/- 1 mm.
  - Aluminum extrusions generally: 50% ADCA standards.
  - Misalignment of mating surfaces: +/- 0.5 mm.

- Submit a schedule of fabrication tolerances for all major building envelope systems components.

- Indicate extremes of allowable base building tolerances on shop drawings.

- Aluminum tolerances regarding thickness, straightness, twisting and flatness generally exceed 50% of ADCA Aluminum Standards and Data-Wrought Products.

- Aluminum sheets for cladding panels shall be tension leveled.

- Flatness of AAI/PMC’s stainless steel shall be not less than "stretcher level" graded. Submit manufacturer's specifications for review and Acceptance.

3.37 Installation Tolerances

- In addition to required fabrication tolerances, all parts of the building envelope for the contract works, when completed, shall be within the following tolerances:

  - Position on plan, or vertical surface: +/- 3 mm.
  - Deviation in alignment: Not more than 1 in 300
  - Deviation in level (horizontal): Not more than 1 in 300
  - Deviation in plumb (vertical): Not more than 1 in 800
  - Offset in alignment of adjoining surfaces: +/- 0.5 mm.
  - Offset in alignment of separated surfaces: +/- 1.5 mm.
  - Bracket fixing tolerance: Not more than 1mm.

- The Contractor shall check at site the cumulative effect of all building tolerances and adjust installation procedures as required.

3.38 Environmental Considerations

- General:
  Design and warrant the building envelope system to be water tight, weather proof and have the required acoustic performance.
Self-Generated Noise:

- Design and install all building envelope systems (generally and all components) to provide for noiseless movement caused by thermal expansion and when subject to dynamic loading caused by wind as well as live loads, Building Maintenance Unit (BMU) and cleaning operations.
- The system shall not generate noise due to creaking, drumming or rattle.
- All building envelope surfaces shall not whistle due to wind.

Thermal Properties:

- The overall heat transfer of the building envelope shall satisfy Overall Thermal Transfer Value (OTTV) requirements of AAI/PMC, and the heat transfer coefficient of the building envelope systems shall not exceed 45W/m2.
- Spandrel glass and other non-vision areas shall have a minimum Thermal Conductance of 0.6 W/m2K, and shall comprise of sealed Aluminum foil backed insulation panel. (USG Thermafibre 50mm thickness or equivalent subject to Acceptance by AAI/PMC).

- The contractors design and build curtain wall frame system assembly including vision and spandrel area U value should not exceed 2.1 W/m2K (0.37 Btu.hr/sqft/F)

- The insulation shall be 1.5mm thk powder coated Aluminum back pan faced, Aluminum foiled at rear side and sealed to the Aluminum frame to prevent condensation in the cavity between the insulation and the glass

Lightning:

- Provide electrical continuity and conductivity within the building envelope systems.
- Include connections and provide earthing straps for connection to the building conductors by the Electrical contractor.
Smoke isolation and Fire Separation:

- Design entire system to provide smoke isolation between every floor at all levels and elsewhere as required.
- Provide baffles fixed and sealed between base structures and building envelope systems.
- Submit details on shop drawings for review and Acceptance.
- Provide materials and methods of fabrication, installation and sealing which meet the statutory requirements.
- Use materials which are non-corroding, or protected against corrosion, or of such thickness that corrosion will not impair the required fire stopping or smoke flashing function during the service life of the system.
- The gap between the building envelope and the concrete slab edge shall be filled with an insulation material with a 2-hour fire resistant period that is accepted for use by the relevant local Authorities and Accepted by AAI/PMC.

Air-Tightness:

- In addition to the requirements for a drained joint system, the design and installation of the air sealing shall be carried out to high standards (ASTM E283) to minimize air-filtration.
- Co-ordinate with installers for adjacent work to achieve the specified maximum air filtration at junction with building envelope systems.
- Air infiltration and exhaust limits shall be confirmed through testing.

Acoustic Performance

- The cladding systems shall be designed to meet the external noise intrusion criteria contained in BS 8233. The Contractor shall provide the acoustic performance specified.
- Reference shall be made to the Acoustic Specification for full details of the acoustic performance criteria.

Terminology and acoustic rating:
- Façade sound insulation refers to the sound insulation between the exterior and interior of the building.
- Horizontal flanking sound insulation refers to the situation where partitions connect to the exterior walls and sound is transmitted from one space to another via the cladding.
- Vertical flanking sound insulation refers to the transmission of sound, via the cladding, from one space to another above or below.
- Acoustic rating values shall be calculated in accordance with BS EN ISO 717: Part 1.

**Test samples:**

- The tested sample(s) shall be representative of the cladding to be installed including typical joints and all other elements that may affect the sound insulation.

**Façade sound insulation:**

- The cladding shall provide the following minimum laboratory sound insulation performance:
  - Minimum Sound Reduction Index (dB)
    
    | Octave band centre frequency (Hz) | 125 | 250 | 500 | 1k | 2k | 4k |
    |-----------------------------------|-----|-----|-----|----|----|----|
    | Exterior walls (let table space and plant rooms) | 25  | 27  | 31  | 35 | 34 | 29 |

  - A deficit of up to 2dB in any octave band may be acceptable, at the discretion of AAI/PMC, provided that the arithmetic of positive and negative deviations from the figures tabled above is greater than or equal to zero.

**Horizontal flanking sound insulation:**

- The cladding shall provide a minimum Weighted Normalised Flanking Level Difference (Dn,f,w) of 45dB.
  - The Weighted Normalised Flanking Level Difference (Dn,f,w) shall be measured in a UKAS accredited laboratory in a way similar to that for Dn,c,w described in BS EN 20140: Part 9
  - Laboratory measurement of room-to-room airborne sound insulation of a suspended ceiling with a plenum above it.

**Vertical flanking sound insulation:**

- The cladding shall provide a minimum Weighted Normalised
• Flanking Level Difference (Dn,f,w) of 45dB when measured in a way similar to that described for horizontal flanking transmission.

4.0 MATERIALS & FINISHES:

4.1 ALUMINUM:

• Provide Accepted aluminum extrusions and/or sheet of alloy and grades suitable for the structural requirements, applied finishes and project conditions not less than the strength and durability properties of the alloy and temper designated in the relevant Standards. Submit details including proposed alloy types with supporting justification data for review and Acceptance.

• All aluminum materials shall be of consistent high quality regardless of source.

• Manufacturers shall be accepted established manufacturers with a reputation for producing high quality materials with a minimum of 5 years documented continuous track record. Submit details for review and Acceptance.

• Mill finish on non-visible surfaces will not be acceptable.

• Submit manufacturer's certificate of compliance or test report for each batch of aluminum supplied.

• Each batch shall be suitably identified and cross referenced with the certificate.

4.1.1 ALUMINUM EXTRUSION

• Aluminum extrusion shall be of Alloy 6061 / 6063 T5/T6 confirming to BS 1470 / BS 1471 / BS 1473 / BS 1474

• Minimum wall thickness for the structural members shall be 2.5mm & non structural member shall be 1.5mm thk.

• The extrusion tolerances shall confirm to BS EN 12020 In case of Aluminum structural support brackets the Alloy shall be 6005 grade & T5 temper.

• Extruded profiles shall be free from die lines, pressure marks, scratches or graphite lines.

• The Extrusions Shall have the webs, walls & flanges of sufficient thickness and eliminated permanent distortion of elements in the finished works

• Extruder shall subject to quality review by consultants
• All matching sections should be extruded with single extruder to avoid profiles mis match

• Solid Aluminum sheet shall be of Alloy 5005 H14 Series

• Solid Metal Panels shall be designed, fabricated & installed in such a manner that the panel should be flat when viewed from any time & any angle.

• Distortions, waviness, ripples shall not permitted in any solid metal panels.

4.1.2   FINISH TO ALUMINUM PROFILES
No part of Alumminum to be left in mill finish. Different types of coatings/finishes applicable to Aluminum are as follows:

4.1.3   PVDF COATING: All External Visible Profiles. (2 Coat system)
• PVDF finish shall be Kynar 500 or Trinar based PVDF / Acrylic blends should not be less that 70% PolyVinylidene Flurode resin.

• The film thickness shall be minimum 35 micron.

• PVDF coatings shall be with solar reflective properties to be used.

• The finish to confirm as per AAMA 2605 and the paint manufacturer’s specification.

• The coating manufacturers shall be as per Approved make (Annexure 1).

• Surface shall not show any dents, scratches, die lines, scratches etc.,

4.1.4   POWDER COATING (High Durability or Super Durable Powder Coating) Internal Visible Profiles
4.1.4.1   GENERAL

• High Durability / Super durable powder coating shall be factory applied by electrostatic spray.

• The finish to confirm as per AAMA 2604

• Coating thickness for single coat shall be 65 to 80 micron with 10 years warranty

• Aluminum, surfaces shall be pre treated in accordance with ASTM B449 under chromates Class 1 to provide maximum corrosion protection.

• Use a single supplier & applicator throughout production to ensure consistency.
• The coatings are to be free of flow lines, streaks, blisters, pin holes, tears, damage & other surface defects.

• Powders shall be of thermosetting and super durable type. It must be Lead, Cadmium and TGIC (triglycidyl isocyanurate) free, to ensure strict environmental compliance. The powder manufacturer shall provide written confirmation on this item.

4.1.4.2 Colour and Finish

• The colour and gloss range samples shall be submitted to AAI/PMC for Acceptance. The two (2) samples in each set shall represent both the degree of specular gloss, and the lightest and darkest shades of that colour that will be acceptable. For colour of coatings, refer to Finishes Schedule.

• Aluminum surfaces shall be pre-cleaned in accordance with the procedures recommended by the paint manufacturer. Aluminum surfaces shall be pre-treated in accordance with ASTM B 449 Class1.

• All coatings, when cured, shall be visibly free of frowziness, streaks, sags, blisters or other surface imperfections or defects.

• The Contractor shall provide a compatible air-dried coating for field touch-up as recommended by the coating manufacturer and based on, at the minimum, the standards set out in AAMA 2605 for external surfaces and AAMA 2604 for internal surfaces, to match the factory-applied finished work.

• Touch-up sample should be provided to AAI/PMC for Acceptance, prior to the commencement of painting.

4.1.4.3 Quality Records and Testing:

• Relevant standards the Contractor shall comply with:
  • AAMA-2605:1998: Colour uniformity
  • AAMA-2605 & ASTM B244-97: Film thickness
  • AAMA-2605 & ASTM D523-89: Specular gloss at 60° viewing angle
  • F-2H ASTM D523-89: Pencil hardness
  • ASTM D1737-62: Post formability, 180 degree bend around 3mm mandrel
  • AAMA-2605 & ASTM D3363: Film adhesion
  • ASTM D968-93: Abrasion resistance, 65min
  • AAMA-2605-98: Chemical resistance
  • AAMA-2605-98: Corrosion resistance
Fed Test 6152, Fed Stds 141a: Weatherthermometer 500 hv exposure
ASTM D714-02 & ASTM D2247-02: Humidity 3000hrs exposure at 100% relative humidity
ASTM B117-02 & ASTM D714-02: Salt spray 3000hrs in salt fog at 95°F
ASTM E84: Flame test

In addition to the standard tests listed above, the coating shall comply with the following:

- Colour shall be in accordance with AAI/PMC’s selection as per the accepted control samples.
- Powder coatings shall be in full compliance with AAMA 2605 for external surfaces and AAMA 2604 for internal surfaces.
- Coating thickness for single coat system to be at least 65 to 100 microns and must be of superdurable polyester grade.
- Powder coatings shall be warranted for a minimum period of 10 years.
- Powders shall be of thermosetting and super durable type. It must be Lead, Cadmium and TGIC (triglycidyl isocyanurate) free, to ensure strict environmental compliance. The powder manufacturer shall provide written confirmation on this item.
- Aluminum surfaces shall be pre-treated in accordance with ASTM B 449 (Standard Specification for Chromates on Aluminum) under chromates Class 1 to provide maximum corrosion protection.
- To ensure optimum weather ability, coated panels must be initially submitted to an independent laboratory for accelerated tests for 3000 hours. QUV A tests must have at least 80 % gloss retention and colour change shall not exceed 5 delta units.
- During production, large size standard colour range samples will be used to compare production colours with the Accepted colour range samples. Upon completion of coating and prior to sealing, each production part will be inspected for comparison of colour range and overall uniformity of appearance.
- Materials shall not be shipped, delivered or supplied when the finish of such material:
  - has not been inspected and tested in the manner and by the means described above;
  - Does not meet all the specifications for the finishes set forth in all the manufacturer’s instructions;
Does not fall within the colour range Accepted by AAI/PMC.

Has not otherwise been processed in accordance with these specifications.

Coatings shall be factory applied and records of samples of the entire coating production shall be maintained. The program of records shall be proposed by the Contractor for Acceptance by AAI/PMC. Records and samples shall be made available to AAI/PMC at his request.

Notwithstanding the Acceptance and implementation of the above-mentioned programmes on samples, quality control and field touch-up air-dried coating systems, any installed work with coating defects or variation in colour or tonality in excess of the Accepted sample range will be subject to rejection by AAI/PMC.

4.1.5 ANODIC COATING

4.1.5.1 GENERAL

• All visible Aluminum panel profiles shall have minimum 20 micron neutral anodic coating, class A

• Confirms to BS 3987 : 1991 Specification for anodic oxidation coatings on wrought aluminum for external architectural applications


• Anodizing shall be hot sealed to close the porosity in the anodic surface for resistance against atmospheric attack

• The minimum coating weight shall be 5.5 milligrams/cm²

4.1.5.2 Colour and Finish:

• Refer to Table Vol.II, Sec.9 Finishes Schedule and Accepted control samples for required colours, gloss, texture, patina and the like.

• There shall be two sets of three range samples 600mmx 600mm in each set representing both the degree of specula gloss and the lightest, median and darkest shades of that colour
to be accepted for use on the project. (One set is to be used by the Anodiser and the other by AAI/PMC for checking).

- Materials acceptable shall be clear (or natural) anodised to AAMA 607.1 or colour anodised to AAMA 601. The etched surface shall be permanently sealed. The etched surface shall have 25 microns minimum of material removed from all exposed surfaces.

- Surfaces to be finished shall be free from imperfections, scratches, scrapes and dents. When the finish is applied, all coatings when cured shall be visibly free of spots, stains and streaks.

- AAI/PMC reserves the right to reject any panels which do not conform to the specification or which he considers visually unacceptable based on the accepted controlled samples.

4.1.5.3 Quality Records & Testing

- Submit manufacturer’s production and test records prior to shipping materials to site.

- Each batch shall be tested for film thickness and the batch number referenced to the delivery documentation for traceability. Testing shall be performed by an Accepted testing laboratory.

- Colour testing shall be carried out an all batches using a Gardiner XL-S Colour meter.

4.1.6 CHROMATIZING : All Non Visible Profiles

- All Non visible Aluminum Profiles shall have achromatizing treatment to improve resistance to corrosion

- Comply with ASTM D 1730 Standard Practices for Preparation of Aluminum and Aluminum-Alloy Surfaces for Painting

- Process shall be as follows.

  - Step 1: Clean - Alkaline or acid uniform mild etching, 1 to 5 minutes, 140 to 180 Deg. F
  - Step 2: Rinse - Water rinse - 30 seconds - Ambient temperature
  - Step 3: Deoxidize - Acid - 1 minute - Ambient temperature
  - Step 4: Rinse - Water rinse - 45 seconds - Ambient temperature.
  - Step 5: Conversion Coating - Amorphous Chrome Chromate - 45 seconds - 75 to 90 Deg F.
• Step 6: Rinse – Water rinse – 30 seconds – Ambient temperature.

• Step 7: Final Rinse – Acidulated rinse or water with T.D.S Less than 300 ppm - 15 seconds - Ambient Or may be heated to 150 Deg F to facilitate drying.

• Coating weight – Coating weights of these coatings are required to be in the range of 30 to 100 mg/sq.ft.

• Minimum Requirement – Coating weight should be minimum of 431 mg/m² or 40 mg/ sq.ft.
4.1.7 QUALITY AND CERTIFICATION

• Submit manufacturer’s certificate of compliance or test report for each batch of aluminum supplied.

• Each batch shall be suitably identified and cross referenced with the certificate.

• Quality control measures shall ensure that materials are inspected before shipment. Where the required testing has not been done, finishes requirements are not satisfied, does not fall within the colour range Accepted by AAI/PMC, or has not been processed in accordance with the specification, then it shall not be shipped.

4.1.8 ALUMINUM WELDING

a) General:

Carry out all welding, including detailing of all joints, welding procedures, appearance and quality of welds, and correction of defective work in accordance with approved samples and AS 1665 welding of aluminum structures.

Welded parts shall be accurately fabricated to ensure proper fit. All welding equipment shall be of suitable type and in good condition.

b) Weld Testing:

If required, perform weld testing by an independent testing laboratory. Submit test results. In the event of test failure, rectify the defect and repeat the test.

c) Experience of Welders:

Welds shall be made only by welders who have previously been qualified for the type of work required. Submit certification for each welder.

d) Procedures:

Submit details of proposed welding procedures before commencing.

Other than site welds indicated on Accepted shop drawings, do not weld on site. Where practical, locate site welds in positions for down hand welding.

Do not weld:
i. Finished surfaces.

ii. Adjacent to finished surfaces or glass, unless adequately protected from damage.

e) Finish:
Finished welds shall be de-scaled and free of surface and internal cracks, and free of porosity.

4.2 SILICON GASKET

- All exposed weather gaskets shall be of Silicon Gasket
- Comply with ASTM C1115: Standard Specification for Dense Elastomeric Silicone Rubber Gaskets and Accessories
- Silicone gaskets shall be Grey in color unless specifically asked for.
- All gaskets must be resistant to oxidation, Ozone & UV degradation.
- Where indicated on the Drawings or required, provide Accepted co-extruded profiles of polypropylene and polypropylene compatible products.

- Warranty:

  The gasket should be warranted for the warranty period.

4.3 EPDM GASKET

- All unexposed weather gaskets shall be of EPDM micro wave cured gaskets confirming BS 4255
- Shore A Hardness shall be 75 +/-5 for Solid Profiles & 60 +/-5 for Hollow Profiles confirming to ASTM D2240
- All gaskets shall be black in color unless specifically asked for
- All gaskets must be resistant to oxidation, Ozone & UV degradation.
- Inaccessible gaskets should remain effective during the life time of the building to ensure the water tightness
- Where indicated on the Drawings or required, provide dense profiles including flashings, wiper seals and the like, complying with ASTM C864, as follows:
Shore A durometer hardness: 75 +/- 5 for solid profiles and 60 +/- 5 for hollow profiles when tested in accordance with ASTM D2240.

Compression set 100% (168 hrs): Not greater than 40% when tested in accordance with ASTM D395.

4.4 SCREWS & FASTNERS

- All Bolts & Nuts for non visible area shall be Stainless steel A2 grade (304 Grade) confirming to BS 6105.
- All Bolts & Nuts for Visible area shall be Stainless Steel A4 Grade (316 Grade) confirming to BS 6105
- Screws and fasteners threading shall confirm to DIN standard or equivalent.
- Tightening Torque shall be as per Manufacturer recommendation by Torque Wrench only

4.5 CAST IN CHANNELS & ANCHOR BOLTS

- The cast in channel of MS Hot dipped galvanized form as per approved make (Annexure-1) with T bolts of grade 8.8.
- Channel shall be installed with polystyrene insets & plastic end caps
- Channel Size (Length / Width / Thickness / No of Studs) shall be checked for the most extreme loading conditions.
- Cast in channels comprise of Channels, rivets & anchor made of Hot rolled steel with hot dip galvanized of minimum 50 micron complete with polystyrene insets & plastic end cap
- The cast in channels need to have European Technical Approval (ETA), i.e. with the CE mark.
- The anchor bolts shall be as per approved make (Annexure-1) Stainless steel grade SS 316 confirming to grade A4 of BS 6105.
- Anchor bolt design loads shall confirm with E 488 - Strength of anchors in concrete and masonry elements.
4.6 SEALANTS

4.6.1 GENERAL

• The sealants shall be as per approved make (Annexure-1) with warranty of minimum 15 yrs.

• All Glazing & Sealants shall be complying with Manufacturer’s (Sika / DowCorning / Momentive) recommendations & relevant standards in the tender specification.

• Comply with minimum dimensional requirements for edge clearance, edge cover, front clearance, back clearance, and as required by AS 1288, GANA and sealant manufacturer.

• Relevant Standards:
  o AAMA CW 13 - Structural sealant glazing systems (A Design Guide), Aluminum Curtain Wall.
  o Dow Corning - Structural Glazing: Industry Code of Practice.

• Sealant manufacture shall be providing testing for adhesion, compatibility & non staining.

• All structural sealants shall use design strength of 140 kPa. (Tensile Stress)

• For structural glazing application, only trained person & experience person shall be eligible for glazing

• All sealants shall be compatible with substrates, materials, sealants.

• All Exposed weather sealant shall be high performance non staining / non beading weather sealant

• Manufactures standard test report & certificates shall be submitted including details of the following test

• Adhesion testing to determine if the proposed sealants will adhere to the project specific substrates such as glass and aluminum.

• All specimens shall be tested to ASTM C794, both primed and unprimed and be subjected to water immersion.

• Seven days immersion is required for structural glazing sealants, and one day immersion is required for weather seals
• Compatibility testing to determine if project specific glazing accessories, such as spacers, gaskets and setting blocks, will discolour the sealant or cause adhesion loss to the substrate.

• All specimens shall be tested to ASTM C1087, an accelerated laboratory procedure using UV light exposure from UVA 340 bulbs to determine if the proposed sealants and substrates are chemically compatible

• Stain testing is required to, if porous stone is used on the project.

• All stone substrates shall be tested to ASTM C1248, a test method that describes an accelerated laboratory procedure to predict the migration of plasticizers from the sealant into porous substrates such as granite, marble, sandstone, and masonry.

• All testing shall be completed prior to the commencement of sealant application.

• No final fabrication or installation will be permitted until all sealant testing is complete.

• Where sealants are used to seal movement joints, movement capability of sealant shall be appropriate to expected maximum deflection or movement.

• Unless otherwise accepted, sealant depth for movement joints shall not exceed half the joint width.

• Fabricator to submit the purchase receipts of all sealants from approved manufacturers.

4.6.2 FIRE RATED REQUIREMENTS

• Provide Accepted fire-rated sealant and joint fillers where indicated or required. Submit test results indicating fire rating and compliance with Regulatory requirements. All fire rated products shall comply with the Relevant Indian Standards.

• Fire rated fillers may include elastomeric sealants and rigid dry foam fillers.

• Rigid dry foam fire rated fillers which may be accepted include Epirez "Fire master", or equivalent.

• Where dry foam fire rated fillers are proposed for wall types which also have acoustic or air infiltration requirements, provide an elastomeric cover bead.

4.6.3 Coloured Sealants:

• Provide coloured or paintable sealants where required in accordance with Accepted samples.
• Sealants shall be resistant to staining due to dirt or pollution, and shall be capable of cleaning.

4.6.4 Sealant Accessories:

• Provide all required accessories recommended by sealant manufacturer, including backing rods, bond breaker tape and the like. Submit details for review and Acceptance.

4.6.5 Quality Assurance for Structural Glazing

• Deglazing should be used as method of quality inspection for units which are structurally glazed.

• Deglazing is used to confirm good adhesion and proper fill of the structural joints.

• Deglazing involves completely detaching the glass from the frame.

• The structural silicone sealant should be tested for adhesion to both the glass and the frame.

• The inspection should include the following:
  • Size of Structural Bite
  • Size of Structural Glue line
  • Adhesion of Silicone Sealant with glass and frame
  • Joint type/Condition of Sealant applied
  • Appearance of the sealant/uniformity of color/bubbles, etc.

• Deglazing frequency should be performed according to the following schedule
  • 1 unit out of the first 10 units manufactured (1/10)
  • 1 unit out of next 40 units manufactured (2/50)
  • 1 unit out of next 50 units manufactured (3/100)
  • 1 unit out of every 100 units manufactured thereafter.

• A deglaze report should be completed after each test and this should be submitted as part of the warranty application.
4.6.6 MANUFACTURER’s STANDARD TEST DATA

• Submit manufacturer’s standard test reports and certificates previously performed on proposed sealants, including details of the following characteristics:
  o Chemical composition.
  o Adhesion, bond strength, cohesion or tensile strength, and elongation.
  o Compatibility.
  o Hardness and viscosity.
  o Colour stability.
  o Compression set.
  o Low-temperature flexibility.
  o Modulus of elasticity.
  o Water absorption.
  o Effects of exposure to ozone and ultraviolet light.
  o Stain resistance.

• Include adhesion characteristics for all relevant surfaces including applied coatings to aluminum, glass and adjacent sealants and gaskets.

• Include statement of differences between the proposed sealants and previously tested products, if any.

• Include long-term aged performance or accelerated exposure performance for the above characteristics.

4.6.7 SITE QUALITY ASSURANCE

• For substrates which cannot be tested in a laboratory, such as concrete, a site adhesion test should be performed to joint substrates, prior to installation of the sealants at site.

• The site adhesion test can be performed on a trial joint which has been sealed at site and allowed to fully cure for a minimum of seven days.

• For all site applied joints field adhesion testing should be performed and results of tests submitted.

• Provide documentation for site adhesion testing at the following rate.
• Adhesion testing should be performed once per floor per elevation.

4.6.8 INSTALLATION

• Install materials in accordance with the manufacturer’s printed instructions, unless otherwise specified and documented.

• Clean all substrates to be sealed using the solvent recommended in the sealant manufacturer’s laboratory adhesion report.

• Suitable solvents include isopropanol, MEK and xylene, but recommended solvent will depend on substrates being cleaned.

• Use masking tape or other precautions required to prevent contact of sealant or primer with adjoining surfaces which could be permanently stained or damaged by cleaning methods required to remove sealant smears.

• Remove tape immediately after tooling without disturbing sealant.

• Prime all substrates recommended by the sealant manufacturer, based upon adhesion testing.

• Primer should be applied before installation of spacer or backer rods.

• Install spacer tape for structural joints, as shown on approved drawings.

• Install backer rod for weather seal joints as recommended by the sealant manufacturer, to prevent 3-sided adhesion, which can impair the performance of the sealant.

• Do not puncture the surface of polyethylene backer rods.

• Apply sealants in continuous beads filling joint from the bottom without openings, voids or air pockets so as to provide a watertight and airtight seal for the entire joint length.

• Apply sealants in the depth shown or apply in accordance with the manufacturer’s recommendations.

• Apply elastomeric sealants, in field joints to a depth equal to half of the joint width, but not less than 6mm and not more than 12mm.

• Immediately after sealant application and prior to skinning, tool sealants to form smooth, uniform beads and to ensure contact and adhesion of sealant to sides of joint.
• Remove excess sealant from surfaces adjacent to joint.

• Do not use tooling agents.

• Only trained glaziers to be used.

4.6.9 CURE & PROTECTION

• Cure sealants in accordance with the manufacturer’s instructions, to obtain maximum bond to surfaces, cohesive strength and durability at the earliest possible date.

• Protect sealants during the remainder of the construction period, so that they will not be subjected to damage before the time of acceptance by the Owner.

4.7 LOUVERS

• Provide Accepted proprietary louver assemblies complete with all accessories and fixings, together with structural calculations for blades, frames, fixings, and blanked off sections.

• Submit drawings and details including structural and test data for review and Acceptance.

• Unless otherwise indicated on Drawings, finish shall match adjacent cladding system finish.

• Design and/or select external louver assemblies to withstand the required design wind pressure without failure or permanent distortion of members, and without blade flutter.

• Structural frames and stiffening rib members shall not deflect by an amount greater than span/240 when tested the required design wind pressure.

• Where required for access, provide framed and hinged louvered access doors to match appearance of the adjacent louvers.

• Install louvers into frames by methods which resist unauthorized removal, but can still be moved by authorized personal.

• Insect wire-mesh
Provide Accepted concealed stainless steel grade 316 insect wire meshes to the interior of all external louver assemblies, and blank off plates to all other false louvers. Mesh opening shall not exceed 5 mm and shall be 1.6mm minimum thickness.

4.8 BRACKETS, FIXINGS & ANCHORS

GENERAL

- Design and provide all connections, brackets and fixings by Accepted methods so that all loads can be transferred from the building envelope system to the base structure in accordance with the design criteria and in a manner that prevents excessive joint displacement, slippage or distortion.

- All components are to be designed for the maximum tolerance of the system, and due consideration shall be given to additional forces from prying action and bolt group effects.

- There shall be no direct fixing or close contact between any part of the building envelope system and the base structure or internal linings, except through Accepted bracket connections.

- Brackets and related components shall be scheduled and described in detail on shop drawings.

- Show details of all related components and connections to areas by others.

4.8.1 Brackets

- All fixing brackets shall be Mild Steel with Hot Dip Galvanized or Aluminum Alloy of 6005 T5 or Stainless Steel (SS 316 Grade)
- Brackets shall be resist all loads, movements & dimensional changes that may occur in the building due to thermal changes, deflections, settlement & creep
- Use locknuts to prevent loosening due to movements / Vibrations
- Brackets shall accommodate the three dimensional building tolerance with serrations / serration washers
- Fixings shall be corrosion resistant, and non-staining to adjacent work.
- Fixings shall be concealed unless otherwise accepted in the drgs.
4.8.1.1 Base Building Substrates

- Provide contingency design and installation procedures for all typical substrate conditions and deficiencies including:
  - Reinforcement clash.
  - Excessive out-of-tolerance concrete.
  - Clash with concrete joints, and other structural details.
  - Mislocated, missed and incorrect embedment.

- Check all base structure reinforcement locations. Coordinate with AAI/PMC and refer to structural drawings to establish bracket fixing locations. Verify relationship between brackets and concrete reinforcement on shop drawings.

4.8.1.2 Anchors

- Provide anchors and other methods of attachment of the building envelope system to the base structure which:
  - Are compatible with the bracket assembly and together provide three-way adjustment to accommodate fabrication and construction tolerances.
  - Fix the building envelope system in its correct position providing for building and building envelope movements.
  - Are structurally adequate to carry the design loads for the worst possible bracket positioning.
  - Comply with all local Authorities requirements.

4.8.1.3 Fixing Brackets

- Design fixing brackets for the worst possible panel eccentricity, packing location, and uneven load sharing. Include prying effects on bolt groups.
- Design and install brackets so that all building envelope loads are transmitted through brackets and prevent transfer of loads through panel joints to adjacent panels.

4.8.2 Bolts, Nuts & Washers

- Stainless steel bolts & nuts shall comply with BS 6105, Strength A4, Class 80.
- Stainless washers comply with BS 1449: Pt2. Grade 316 S 31.
- Stainless steel bolts & nuts shall be corrosion resistant.
4.8.3 **HSFG Bolts**

- High Strength Friction Grip Bolts and associated nuts and washers shall comply with BS 4395: Part 1 unless otherwise specified. Contact surfaces shall be left unpainted or prepared as otherwise indicated on the shop drawings. HSFG Bolts shall be installed in accordance with BS 4604 using a wax based lubricant and coronet type load indicator washers or as Accepted by AAI/PMC.

4.8.4 **Holding Down Bolts**

- Holding down Bolts and associated nuts and washers shall be galvanised Grade Class 4.6 to ASTM A307 or BS 4190 unless otherwise specified.
- They shall be rigidly held in place at the top and bottom by tack welding to mild steel links before galvanising.
- They are to be located using a template that is firmly secured to the formwork or reinforcement.
- The threaded length is to be sufficient to take up all construction tolerances, and is to be protected by taping and covering where impact damage may occur.

4.8.6 **Screws / Studs**

- All screws shall be stainless steel, those located outside the air seal line shall be SS 316 & located behind the air seal shall be SS 304

4.8.7 **Masonry Anchors**

- All Anchors shall be installed in accordance with the manufacture's requirements
- Contractor is responsible for confirming the all edge distance, spacing and embedment requirement are satisfied

- Minimum distance from the concrete edge to the nearest part of the anchor : 100mm
- ASTM E488 - Standard test methods for strength of anchors in concrete & masonry elements
- BS 5080 : Methods of test for Structural fixings in concrete & masonry
- BS 5080.1 : Tensile loading
- BS 5080.2 : Method for determination of resistance to loading in shear

4.8.8 **Anchorage to Superstructure:**
1. **General:**

- Provide proprietary anchorage, with corrosion-resistant finish, suitable for the substrates and conditions, with holding power at least 10 x design load. The selected anchorage system shall be accepted for use by AAI/PMC.

- Products which may be used include those manufactured by Hilti or Fischer, or equivalent as accepted by AAI/PMC.

- Do not use explosive shot fired devices unless accepted in writing before commencing installation.

2. **Channel anchorage:**

- Provide channel anchorage in hot-dip galvanised steel or Grade 304 stainless steel where required, complete with polystyrene insets and plastic end caps. Anchorage system shall be accepted for use by AAI/PMC.

- Channel length, tail size and tail locations shall satisfy the most extreme loading conditions allowed for in the structural calculations.

4.8.9 **Anchorage and Bracket Installation**

- Anchors to installed concrete substrates:

  - Install mechanical and/or chemical anchors as required to support the work by Accepted methods into base-structure. Submit details of proposed methods and obtain Acceptance in writing prior to commencing installation. Comply with hole diameters, spacing, depth and minimum edge clearances indicated on accepted shop drawings.

  - Be responsible for providing setting out details for all cast-in. Check building structure setting out prior to concreting to confirm that cast-in items are correctly positioned.

  - Refer to Drawings for concrete reinforcement locations, and position anchors to minimise risk of conflict with reinforcement.

  - Do not install anchors into post-tensioned concrete structures, void sections of precast concrete panels, and non-conventional concrete structure, unless accepted in writing.

  - Accepted methods may include drilling, pre-formed pockets, or explosive driving. Select and install anchors strictly in accordance with manufacturer's instructions.
Relevant Standards:

a) ASTM E488 - Standard test methods for strength of anchors in concrete and masonry elements.
b) BS 5080 - Methods of test for structural fixings in concrete and masonry
c) BS 5080.1 - Tensile loading.
d) BS 5080.2 - Method for determination of resistance to loading in shear

Anchor placement tolerances:

Install anchors to not exceed:

a) Maximum deviation from correct position: +/- 12 mm.
b) Minimum distance from the concrete edge to the nearest part of the anchor: 100 mm.

Testing of built-in anchors:

Carry out testing of installed anchorage in accordance with ASTM E488 and a testing programme to be submitted to AAI/PMC for review and Acceptance before commencing.

Anchors shall be tested to demonstrate:

a) No permanent deformation of the anchor at 1.5 x the design load.
b) No failure of the anchor at 2 x the design load.
c) No failure of the structural concrete at 3 x the design load.

Testing shall be carried out by the anchor manufacturer or an at an Accepted laboratory.

Submit full report on proposed testing procedures, including any additional test criteria proposed, substrate inspections, and the like.

Submit test results and reports on unsuitable substrates, progressively, if found.

Testing of anchors to installed concrete soffits

Test anchors supporting loads suspended from concrete soffits as follows:
a) Test the first 10 anchors installed.

b) If any of the first 10 fail, re-install and re-test failed anchors and test a further 10 anchors.

c) Repeat until no anchors fail.

d) Test 1 in 40 of subsequent anchors.

e) If any subsequent anchors fail, re-install and retest, together with 5 additional tests on the previous 40 anchors.

f) Repeat until no anchors fail

4.9 FIRE STOP AND SMOKE SEAL

- The fire stop for 2 hr Fire rating with smoke seal at all floor slab levels required as per local fire authority.

- Fire stop shall be designed to allow for movement

- 100mm thk and 100 Kg/m3 density of Rockwool slab with 1.5mm GI flashing to hold the assembly shall be fixed in compressed form between the gap of Building RCC and Curtain wall system at soffit / Floor level.

- Fire Stop Mineral Wool to be compressed by 33% in installed state leaving no voids and assuring a tight seal.

- Smoke seal intumecent of 10mm shall be applied in the gap of top side GI flashing and curtain wall assembly.

- Fire rated fillers may include elastomeric sealants and rigid dry foam fillers. Rigid dry foam fire rated fillers which may be accepted include Epirez "Fire master", or equivalent.

- The whole assembly also to act as acoustic assembly between the floors.

- The fire stop assembly shall run vertical side where there is a shear wall condition or break in horizontal fire stop.
• The floor closure shall be provided continuously at floor level with 1mm thk GI flashing with USG Fire safing (or Accepted equivalent) closing gap between transom and building line with minimum of 10mm gap filled with smoke seal intumecent.

• The complete assembly to be tested for performance at approved laboratory as per ASTM standards.

• Smoke seal shall be Hilti CP 611 A or Sika FS 665

• contractor shall be submitted test result for all Fire rated material.

4.10 SPACER TAPE

• Spacer tape shall be Open PU cell

• Open PU Cell structure shall allow air & moisture to reach the silicon, permitting optimum curring.

• Spacer tape shall be chemically compatible with all silicones, non-gassing and non-staining.

• Where tapes are exposed in glazing rebates they shall be continuous and of uniform color.

• They shall align with the glass edge to within +/- 1mm.

• They shall be held by sealant or a captive edge so as to be prevented from dislodging in the event of a breakdown to the adhesive surfaces.

• Tapes shall not be used to permanently hold any building envelope components in position.

• Tapes are not permitted to be used as an air seal or rain screen to the building envelope system or in place of a compression gasket in a glazing rebate.

• Spacer tape shall be tested with following standards

  • ASTM D 1667 : Standard specification for flexible cellular

  • ASTM D 2240 : Standard test method for rubber property - Durometer hardness

  • ASTM D 412 : Standard test methods for vulcanized rubber & thermoplastic elastomers - tension
• ASTM D 925 : Standard test methods for rubber property - Staining of surfaces (Contact, Migration & Diffusion)

• Warranty:

The spacer tape should be warranted for the warranty period.

4.11 BACKER ROD

• Backer rods shall be silicone compatible, non-gassing and non-staining.

• They are to be compressed to limits specified by the Manufacturer and shall be located in a manner which prevents them from dislodging from the rebate that is being sealed.

• Backer rods shall not inhibit movement joints from allowing the designed movement of the joint from occurring.

• Warranty:

The backer rod should be warranted for the warranty period.

4.12 SETTING BLOCK

• Shall comply with BS 2571

• Where indicated on the Drawings or required, provide Accepted setting blocks of dense material as follows:

  o Shore A durometer hardness: 85 +/- 5 when tested in accordance with ASTM D2240.

  o Compression set (168 hrs.): Not greater than 25% when tested in accordance with ASTM D395.

• Locate setting blocks at quarter points (1/4 of the unit width from each corner) unless otherwise Accepted but not less than 150 mm or 0.125 x glass width between edge of glass and edge of setting block.

• Shims used with setting blocks shall be the same material as the setting block.

• Setting blocks shall be secured against dislodgement.
• Setting Block lengths shall be calculated in accordance with BS6262 and shall be not less than 100mm.

4.13 SIDE BLOCK

• Where indicated on the Drawings or required, provide Accepted side blocks of dense material as follows:
  o Shore A durometer hardness: 55 +/- 5 when tested in accordance with ASTM D2240.

• Install side block with 3 mm clearance between block and bearing surface. Block shall be of sufficient length to prevent point loading on the glass.

• Side blocks are not required where glass is supported along the vertical edges with structural silicone.

• Side blocks of extruded silicone may be accepted for IGUs with silicone edge seals. Neoprene or EPDM side blocks may be accepted only if recommended by the IGU manufacturer.

4.14 PADS

• Provide Accepted friction reducing pads to separate moving surfaces at all connections subject to thermal or other movement (Acceptable materials include Teflon or Graflon or Herculon).

• Pads shall have minimum 3 mm thickness, shall sufficiently reduce friction to permit movement, shall be resistant to wear, shall be positively retained in position (open ended slots are not acceptable).

• Pads shall not be subjected to heat damage from welding or cutting or to excessive pressure from over-tightening of bolts.

• Warranty:

The pads should be warranted for the warranty period.
4.15 FLASHING / TRIMS / FLOOR CLOSURE

- Provide all required flashings, baffles, trims, capping and the like to prevent the entry of water and weather, and make neat and clean junctions with the base-structure and adjoining work.

- Where visible, provide matching materials and finishes. Include all fixings and sealing.

- All flashings shall be cut and folded to Accepted profiles out of non-corrosive materials, with protective coatings as required.

- Flashing shall be factory fabricated in long lengths where practical, and pre-painted on visible surfaces.

- Flashing shall be of adequate stiffness to retain shape and to resist lifting by the wind.

- Make provision for differential movements and for separation of dissimilar materials.

- Continuous flashings shall be welded or mechanically fixed to form continuous uninterrupted lengths.

- Corners shall be accurately scribed and mitred. If the flashing is concealed, flashing joints shall be lapped at least 100mm and sealed.

- Where flashings are fitted to pre-formed rebates, co-ordinate cast-in grooves or reglets as required.

- Construct weep-holes as required to enable the passage of moisture to the outside of the building.

- Lap and seal all flashings by Accepted methods.

- Internal & External concealed flashings shall be 1.5mm thk. GI Finish

- External exposed flashing shall be 3mm thk. Aluminum sheet with PVDF coated matching with external Aluminum profiles

- Internal exposed flashing shall be 2mm thk. Aluminum sheet with powder coated matching with internal aluminum profiles.
• Unless otherwise indicated on the Drawings, types and locations shall be as follows: (Location)

  o Concrete wall flashings at every second storey: Stainless steel sheet.
  o Louver flashings: Stainless steel sheet.
  o Continuous horizontal and vertical smoke flashings: Zincanneal steel.
  o Feature column flashing at every second storey: Stainless steel sheet.

• Unless otherwise indicated on the Drawings, types and locations shall be as follows: (Material)

  o Lysaght "Zincanneal" steel, or equivalent, steel base grade G2, coating class ZF 100.

  o Stainless steel sheet, 0.8 mm thick, Grade 304.

  o Lysaght "Galva bond", or equivalent, steel base grade G2, coating class Z 275.

  o Aluminum sheet, not less than 0.4 mm or more than 1.0 mm thick, in accordance with ASTM B209, Type A3203 or D5050, containing magnesium or manganese or both, with a maximum copper content of 0.25%.

  o Neoprene strip shall be 3mm minimum thickness, and shall comply with ASTM D1149 with regard to ozone and flame resistance. The materials shall have the following properties:

    o Shore hardness: 70 - 80 degrees
    o Minimum tensile strength: 13.8 MPa
    o Minimum elongation at break: 150%
    o Minimum tear strength: 1.38 MPa

    o Comply with BS 6561 - Specification for zinc alloy sheet and strip for building.

    o ASTM D1149 - Test method for rubber deterioration - Surface ozone cracking in a chamber (Flat Specimens).

• ANTI-CARBONATION COATING:

  o All concrete surfaces that are not protected by an air-sealed building envelope shall receive a protective finish layer.
These surfaces are typically behind stone cladding, Aluminum rain-screen cladding and louvers.
The surface protection shall be an anti-carbonation coating by Vandex, Sika or Accepted equivalent.

**EARTHING TABS:**
The Contractor shall Co-ordinate with the Electrical Contractor for details of connection tabs for earthing strap connection.
Earthing straps shall be provided and installed by Electrical Services contractor.

**TRIANGLES FOR F.A.P.:**
Provide and install triangles for the marking of Firemen Access Panels, in accordance with local Authorities requirements.

### 4.16 SHIMS

- Provide shims where necessary up to but not exceeding the limits specified on the drawings and designed for in the engineering calculations.
- Shims which transfer shear forces shall be steel plates, set in a staggered pattern and fillet welded to each other and adjacent steel surfaces. Design shims and welds to support the applied loads.
- Polypropylene shims may be accepted at static connections where shims transfer only compressive loads.

### 4.17 INTERNAL WALL LININGS:

- Internal lining shall be 12mm thick cement sheet to ISO/TC77/DP8336 and ASTM C1186-2002 (with no asbestos).
- The lining shall be supported off galvanised cold formed steel battens, separated from the building envelope frame to prevent bimetallic corrosion.
- The cement sheet and batten frame shall be separated from the building envelope so that in-plane movements of the building envelope can occur without transferring loads into the cement lining.
• The building envelope can, however be used to prevent in/out movement.

4.18 INTERNAL TRIMS TO HEADS & JAMBS:

• Internal trims shall be provided to jambs and ceiling transoms at all floors. These trims are to provide a uniform surface, with hairline joints.

4.19 SPANDREL INSULATION

• Spandrel Insulation of 50mm thk. & 48 Kg/CUM shall be provided as thermal insulation held GI or Zinc Anneal Plate.

• When fire rated an additional rear sheet of galvanized steel sheet or Zinc anneal plate with minimum thickness 1.5mm shall be provided, it shall be reliably isolated from the aluminum frame

4.20 SHADOW BOX (Back Pan)

• All back pans shall be aluminum 1.5mm minimum thickness, fully sealed with backing rods and sealant to form a drained spandrel cavity.

• All back-pan installation details shall allow for all possible movements, installation and fabrication tolerances.

• Back-pan construction should have folded back edges providing a continuous sealing edge

• Back-pans to spandrel glass shall be powder coated to a specified colour as instructed by AAI/PMC.

• Colour mock-ups shall be provided by the Contractor for review and acceptance.

• The insulation shall be sealed to the aluminum frame on 3 sides using foil tape to prevent condensation in the cavity between the insulation and the back-pan.

4.21 Hardware

4.21.1 Operable Vents

• All Hardware shall be with Stainless steel SS 316 grade
• contractors shall be submit technical catalogue including the Test results of each hardware

• Friction hinges shall be Self balancing type with provision to hold open up to 200mm

• Locking System for operable vents shall be Ferco Multi-Point Locking System or equivalent

• Locking Points shall be calculated based on acceptable vent deflection and stress limits, with a minimum of 4 locking points with top wedge blocks

• Locking system shall be fully concealed within the body of vent frame.

• The vents shall be manually opened to a point of full extension (minimum of 45 degree) allowing the full cross-sectional area of the vent opening to be vented.

4.21.2 Doors / Hinges / Revolving doors

• Entry door hinges shall be Dorma concealed spring hinges

• The hinges shall be free-moving but shall be designed to a ‘snug’ fit so as to prevent any vibration of the vent in either closed or open positions.

• Revolving Doors shall be Dorma or Accepted equivalent the type of door to be having proper air and water seals around the periphery, human detection sensors the type of door to be based on the hourly footfall.

• Door locks and handles shall be Dorma, Assa Abloy or Accepted equivalent.

• Locking mechanisms shall be Assa Abloy, Dorma or Accepted equivalent and shall be based on a Master-Keying System.

• All hardware shall be SS 316 grade stainless tell

• Revolving doors shall be Dorma make

4.22 GLASS FOR STRUCTURAL GLAZING
4.22.1 Vision Panel: IGU: Hermetically sealed unit of 28mm

• Outer lite: 8mm thk solar control Low E reflective coated glass, Heat Strengthened with edge arised.

• Air Gap (Spacer):12 mm thick natural anodized Aluminum one piece bent spacer profile.

• Inner lite: 8mm thk clear float Heat Strengthened with edge arised.
• Desiccant: Silica molecular sieve.

• Primary Seal: Butyl seal (PIB = Poly Iso Butyl)

• Secondary seal: Insulating Glass sealant - Two part sealant

### 4.22.2 Vision Panel (Gate House): IGU: Hermetically sealed unit of 24mm

- Outer lite: 6mm thk solar control Low E reflective coated glass, Heat Strengthened with edge arised.

- Air Gap (Spacer): 12 mm thick natural anodized Aluminum one piece bent spacer profile.

- Inner lite: 6mm thk clear float Heat Strengthened with edge arised.

- Desiccant: Silica molecular sieve.

- Primary Seal: Butyl seal (PIB = Poly Iso Butyl)

- Secondary seal: Insulating Glass sealant - Two part sealant

### 4.22.3 Back Pan Painted Panel : SGU

- 6mm thk solar control Low E reflective coated glass, Heat Strengthened with edge arised.

### 4.22.4 Heat strengthened and toughened glass shall be examined by the glass manufacturer to detect and discard any lights, which exceed the following tolerances:

- Where the strengthening process results in essentially parallel ripples or waves the maximum peak to valley distance shall not exceed 0.076 mm over 300mm. Except for leading and trailing 250mm of the glass where the value shall be within 0.2 mm.

- Where bow tolerance and wave tolerance differ, the stricter requirements shall govern. Direction ripples shall be consistent and in conformance with Architectural design. Normally parallel to the eye sight or ground surface.

- Overall bend in the glass shall not exceed 1.5mm over 3 mtr span.

### 4.22.5 Standards for Architecture Glass

ASTM C1036: Standard Specification for Flat Glass
ASTM C1048: Standard Specification for Heat-Treated Flat Glass
ASTM C1087: Standard test methods for determining compatibility of liquid-Applied sealants with accessories used in structural glazing systems
ASTM C1172: Standard Specification for Laminated Architectural Flat Glass
ASTM C1376: Pyrolitic and Vacuum Deposition Coatings on glass
ASTM E2190-08: Standard specification for IGU performance & Evaluation
ASTM E546: Standard Test Method for Frost/Dew Point of Sealed Insulating Glass Units
E2188-02: Standard test method for IGU Performance
E2189-02: Standard test method for testing resistance to fogging in IGU
E546-08: Standard test method for frost / Dew point of sealed DGU
E1249-06a: Standard guide for secondary seal for sealed IGU for structural sealant glazing application

4.22.6 Safety Glazing Requirements
CPSC 16 CFR 1201 Safety Standard for Architectural Glazing Materials
CCPS: Use of Glass in Buildings – Human Safety

Industry Publications:

Tempering Division: Engineering Standards Manual
Laminating Division: Laminated Glass Design Guide
AAMA: Curtain wall Series
IGMA: Insulating Glass Manufacturers Alliance
TM3000: Recommended Practices for Vertical and Basic Field Glazing of Organically Sealed Insulating Glass
4.22.7 The glass fabricator (and raw glass manufacturer) shall demonstrate that their internal standards and quality policies have been documented in ISO 9002, and verify continual compliance with those documents. Insulating glass units shall be an engineered product and the glass fabricator shall provide solar and optical performance data, based on LBL Window 5.2 program methodology. The insulated glass units shall meet IGBC CBA level certification.

4.22.8 In addition to complying with established industry standards, the glass fabricator (for all heat-treated, laminated, and insulated glass products) shall provide finished glass products which comply with the following requirements:

4.22.9 Optical distortion is mentioned in ASTM C 1048 Standard Specification for heat-treated glass, but the parameters for acceptability involve viewing the glass in transmission at the proper vision interference angle. To ensure the final glass products will have minimal optical distortion, the glass fabricator shall employ Quality Control procedures to ensure that distortion remains within the following allowable limits: maximum peak to valley roller wave tolerance is .003" (0.076mm) in the central area, and .008" (0.2mm) within 10.5" of the leading and trailing edge.

4.22.10 Additionally, note that roller wave distortion should typically run parallel to the base dimension to minimize visual perception, as viewing the reflection horizontally is usually less to run parallel to the second dimension, if the first dimension is greater than 84” (2134mm)

4.22.11 Insulated glass shall have double edge seals. The primary seal between Aluminum spacer and glass shall be a continuous butyl tape with no skips or voids. The preferred primary seal shall be Poly Isobutylene (PIB). The Aluminum spacer shall be of silver anodized and the same shall be bent to shape of glazed unit profile and the bent Aluminum spacer shall be filled with desiccant drying agent. The secondary seal shall be Two part silicon sealant. The secondary seal shall completely cover the spacer with no voids or gaps, and shall be continuously bonded on both plates of glass. The required thickness of the secondary seal be determined by calculation and verified by testing of samples as specified.

4.22.12 The Glass panel shall be separated by a de-hydrated air space. Edge seal construction of the insulated unit shall be able to withstand at least three time the stress caused by design wind pressures Specified in the Technical Specifications. The Double glazed unit processor shall be approved by AAI/PMC and shall use only approved sealant. Necessary test Certificate shall be produced by the processor ensuring the approved sealant and its bite size and application method. Glass supplier shall provide test certificate of Spectrophotometric values from independent laboratory based in Europe or USA for final clearance. Flatness of both lites of IGU shall be within 2mm per 3mtr span.
4.22.13 THERMAL STRESS

Submit computations demonstrating the elimination of thermal stress breakage risk, methods of overcoming thermal stress problems, and all assumptions for review and Acceptance. The Contractor shall consider all potential risk locations including but not limited to the following:

- Heat build-up at shadow boxes and other non vented spaces/zones.
- Make provision for internal curtains or blinds within the building envelope framework which may temporarily create non vented spaces prone to heat build-up adjacent to the vision section of the building envelope system.
- Shadowing effects.

Probability of breakage of glass due to anticipated thermal stress in glass shall not exceed 8/1000).

4.22.14 REPLACEMENT OF GLASS:

- Submit details of replacement procedures, including glass size limitations, and equipment required for review and Acceptance. Include estimated maximum lead-time required by the glass manufacturer to supply replacement units for each type of glass unit.

4.22.15 VISUAL EFFECTS, OPACIFIERS AND COATINGS

4.22.15.1 GENERAL

- Provide coatings and visual effects of paint, coatings or interlayer to glass to match Accepted samples. Submit details.
- Coatings may include:
  - Translucent, coloured or patterned interlayer to laminated glass.
  - Surface applied opacifier film to spandrel or vision glass.
  - Decorative painted patterns, colours and textures.
  - Reflective or Low-E solar control coatings.
- Colour, reflectivity and appearance shall be uniform for each glazing type. All clear, coated and tinted glass of each type and thickness shall come from one float line and production run. All glass provided for the project shall match Accepted colour samples and fall within the limits of the colour range allowed.
- Relevant Standards:
  - PBS-4-0885.

4.22.15.2 GLASS COATINGS

- Glass coatings shall conform to the following criteria
a) Inspection shall be made at a distance of three metres from the glass for scratches and chips, viewing perpendicular to the glass plane, with any natural light for which flaws are clearly visible. All other imperfections will be viewed at a distance of 300mm.

b) The central area is a square or rectangle concentric with the daylight opening and having width and height respectively equal to 80 percent of the daylight opening width and height.

c) The outer area extends from the border of the central area to the edges of the daylight opening.

d) Pinhole diameter shall not exceed 0.8mm in the central area, and 1.5mm in the outer area.

e) Within any 300mm diameter circle, there shall be no more than one pinhole with diameter in the range 0.8mm to 1.6mm.

f) Scratches, rub marks or other gaps in the coating are not permitted where any portion thereof could include a circle with diameter exceeding 0.8mm. Where the included circle is 0.8mm or less, length of the scratch, rub marks or other gap shall not exceed 25mm in the central area and 75mm in the outer area.

g) Streaks or splotches resulting from non-uniformity of the coating that appears visible from the building interior or exterior are not permitted.

h) Colour range must fall within the limits established by Accepted samples.

- Relevant Standards:
  - PBS-4-0885
  - BS (EN) 1096
  - ASTM 1376

4.22.15.3 DECORATIVE CERAMIC PAINTS

- All ceramic fritted glass shall have ceramic paint applied to the glass using the silkscreen process, and fused into the surface of the glass during the heat treatment process.

- Decorative paints with glass substrates shall be from list of approved makes accepted by AAI/PMC. Colours (approved make accepted by AAI/PMC) shall be matched to the RAL Colour System or other approved colour range. Colour to match AAI/PMC’s approved sample.

- Paint coverage shall be to within 6 mm of the edge of the glass.
• All ceramic fritted glass shall be resistant to attack from mechanical damage or abrasion, during normal use and maintenance.

• All ceramic fritted glass shall be resistant to weathering, fading or discolouration due to attack from climatic conditions, UV or atmospheric pollutants.

• The screen-printed surface of the glass shall face the inside of the building in the final construction.

• Defects, including scratches and pinholes shall not be visible when viewed at a distance of 3m.

• Glass shall be Fully Tempered and 100% Heat Soak Tested to EN 14179 part 1.

• Ceramic Colour backing shall be flood coat or pattern frit subject to Ceramic Colour Pattern as specified by AAI/PMC.

• Cutting of panels, edge distance for colour coverage and ceramic pattern orientation shall be closely co-ordinated. Confirm pattern / layout with AAI/PMC prior to the start of mass production.

• All fully tempered Seraphic Glass shall be manufactured, coated and installed with the roller-wave distortion, i.e. peak-to-trough-to-peak, undulating vertically.

**4.22.15.4 CERTIFICATION:**

• Submit manufacturer's certification that applied films and coatings will not be detrimental to the glass or limit in any way the glass product warranty.

**4.22.15.5 OPACIFYING FILMS:**

• Provide approved opacifying films of polythene or polyester to restrict vision to spandrel areas.

• Film to match AAI/PMC's approved sample. Opacifier coatings and films are required to be suitable for the proposed temperature and exposure conditions of the glazing and are required to function without bubbling, blistering or colour shift for the design life of the building. Submit details.

• Film shall be fully bonded to glass with solvent based adhesive. Provide safety backing restraint for fallout resistance. Edge deletion of Opacifying films shall be provided at all insulating glass and structural glazing unless manufacturer submits test data acceptable to AAI/PMC indicating that edge deletion is not required.

• Opacifier coatings are to be applied to surface 2 of monolithic or surface 4 of insulating glass units and prevent “read-through” of the glass.
4.22.15.6 OTHER OPACIFYING TREATMENTS:

• Submit opacifying paints and products details for approval.

4.23 ANNEALED FLOAT GLASS

4.23.1 GENERAL

• Clear float glass shall be in accordance with ASTM C1036, Type 1 and Class 1. Submit details.

• Tinted, heat absorbing float glass shall be in accordance with ASTM C1036, Type 1, Class 2 and Quality Q3. Submit details.

• All glass shall have clean, wheel cut edges with minimum feather, free from vents, notches, or shells.

• Refer to Drawings and Table Vol.II, Sec.9: Materials Schedule, for locations and types of glass.

• Products shall be reputable proprietary products, factory manufactured under ISO 9001. Submit quality assurance documentation for all products, including brought-in products, including ISO 9001 certification, and evidence of satisfactory long-term performance in similar commercial conditions.

• Products which may be accepted include those manufactured by:

  o Asahi Glass
  o Saint Gobain
  o Glaverbel
  o Pilkington Glass

• Relevant Standards:

  o ASTM C1036 - Standard specification for flat glass.
  o FGMA - Glazing Manual.
  o IS:2835/1987 Specification for flat transparent sheet glass(third revision)

4.23.2 TOLERANCES:

Dimensional tolerances of glass generally shall comply with ASTM C036 Table 2.

4.23.3 QUALITY RECORDS:
Submit inspection and test records to ASTM C1036, Table 4, proportionally adjusted to proposed project glass thickness. Indicate test procedures, acceptance criteria and pass and/or fail rate.

**EDGE QUALITY:**

1. Edge quality criteria for annealed and heat strengthened glass are as follows:
2. Shark teeth shall not penetrate more than half of glass thickness.
3. Serration hackle may occur only within 150 mm of corners.
4. Flare shall not exceed 1 mm measured perpendicular to glass surface across the edge. Flare shall not occur at setting blocks.
5. Bevel shall not exceed 1.5 mm.
6. Flake chips may occur only within 200 mm of corners. Depth shall not exceed 1 mm and length or diameter shall not exceed 6 mm.
7. Rough chips which exceed any of the dimensional limits for flake chips are not permitted.

**4.24 HEAT TREATED-STRENGTHENED AND FULLY TEMPERED GLASS**

**4.24.1 GENERAL**

- Provide Accepted heat strengthened glass and fully tempered glass, manufactured using the "roller hearth", or an equivalent Accepted horizontal process in accordance with AS 2208, ASTM 1048 and/or ANSI Z97.1. Submit details.
- Base material shall be an Accepted selected quality float glass.
- Relevant Standards:
  a) ASTM C1048 - Standard specification for heat-treated flat glass - Kind HS, kind FT coated and uncoated glass.
  b) ASTM C1087 - Standard test method for determining compatibility of liquid-applied sealants with accessories used in structural glazing techniques.

**4.24.2 EDGE QUALITY:**

- Heat treated toughened glass used for but jointed edges with silicone seal shall have belt arised straight, flat ground edges.
• Heat treated glass used for structurally glazing shall have straight, belt arrised edges.

• Do not cut, work, or permanently mark after toughening. Use installation methods which prevent the glass making direct contact with metals or other non-resilient materials.

4.24.3 COMPRESSION STRENGTH:

• Toughened glass shall have a surface compression stress of not less than 69 MPa (10,000 psi) an edge compression of not less than 67 MPa (9700 psi) in accordance with ASTM C1048.

4.24.4 QUALITY RECORDS:

• Submit production and test records to AS/NZS 2208 and/or ASTM 1048. Indicate test procedures, acceptance criteria and pass and/or fail rate.

4.24.5 WARRANTY:

• All toughened glass in single pane applications shall be warranted for the warranty period.
• Glass supplier to provide specific warranty against Toughened glass NiS breakages for 5 years and provide free replacement against NiS breakages during the warranty.

• Glass supplier/Processor to provide warranty of min. 5 years for any type of glass lamination, high performance coating of glass, DGUS, etc,

4.24.6 ROLLER WAVE DISTORTION:

• Roller Wave Distortion: in the installed work shall be horizontal unless otherwise approved in writing.

• The maximum roller wave shall not exceed 0.076 mm in any 300mm length of glass.

4.24.7 GLASS DISTORTION:
• Bow Distortion: ‘bow’ and ‘warp’ shall have the same meaning.

• Toughening bow shall not exceed 2mm (Max.)

• Distortion / Roller wave shall be max 0.076mm per 300mm and edge curl shall be max 0.25mm

• Refer to relevant section of this specification.

a) BS 6262 - Code of practice for glazing for buildings.

b) AAMA 101 - Voluntary specifications for aluminum prime windows and sliding glass doors.
4.24.8 HEAT-SOAK TESTING:

- 100% heat soak testing will be required for all glass with edge stress exceeding 50mpA (7500 psi).

- Submit Heat Soak method, temperature, and duration for review and Acceptance, prior to commencement.

4.25 LAMINATED GLASS
4.25.1 GENERAL

- Provide all required laminated glass in accordance with AS/NZS 2208 and GANA Glazing Manual.

- Submit details for review and Acceptance.

- The base material shall conform to Section 2.1.2 - Annealed Float Glass and Section 2.1.3 – Heat Treated Glass.

- Glass for laminating is to be cut into individual panels prior to the laminating process.

- Glass thickness of successive panes being laminated together is not to exceed a difference of 2mm.

- Heat treated glass is to be orientated so that warp, bow and roller wave between successive panels are matched. Two stage convection tempering ovens are to be used to ensure glass distortions are minimized. Edge clamping of glass is forbidden

- Relevant Standards:
  - FGMA - Glazing Manual
  - ANSI Z97.1- Glazing materials used in building - Safety performance specifications and methods of testing.

4.25.2 INTERLAYER

- Provide an Accepted polyvinylbutyral (PVB) interlayer or Dupont “SGP” (Sentry Glass Plus) interlayer of not less than 1.52 mm nominal thickness. Submit details including test results for adhesion, durability and compatibility with proposed sealants.

- Products which may be Accepted include DuPont "Butacite", or Accepted equivalent.
• Special performance films such as California Series XIR must be fully encapsulated in the PVB with 10mm overlap at edges and bolt holes.

4.25.3 EDGE QUALITY

• All laminated glass shall have clean cut edges, or polished edges if required to eliminate thermal stress breakage risk. Laminated glass units shall be fabricated with autoclaved edges on all four sides.

• Edges of laminated glass are to be protected to prevent delamination, contamination or other defects, caused by moisture, sealant contact or other external/interal source.

• All exposed laminated glass edges shall be protected from blushing by hot rolling the interlayer back into the glass edge, or by use of an approved edge seal material.

4.25.4 QUALITY RECORDS

• Submit production and test records to AS/NZS 2208, ANSI Z97.1 and/or ASTM 1048, BS 6206.

• Indicate test procedures, acceptance criteria and pass and/or fail rate. Include records for interlayer.

• Provide daily records of maximum factory temperature and humidity and weekly records of water quality used for washing glass. In the event that Interlayer Supplier application requirements are not satisfied, batches of non-complying glass shall be rejected.

4.25.5 INSTALLATION

• Use glazing materials which do not cause deterioration or discoloration of the interlayer.

• Submit test results to confirm the compatibility of laminated glass with adjacent glazing materials.
4.26 INSULATING GLASS UNIT
4.26.1 GENERAL

- Provide Insulating Glass Units (IGUs) (also known as double-glazed units) of Accepted types in accordance with ASTM E2190, AS/NZS 2208, and the recommendations of IGMA. Submit complete details, including all construction details, primary and secondary seals, gas filling and corner treatment, nature of spacers, evacuation and assembly process.

- Relevant Standards:
  - ASTM C1087 - Standard test method for determining compatibility of liquid-applied sealants with accessories used in structural glazing techniques.
  - ASTM E546 - Test for dew point of sealed insulating glass units.
  - ASTM E773 - Standard test methods for seal durability of sealed insulating glass units.
  - ASTM E774 - Standard specification for sealed insulating glass units.
  - IGMA - Insulating Glass Manufacturer’s Alliance.

4.26.2 SEAL PERFORMANCE

- IGUs shall incorporate Accepted polyisobutylene primary (vapour) seals continuously bonded to glass, and two-part silicone secondary (structural) seals. Primary seal shall be not less than 3 mm deep. Secondary seal shall completely cover spacer with no gaps or voids, continuously bonded to glass.

- The secondary sealant is to be Dow Corning Structural Silicone specifically used for IGU manufacturer. The sealant bite for the secondary seal is to be determined based on load sharing principles developed by J.E. Minor – Texas Tech University.

- In cases where the thickness of the outboard lite is greater than that of the inboard lite, the 50/50 load sharing (or 50 percent of structural bite) no longer is valid and the load-sharing must be determined.

- Spacer bar shall be a proprietary aluminum type, desiccant filled, anodised in a colour compatible with seals. Conceal spacer bar within the depth of the glazing gasket line to ensure smooth sight line. Submit details and colour samples for review and Acceptance.
4.26.3 STRUCTURAL EDGE DISTANCES

- Submit, for review and Acceptance, computations for distance between the outer edge of the glass and the innermost edge of the aluminum spacer indicating minimum bite of secondary (structural) seal and spacer bar depth. Include sealant manufacturer’s recommendations and load tables.

4.26.4 EDGE QUALITY

- Heat treated glass lights of IGUs shall have clean cut edges. Internal toughened lights of IGUs shall have belt arised edges.

4.26.5 QUALITY RECORDS

- Submit production and test records for IGUs. Indicate test procedures, acceptance criteria and pass/fail rate to AS/NZS 2208 or an equivalent Standards.

4.26.6 TESTING

- Submit report from an accredited and approved testing laboratory the unit type has attained Class A as defined in ASTM E2190 when tested in accordance ASTM E2190.

4.26.7 WARRANTY

- For a period not less than the warranty period, all IGUs shall be free from evidence of manufacturing defects and shall be free from:

  - Intrusion of moisture or dirt.
  - Internal condensation at temperatures above -10° C-degrees.
  - Other visual evidence of seal failure or performance failure.

4.27 LOW-e GLASS UNIT

4.27.1 GENERAL

- Low-emissivity (low-e) coating(s) shall be neutral in transmitted and reflected colour and otherwise exhibit the visual and performance characteristics of the products specified and shall comply with ASTM C 1376.
- The coating shall be approved by AAI/PMC and fall within the limits of the colour range allowed.
• Colour difference shall not exceed 3 E Hunter.

• Visual Quality Control acceptance criteria of the low-e coating shall be consistent with industry guidelines, subject to approval by AAI/PMC and the Owner.

• Pinholes with diameters shall not exceed 0.8mm in the central area, and 1.5mm in the outer area of the glass panel.

• Clusters of pinholes are not acceptable.

• Streaks or splotches resulting from non-uniformity of the coating that appears visible from the building interior or exterior are not permitted.

• Scratches no longer than 75 mm in length are acceptable provided that they occur within 75 mm of an edge.

• Edge deletion of low-e coatings shall be provided at all insulating glass and structural glazing unless manufacturer submits test data acceptable to AAI/PMC indicating that edge deletion is not required.

• Contractor shall ensure that the coating(s) conforms to the codes and regulations. Any fees incurred from an application of waiver and variance shall be the responsibility of the Contractor.

• Manufacturer shall warrant that low-e coating shall not peel, crack, fade or deteriorate for a period of ten (10) years. Manufacturer shall warrant that any glass that is not edge deleted will not develop loss of adhesion with insulating glass or structural glazing sealants for a period of ten (10) years.

4.28 ALUMINUM COMPOSITE PANEL CLADDING (ACP)

• The alloy for the aluminum panel shall be of alloy 3005 / 3105-H14 confirming to BS 1475.

• Composite panel shall have a minimum total thickness of 4 mm. The panel shall be reinforced behind to meet the required structural design and deflection criteria.

• The panel shall be designed with the fixity to allow temperature variance and surface temperature differentials due to ambient temperature differential without causing any effect on flatness of the panels.

• The installed composite panel surface Shall not have irregularities such as oil canning, waves, buckles, and other irregularities. When viewed at any position not less than 15 degrees to the true plane of the panel.
• The Aluminum composite panel shall be of total 4 mm thickness comprise of Aluminum skin of minimum 0.5mm with KYNAR 500 or LUMIFLON based fluorocarbon paint finish + 3mm thick mineral core with Fr grade “B” (Confirms to EN 13501) + 0.5 mm aluminum skin with service coat.

• Incase of Non Fr grade (Subject to written confirmation from AAI/PMC) then the core shall be 3 mm Virgin PolyEthylene (PE) Core in Translucent in color (No Black in color)

• ACP aluminum outer skin and inner skin should confirm to alloy 3005/3105 grade and H16 or suitable temper with minimum mechanical properties as per given values.

• The thickness shall be minimum 0.5 mm thickness and PVDF shall be add on to this thickness.

• Surface of the Composite Panel should be finished with Lumiflon based fluorocarbon coating or Kynar-500 based PVDF coating (Polyvinylidene Fluoride) on the topside with minimum 30 micron thickness and a service coating on the reverse side.

• Lumiflon – based fluoro carbon coating or Kynar-500 based PVDF coating on the topside shall be done in two types as below.

  • “Solid Color” is two coat two-bake system.

  • The total dry film thickness of the topside shall be 25 micron minimum consisting of a conversion coating, an inhibitive primer and Lumiflon-based fluorocarbon coating or Kynar-500 based PVDF coating.

  • “Metallic Color” is three coat three-bake systems or two-coat two-bake Systems. With minimum thickness of 30 micron.

  • The top coated surface shall comply with the “specification for coated coil for exterior building applications” issued by ECCA (European Coil Coating Association) to achieve the quality level for each Association. The coating shall confirm to AAMA 2605 for exterior grade finish.

• The reverse side of the cladding panel surface facing the wall shall have polyester base coating to protect against the possible corrosion problems.

• The finished surface shall be protected with a self adhesive peel off foil with 80 microns thickness white or black, tested to with stand at least 6 months exposure to local weather condition without losing the original pill off characteristic or causing stain or other damages on the coated surface of the aluminum composite panel.

• If the stain or any damage noticed after pill of by the fabricator, such panel should be replaced with new one of the same shade and color, at no extra cost.

• Skin Material: 0.5 mm thick aluminum sheets of Alloy 5005A – H22/ 3105 – H14 or 3003 – H14 and manufacture by adopting Direct Casting Method
• Core Material: 3 mm thick mineral core material based on Aluminum / Magnesium Hydroxide having fire retardant property. (Class B)

Class B – S1 – d0 Confirming to EN 13501-1

Confirms to Class O as per BS 476 Part 6 & 7

• As per approved make (Annexure-1)

• PHYSICAL PROPERTIES

• Specific Gravity : 1.23- 1.9

• Weight : 7.6 Kg/m2 for 4 mm

• Thermal Expansion (ASTM D-976) : 2.4mm/m at 100 deg Cel or 1.2mm/m/500° C

• Thermal Conductivity (ASTM D-976) : .41- 0.5 W/m.K

• Deflection Temperature (ASTM D-648) : 110 - 1150 C

• MECHANICAL PROPERTIES

• Tensile Strength  (ASTM E-8) : 49 -130 N/mm2

• Yield Strength  (ASTM E-8): 4.5 Kg/ mm2

• Elongation  (ASTM E-8) : 5- 14%

• Flexural elasticity (ASTM C-393) : 14*105 Kg.mm2

• MECHANICAL PROPERTIES OF SKIN ALUMINUM

• Yield Strength (ASTM E8) :15.5 Kg/mm2 (3105 H14)

• Modules of elasticity (ASTM C393) :7000 Kg/mm2
• Bond integrity (Vertical Pull, ASTM C-297) : 120 Kg/mm2 (12.2 N/cm2)

• Deflection temperature (ASTM D648) : 1150°C

• Sound transmission loss in Accordance with ASTM E413 (STC) 26 – 30 dB

• Aluminum coil for coating: Manufactured by direct casting method to ensure the compressive strength and other characteristics of the coil as per standard.

• The panels shall be finished in a manufacturer’s continuous coating line with Lumiflon-based fluorocarbon coating or Kynar-500 based PVDF that should be tested by the manufacturer to meet the criteria published as per the product.

4.29 SOLID ALUMINUM PANELS

• Aluminum panels shall be 100% solid aluminum shall satisfy the following minimum requirements:

  o External Panels (min thickness) - 3mm solid Aluminum
  o Internal Panels (min thickness) - 2mm solid Aluminum
  o Perforated Panels (min thickness) - 3mm Aluminum

• Installed panels shall be look flat when viewed from any angle

• Aluminum alloy shall be 5005 - H14

4.30 EXTERIOR STONE SPECIFICATION

• Comply with current edition of required Standards and Codes of Practice, including British Standards (BS and CP)
  • AAMA Architectural Aluminum Manufacturers' Association Standards mentioned herein.
  • ANSI American National Standards Institute Standards mentioned herein.
  • AS/NZ Australian/New Zealand Standards mentioned herein
  • ASTM Standards mentioned herein.
  • CWCT Guide to the Selection & Testing of stone Panels for external use.
  • CWCT Performance and testing of fixings for thin stone cladding.
a) Installation Procedures

Submit a comprehensive manual containing all installation procedures, equipment and personnel required for acceptance prior to the commencement of installation works.

b) Stone Selection & Testing

- All Sandstone panels shall be dense, fine-grained, and shall be carefully selected to provide uniformity in colour, texture and finish (following polishing).
- The sandstone panels shall be free of fractures, veins or clefts which may affect the structural integrity of the stone.
- The sandstone panels shall be free from minerals that may cause deterioration, objectionable staining under normal environmental conditions.
- Stone – sandstone type and finish as per AAI/PMC’s selection and approval.
- The minimum panel thickness shall be 30mm thk. & 80mm thk.
- The stone should be in gang saw cutting, polishing to be done by minimum 12 (multi) heads line polisher.
- Sandstone shall be test according to following requirements.

c) Stone Manufacturing

- Manufacturing shall comply with BS 8298.
- Grinding and polishing: all exposed surfaces shall be accurately machine polished to a distortion free mirror finish.
- Finish: all exposed surfaces shall be as per AAI/PMCs Design Indent.
- Edge Treatment: Edges shall be gauged arrised, bevel chamfered or Rebated and polished where shown on drawings.
- Manufacturing Tolerances:
  o Finished polished granite panel shall be in accordance with the following tolerances:
  o Length and width of a unit: +/- 1.5mm
  o Deviation from square: Diagonals not to differ by more than 2mm.
d) **Stone Sealers**

- All external stone cladding shall be impregnated with a stone sealer. Accepted sealer type shall be HMK S34 (by The HMK® Stone Care System), aquamix, Rep-oil (by Federchemicals) or approved equivalent.
- Impregnated stone sealers to be applied on all surfaces except the rear surface of stone panel or in strict accordance to the manufacturer’s recommendations and / or requirements.
- A method statement for the application of the sealer is to be submitted for AAI/PMC’s approval.
- No application of the sealer shall commence prior to written permission from AAI/PMC.

e) **Joint Sealant**

Joint sealants shall be provided to all exposed (sealed) joints where specified and shall satisfy the following requirements:

- The sealant is to be non-staining when tested to ASTM C510
- The sealant shall not harden to prevent the natural movement of the stone.
- Colour of sealant to be submitted to AAI/PMC for approval.

### 4.31 TERRACE COPING

- Copping at terrace level sealing the glazing system and parapet wall shall be of 3mm thk solid aluminum sheet cladding / 4mm thk. ACP in PVDF finish / Al. Extrusion with required Aluminum structural back up support designed for wind load.
- Additional stiffeners shall be provided in the form of top hat profile running continuous length wise and connected mechanically at panel joint returns.
- Joints at the grid center shall have weather sealant covered with Aluminum Cap on top to avoid any insect or birds damaging sealant as 1st barrier and GI Sheet laid under to provide 2nd barrier for weather.
4.32 STRUCTURAL STEEL

Façade structural steel works shall be a part of EPC contractor scope, unless noted in tender drawing clearly. Scope of work shall be Design, supply, fabrication, surface treatment, storage, delivery & erection of all the steelwork. This also includes the supply and installation of all cast-in items used to support the steelwork, the grouting of base plates, the provision of cleats and drilling of holes for the attachment of the cladding system, and repairs to damage surfaces during construction.

The work shall be carried out in strict accordance with the EPC contractor’s drawings (to be reviewed and Accepted by AAI/PMC), this specification, all other drawings and specifications included in this contract, and any Contractor authorized written instruction that may be issued during the course of this project.

Contractor shall comply all applicable Indian Regulations / Standard, British standard, but not limited to the following standard as specified.

- **IS 800 – 2007** General Construction in Steel – Code of Practice
- **BS EN 10025** Hot rolled products of structural steels
- **BS 638** Arc Welding Plant, Equipment and Accessories
- **BS 639** Covered Electrodes
- **BS 709** Methods of Non-Destructive Testing Fusion Welded Joints
- **BS 729** Hot Dip Galvanized Coatings on Iron and Steel Articles
- **BS 916** Black Bolts, Screws and Nuts
- **BS 1449** Steel Plate, Flat and Strip
- **BS EN ISO 1461** Hot Dip Galvanized coatings on fabricated iron & steel articles
- **BS 1580** Unified Screw Threads
- **BS 2600** Methods for Radiographic Examination of Fusion Welded Butt Joints in Steel
BS 2910  Methods for Radiographic Examination of Fusion Welded Circumferential Butt Joints in Steel Pipes

BS 2989  Specification for continuously hot-dip zinc coated and iron-zinc alloy coated steel

BS 3019  TIG welding

BS 3100  Steel Castings for General Engineering Purposes

BS 3571  MIG welding

BS 3889  Methods of Non-Destructive Testing of Pipes and Tubes

BS 3923  Methods Ultrasonic Examination of Welds

BS 4165  Electrode Wires and Fluxes for the Submerged Arc Welding of Carbon Steel and Medium Tensile Steel

BS 4190  ISO Metric Black Hexagon Bolts, Screws and Nut

BS 4232  Surface Finish of Blast Cleaned Steel or Painting

BS 4320  Metal Washers For General Engineering Purposes

BS 4360  Weld able Structural Steel

BS 4515  Field Welding of Carbon Steel Pipelines

BS 4848  Hot Rolled Structural Steel Sections

BS 4871  Approval Testing of Welders

BS 4882  Bolting for Flanges and Pressure Containing Purposes

BS 5135  Metal Arc Welding of Carbon and Carbon Manganese Steels

BS 5400: Part 6  Fabrication tolerance for steel work

BS 5493  Protective Coating of Iron and Steel against Corrosion
| BS 5950: Part 2 | Fabrication tolerance for steel work |
| BS 6072      | Method of Magnetic Particle Flaw Detection |
| BS 6323      | Seamless and Welded Steel Tube |
| BS 6399.1    | Code of Practice for Dead and Imposed Loads |
| BS 6399.2    | Code of Practice for Wind Loads |
| BS 5588      | Fire Precautions in Design, Construction and Use of Building |
| BS 7543      | Guide of Durability of buildings and building elements, products and components |
| BS 476       | Fire tests on Building Materials and Structures |
| BS 6651      | Code of Practice for the Protection of Structures against Lightning |
| IS 800 - 2007| Code of Practice for General Construction in steel |
| IS 2062      | Hot rolled Low, Medium and High Tensile Structural steel. |
| IS 801       | Code of Practice for use of Cold-Formed Light Gauge Steel Structural Members in general Building Construction. |
| IS 806       | Code of Practice for use of Steel Tubes in General Building Construction. |
| IS 811       | Specification for cold formed Light Gauge Structural Steel Sections. |
| IS 816       | Code of Practice for use of Metal Arc Welding for General Construction in Mild Steel |
| IS 1161      | Steel Tubes for Structural Purposes - Specification |
| IS 1477      | Code of Practice for Painting of Ferrous Metals in Buildings & Allied Finishes |
| IS 7215      | Tolerances for fabrication of steel structure |
**IS 12843**  Tolerance for erection of steel structure

**S15 055900**  Surface Preparation for Painting Steel Surfaces

American Welding Standards

AWS D1.1-84, 1986

Cidect Monograph 9

### 4.31.1 MATERIAL

- All material shall be confirm to Weld able structural steel confirming to BS EN 10210 Grade S275 (Mild steel) or Grade S355 (High Yield steel)
- Hot Rolled sections
  All Structure shall be comply with following standard
  
  a. Universal beams, columns, tee sections & channels to BS 4
  b. Hollow sections to BS EN 10210-2
  c. Angles to BS EN 10056-1
  d. Flats, plates, bars to BS EN 10210
- Cold Rolled Sections:
  All Structure shall be complying with BS EN 10162.

  Cold roller sections are not permitted unless specially mentioned in the drawings.

- Cast Iron & Cast Steel
  Grey cast iron shall confirm with BS EN 1561, grade 10

  Malleable cast iron shall confirm with BS EN 1562

  Spheroidal cast iron shall confirm with BS EN 1563

  Carbon manganese steel castings shall comply with BS EN 10293

- Stainless Steel
  Wrought Stainless Steel shall confirm with BS EN 10083, Grade S16
Flat rolled Stainless steel shall confirm with BS 1449 & Grade 316 S16 softened

Stainless steel tubes shall confirm with BS EN 10296, designation LW 23 GZF(S)

- Forged Steel
Steel forgings shall confirm with BS EN 10250-2

### 4.31.2 WELDING

- Welding procedure (Consumables used / Tools / Method / Angel of weld/ Number of welding pass) shall be submitted for Consultant review

- All welding shall be confirm with BS EN 1011-1

- Welding consumables for fusion welding shall be confirm with BS EN 1011-8

- Welding consumables for metal arc welding of austenitic stainless steel shall be confirm with BS 4677

#### 4.31.2.1 FORGED STEEL WELDING CONSUMABLES

- All welding of structural steel shall comply with BS EN 1011-1. Welding consumables used in fusion welding shall comply with BS EN 1011-8. Welding consumables used in metal arc welding of austenitic stainless steel shall comply with BS 4677.

- Welding consumables and the procedures used shall ensure that the mechanical properties of the deposited weld metal shall not be less than the parent metals.

#### 4.31.2.2 FORGED STEEL PREPARATION FOR WELDING

- Prepare fusion surfaces to BS EN 1011-1. Surfaces must be dry. Warm the surfaces if required to remove condensation.

- Remove welding slag by chipping before depositing subsequent runs.

#### 4.31.2.3 TYPES OF WELDS

a) Forged Steel Tack welds

Tack welding may only be used with express approval. Tack welds to be minimum 50mm long.

b) Forged Steel Butt welds
Butt welds shall be full penetration welds between prepared fusion faces, unless otherwise specified. Carry out back chipping, grinding or gouging of the deposited weld as required to obviate imperfections in the root run. Grind butt welds flush without loss of parent metal.

c) Forged Steel Fillet welds
Deposit fillet welds to the required length, throat thickness and with partial or full penetration as specified.

4.31.2.4 WELD TESTING

a) GENERAL

- Provide an experienced and competent operator to supervise welding. Submit certificates proving that all welders have passed the training tests in BS1295 and if specified, carry out approval tests to BS EN 287-1 or BS 4872: Pt. 1 as applicable.

- Keep a record on Site when specified to identify welders responsible for major welds
- Obtain Acceptance of the proposed welding procedures prior to commencing welding including

  - Preparation of fusion faces
  - Preheating temperature where required
  - Type of electrodes
  - Number and sequence of runs to build-up the weld bead
  - Post-heating treatment if required
  - Do not depart from the agreed welding procedure without the prior agreement of the Contractor

- Carry out approval testing of welding procedures to DIN EN ISO 15614-1, when specified, strictly in accordance with the proposed welding procedure using representative samples of the materials.

b) BUTT WELD

Carry out the following tests:

- Transverse tensile tests to BS EN 10002-
• Transverse bend tests to BS EN ISO 7438, with the root of the weld in tension and compression respectively.

• Side bend tests.

• Macro-examinations

c) **FILLET WELDS**

Carry out the following tests:

• Fracture test

• Macro-examinations

Strictly follow the procedures of welding established in the successful approval test for the works.

Carry out further approval tests if either the material or procedure changes

d) **EXTENT OF TESTING**

Weld testing is to be carried out by an independent Accepted Testing Company. The following testing is required:

<table>
<thead>
<tr>
<th>Weld Description</th>
<th>Connection Type</th>
<th>Visual</th>
<th>Ultrasonic or X-ray or MPI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fillet Welds</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>All plates less than 12mm</td>
<td>Secondary</td>
<td>25 %</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Primary</td>
<td>50 %</td>
<td></td>
</tr>
<tr>
<td>Plates between 12 and 24mm</td>
<td>Secondary</td>
<td>50 %</td>
<td>10 %</td>
</tr>
<tr>
<td></td>
<td>Primary</td>
<td>100 %</td>
<td>25 %</td>
</tr>
<tr>
<td>Plates over 24mm</td>
<td>Secondary</td>
<td>100 %</td>
<td>25 %</td>
</tr>
<tr>
<td></td>
<td>Primary</td>
<td>100 %</td>
<td>100 %</td>
</tr>
<tr>
<td>Butt Welds</td>
<td>-all-</td>
<td>100 %</td>
<td>100 % (no MPI)</td>
</tr>
</tbody>
</table>

Combination butt fillets

<table>
<thead>
<tr>
<th></th>
<th></th>
<th>100 %</th>
<th>25 %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tubes &lt; 10mm</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tubes &gt; 10mm</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: Secondary connections are to minor cleats, stiffener plates etc.

Primary connections are at the ends of a member
### 4.31.3 Quality Manual

- Contractor shall submit the document & maintain an inspection and testing system should be confirming the specification. All test certificates shall be provided for all steel works in accordance with BS EN 10002-1
- All the welders shall be trained as per BS 1295

### 4.31.4 Protective Coating

All steel shall be provided with a protective coating with 25 years minimum design life. Complete method statement to be submitted by the contractor.

- **External concealed Steel work**
  - Shall be hot dip galvanised with a minimum 100 micron

- **External exposed Steel work**
  i. Surface Preparation – Blast cleaned to Sa 2.5 confirming to BS EN ISO 8501-1
  ii. Primer: Zinc Rich Epoxy 75 micron
  iii. Barrier: Epoxy Mio 125 micron
  iv. Finish: Polyurethane – 50 Micron (Only for exposed steel)

- **Internal concealed Steel work**
  - Shall be hot dip galvanised with a minimum 70 micron

- **Internal exposed Steel work**
  i. Surface Preparation – Blast cleaned to Sa 2.5 confirming to BS EN ISO 8501-1
  ii. Primer: Zinc Rich Epoxy 75 micron
  iii. Barrier: Epoxy Mio 125 micron
  iv. Finish: Polyurethane – 50 Micron (Only for exposed steel)

### 4.31.5 Fire-Proofing Material:
• The sprayed fireproofing material shall be an intumescent paint type fireproofing unless noted otherwise. All structural steelwork where specified shall be protected by Accepted fireproofing material and must be Accepted by local authorities.
• All manufactured material shall be delivered in original, unopened packages bearing the name of the manufacturer, the brand, and a recognised testing body's label verifying compliance with said body's quality control inspection programme and the appropriate fire resistance ratings.

4.32 Stainless Steel:

• General
  - Provide all stainless steel in the required profiles finishes sizes and grades.
  - Stainless steel generally Grade 304 or 316. Grade 302 shall not be used. Structural applications and all exposed stainless steel works shall be Grade 316.
  - Provide 1.0mm radius at all corners with 'v-cut' where necessary.

  - All stainless steel is to be a minimum thickness of 2.0mm.
  - Relevant Standards:
    ▪ AS 1449
    ▪ BS1449: Part 2
    ▪ ASTM A666

• Mechanical finish:
  - Unless otherwise indicated on Drawings, exposed stainless steel shall be finished to match
  - Accepted samples in accordance with AS 1449, designated as follows:
    ▪ "Linished".
    ▪ "6" Soft satin.
    ▪ "7" Semi-mirror.
    ▪ "8" Bright mirror.
  - Grain shall be vertical in all locations, unless otherwise indicated on the Drawings, surface roughness Ra <20 to avoid tea staining corrosion.

• Flatness
- Flatness of stainless steel shall be not less than "stretcher level" grade. Submit manufacturer's specifications.

- Panel deflection criteria: deflection normal to the plane of construction shall be limited to 1/175 of the clear short span of the face material between supporting (stiffening) members. This deflection is to be measured in relation to the actual (deflected) position of the supporting member.

- **Colour**

- Where indicated on the Drawings to be colour finished, stainless steel is colour treated by an Accepted permanent process to match Accepted colour samples. Submit details.

- **Certification**

- Submit certificate of compliance or test report and properly identify each batch of stainless steel in accordance with the relevant standard.

### 5.0 QUALITY ASSURANCE:

- The project specific quality plan should be produced to demonstrate the quality management system implemented from award of contract to contract completion. Quality plan to include design plan, design Verification, validation procedure, inspection procedures and check list at all stages of work.

- Qualification of manufacturers: Products used in the work shall be in line with the approved make list and produced by manufacturers regularly engaged in manufacturing of similar items and with a history of successful production acceptable to AAI/PMC.

- Glazing & Cladding Sub-Contractor’s qualification: The EPC contractor who is regularly engaged and successfully performed in engineering, fabrication and installation of similar comparable project in unitized and point fixed suspended glazing & dry stone cladding over the last Five years.

- All the work shall be executed only by pre-qualified specialized contractor under single point responsibility for suspended point fixed glazing and cladding having experience in design & engineering, fabrication and installation in similar kind of projects. Point fix glazing design & installation shall be under responsibility of specialized agency like Kinlong, Dorma, Lisus or Sadev.
• Subcontracting of any part of work by specialized Glazing agency shall be strictly on approval by AAI/PMC.

• **Source Quality Control**

○ Shop and field materials and workmanship activities shall be subject to inspection by AAI/PMC or their representative at all times. Such inspection does not relieve the Contractor from obligations to provide materials conforming to all requirements of the Contract Documents and industry standards for material quality.

• **Each bidder shall submit with his bid Project proposal Shop Drawings for AAI/PMC’s review.**

5.1 **Design responsibility**

5.1.1 The tender drawings and performance requirements are design intent of AAI/PMC and are preferred profile system with science and technicalities as demonstrated. The total responsibility of system design meeting the performance requirement lies with the EPC contractor. The system shall go thru necessary corrections till it passes all the required performance criteria in the performance tests.

5.1.2 The EPC contractor is responsible for design, engineering calculation for each element and components & preparing shop drawings fully acceptable to AAI/PMC.

5.1.3 The EPC contractor is to take in to account the wind loads, dead loads, building movements, earth quake movements, thermal expansions and contraction resulting from the ambient temperature range of 15 to 45 deg C variance including surface temperatures up to 80 deg cel. The design must account for cracking sound, combined stresses on the components, sealants, glass and joint seals without any damaging effects.

5.2 **Water penetration.**

5.2.1 The system design of the Unitised system to be based on three barriers, and pressure equalization principle with effective drainage system to drain out uncontrolled water entering first barrier of the gasket. The system must provide pressure release slots in the spandrel panel to eliminate condensation and water leakage due to condensation and pressure built up. The system shall have proper sealing from inside for air and vapor barrier, also effective weather barrier at 2nd level gasket defense with effective drainage system & pressure equalization slots thru 1st barrier gaskets to ensure that the pressure equalization system will operate adequately even under the most severe rain periods and also during severe wind
effect expected in the area. The glass joints must be limited to 15-20 mm with open joint with no sealants exposed in the grooves.

5.2.2 The EPC contractor shall provide complete path of water drainage in shop drawings.

5.2.3 All exposed weather sealing gaskets shall be EPDM gaskets also when in contact with silicone and unexposed must be of EPDM micro wave cured to prevent deformation due to temperature effect and weathering. The openable vents if any given in the system must be provided with multipoint locking mechanism to keep the system sealed under severe wind load and rainy condition. The continuous gutter formation at each floor must be sealed properly and tested before the upper units are installed over them.

5.2.4 The provision of hard EPDM rubber setting blocks at every glass bottom fixed at W/4 distance to support the dead load of the glass

5.2.5 All movable frames like outer frames & shutter frames shall have crimped (and sealed) corner joints to avoid failure of the corner joints at later stage under load condition.

5.2.6 The provision to be made for gondola restrains pins and lightning system to pass through Curtain wall as per the project requirement.

5.3 Sealant

5.3.1 Execute design review, silicone bite size recommendation, surface preparations, compatibility test of all materials and final recommendation to be called from silicone supplier for DGU sealant. IGU sealant application to be carried out under controlled condition and with two part IGU silicone as per approved make (Annexure-1). Execute adhesion testing the record maintained recommended by silicone supplier along with the required tests Butterfly test, snap time test, shore A hardness test, peel adhesion test to be performed and recorded.

The weather sealant applied at the perimeter joints and inter faces shall be of non staining kind and able to withstand the building movements and seismic movement without any failure. The size of the sealant at the perimeter shall be determined based on the movements and shall not be less than 15 mm.

The sealant compatibility test shall be carried out with the kind of granite stone cladding to ensure non reacting kind sealants and non staining of stone over a period.

6.0 PERFORMANCE TESTING:

• Performance test shall be carried for the different wall types as per Annexure No: 03
• Supply and erect off-site full-scale building envelope Test Performance Prototypes for façade testing in accordance with the Specifications, including a suitable simulated building frame, and incorporating at least one example of each repetitive design element and construction method in the system, as indicated on the Drawings. Testing shall include structural performance, air infiltration, water penetration, seismic raking, and proof-load testing and visual assessment.

• The test prototypes will be Accepted subject to the successfully carrying out of the test program and the submission of all specified requirements, and the satisfactory passing of all structural performance, seismic raking, air infiltration, water penetration and proof criteria by the testing laboratory. When Accepted, the test prototype shall be the accepted control standard for the contract works. Test panels and components shall not be re-used in the contract works.

• Submit details of the proposed laboratory, including curriculum vitae of the testing officer in charge. Submit a detailed and sequential outline of the proposed test procedure with schematic diagrams describing the type and location of all data collection instruments. The proposed testing program and procedure shall be accepted prior to the commencement of testing.

• The Contractor prepares and submits to AAI/PMC, for review and Acceptance the overall test schedule, prior to the commencement of any tests. The Test Plan shall include, but is not limited to the following items:

  o A detailed description of the tests to be performed.
  o A detailed description of the conditions under which the test shall be conducted and accepted;
  o A schedule of actions to be taken in the testing of the various parts of the building envelope and the forms of documentation of the test results.

• Testing shall be carried out in a number of phases, including, but not limited, to:

  o Tests during manufacture and Project site Tests
  o Pre Commissioning
  o Commissioning
  o Performance Tests
  o Integration Tests

• The testing agency shall carry out on site tests as specified and the cost of the same shall be included by the contractor.
• The cost of visit of 6 persons i.e. AAI/PMC representative to witness the test shall be included.
• After approval of Mock-up Elevation, Shop drawings and structural calculations the mock-up test units of the curtain wall for performance testing shall be constructed by the Contractor at the testing laboratory.
• The Contractor shall forward the copies of approved mockup elevation and shop drawings to the Test Laboratory prior to installation of the test units. These drawings shall include:
  • Test elevation and sections;
  • Full scale typical details of façade panels
  • Typical support details
  • Extent of sealants
  • Method of installation

Any deviations from the drawings shall agreed upon before commencement and recorded in the final test report.

Test Units:

1) The test units shall comprise components representative both in size and shape of the facade of the building under examination. The width of the test sample shall be not less than of three typical adjoining wall panels/units. The height of the test sample shall be not less than 2 storeys high and must contain full height modules of the Unitized Structural Glazing. Vertical and horizontal movement joints shall be included in the test sample.

2) Where details of the building facade differ from those in the representative test sample, such as critical corners, overhangs and the like, supplementary on site test shall be performed for water tightness on such part of the facade.

3) The materials of the test sample (glass thickness, size and strength, aluminum profiles, bracket spanning, sealant, gaskets, accessories etc.) shall be of the sample, type and size and have the same details, methods of construction, flashing and anchorage as the building facade.
4) If not actual on site representative sample of the wall of the building, the test sample shall be mounted and sealed into a simulated building frame in the same manner and by the same fixing which are intended to attach the facade to the building structure. The support frame shall be of equivalent stiffness to the supporting the building to prevent unrealistic deflection of the prototype sample.

5) Simulated floor slabs and spandrel shall be to actual depth if for example in curtain walls the air seal is connected to the slab. The internal finishes and linings shall be installed where they contribute to the air seal of the facade. The air seal of the test sample shall be continued to the air seal of the test chamber.

6) All panels and other interconnected joints in the facade shall be sealed at the sample boundaries. This is to minimize the effects that the surrounding construction will have on the test performance of the sample. All pressure equalization and drainage slots or holes in the test sample shall be left open.

7) Transparent viewing panels (or other means of observation such as an optical fiber probe) shall be provided so that the performance of the facade in areas that are not readily seen can be determined.

**INSPECTION OF TEST UNITS**

1) The Contractor shall allow for AAI/PMC to inspect the test sample regularly during erection. At this stage the adequacy and stiffness of the support structure shall be assessed. When the installation of the test sample is complete, AAI/PMC shall inspect the test sample and, if satisfied, shall approve its completeness.

2) Submit notice in writing of proposed commencement of the Performance Testing, complete with Program, not less than 1 month before commencement. The testing shall include all actual jobsite components, including all glazing configurations, sealants, adhesives and gaskets. Instruments and gauges shall be selected, tested and located by the testing officer-in-charge in consultation with AAI/PMC.

3) Testing shall not commence until this approval has been given.
4) Full time attendance by approved representatives of the contractor shall be provided for the erection of the test unit and all testing of the test units.

Unless otherwise specified the test sequence shall be as follows

- Pre load at 50% of inward design pressure.
- Air infiltration – Air leakage test – ASTM E 283-04
- Water infiltration under static pressure (or) static water resistance – ASTM E 331-00.
- Water infiltration under dynamic pressure (or) Dynamic water Resistance – AAMA 501.1
- Structural test at 50% and 100% of inward design pressure (or) structural performance @50% and 100% Design wind pressure – ASTM E 330-02
- Structural test at 50% and 100% of outward design pressure (or) Structural performance @50% and 100% Design wind pressure – ASTM E 330-02
- Water infiltration under static pressure (or) static water resistance – ASTM 331-00 (Repeat).
- Seismic rack test @ 100% - two directions Design pressure at design movement (or) Seismic movements @ design displacement at two directions AAMA E501.4
- Water infiltration under static pressure (or) static water resistance – ASTM 331-00 (Repeat).
- Structural test at 150% of inward design pressure (or) Structural performance @ 1.5 X Design wind pressure at two directions – ASTM E 330-02
- Structural test at 150% of outward design pressure Structural performance @ 1.5 X Design wind pressure at two directions – ASTM E 330-02
- A BMU Tie Back shall be tested in all directions (for values of loads to be applied, refer to the relevant section of this specification). A static pressure of 0.5 kPa shall be applied for the duration of the testing. The Tie back shall not fail, exhibit permanent distortion, or interfere with the performance of the curtain wall and related seals.
- Degradation Testing: If deemed necessary by AAI/PMC, on completion of the structural testing, a further series of water penetration tests shall be undertaken with portions of various gaskets and sealant beads removed on each test assembly. The purpose of such
testing is to simulate the effects of degradation and failure of such seals and is carried out for information only.

6.1.1 Air infiltration test shall conform to ASTM E 283-04. Differential static test pressure shall be 300Pa. Chamber leakage shall be accurately determined, not estimated. Air leakage of test specimen shall not be more than 1.1 m$^3$/hr. mtr.

6.1.2 The occurrence of condensation during water infiltration tests is acceptable. Other water leakage is acceptable only if all of the following conditions are satisfied,

- The water is contained and drained to the exterior.
- There is no wetting of surface that would be visible to building occupants.
- There would be no staining or other damage to any part of the completed building or its finishing. This definition of water leakage shall govern over other definition that may appear in referenced documents. State criteria of temperature and humidity.

6.1.3 Where the test sequence or test failures requires successive water infiltration tests. The only means used to drain water from internal cavities shall be gravity drainage through the weep systems (pressure equalization system) for a minimum of 10 minutes. Air pressure removal of parts or other means of draining water not be used.

6.1.4 Static water infiltration test shall conform to ASTM E 331-00, except as otherwise specified herein. Differential test pressure shall be 600 Pa. There shall be no unacceptable water leakage as defined herein.

6.1.5 Dynamic water infiltration test shall conform to AAMA 501.1 except as otherwise specified herein. Differential test pressure shall be 600 Pa. There shall be no unacceptable water leakage as defined herein.

6.1.6 Structural test shall conform to ASTM E 330. Deflection gauges shall be set zero prior each application of pressure at 50 & 100 % of design pressure. Deflection gauge readings shall be recorded after each application of pressure. Deflection measurements are not required for the initial pre load.

(I) Structural loads (ASTM E 330-70) held for ten seconds each as follows.

- 50% of positive pressure – design load (To remove the slack)
• 100% of positive design load.
• 50% negative pressure – design load (to remove the slack)
• 100% of negative design load.

(II) Typical deflections at the above loads will be measured with micrometer dial indicators or Displacement transducers. Allowable deflections of metal framing members at design load are limited to L/200 of the span or 15 mm maximum whichever is less.

(III) Supplementary loads (ASM E 330-70) held for ten seconds as follows:
• 50% Positive design pressure (to remove slack)
• 150% Positive Design Pressure (1.5 * design load)
• 50% Suction Design Load (to remove slack)
• 150% Suction Design Load (1.5 design load)

(IV) No failures in glass breakage nor permanent deformation in Aluminum structural members and Aluminum Composite panel in excess of L/1000 allowed. Deflections are not normally measured.

6.1.7 Mock-up test as per the sequence specified above shall be carried till system finally passes with corrections.

6.2 Field test on actual building-Hose Test:

6.2.1 Hose test for water leakage shall be carried out confirming to AAMA 501.2-03 by the same independent test agency at 8-10 locations as desired by AAI/PMC. Initial installation of 4 units by two floor height to be tested to check the workmanship inline with the design intent and performance. The locations are typical building façade, different corners of the building, copping, critical roof glazing junctions and inclined glazing corners.

6.2.2 There shall be no water leakage.

6.2.3 Begin testing as early as possible i.e. 5% of installation during erection so that approved corrections can be incorporated into the remaining work.
6.2.4 Correct defects revealed by test. Retest corrected work to determine effectiveness of remedial measures.

6.2.5 Provide power, scaffold, water supply and manpower to perform test as desired locations till successful tests. The test areas shall be as selected by AAI/PMC.

6.2.6 AAI/PMC will select typical areas to be tested, each equivalent to three bays wide and two Stories high.

6.2.7 Corrective measure shall meet standards of quality represented by successfully tested mock-ups and are subject to AAI/PMC.

6.2.8 Sealant: Periodically test sealants in place for adhesion, using methods recommended by sealant manufacturer. Promptly replace sealant that does not adhere or fails to cure.

6.2.9 Material Testing:

6.2.10 Brackets, Aluminum Studs and Screw Fixings: Arrange and pay for testing at the accepted laboratory and submit test result for components as follows:

a) Fixing brackets:

- Test a minimum of 3 brackets and embedment fixed to the base structure for each fixing condition. The brackets shall be fixed to prefabricated concrete blocks which exactly represent the base structure in relation to edge distances, reinforcement and concrete strength.

- Prepare and submit shop drawings prior to fabrication of the concrete blocks. Be responsible for making and transporting the concrete blocks to the testing laboratory.
• Install test fixings in accordance with Accepted shop drawings, but locate with most adverse tolerances and application of loads. Acceptance of the fixing system is dependent on each test failure load being at least 3x the design working load for concrete failure, 2x for metal failure and the absence of permanent deformation at 1.5x the design load.

• The test report shall be submitted and accepted prior to casting-in any embedment or fixings into the structure.

b) Aluminum stud fixings

• Where required for fixing face sheeting to support frames, provide not less than M6 fully threaded welded studs of approved type, and welded according to AWS C5.4. Prior to the start of fabrication, demonstrate the strength of welded aluminum stud fixings by testing in tension to destruction six fixings attached to test panels cut from sheets identical to the permanent aluminum panels. Repeat process at 30% and 60% stages of the fabrication programme. Submit a test report prepared by the Accepted laboratory prior to the start of fabrication.

• Test all studs on 1 panel out of 10 to 1.5 times design load. Record and submit records when requested. Any failure will require 100% testing of the particular batch.

• Acceptance of the fixing system is dependent on the average of each set of six test failure loads being at least twice the design load and the absence of permanent deformation at 1.5 times the design load.

c) Screws secured in extrusion flutes: Demonstrate the strength of each connection by testing 18 screws in accordance with AS 1664 or an equivalent Standard. Stagger tests in groups of 6. The test report shall be submitted and accepted prior to fabrication. Any works that are carried out prior to successful completion of the tests will be at the Contractors own risk.

6.2.11 Silicone compatibility testing: Test procedures and minimum acceptance criteria shall comply with AAMA CW 13.
6.2.12 Sealant - Adhesion and compatibility testing: Submit manufacturer's test reports prepared by the accepted lab to conduct sealant test for all structural adhesives (silicone) used in structural glazing before commencing installation. Include details of sampling and test procedures. Carry out and submit results for initial adhesion and compatibility testing by the Accepted laboratory including "peel" tests to ASTM C794 and ASTM C510. Verify unconditional acceptance of all materials in contact with structural adhesives, and that no material in contact with the structural adhesives will cause deterioration of structural adhesives, and the structural adhesives will not cause intrusion into laminated glass interlayer or IGU seals.

6.2.13 Sealant - Direct tension tests: Carry out and submit results for direct tension tests by the Accepted laboratory on samples of vision glass and spandrel glass adhered to finished aluminum. Use an Instron Tensile Tester, or Accepted alternative. Test ten samples of each joint type without weather seals and using actual materials and joint configuration identical to that proposed and complete testing prior to manufacture, as follows:

- Five samples shall be air-cured 21 days then water immersed 7 days before testing.
- Repeat procedure on completion of manufacture of 30% of the materials.
- Apply a 5x safety factor to the mean of the ultimate strength results to determine joint dimension. Complete initial tests prior to commencement of manufacture.

6.2.14 Sealant - Adhesion (de-glazing) tests: Carry out and submit results for factory adhesion (de-glazing) tests to fully cured glazed panels selected randomly. Cut joint at midpoint to leave half the sealant attached to the glass and half to the substrate. Carry out visual examination of joint fill, voiding and structural bite adhesion. After testing fully remove silicone tape and spacers, thoroughly clean and re-apply sealant in accordance with Accepted procedures in the factory. Testing shall be carried out at the rate as follows:

- One unit in the first 10 units delivered to Site.
- One unit in the next 40.
- One unit in the next 50.
- One unit in each 100 thereafter.

After testing, replace the adhesive by Accepted factory procedures.

Any unsatisfactory occurrence including lack of joint fill, lack of adhesion, excessive voiding or other defect be apparent, may be grounds for all units represented by that testing to be rejected. Carry out additional testing of units manufactured on the same day and one day
either side (a further five units). Such units may be accepted on the condition that a satisfactory explanation of such occurrence is submitted and that no additional unsatisfactory occurrences occur.

6.2.15 Sealant - Peel tests during glazing: Carry out periodic "hand pull" peel tests in the factory on finished metal samples out at a rate of one per day. A silicone bead shall be applied to an area not exposed to view in the final location, on a random basis. After curing, a peel test shall be performed to demonstrate adhesion. Record results in glazier's logbook. Submit copies at weekly intervals.

6.2.16 Prototype de-glaze: At completion of testing, de-glaze and replace one vision and one spandrel glass pane in accordance with proposed reglazing procedure to demonstrate the procedure to AAI/PMC. Acceptance: Production of building envelope systems shall not proceed until final test results have been accepted.

6.2.17 Structural glazing restraint testing: Samples of the secondary cover mould restraints shall be tested to demonstrate structural integrity in the event of structural glazing adhesion failure. Structural silicone shall be cut to simulate total adhesion failure and cover mould restraints fitted and tested.

6.2.18 Structural Glazing Testing: Submit manufacturer's test reports prepared by the Accepted laboratory for all structural adhesives (silicone) used in structural glazing before commencing installation. Include details of sampling and test procedures. Test procedures and minimum acceptance criteria shall comply with AAMA CW 13.

7 SUBMITTALS:
(Refer Annexure 02 for formats and no. of copies)

7.1 SHOP DRAWINGS & METHOD STATEMENT:

7.1.1 Submit preliminary shop drawings with Tender submission. Drawings shall show all major Curtain wall systems components. Submit samples of cruciform, glass, ACP and Al. Sheet as etc. Tender will not be considered without preliminary Drawings, basic calculations and samples.

7.1.1 Comprehensive, detailed and dimensioned shop drawings to indicate all set-out and construction details, adjacent work by others and for all proprietary products where required
details are not indicated in the manufacturer’s product data. Separate packages of shop drawings should be submitted without limitation for the following:

- Building Envelope Test Prototypes
- Curtain Wall
- Metal cladding (ACP/Solid Aluminum sheet/Perforated screen)
- Louvers

7.1.2 The approval of shop drawings is for member sizes, surface treatment and the soundness of structural connections. Acceptance will not be given for any setting out or fabrication related issues. Furthermore, Acceptance and Endorsement in no way alleviates the Contractor from responsibility for errors or omissions.

7.1.3 Shop Drawings shall be scaled for A1 size presentation, and submitted for review as A3 size.

7.1.4 The successful bidder shall submit the system design drawings in line with tender drawing design intent complete with engineering calculations for all curtain wall elements.

7.1.5 Time required for examination of shop drawings will be 15 working days for each submission, including re-submissions. The Contractor shall incorporate required changes due to inaccurate data or incomplete definition so that delivery and installation schedules are not affected. The Contractor’s revision response time is not justification for delivery or installation delay of the contract works. Any re-submission shall include requested corrections and shall be responded to previous comments in point-by-point format.

7.1.6 Prepare and submit shop drawing for the entire external façade system including plan, elevations, building section and construction detailing including interface details and submit to AAI/PMC for review to the satisfaction of AAI/PMC.

7.1.7 Manufacture should not commence until Acceptance and Endorsement has been obtained to use the relevant shop drawings. Packages of Shop Drawings shall, without limitation, include and indicate:
• A drawing index sheet indicating all drawing numbers and full description of content. The drawings shall be clear and all texts must be written in English.

• General notes indicating: (1.) relevant codes and standards, (2.) project load conditions, acoustic requirements, and other performance criteria, (3.) material and structural properties and specifications for all metals, glass, silicone, etc., (4.) material properties and specifications for all other materials, insulation, etc., (5.) schedules of all hardware, (6.) schedules of fasteners, bolts, fixings, and anchors.

• Overall elevations and plans for entire building, indicating: (1.) Complete scope of works (2.) references to packages of details (3.) dimensions for AAI/PMC’s review (4.) largest critical dimensions of various components (5.) zones of wind loading (6.) numbering system for building envelope panels (7.) locations of Fire Access Panels (8.) locations of operable lights, doors and direction of opening.

• Set-out of all work, including reference points, edge conditions and joint pattern, indicated on plans, elevations and sections as applicable.

• Tables showing full-size sections of all extrusions and structural members, including descriptions of structural properties, and specifications of materials.

• Framing, anchorage and fixings supported from base-structure, and embedment in the base structure, if required.

• Movement joints.

• Methods of assembly at all junctions, including sealing and fixing, indicated by three-dimensional and exploded views if requested

• Method of installation, including but not limited to:

  o Erection tolerances.
  o Machined slots, keyholes and other methods for handling and connecting components.
  o Junctions and trim to base-structure and adjoining surfaces.
  o Fully dimensioned set-out drawings and templates.
- All pre-tensioning and pre-stressing stages required to meet the design criteria. (For Frameless Glass Walls.)
- Access and materials handling equipment and requirements.

- Supporting Steelwork details including but not limited to the following:
  - Section sizes with accompanying steel grades
  - Grade of bolts
  - Types and positions of welds
  - Weld preparation requirements
  - Cambers to steel sections
  - Locations and sizes of bleed holes in tubes
  - Cover plates
  - Temporary cleats and lifting points, with load capacities
  - Spider Fitting connection points (For Frameless Glass Walls)

- Glazing details, including but not limited to the following:
  - Glazing materials including sealants, gaskets, tapes, setting and spacer blocks.
  - Rebate depth and edge restraint.
  - Clearances and tolerances.
  - Methods of in-service glass replacement.
  - Hardware, fittings and accessories.

- Method of draining the assembly, including details showing:
  - Pressure equalized drained joints.
  - Location, number and size of weep-holes/slots.
  - Mechanical baffles to drainage outlets which are not pressure equalized.

- Methods of meeting performance criteria for thermal insulation, fire resistance, sound transmission loss and the like.
- Method of cleaning and maintenance in service.
- Panel details, including all joints and junctions, and support systems and panel stiffening.
• Connection details (including component parts, all information relevant to fabrication surface treatment, and erection) and provision of lightning protection. Shop drawings shall be in strict compliance with "prototype as tested" drawings which forms part of the prototype testing procedure. No alterations are permitted to the shop drawings after Acceptance and Endorsement without written confirmation of the change from AAI/PMC.

• Provide a complete numbering system and schedule for all cladding and glazing panels. Each panel shall be individually numbered in such a way that the manufacturing and installation history can be traced.
• Design and implement a permanent concealed marking system showing correct location and orientation when installed.
• Submit details for review and Acceptance.
• Indicate the location of each individual panel on shop drawings. Submit as-built elevations progressively indicating the location of each individual panel.

• Installation Procedures Manual

Submit a comprehensive manual containing all installation procedures, equipment and personnel required for acceptance prior to the commencement of installation works for review and Acceptance.

• Operation and Maintenance Manuals

The O&M Manual shall include, without limitation, recommendations for operating, and routine cleaning and maintenance, and all information required to ensure the full service capability of the work, including source of replacement components, and methods of replacement of damaged components. The method of cleaning and timetable shall be specified together with cleaning agents which can and cannot be used.

The Operation and Maintenance Manual is to include the following documents:

  o Comprehensive list of all materials suppliers and agents.
  o Sealant and Gasket Information – All brands.
  o Finishes information – coating system type colour, supplier.
  o Defective works log to be kept up to date for the duration of the warranty period outlining each defect type location and corrective action to rectify each defect.
  o All Warranties from suppliers and Contracting Parties.
  o As-built drawings (AutoCAD Files and A3 hard copy).
• **As-Built Record Documents**
Prepare as-built drawings, photographs and other records progressively as the work proceeds. Submit progress reports on monthly intervals and provide complete as-built documentation at Completion of contract works. As-built drawings shall be submitted to AAI/PMC for necessary onward submission to the relevant Regulatory Authorities for endorsement. These drawings should have been updated to reflect all construction-related modifications to the original drawings. This set of drawings shall be indexed and bound.

7.1.8 Submission of design engineering and Shop Drawings to the satisfaction of consultant and taking final approval from the AAI/PMC shall be EPC contractor’s responsibility.

7.1.9 Hardware accessories details also included in the shop drgs

7.2 **Visual Mock-up Submissions**

The Contractor shall install a full scale mock up for a 3 x bay typical elevation treatment at locations to be confirmed by AAI/PMC.

The visual mock-up for the IGU assembly will be required to be Accepted and Endorsed with respect to appearance of colour.

7.2.1 **Performance Prototype & Prototype Trial Assemblies Submissions**
Refer to Annexure 3 for types and systems that require performance prototype for testing

Submit (within one month of the approval of relevant sample submissions prototype samples for review, and installations for testing, as follows:

Detail Prototype Trial Assemblies of mullion/transom junctions (full-size, 600 x 600 mm): Trial assemblies shall include a typical 4-way stack joint, a typical interface at ceiling level, and a typical vent panel. The assemblies should include all components such as baffles, gaskets, seals, fixings, sponge blocks, sleeves, trims, etc. These assemblies shall be complete and shall not be limited by this list. Test assemblies shall be submitted for review, Acceptance and Endorsement prior to erection of any Performance Prototypes.

7.3 **STRUCTURAL CALCULATIONS**
7.3.1  Submit for review structural computations, of all the critical elements that constitute the Curtain wall including mock up. Comply with given design criteria and loads following the given standards. Include analysis for design wind pressure, dead loads, thermal stresses and seismic loads for all elements in the load path. Show section computations for farming members and full size die drawings.

In no case shall glass be considered as a lateral brace for the farming members.

7.3.2  Submit structural calculations for the silicone bite size as required for DGU. Staad analysis and FEM analysis for panels.

7.3.3  Calculations shall be signed and sealed by a registered structural Engineer experienced in the field of structural glazing design.

7.3.4  The submission of calculation shall include the checks as per load path Annexure 2.

7.4  SUBMITTAL PROCEDURE:

7.5.1  As per the decided protocol, submit preliminary shop drawings as project proposal by the successful bidder to AAI/PMC’s review.

7.5.2  Incorporate AAI/PMC Review comments related to the preliminary shop drawings, in the final shop drawings for approval.

7.5.3  Submit glass Analysis, glass manufacturer’s wind pressure analysis and thermal analysis showing that the specified maximum deflections and probabilities of breakage are not exceeded.

7.5.4  Submit thermal analysis for the Framing system for the U value of framing as per ECBC requirements.

7.5.5  Submit results of silicone Adhesion Tests for records. Sealant manufacturer’s test report for weather seal silicone adhesion to all relevant substrate. Test must include a seven-day water immersion after which silicone must have excellent adhesion to substrate. Report
adhesion strength in terms of shear stress and tensile stress. Test samples shall approximate sealant joint sizes and configurations intended for production materials.

7.5.6 Submit a letter of certification from the sealant manufacturer stating that the sealant has been tested for adhesion and compatibility on production samples of metals, Granite, glass, and other glazing components and that all sealant details and application procedures shown on the reviewed shop drawings are acceptable for use. If required specifically the following submittals shall be provided by the contractor.

7.5.7 Sealant Manufacturer review of the Mockup Drawings prior to the mockup.

7.5.8 Test results for all job specific concealed and exposed sealant conditions confirming compatibility are mandatory for all material prior to mock-up and testing. Preliminary results in advance of final report will be acceptable.

7.5.9 Complete instructions for handling, storage, priming, installation, curing and protection of each type of sealant, joint filler and accessory.

7.5.10 Manufacturer’s Data sheets, clearly indicating shelf life of sealant to be supplied.

7.5.11 Manufacturer review of the final drawings clearly indicating that each product furnished complies, with this specification is recommended for the application shown, and is compatible with each other materials in the joint system.

7.5.12 Quality assurance sample for the curtain wall. Submit weekly Quality Assurance Documentation.

7.5.13 Manufacturer’s warranty at job completion.

7.5.14 Chart of required submittal pertaining to sealant.
### Completion

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### 8.0 SAMPLES:

The Bidder shall submit the following samples along with bid submission for review:

8.1 Submit the following items representative samples of products and materials, including finishes and representative factory-fabrications and site-installed assemblies. Samples to be typically 300mm x 300mm. Include minimum 3 samples without limitation for each of the following:

- Metal types and finishes, including proposed finished shapes, sections and extrusions. Provide metallurgical analysis certificates for alloy and temper of metal components.
- Glass types and finishes indicating colour, surface pattern or texture, finish, surface coatings, and the range of variation, if any.

- Colour samples of pre-finished production material showing the limits of the range of variation in the selected colour.
  - Check samples to confirm or match AAI/PMC’s sample.
  - Preliminary finishes control samples.
  - Final finishes control samples.
  - Colour samples for all sealants, gaskets, and accessories.

- Joint system components, including sealants, gaskets, interlayer, rain-screens, baffles, flashings, elastomeric sealants, backing rods, etc, with details of compatibility with silicone and polyurethane based sealants, and all extruded gaskets, interlayer’s, sealants, tapes and fixings.

- Typical fabrications and assemblies, showing welds and grinding, screwed and bolted junctions, fastenings and workmanship.

- Fixing and accessory items:
  - Bolts, nuts, washers, screws, pins and rivets (with all grades indicated)
  - Proprietary hardware

- Miscellaneous materials:
  - Insulating material.
  - Backing material.
  - Interlayer.
  - Lightning protection tabs.
  - Panel materials for spandrels and other non-vision areas.

- Examples of repairs and making good to typical range of in-service damage to finishes, including chips, cracks and scratching.

- Additional samples for testing sealants and finish coatings as required.

- A range of colour samples of pre-finished materials samples material showing the limits of the range of variation in the selected colour.
8.2 AAI/PMC reserves the right to ask for samples which shows the fabrication techniques and workmanship of the components parts, accessories and other exposed auxiliary items, before fabrications of this work proceeds.

9.0 FABRICATION:

9.1.1 Complete fabrication shall be done at the factory with competent workforce thoroughly skilled in their trade. The fabrication shall follow the procedure manual and sequence. Before the critical assemblies are carried out the inspection of components shall be completed including cleaning of panels in no access area.

9.1.2 Assemblies shall be neat and free off defects that impairs strength, function or appearance. The work shall be accomplished on compliance with the specified criteria without buckling, opening of joints, undue stress on fasteners, sealants and gaskets, opening of welds, cracking or chipping of glass, leakage, noises and other harmful effects. Complete production shall be done in the factory.

9.1.3 All exposed work shall be carefully matched to produce continuity of line and design. All joints in exposed metal work, unless otherwise shown or specified, shall be accurately fitted and rigidly secured with joint sizes conforming to industry standards. The movable frames like openable vent shutters shall need to be crimped at the corner for better strength and aesthetics.

9.1.4 Except where otherwise shown, specified or directed, the method of assembly and joining shall be the Contractor’s option provided the results are satisfactory. The manufacturer’s proven methods that will produce the required standards of workmanship shall be used subject to approval. Fabricate and fasten metal work so that the work will not be distorted nor the fasteners overstressed from the expansion and contraction of the metal.

9.1.5 All welding shall be in accordance with the appropriate recommendations of the American Welding society and shall be done with electrodes and/or by methods recommended by the manufacturer of the alloys being welded. All welds behind finished surfaces shall be carefully done as to minimize distortion and discoloration on the finished side. Unless otherwise shown or specified, all weld beads or expose surfaces shall be grounds and finished to match and blend with finish on adjacent parent metal. Grinding and polishing of nonferrous metal shall be done only with clean wheels and compounds free from iron and iron compounds. No soldering and/or brazing shall be allowed.
9.1.6 Use concealed fasteners in visible finished work.

9.1.7 All Composite aluminum panels shall be factory fabricated in compliance with the manufacturer’s Data sheets. All panels shall be cut and routed using equipment and tools recommended and approved by the panel manufacturer.

9.1.8 Complete method statement shall be submitted by the contractors

9.1.9 All the Glazing units shall be air and water tight.

10.0 PRODUCT HANDLING & STORAGE

10.1.1 Package and store materials in manner that will prevent surface damage or contamination distortion breakage or structural weakening.

10.1.2 The material shall be packed and dispatched properly without any damage to the finish, glass and joints. Proper cushioning to be provided to avoid rubbing with each other.

10.1.3 Proper stacking arrangements at site to ensure no damage to the finish and finished product takes place. Storage plan shall be presented and approved before the material arrives at site.

10.1.4 The factory applied protective peel-off foil shall only be removed after the panels have been installed on site. Replace damages panels if any after peel-off protective foil.

10.1.5 Replace any material damaged during manufacture, shipping, storage or erection.

10.1.6 Protect materials in place from contamination and damage.

10.1.7 Protect factory applied finishes from staining and scratches.

10.1.8 Sealants to project site in manufacture’s original unopened containers with manufacturers name, product name, and color fully indicated thereon. Store in accordance with manufacturer’s instruction.
11.0 INSPECTION:

11.1 All shop and field materials and workmanship shall be subject to review by AAI/PMC at all times. Such reviews shall not relieve the Contractor from the obligation to provide materials conforming to all requirements of the Contractor Documents, and matching approved samples. The Contractor shall promptly correct any deficiencies reported and carry out his own control measurements for all materials, whether reviewed or not.

11.1.2 Verify that surfaces and conditions are situated to receive the work of this Section at site, and that conditions will not adversely affect the installation and performance of the installed work.

11.1.3 Correct all unsatisfactory conditions prior to beginning erection of specified work.

12.0 INSTALLATION

12.1 GENERAL

12.1.1 Erection shall commence only as per written procedure. Bracket layout shall be checked properly by accurate instruments before grid fixation to start.

12.1.2 Erect Grid system in accordance with the approved Shop Drawings.

12.1.3 Provide competent workmen, materials lifting machines, tools & accessories and supervision necessary to erect the complete material.

12.1.4 Do not install components, which are defective in any way, including warped, bowed, dented, abraded, and broken members and glass with edge/surface damage. Remove and replace all damaged components to AAI/PMC’s Satisfaction.

12.1.5 The initial installed panel to be checked for plumb line level and using fixtures for maintaining line levels.

12.1.6 Set walls plumb, squareness, level and fasten securely to correctly verify horizontal alignment. Seal joint within wall and between adjacent constructions.
12.1.7 Do not cut, trim or weld components during erection in any manner, which would damage the finish, decrease strength, or results in a visual imperfection or failure of such components. Return components that require alteration to the shop for re-fabrication, or for the replacement with new parts or components.

12.1.8 Install components level, plumb, true to line, and with uniform joints and reveal. Attach to structure with non-staining and non-corrosive anchors, fasteners, spacers, and fillers as required.

12.2 TOLERANCES:

12.2.1 Tolerances for building frame and other work are specified in other Sections. Make provisions for these tolerances, including a ±30 mm concrete slab tolerance.

12.2.2 All parts of the work when completed shall be within the following tolerances:

* Deviation from plumb, level or dimensioned angle shall not exceed 2 mm per 3.2 of length of any member, or 3mm in any total run in any line.

* Deviation from theoretical position in plan or elevation, including deviation from plumb level or dimensioned angle, shall not exceed 5 mm total at any location. Change in deviation shall not exceed 2mm for any 3.2 mtr in any direction.

* Maximum offset from true alignment between two consecutive members placed end to end shall not exceed 1.5mm.

12.2.3 Maximum offset between glass framing members at corners of glazing pocket shall not exceed 1mm.

12.2.4 Provide accurate bench marks for use in wall erection at all floors. Promptly correct any errors or inconsistencies.

12.3 ASSEMBLY AND ANCHORAGE:

12.3.1 Anchor components/ parts securely in place by bolting, welding or other permanent mechanical attachment system, which will comply with performance requirements and permit movements which are intended or necessary. Install slip pads between moving parts.
12.3.1 Provide a separator at contact surface of dissimilar material Whenever there is a possibility of corrosive or electrolytic action.

12.3.2 Remove weld slag and apply prime paint over welds. Also paint exposed portions of inserts. Touch up shop applied paint that is damaged by welding.

12.3.3 Complete method statement shall be submitted (Building wise)

12.3.4 Ensure that no loads from, due to or generated by the base-structure are transferred to the cladding system, including loads resulting from short or long term structural deflection or shortening of slabs or beams. It shall be transferred on the base building.

12.4 SITE MODIFICATIONS

Finished work which contains unauthorized site modifications, or work not in accordance with the Accepted shop drawings, may be required to be removed and replaced.

Unauthorized work may be Accepted subject to additional computations and testing at the Contractor’s sole discretion. If requested, carry out and pay for all such testing, and submit all computations, test results and any other information required.

12.5 STAGED COMPLETION

Cladding shall be installed in an orderly sequence. Where practical, cladding shall be completed and closed off on a floor-by-floor basis.

Provide temporary flashings at completion of each stage to waterproof and weatherproof the enclosed work. Remove temporary flashing before proceeding with subsequent work.

Sections of cladding which are left open for any reason shall be designed in accordance with the design wind serviceability load with an allowance for wind funneling through the base-structure.

12.6 TEMPORARY MARKING:

Provide temporary marking of glass (if necessary). Use a soluble marking compound and remove all traces on completion. Do not use lime or advertising stickers.

12.7 GLAZING:
12.7.1 All glass processing shall be under controlled condition. Mock-up glass shall not be used on the building. Glass shall be of the specified types and quality, with seamed edges and corners. Inspects all lights of glass before installation. Do not install defective glass.

12.7.2 Before setting glass, inspect frame for proper dimensions and squareness. Adjust frame and/or glass size as required to meet specified requirements. Use fixtures to keep the frame in true squareness.

12.7.3 Except as otherwise specified, comply with FGMA Glazing Manual. Provide a minimum nominal glass bite of 15mm. Where glass bite will be reduced by frame thermal movements increase nominal glass bite to provide 12mm bite when splice joints are fully opened.

12.7.4 Thoroughly clean glazing pocket before setting glass. Solvents shall be compatible with aluminum, glass and glazing materials. Place glass support blocks at end points as per guidelines.

12.7.5 Details of installation shall permit replacement of glass after the construction period.

12.7.6 Replace any glass, which breaks or sustains edge damage, surface damage or damages to reflective coating as defined above.

12.7.7 Experience of glaziers and log-books:

• Glazing shall be carried out by experienced personnel who have pre-qualified for the type of work undertaken. All work shall be supervised by an Accepted glazing supervisor.

• Details and experience of each glazier shall be recorded in the logbook. Samples of each glazier's work shall be periodically removed for testing.

• Maintain a glazing logbook on a daily basis for all glazing and submit progressively. The glazing log book shall be available for inspection at any time without notice.

• As a minimum the logbook shall contain:
  - Date.
  - Name of glazier.
- Individual panel numbers glazed / intended location of installed work.
- Sealant manufacturer and type, colour and batch number.
- Daily air temperature inside and outside the factory.
- Tape and accessory manufacturers and types.
- Test results, including "skin over", "de-glaze, and "hand pull" results, as applicable.
- Glazing supervisor's verification.

12.8 SEALANT APPLICATION

12.8.1 Apply sealant materials in accordance with sealant manufacturer’s recommendations.

12.8.2 Apply sealant using a continuous bead of sealant.

12.8.3 Apply a continuous sealant bead between flashing and adjacent construction.

12.8.4 Before application of sealant, examine the substrates, adjoining construction and the conditions under which the work is to be installed. Do not proceed with the work until unsatisfactory conditions have been corrected. In no instance shall the installer install sealant in conditions which conflict with this specification without approval.

12.8.5 Clean bonding joint surfaces to remove dirt substances, which might interfere with bond or otherwise impair the work. Do not apply elastomeric sealants to joint surfaces previously painted or treated with sealer of curing compound of other coatings, unless a laboratory adhesion and peel test in accordance with ASTM C 920 and ASTM C794 has been performed and successfully demonstrated that bond will be durable.

12.8.6 Unless otherwise shown or specified and documented, install materials in accordance with the manufacturer’s printed instructions.

12.8.7 Confine sealants and primers to joints using masking tapes or other precautions where required to prevent contract of sealant or primer with adjoining surfaces which otherwise would be permanently stained or damaged by such contractor by cleaning methods.
required to remove sealant smears. Remove tape immediately after tooling without disturbing sealant.

12.8.8 Where joint filler is used as backup for sealant, install filler continuously without voids or interruptions to depth and shape specified by sealant manufacturer for proper application and performance of product.

12.8.9 Install bond breaker in joints as shown and wherever recommended the sealant manufacturer to prevent bond of the sealant to surfaces where such bond might impair the performance of the sealant. Do not puncture surface or skin of expanded polyethylene joint filler backer rods.

12.8.10 Apply joint fillers accurately according to the joint profile shown in the drawings after joint cleaning and priming. Provide water tight and airtight corners and joints in a manner recommended by the manufacturer.

12.8.11 Apply sealants in continuous beds filling joint from the bottom without openings, voids or air pockets so as to provide a watertight and airtight seal for the entire joint length. Apply elastomeric sealants, in field joints not subject to traffic to other abrasion to a depth equal to 50% of the joint width, but not less that 6mm and not more than 12mm.

12.8.12 Immediately after sealant application and prior to time skinning or curing begins, tool sealants for smooth, uniform beads, to eliminate air pockets and to ensure contact and adhesion of sealant with sides of joint. Remove excess sealant from surfaces adjacent to Joint. Do not use tooling agents which discolor sealants or adjacent surfaces or are not approved by sealant manufacturer. Tool exposed surfaces of sealants to the profiles if not shown, tool slightly concave to match the configuration as in ASTMC1193.

Provide a slight slope or horizontal joints where horizontal and vertical surfaces meet.

12.8.13 Remove excess sealant promptly as the work progresses and clean the adjoining surfaces as may be necessary to eliminate any evidence of spillage.

12.8.14 Do not proceed with installation of field sealants during inclement weather. Do not proceed with Application of sealants when heavy wind loads are forecast during the period it required for initial or nominal cure of sealants, whenever possible, schedule the application and cure of elastomeric sealants during periods of mean temperatures.
Install field sealants in accordance with manufacturer recommendation to reduce sealant wrinkling from movements during cure. Do not install sealants into joint widths that are less than specified without approval of the AAI/PMC.

12.8.15 LOG BOOKS

- Maintain and submit progressively logbooks for all sealant installation.
- Include quality assurance records, indicating Standards and Codes of Practice, test procedures, acceptance criteria and pass/fail rate.
- Details and experience of each applicator shall be recorded in the logbook. Samples of each applicator's work shall be periodically removed for testing.
- The sealant log book shall be available for inspection at any time without notice.

12.8.16 CURING

- Provide for the appropriate cure conditions, in accordance with the sealant manufacturer’s written recommendations at factory and on-site. Protect external sealants from inclement weather until fully cured.
- Cure sealants in compliance with manufacturer’s recommendations, to obtain high early bond strength, internal cohesive strength and surface durability.
- Submit details of procedures required for cure and protection of joint sealers during construction period to prevent deterioration or damage (other than normal wear and weathering).
- Do not relocate sealed components within the factory or on-site, until the joint has developed sufficient bond strength and cohesive integrity.
- Install sealants to interior at the same time using the same or compatible materials as the exterior sealants.
- Supply glazing unit’s factory pre-glazed in accordance with BS952 or AS1288. No site glazing or re-glazing shall take place unless accepted in writing.

13.0 PROTECTION:
13.1.1 Take all necessary means to prevent any damages (scratches, dents, nicked edges etc.) to components during handling and erection. Replace components beyond acceptable field repair at no additional cost to the AAI/PMC. Special protection tape of 70 microns shall be applied on to the profiles. The tape glue should not get transferred on to the profile surface or react with the finish till hand over time. Sample of the final finish of profile and protection tape shall be submitted for approval before production start.

13.1.2 Protect glass surfaces by protection sheet. Do not apply markers of any kind to glass surfaces.

13.1.3 Remove and replace glass which is broken, chipped, cracked, abraded or damaged in any manner as a result of construction activities, natural cause’s accidents or vandalism. Replace with new material at no additional cost to the AAI/PMC.

13.1.4 Maintain glass in a clean condition at all times, including during construction to prevent glass damage from corrosive action from the elements and contributing side-effects (by wash off) to the components and other work.

13.1.5 Complete method statement shall be submitted by the contractor.

13.1.6 Adjacent work by others

At the completion of all adjacent work by others, including services work, attend the Site, inspect the work areas generally, and repair all damage, complete or make good finishing, trimming and sealing, and replace any damaged or dislodged work.

14.0 CLEANING & MAINTENANCE:

14.1.1 Clean surfaces as required to remove corrosive substances. At the conclusion of construction, clean all surfaces to the satisfaction of AAI/PMC.

14.1.2 Provide written cleaning procedure and cleaning agents which are compatible with aluminum, glass, glazing materials and sealants.

14.1.3 Periodically removes from the site debris, excess materials are unused tools and equipments resulting from this work. At the conclusion of construction, leave the premised in a clean condition acceptable to AAI/PMC.

14.1.4 Complete method statement shall be submitted by the contractor.
15.0 WARRANTIES:

- Contractor has to submit a written warranty for failures of any facade element includes but are not limited to structural, weather performance, durability and finishes.
- Suppliers of the glass, facade panel systems and sealants will be required to supply warranties direct to AAI/PMC for supply and installation for 10 years after the end of the 12 (twelve) months defects liability period.
- Glass supplier to provide specific warranty against Toughened glass NiS breakages for 5 years and provide free replacement against NiS breakages during the warranty.
- Glass supplier/ Processor to provide warranty of min. 5 years for any type of glass lamination, high performance coating of glass, DGUS, etc.
- The system warranty shall include all materials and workmanship.

16.0 PROFORMA FOR WARRANTIES:

The Contractor shall furnish performance Warrantee for the entire external façade systems for a period of specified above from the date of completion of work. The Warrantee shall be in legal paper in acceptable form. The performance Warrantee shall cover for replacement if any or all members and components involved in the above systems by the contractor at his own cost in case if any deficiency or failure in performance of the Aluminum work as per the design requirements during the Warrantee period. The contractor has to undertake responsibility for safety with respect to set out of glass with or without member with which it is held in position during the Warrantee period.

17.0 SPARES (Attic stock)

- Submit certification that all spares will be available off-the-shelf, or with a lead time not exceeding 4 weeks from date of order, for the warranty period.

- Provide name and address of all suppliers and manufacturers.

- Spare glass shall not be used for glass breakage replacements as may be required during the course of installation or the Defects Liability Period.

- All spares shall be new, protected in Accepted wrapping with identifying labels.
• Deliver the spares at the completion of the work as per owner’s direction as and when required.

• Formally hand over and submit complete schedule of types and quantities, including full replacement instructions, and any special tools required.

• Required spares shall include:

  • 1 replacement glass panel for every 50 panels used on the building.
  • Quantities are to be proportioned according to the glass sizes that are used. (Curtain Wall)
  • 1.5% panels maximum of each Cladding panel type and size.
  • 5.0% of painted aluminum band rails/Louvers/windows if any
  • 1.0% of hardware, stays, hinges etc. for all louvers/ windows if any
  • All percentages are based on actual installed quantities of each type.
  • All the dies used to extrude the sections on this project shall be available for the warranty period.

18.0 MODE OF MEASUREMENT:

Terms will be measured generally in accordance with IS 1200 subject to the following:

Measurements shall be in square meter of net visible area fixed.

19.0 RESPONSE TIME:

EPC Contractor shall resolve the Non conformance raised by AAI/PMC within the given time frame. But not later than 2 wks.

20.0 SAFETY:

a) First aid appliances including adequate supply of sterilized dressings and cotton wool shall be kept in a readily accessible place.

b) An injured person shall be taken to a public/private hospital without loss of time, in cases where the injury necessitates hospitalization.
c) Suitable and strong scaffolds should be provided for workmen for all works that cannot safely be done from ground.

d) No portable single ladder shall be over 8 meters in length. The width between the side rails shall not be less than 30 cm. (clear) and the distance between two adjacent rungs shall not be more than 30 cm. When a ladder is used an extra mason shall be engaged for holding the ladder.

e) The excavated material shall not be placed within 1.5 meters of the edge of the trench or half of the depths of trench whichever is more. All trenches and excavations shall be provided with necessary fencing and lighting.

f) Every opening in the floor of a building or a working platform shall be provided with suitable means to prevent the fall of persons or materials by providing suitable fencing or railing whose minimum height shall be one meter.

h) No floor, roof or other part of the structure shall be so overloaded with debris or materials as to render it unsafe.

i) Fire Extinguisher minimum 2 numbers to be provided by contractor at the period of execution of the site.

j) Those engaged in welding works shall be provided with welder’s protective eye-shields and gloves.

k) The Contracto to the painters shall supply overalls and adequate facilities shall be provided to enable the working painters to wash during the periods of cessation of work.

l) Hoisting machines and tackle used in the works, including their attachments, anchorage and supports shall be in perfect condition.

m) The ropes used in hoisting or lowering materials or as a means of suspension shall be of durable quality and adequate strength and free from defects.

n) Those engaged in working at heights shall use safety belts.

o) Provide fully toughened glass on the inner side of the IGU if glass is abutting with floor.
21.0 **ITEMS TO BE CO-ORDINATED:**

- **General:**
  - The Contractor shall initiate and manage the design, development, coordination, installation and testing of the interface between other trades, services and systems carried out on site.
  - The following are a list detailing the trades that are to be considered.

- However, the scope of interfacing required by the Contractor shall not be limited by this list.
  - All building Mechanical and Electrical systems (HVAC, Hydraulic, Electrical, Lighting, PA, IT Systems, Communication systems, Security systems, BMS)
  - Internal partitions, balustrades and wall finishes
  - Internal floor finishes including raised floors
  - Internal suspended ceilings and other ceiling finishes
  - Building Maintenance Units (BMU)
  - All integrated, non-integrated, illuminated and non-illuminated signage and other information display systems.
  - External paving and landscaping
  - All roofing and weather proofing works
  - Building Civil works.
  - Façade Signage
  - Roofing

- **Drainage:**

  - All materials, design and installation necessary for the drainage of all cladding systems shall be provided by the contractor.

  - The design of system drainage shall be co-ordinated with the works of the PHE (Public Health Engineering) where necessary. Connection of external gutters and flashed areas to drainage pipes shall by the EPC contractor.

- **Lighting:**

  - Design of Lighting which is integral to or interfaces with any of the cladding systems shall be fully co-ordinated with the Electrical / Lighting works. All openings around conduits in the building envelope system shall be properly designed, co-ordinated and sealed.
• Security Services and Fire Services:

  o All Security Systems and Fire Services which interface with the external cladding systems including locking mechanisms, intercoms, PA systems, CCTV's, fire services inlet cabinets, fire service control panels, and so forth shall be incorporated into the design of the cladding systems where necessary.

  o This shall include provision of openings, lockable hinged panels with glazed in-fill lights where required, concealed conduits and appropriate ironmongery as is necessary. All E/M equipment shall be provided and installed by the EPC contractor.

  o The Contractor shall rigorously coordinate the technical requirements of the E/M works and the aesthetic requirements of the Contractor.

  o Where there is uncertainty regarding location or extent of co-ordinated works, the Contractor shall be consulted and Acceptance received before any required fabrication of the building envelope works may precede.

• Signage and Information Display Systems:

  o Signage Boxes and Information Display Systems shall be fitted with a hinged heat strengthened glass cover that allows the inside and outside of the glass to be cleaned and the lights to be replaced.

  o For Information Display Systems of a larger scale the Manufacturer’s installation and maintenance requirements shall be complied with.

  o A Manufacturer’s certificate of compliance shall be submitted by the contractor upon completion of the works. All works shall be closely coordinated between the Lighting works and the Facade works.

• Louvers:

  o At louver locations in front of duct work for intake or exhaust the Contractor shall lease with the contractor to provide a fully integrated detail allowing for access to the duct and louvers for both maintenance and cleaning.
- The louver assembly shall be noise and vibration free and shall provide the percentage of free area required for duct performance, as specified by the Contractor.

- The Contractor shall provide a metal collar for connection of the duct-work to the E/M Louvers.

- BMU System:

- The Contractor shall co-ordinate closely with the BMU works and design, manufacture, supply and installs a façade cleaning system for the entire contract works.

22.0 DRAFT GUARANTEE:

GUARANTEE DRAFT FOR EXTERNAL GLAZING CURTAIN WALL SYSTEM

The Guarantee confirms that the installed Façade Products have been designed, tested, fabricated and installed to the specification as set out in the contract tender document and is in line with the International standards and correct practices. The installed products will perform as per the performance criteria given in the specification for a minimum of 10 (TEN) years after the defect liability period.

The Guarantee covers Design defects, material defects & workmanship defects for a period of 10 years.

Any non-conformance found during the Guarantee period shall be corrected or replacement carried out only after given correction and replacement is agreed by the AAI/PMCs authorized representative.

B. PREAMABLE TO THE TECHNICAL SPECIFICATIONS

A. Unless otherwise specified rate quoted for External Glazing works shall

   Include the following:-

1. Design, supply, Cost of all materials, labor, equipment, tools & plant required, conveyance, infrastructure facilities, single / double – Scaffolding, staging, formwork, working platform, suspension platforms, davits, hosting equipment, protective materials etc. as required at any stage of execution / maintenance.
2 Work at all levels, heights & elevation and location.

3 Items should strictly comply with the drawings and Technical specification. Specifications, and Drawings furnished herewith will only be the governing factor for the bidders to choose the system and Materials as per design Intent.

4 Entire Curtain wall glazing system including type & thickness of Glass, extruded frames, sleeves, inserts, Gasket, Adhesive tapes, Sealant, Supporting arrangements including fastening and anchoring system envisaged in the Technical Specifications is only indicative and is meant to set out a general outline of the Proprietary system as commonly understood. Since the Curtain wall Glazing system, both in items of Design, materials, details, methodology of execution are proprietary in nature, the onus of the design, drawings specifications and execution satisfying design intent, performance requirements and site conditions lies solely on the bidder.

5 Bidder shall be responsible to design the system as per the sizes and shapes of the panels shown in the drawings including any modifications as may be required during execution and the designed system should withstand the wind pressure specified in the Documents as well as all other incidental forces and stresses likely to be experienced under service conditions, i.e. dead weight, thermal expansion due to building movement both vertical and horizontal etc. Bidder shall also be responsible to design the entire aluminum farming system, type & thickness of Glass considering the minimal spectral and physical parameters of the glass set out in the technical specifications, sealant including Bite thickness, supporting arrangements including fastening device size & material, preparation of shop drawing in two stages namely project proposal stage and execution stage, fabrication, supply, erection of the system and testing the system as envisaged in the Technical specification i.e. For both Mock-up & Field test.

6 Bidders note that the eventual requirement is performance oriented within the profile, to achieve total Glazing Unitized system specified in the Technical Specifications expected from the design that is adopted. i.e. Resistance to design wind pressure, Prevention of Air & water penetration, continuous Pressure Equalization system, built-in-continuous internal drainage for condensation & penetration & built-in adjustability for thermal movement, thermal barrier, separator Gaskets for Bi-Metallic Correction, smoke seals wherever essential etc.

7 Bidder shall be responsible to design the farming system to support both Vision & Spandrel panel on a continuous framing system. Bidder shall be responsible to provide a full scale mock-up at site for at least 2 bay (Vision and Spandrel panel) and for 2 storied prior to commencement of fabrication based on approved project proposal in such a way, the system provides aluminum member, glass, Aluminum metal Panel, EPDM, Sleeve details in the
system for expansion, pressure equalization concept and in-built drainage system, details of drain point etc.

8 Bidder shall be responsible for incorporating the air pressure equalization principal with Concealed continuous gutter at all levels and at all Floors for self drainage to achieve water tightness besides providing air & water barrier with Gaskets. Barrier should be at minimum three stage Curtain wall system. Entire system shall be designed to accommodate thermal movement of the aluminum components and glass resulting from the exterior ambient temperature from 15 to 45 deg. Celsius and to accommodate vertical movement of maximum 10 mm between floor elements conforming that no aluminum members shall be visible from outside.

9 Bidders to note that the quoted rate for the items covered External glazing works shall Comprehensive and appropriate and shall include all the applicable items envisaged in the System, whether not they been specifically described in the documents/information Supplied, including charge in thickness of members as appropriate.

10 Bidders to note that the minimum spectral parameters of Glass, Technical characteristics Of Aluminum composite panel, Technical properties of the sealant given in the Annexure to technical specifications shall be strictly complied with.

11 Bidder shall be responsible to design the system in such a way they the sealants shall withstand movement up to 50% or to the limitation of manufacturer’s specification. Exposed Sealant surface shall not crack on bubble. No acetify sealant shall be used. Electrometric Sealant shall not be allowed to use, unless otherwise the sealant manufacturer render the service on Product back-up and guarantee.

12 Bidder shall produce design parameters of the following components in 2 stages namely, Project proposal stage in line with bid submission and shop drawing based on the system Approval, but not limited to,

a) Glass
b) Sealants
c) Aluminum members
d) Fasteners
e) Brackets
f) Separators, Anchors.

13 Aluminum extrusions shall be of aluminum alloy 6063 – T5/T6 conforming to BS 1475.

14 Aluminum composite panels shall be of aluminum Alloy 3105 – H14 or 3003 – H14

ACP thickness of panel shall be 4mm, (skin aluminum on both sides should not be less than 0.5mm) suitably stiffened internally on the back side (Methodology of fixing the stiffener to be described by the Bidder for approval) for preventing deflection due to design wind pressure beyond permissible limits.

15 In general the proposed glass shall be approved make and as specified in the document. The double glazing unit shall be supplied by the approved processor. Only new substrate glass shall be used for coating and to ensure the same, the manufacturer shall produce the certificate.

16 Float glass shall conform to ASTM C 1036.

17 Heat strengthened and tempered glass shall conform to ASTM C 1048

18 Tempered glass shall conform to ANSI Z 97

19 Glass canopy shall be designed to satisfy the requirements of AS 1288.

20 All safely glass shall conform to the requirements of AS2208 or CPSE 16 and CFR 1201.

21 In general, the glass products shall conform the following International standards.

   a. BS 952 – Part I

   b. ASTM C 1036 – 91

   c. EN 572 – 1 & EN 572 – 2

   d. NBN S 23 – 002

   e. NF P 78 – 302

   f. DIN 1249 TEIL 3

   e. NEM 3264

22 Weather Gaskets shall be EPDM micro cured of Amee Rubber make or equivalent with shore 60 & 65 EP / TN. Structurally glazed glass shall have silicone gasket covering the edge of the glass.
Baker rods shall be polyurethane foam of “supreme of approved equivalent make”. Spacer tape (Adhesive tape) shall be of open cell polyethylene foam of “Nortan make”

23 Secondary sealant, primary sealant, spacer, setting blocks made out of solid extruded silicon rubber with a hardness of 85 Durometer – Shore A shall be provided.

24 All supported brackets for aluminum members in the structural glazing shall be 6005 – T6 – structural grade and the brackets to have serrations.

25 All supporting system, such as brackets and similar attachments used for fixing & erection of the aluminum members, aluminum composite panel shall be of hot dip galvanized steel. Anchors, fasteners with nuts & washers and all other fastening materials shall be non-magnetic stainless steel of SS 316 grade steel.

26 All Flashings / smoke seals / fire stops shall be provided to all floor levels, skill and to proof parapet at terrace and slides of vertical surfaces where necessary.

27 All bolted connections shall include lock washers, lock nuts or other locking device and conceal the fasteners here visible in the finished work. Fasteners in non-wetting locations shall be cadmium plated, if directed.

28 All hot dip galvanized steel shall conform ASTM A 123.

29 All electro galvanized steel shall conform ASTM A 164 or FS-Q-Z-325b(2).

30 All stainless steel shall be 316 grades, brush finish and 300 series non-magnetic steel.

31 Where finishes are not specified all such metals shall be finished in a manner consistent with similar and necessary to conform to the design intent.

32 Shop Drawing for Mock-up as well as for entire external glazing system based on approval Design Parameters shall be provided for approval, in two stages as described elsewhere.

33 Structural test shall confirm to ASTM E 330

34 Mock up test and Field test shall be carried out accordance with Technical specification including all material required for Mock-up test and Field test. Full scale mock up testing is mandatory and is governing parameter for performance verification.

35 Conducting mock up test including necessary arrangements at FITI laboratory with the design wind pressure. If Mock-up test fails, correct the defects revealed till the satisfaction of the performance data as setout in the Technical specification.
36 Conducting Field test including necessary arrangements scaffolding hose, water & manpower. If field test fails, correct the defects revealed till the satisfaction of the performance data.

37 Aluminum Extrusions, Glass, Aluminum composite panel or Aluminum solid panel, Gasket, sealant supposing system including fastening devices provided at site shall be in line with approved Mock-up and shall be identical.

38 Samples of all components such as aluminum Extrusions (Main manners, supporting member, sleeve member etc.) Glass, Sealants, aluminum composite panel etc. shall be submitted along with tender for approval. 300mm square size samples labeled of Glass, ACP sample shall be produced. All the approval samples of Material shall be stored by the success full bidder at site and to be produced as and when required for scrutiny.

39 Provide accurate benchmarks for use in wall erection at all floors and if there are any errors or inconsistencies rectify at no extra cost.

40 Tolerances for building frame and other work shall be strictly adhered to.

41 Seal the joints within the wall and between adjacent constructions using the approved sealant.

42 Remove and replace all damaged or disfigured components to the satisfaction of AAI/PMC at no extra cost.

43 Provide a separator at contact surface of dissimilar material whenever there is a possibility of corrosive or electrolytic action.

44 Cleaning agents which are compatible with aluminum, glass, glazing, glazing material & sealants shall only be used and the same shall get it approved before use on work.

45 Cleaning the glazing pocket before setting the glass.

47 Cleaning the entire glazing, aluminum, composite panel and other components prior to handing cover.

48 Specifications furnished in the Technical Specifications are indicative/tentative and are subject to reconciliation on award of work between success full bidder and AAI/PMC, if there is any discrepancy at the shop drawing stage.
49 Supply an adequate number of glass panels as spares so as replace broken panels in event of accident all breakage in the future for maintenance at mutually agrees rate.

Number of spares required shall be decided by AAI/PMC.

50 Submittals should be provided as mentioned in the Technical Specification for approval.

Tender submission should include a statement showing the conformity for each components with technical specificity on or otherwise the never should specify / highlight he Material or components prospered, which does not comply with Technical specification.

51 Protect all components and material from damage or disfiguration of any kind of at all stages of work until handling over. Te entire cladding work including all the components involved in these items shall be guaranteed by the external cladding agency as General and system Guarantee for a period 10 (Ten) years (After the DLP) including special guardant for glass, reflective coating of the Glass. Aluminum composite panel including coating and Sealant by the Manufacture./ Suppliers for the period specified in the Technical specification in an approved Performa acceptable to AAI/PMC on a stamp paper. The guarantees from spec list applicators such as sealants, Double Glazed unit fabrication / Processor. Glass processing & coating, Aluminum such as for sealants, double Glazed unit fabrication / Processor, Glass procession & coating Aluminous composite Panel including skin Material from the Coil Manufacturer and processor etc, shall also be submitted form the respective Manufacturer / sub – vendor, counter signed by the Spec list external cladding agency.

52 The fabricator shall design the system suitable for installing the glass from the Exterior surface after handing over and during maintenance by AAI/PMC. However, the vertical in site the glazing in the system shall not be allowed during construction / Erection of the system under any circumstances.

53 All the drawings and samples submitted along with tender documents shall form part of the contract. Bidding are requested to submit the tender drawings and the samples of materials required along with tender submission duly signed & stamped, falling which the tender is liable for rejection.

54 All the Questionnaires attached with the tender document should be filled by the Bidder without fail and the same shall form part of the contract. Bidders are requested to fill all the details called for in the pre-qualification, should duly signed & stamped, falling which the tender is liable for rejection.
ANNEXURE 1 : FAÇADE WORKS CONSISTS OF LIST OF APPROVED MAKES ATTACHED SEPARATELY
## Annexure No: 02

### Format for Drgs & Calculation to be submitted by EPC Contractor

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<td>1.5</td>
<td>Proposed System drgs for all Main elements by Bidders. Single details in Single Page only</td>
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<td>05</td>
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<td>1.6</td>
<td>Structural Calculation for main Elements by Bidders</td>
<td>A4</td>
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<td>Post Award Stage</td>
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<td>2.1</td>
<td>System Drawing for All Wall Types in 1 : 1 scale</td>
<td>A2</td>
<td>05</td>
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<td></td>
<td>Single details in Single Page only</td>
<td>A3</td>
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<td>2.2</td>
<td>Structural Calculation for All Wall types</td>
<td>A4</td>
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### Annexure No: 03

**List of Visual Mockup / Performance Testing Mockup / Material Test**

<table>
<thead>
<tr>
<th>WALL TYPE</th>
<th>TYPE OF TESTS</th>
<th>FREQUENCY &amp; SAMPLES</th>
<th>TEST REQUIREMENT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Visual Mockup</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>All Wall Types</td>
<td></td>
<td></td>
<td>1 Bay &amp; 1 floor Height / 2 floor height</td>
</tr>
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**Performance Mockup Test at Laboratory Condition from NABLA Accredited Lab**

<table>
<thead>
<tr>
<th>WALL TYPE</th>
<th>TYPE OF TESTS</th>
<th>FREQUENCY &amp; SAMPLES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conventional Curtain wall (WT 01)</td>
<td>Vent Open Cycles</td>
<td>1 Window</td>
</tr>
<tr>
<td></td>
<td>Air Infiltration</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Air Exfiltration</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Static Water / Repeat</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Dynamic Water</td>
<td></td>
</tr>
<tr>
<td>Test Type</td>
<td>Description</td>
<td></td>
</tr>
<tr>
<td>-----------------------------------</td>
<td>-----------------------------------------------------------------------------</td>
<td></td>
</tr>
<tr>
<td>Structural / Proof Structural</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Seismic / Proof Seismic</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Degradation</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Onsite Test from NABL Accredited Lab</strong></td>
<td>Site Water testing-Testing method to be as per AAMA standard with Monarch Nozzle with standard pressure gauges. The Contractor shall carry out rectification in case of any leakage. 1st test for typical facades to be tested for field water test upon completion of 1000 sqm facade area or 100/o of glazing area whichever is less. Minimum 3 locations for each system. Subsequent water test shall be upon progressive work. One test for every 3000 Sqm of facade area or part thereof. Area of testing shall not be less than 100 sqm per test.</td>
<td></td>
</tr>
<tr>
<td>Test Type</td>
<td>Test Details</td>
<td>Minimum Percentage to be Tested</td>
</tr>
<tr>
<td>-----------------------------------------------</td>
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<td>---------------------------------</td>
</tr>
<tr>
<td>Anchor Fastner Pullout Test</td>
<td>Pull out test for Proof load factor of 1.5 on Service load anchors.</td>
<td>Min 100/o of Installed Anchors shall be tested.</td>
</tr>
<tr>
<td>Site Weld Test</td>
<td>Visual Check Die penetration test Magnetic particle test Ultrasound Examination</td>
<td>All major critical joints should be tested after Mock up approval during construction as progressive test.</td>
</tr>
<tr>
<td>Mechanical &amp; Chemical Test from NABL Accredited Lab</td>
<td>Chemical Test- Wet and Spectrograph (per every 5000 Sqm of facade)</td>
<td>3nos of samples per testing 100 tons / 5000 Sqm of facade</td>
</tr>
<tr>
<td>Aluminium Extrusions</td>
<td>Mechanical Test- Tensile Proof Stress tests</td>
<td></td>
</tr>
<tr>
<td>Gasket</td>
<td>Shore Hardness Chemical Test</td>
<td>1 sample per each type of Gasket.</td>
</tr>
<tr>
<td>Glass Fittings &amp; Hardware,</td>
<td>Mechanical Properties Chemical Properties</td>
<td>3 no's of Samples shall be for each type of test. Test certificate/ MTC which is carried out with in last 1 year is acceptable.</td>
</tr>
<tr>
<td>Material</td>
<td>Test Criteria</td>
<td>Test Numbers</td>
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<tr>
<td>----------------------------------</td>
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<tr>
<td>Aluminium Finish</td>
<td>Stain test / Thickness</td>
<td>Random / Minimum 4 test</td>
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<tr>
<td>ACP</td>
<td>Alloy / Mechanical / Skin / Coating Thickness / Core test</td>
<td>Random / Minimum 2 test</td>
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<tr>
<td>Solid Aluminum Sheet</td>
<td>Alloy / Mechanical / Skin / Coating Thickness</td>
<td>Random / Minimum 2 test</td>
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<td>Anchor Fastner</td>
<td>SS 316 Check</td>
<td>Random / Minimum 2 test</td>
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<td>MS Bracket</td>
<td>Hot Deep Galvanized check</td>
<td>Random / Minimum 4 test</td>
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<tr>
<td>SS Fastners</td>
<td>SS 316 / SS 304 Check</td>
<td>Random / Minimum 4 test</td>
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<tr>
<td>Sealant</td>
<td>Structural / Weather Sealants</td>
<td>As per Dow Corning / Sika Guidelines</td>
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<tr>
<td>DESCRIPTION</td>
<td>CONFIRMATION</td>
<td>MAKE</td>
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<td>-----------------------------------------------</td>
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<tr>
<td>Conventional Curtain Wall Glazing</td>
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<tr>
<td>Mullion Ixx Value for WT01</td>
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<tr>
<td>System weight (Kg/m²) for WT01</td>
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<td>3 barrier gasket system ?</td>
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<td><strong>General Details</strong></td>
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<tr>
<td>Pressure equalised system ?</td>
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<tr>
<td>Anchor Fastener Size / Make</td>
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<td>Performance testing consideration for PE 01</td>
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<table>
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<td>Extrusion Tolerance standard</td>
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<tr>
<td>Internal visible profile finish Thickness Super Durable / High Durability</td>
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<tr>
<td>External visible profile finish Thickness PVDF Coating</td>
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<tr>
<td>EPDM Gasket Spec / Make</td>
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<tr>
<td>Silicon Gasket Spec / Make</td>
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<tr>
<td>Aluminium Trims &amp; flashing for Sealing</td>
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<td>Rivet Center distance for ACP Panel</td>
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<td>Extended Bracket Finish with HDG</td>
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<td>Bracket design with 3 dimensional movement</td>
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<td>Bracket with serrations &amp; Serrated washer</td>
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<tr>
<td>Spacer tape</td>
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<tr>
<td>All Hardwares / SS Bolts &amp; Nuts</td>
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<tr>
<td>Spandrel Insulation Spec / Make</td>
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<td>Fire Stop Spec / Make</td>
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<td>GI Flashing for Fire stop</td>
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<td>Smoke Seal Intumuscent</td>
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<td>Baker Rod</td>
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<td>Top Hung Openable Vent</td>
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<td>Company Incorporated Year</td>
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<td>2</td>
<td>2 part pump (No / Spec / Make)</td>
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<td>Double Head Sawing Maching (No / Spec / Make)</td>
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<td>Single Head Sawing Maching (No / Spec / Make)</td>
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<td>5</td>
<td>Copy Router (No / Spec / Make)</td>
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<td>6</td>
<td>End Milling Machine (No / Spec / Make)</td>
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<td>7</td>
<td>Crimping Machine (No / Spec / Make)</td>
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<td>8</td>
<td>Project Executed more than 25000 m² in Unitized system</td>
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<td>Project Name No: 1 / Area (SQM) / Location</td>
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<td>Project Name No: 3 / Area (SQM) / Location</td>
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<td>Project Name No: 5 / Area (SQM) / Location</td>
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<td>Design office Resource strength in India</td>
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<td>Structural engineer strength inhouse</td>
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<td>Total Shifts in production</td>
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<td>Per Day Production (Unitised panel Nos /m²)</td>
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<tr>
<td>Per Day Installation (Unitised panel Nos /m²)</td>
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<td>PARAMETERS</td>
<td>SPECIFICATION</td>
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<tr>
<td>Insulated Glass</td>
<td>30mm IGU (8mm Outside Glass + 16 mm Air gap + 6mm thk. Inside Glass)</td>
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<td>PERFORAMNCE GLASS SPEC.</td>
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<td>LIGHT TRANSMISSION (%) : 23 - 34 %</td>
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<td>SHADING COEFFICIENT : 0.27 - 0.28</td>
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<tr>
<td></td>
<td>SUMMER U VALUE W.M2K : 1.6 - 1.8</td>
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<tr>
<td>Outer Type Glass</td>
<td>8mm Thk. Reflective coated</td>
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<tr>
<td>Inner Type Glass</td>
<td>6mm thk. Clear Float</td>
</tr>
<tr>
<td>Size Tolerance</td>
<td>± 2 mm</td>
</tr>
<tr>
<td>Type of Coating</td>
<td>Magnetically sputtered vacuum deposition (MSVD)</td>
</tr>
<tr>
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<td>-----------------------------------------------</td>
</tr>
<tr>
<td>Coating position</td>
<td>Face # 2.</td>
</tr>
<tr>
<td>Coating Edge Deletion</td>
<td>Edge Deletion Required As per Supplier Guidelines</td>
</tr>
<tr>
<td>Toughening (Both Glass)</td>
<td>Heat Strengthened</td>
</tr>
<tr>
<td>Surface Compression</td>
<td>5000-7500 Psi</td>
</tr>
<tr>
<td>Roller Wave Distortion</td>
<td>Parallel to the bottom edge of the glass as installed (Parallel to the width of the glass)</td>
</tr>
<tr>
<td>Strain Pattern</td>
<td>Should not be visible</td>
</tr>
<tr>
<td>Toughening BOW</td>
<td>2mm (Maximum)</td>
</tr>
<tr>
<td>Distortion / Roller Wave</td>
<td>Max 0.076mm / 300mm ; Edge curl max 0.25mm</td>
</tr>
<tr>
<td>Concavity / BOW in IGU</td>
<td>2mm (Maximum)</td>
</tr>
<tr>
<td>Outer Glass Edge Finish</td>
<td>Flat Machined ground</td>
</tr>
<tr>
<td>Inner Glass Edge Finish</td>
<td>Edge Arised</td>
</tr>
<tr>
<td>Aluminium Spacer</td>
<td>16mm Thick natural Anodised</td>
</tr>
<tr>
<td>DGU Offset Tolerance</td>
<td>± 1 mm</td>
</tr>
<tr>
<td><strong>Parameters</strong></td>
<td><strong>Specification</strong></td>
</tr>
<tr>
<td>----------------</td>
<td>-------------------</td>
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<tr>
<td>Dessicant</td>
<td>Silica Molecular Sieve.</td>
</tr>
<tr>
<td>Primary Seal</td>
<td>PIB seal (Polyisobutyle seal)</td>
</tr>
<tr>
<td>Secondary Seal</td>
<td>Two part IGU silicone sealant</td>
</tr>
<tr>
<td>Sealant Type &amp; Bite Size</td>
<td>Sika IG 25 / Dow Corning DC 982 Bite Size as per structural requirement</td>
</tr>
<tr>
<td>Corner / Vent glass</td>
<td>Ceramic frit edges incase of stepped glass</td>
</tr>
<tr>
<td>HS Logo</td>
<td>HS logo in small dia of 15mm within 25mm Edge of bottom corner</td>
</tr>
<tr>
<td>Label</td>
<td>Type of Glass / Thickness / HS Mark / #</td>
</tr>
<tr>
<td>Packing Method</td>
<td>Square foam pads between 2 glasses as separator to avoid scratches &amp; damage to coating. Wooden crates with proper cushioning to avoid glass edge chip off &amp; breakages. Sea worthy &amp; local transport worthy</td>
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</table>

**Annexure No: 05B**

**Glass Specification for ATC Tower**

<table>
<thead>
<tr>
<th><strong>Parameters</strong></th>
<th><strong>Specification</strong></th>
<th><strong>Standard</strong></th>
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<tbody>
<tr>
<td>Insulated Glass</td>
<td>34.89mm Laminated IGU (8mm Outside Glass + 16 mm Air gap + 10.89mm thk. Inside Glass PERFORAMNCE GLASS SPEC. LIGHT TRANSMISSION (%) ; 23 - 34 %</td>
<td>ASTM E 774</td>
</tr>
<tr>
<td>Description</td>
<td>Details</td>
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</tr>
<tr>
<td>-----------------------------------------</td>
<td>-------------------------------------------------------------------------</td>
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<tr>
<td>SHADING COEFFICIENT</td>
<td>0.27 - 0.28</td>
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</tr>
<tr>
<td>SUMMER U VALUE W.M2K</td>
<td>1.6 - 1.8</td>
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</tr>
<tr>
<td>Outer Glass Type</td>
<td>8mm Thk. Reflective coated</td>
<td></td>
</tr>
<tr>
<td>Inner Glass Type</td>
<td>10.89mm thk. Clear Float laminated glass</td>
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</tr>
<tr>
<td>Size Tolerance</td>
<td>± 2 mm</td>
<td></td>
</tr>
<tr>
<td>Type of Coating</td>
<td>Magnetically sputtered vacuum deposition (MSVD)</td>
<td></td>
</tr>
<tr>
<td>Face # 2.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Coating position</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Coating Edge Deletion</td>
<td>Edge Deletion Required As per Supplier Guide lines</td>
<td></td>
</tr>
<tr>
<td>Toughening (Both Glass)</td>
<td>Heat Strengthened</td>
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<tr>
<td>Surface Compression</td>
<td>5000-7500 Psi</td>
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</tr>
<tr>
<td>(Paral) Wave Distortion</td>
<td>Parallel to the bottom edge of the glass as installed</td>
<td></td>
</tr>
<tr>
<td>(Paral) Wave Distortion</td>
<td>(Parallel to the width of the glass)</td>
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</tr>
<tr>
<td>Strain Pattern</td>
<td>Should not be visible</td>
<td></td>
</tr>
<tr>
<td>Toughening BOW</td>
<td>2mm (Maximum)</td>
<td></td>
</tr>
<tr>
<td>Distortion / Roller Wave</td>
<td>Max 0.076mm / 300mm ; Edge curl max 0.25mm</td>
<td></td>
</tr>
<tr>
<td><strong>Concavity / BOW in IGU</strong></td>
<td>2mm (Maximum)</td>
<td></td>
</tr>
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<td>---------------------------</td>
<td>---------------</td>
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</tr>
<tr>
<td><strong>Outer Glass Edge Finish</strong></td>
<td>Flat Machined ground</td>
<td></td>
</tr>
<tr>
<td><strong>Inner Glass Edge Finish</strong></td>
<td>Edge Arised</td>
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</tr>
<tr>
<td><strong>Aluminium Spacer</strong></td>
<td>16mm Thick natural Anodised</td>
<td></td>
</tr>
<tr>
<td><strong>DGU Offset Tolerance</strong></td>
<td>± 1 mm</td>
<td></td>
</tr>
<tr>
<td><strong>Dessicant</strong></td>
<td>Silica Molecular Sieve.</td>
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<td><strong>Secondary Seal</strong></td>
<td>Two part IGU silicone sealant</td>
<td></td>
</tr>
<tr>
<td><strong>Sealant Type &amp; Bite Size</strong></td>
<td>Sika IG 25 / Dow Corning DC 982 Bite Size as per structural requirement</td>
<td></td>
</tr>
<tr>
<td><strong>Corner / Vent glass</strong></td>
<td>Ceramic frit edges incase of stepped glass</td>
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<tr>
<td><strong>HS Logo</strong></td>
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</tr>
<tr>
<td><strong>Label</strong></td>
<td>Type of Glass / Thickness / HS Mark / #</td>
<td></td>
</tr>
<tr>
<td><strong>Packing Method</strong></td>
<td>Square foam pads between 2 glasses as separator to avoid scratches &amp; damage to coating. Wooden crates with proper cushioning to avoid glass edge chip off &amp; breakages. Sea worthy &amp; local transport worthy</td>
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<tr>
<td>No</td>
<td>Wall Type Identification</td>
<td>Wall Type Number</td>
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</tr>
<tr>
<td>1</td>
<td>Punctuated point fixed Glazing</td>
<td>WT-01, WT-01A</td>
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<tr>
<td>2</td>
<td>Fixed Glazing with horizontal members</td>
<td>WT-02</td>
</tr>
<tr>
<td>3</td>
<td>Conventional Cap curtain wall</td>
<td>WT-03, WT-03A</td>
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<tr>
<td>4</td>
<td>Vestibule Entrance</td>
<td>WT-04</td>
</tr>
<tr>
<td>5</td>
<td>Sliding Door, Patch fitting Door</td>
<td>WT-05A, WT-05B,</td>
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<td>Aluminum frame doors</td>
<td>WT-05C</td>
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<td>6</td>
<td>Glass Canopy</td>
<td>WT-06A</td>
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<td>7</td>
<td>Glass Canopy</td>
<td>WT-06B</td>
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<td>8</td>
<td>Aerobridge Glazing</td>
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<td>9</td>
<td>Internal Glazing</td>
<td>WT-08</td>
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<tr>
<td>10</td>
<td>Railing</td>
<td>WT-09</td>
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TS-08
INTERIOR WORKS
NOTE:

(The Technical Specifications are intended only to provide a fair idea about the requirements and concepts of the Project. The designs, technical specifications etc. to be executed at site are required to be submitted by the EPC Agency to AAI/ PMC for prior approval)

Work shall be carried out to Indian Standards, CPWD Specifications and Code of Practices. In absence International Standards shall be followed. These shall be latest issue. Specifications given hereunder are not to be considered as conclusive and are for reference and guidance only. Any discrepancies noticed shall be directed to the notice of PMC/ AAI for direction and approval. However as a general rule more stringent specification shall take precedence.
Part A : FLOORING WORKS

A. SCOPE OF WORKS

This specification covers the general requirements for flooring of various types of finishes including supplying, installation, finishing, curing, testing, protecting, maintaining until handing over.

B. TECHNICAL SPECIFICATIONS

1. GRANITE FLOORING

The slabs must be of uniform thickness as specified the variation in the thickness not exceeding 2mm and must be from the same source. They shall be of uniform texture and colour free of any veins and streaks. All the edge shall be chiseled true to line, square and shape. The brushes in the joints are not more than specified thickness.

Rough Finish:

The surface should be rough dressed/one line dressed/two lines dressed/three line dressed finish using palmane tools as specified.

a) Rough dressing- The stone surface to be chisel dressed to one plane by removing all bushings so that the maximum depression is not more than 6 mm.

b) One line dressing - This is done after the rough dressing is completed by point chiseling so that the variations are not more than 4 mm. Work includes rough dressing also.

c) Two line dressing- This is done after one line dressing is done by chiseling so that variations are not more than 2.5 mm. Work includes rough and one line dressing also.

d) Three lines dressing- This is done after two lines dressing is over by chiseling so that the variations are not more than 1.5 mm. Work includes rough, one line & two lines dressing also.

d) Palmane dressing- After the three line dressing is over the surface is smoothened by using a special palmane tool to further even out the 3 line dressed surface so that the maximum variation in surface evenness is not more than 1.0 mm. Work includes rough, one line, two line & three line dressing also unless otherwise stated.
Mirror Finish:

The surface will be polished by grinding using manual or mechanical process to give a smooth, even, perfect plane surface or as may be directed. The polished surface should reflect light like a mirror free from scratches and depressions.

Protection:

Granite slabs in flooring shall be protected with layer of pop to a required thickness over aplastic sheet. The pop and plastic sheet shall be removed and one coat of polishing to be carried out if required before handing over.

Physical Properties:

• The stone slabs shall be of selected quality, hard, sound, dense and homogeneous in texture free from cracks, decay, weathering and flaws. They shall be machine cut to the requisite thickness.

• The slabs shall be of size approved by engineer in charge and have the top (exposed) face polished before being brought to site, unless otherwise specified.

<table>
<thead>
<tr>
<th>Sr.No.</th>
<th>Characteristic</th>
<th>Standards</th>
<th>Method of Test</th>
</tr>
</thead>
<tbody>
<tr>
<td>01</td>
<td>Moisture absorption after 24hrs immersion in Coldwater</td>
<td>Max. 0.4% by weight</td>
<td>IS :1124</td>
</tr>
<tr>
<td>02</td>
<td>Hardness</td>
<td>Min 3Mohs</td>
<td>Mohs Scale</td>
</tr>
<tr>
<td>03</td>
<td>Specific Gravity</td>
<td>Min 2.5g/cc</td>
<td>IS :1122</td>
</tr>
</tbody>
</table>

The bottom surface & four sides of the granite stone flooring shall be pre-treated before laying with two or more coats of approved water proofing penetrating shield treatment of approved make and quality with minimum three years warranty.

DRESSING:

Every slab shall be cut to the required size and shape and machine cut and table rubbed on the sides to the full depth so that a straight edge lay along the side of the stone shall be in full contact with it. The sides (edges) shall be table rubbed with machine edges of the slabs shall be true, square and free from chippings and the surface shall be true and plane.
2. ANTI STATIC VINYL FLOORING

PVC based Synthetic Homogenous Vinyl Tiles and Rolls set with adhesive on to a concrete or masonry base shall conform to latest EN 649.

Materials:

1) Tiles: The tiles should be calendared laminated solid resilient unbreakable and homogeneous flexible quartz reinforced PVC Vinyl tiles composed of 100% vinyl from face to back with alkaline resisting colour pigments and other plastic compounds in different shades and designs and in different sizes and thickness and shall conform to ES428. Unless otherwise mentioned the tiles shall be squares of approved dimensions. Tiles shall have properties of a high wear resistance and resilience, designed to withstand high traffic and abrasion. The face of these tiles shall be free from porosity, blisters, cracks, embedded foreign matter, or other physical defects, which affect the appearance or impair the service ability of the tiles. All edges shall be cut true and square. The colour shall be non-fading and uniform in appearance, insoluble in water and resistant to alkalies cleaning agents and usual floor polishes. Cove base shall be extruded PVC (100% putty) with moulded top set cove colour and the height of the base shall be as indicated on the drawings, scheduling and / or as approved by AAI/PMC. Samples of tile and cove base shall be submitted to the AAI/PMC along with test certificate for approval.

2) Rolls: It should be calendared laminated solid resilient unbreakable and homogeneous quartz reinforced flexible PVC Vinyl Flooring in different shades and designs and indifferent width and thickness with inherent characteristics of wear resistance, dimensional stability, elegance etc and shall conform to EN 649. Each packet of tile or roll shall be legibly and indelibly marked with the manufacturer’s trade mark, thickness, size batch number and date of manufacture. Tiles shall be delivered securely packed and store in clean, dry, well ventilated places.

3) Adhesive: Synthetic rubber based adhesive to be used for fixing tiles shall be Dunlop S-758 or Fevicol SR-998 or equivalent or as recommended by the manufacturer. The adhesives shall have a short drying time and long life. Each container shall show the self life, date of manufacture and over age container shall be immediately removed from the site.

4) Sub-floor: The surface of sub-floor to receive this finish shall be firm, hard, smooth even textured, without undulations and other deficiencies. The surface shall be thoroughly cleaned. All loose dust particles shall be removed. Oil grit and grease, if any shall be removed completely by the use of detergent and sub-floor should be carefully dried prior to laying.
5) **Laying:** The tiles shall be stored in the room to be tiled for at least 24 hours to bring them to the same temperature as the room. In air conditioning spaces, the air conditioning shall be fully operational before the tiling is laid. The adhesive shall be applied uniformly at the rate recommended by the Manufacturer to the fully dry surface in the desired thickness. The adhesive shall also be applied to the backs and edges of the tiles and surface shall be allowed to “touch dry” before fixing. The tiles shall then be placed neatly on the surface exactly to the approved pattern and set firmly with a suitable tool. After it has adhered, vinyl tiles shall be rolled in two directions with a roller weighing 45 Kg. or more. If the edges tend to curlup, weights are to be applied to keep the edges down. Special care shall be taken to avoid the formation of air pockets under the tiles. The joints shall be very fine. Any adhesive squeezed out through the joints shall be removed and cleaned immediately. Rolls are to be stacked on the sub-floor following the grain directions of the rolls. Joint welding can be provided where ever the PVC Rolls are installed in order to avoid dust accumulation leakage of water and prevention from wear and tear in joints. In this, a PVC cord is put into the joint after making grooves with machine and is welded with hot thermo welding machine. Adhesives and other materials used must have resistance against the corrosive chemicals. Any defective surface must be capable of easy replacement. Joints shall be finished smooth and will not be a source of accumulation of dust, pool of liquid etc. Tile shall be fitted to and around all permanent fixtures. Borders shall be fitted accurately. Exposed edges or tile at door sills etc. shall be protected with metal molding. Cove base shall be firmly cemented to the walls and accurately scribed to trim and plinth.

6) **Finishing:** Any adhesive marks on the surface shall be removed by wiping with a soft cloth soaked in solvent. The surface shall be cleaned with soft soap, dried and then polished with approved type of acrylic base emulsion polish using a soft cloth. A time interval of at least 60 minutes must be given between the applications of each coat of polish. After the polishing is done, a duration of eight hours must be provided for the adhesive and polish to set before the area is put into regular use.

7) **Protection –** The surface shall be protected by covering with a plastic sheet over which, Gypsum powder / POP shall be provided. The same shall be removed before handing over the area for use of work.

3. **VINYL FLOORING**

Flexible timberline range PVC sheet flooring in min. 2 mm thickness with top wear layer of min. 0.75 mm thick:
Sizes:
The size of flooring shall be 1.83 mtr X 25 mtr use area classification 23/34/43 results from independent testing demonstrate that product inherently inhibits the growth of microbial strain MRSA.

Technical Specifications:
The flooring shall incorporated a specially (PUR) to give polish free maintenance imported PVC vinyl flooring with total weight 2800 g/m2, dimensional stability EN-434, static electrical charge <2kv, impact sound reduction approx ISO 717-2, wear resistance-group-T, slip-appendix A:wet preedium:y Appendix D:oil-wet ramp:R10, good resistant to scratch, fire, chemical & does not favor in growth fungi & bacteria.

Fire Classification:
- Critical radiant flux: ≥ 8 KW/m2, smoke development rate: <750% minutes
- Other properties of flooring:
- Type of floor covering: EN 649 vinyl sheet
- Manufactured in: Asia
- Polyurethane reinforced: yes
- Safety criteria: Slip resistance: Appendix A: Wet pendulum’s, Appendix D: Oil-wet ramp: R10
- General Properties:
  - Roll width: 1.83 m
  - Roll length: 25 m
  - Overall thickness: 2.0 mm
  - Wear layer thickness: 0.75 mm
  - Product Weight: 2.8 kg/m2
  - Wear Resistance: Group T
  - Residual indentation: ≤ 0.10 mm
  - Dimensional stability: X: <0.4%, Y: <0.4%
  - Flexibility: 20 mm mandrel, no cracking
  - Colour fastness: ≥ 6
  - Resistant to staining: Good resistance

Accessories:
Coving 32 X 32 or 20 X 20 MM depends on site condition, Caping 8 X 15 LM coil. Welding rode Het 50 M.

Installation:
Timberline flexible vinyl flooring shall be installed on smooth & hard surface with water based company recommended adhesive & hot welding coil for seamless joint.
4. **VITRIFIED TILES**

**GENERAL:**

Double charge heavy duty- homogenous- Vitrified tiles (Polish/ satin Finish/ anti-skid/ Matt finish) having water absorption less than 0.5% and confirming to IS:15622, of approved make, in all colours and shades laid in approved design and pattern over duly cured and dried 15 mm (average) thick correction layer base of cement mortar 1:4 (1 cement : 4 coarse sand) followed by laying and fixing with high polymer modified quick set adhesive Type II, IS: 15477, with average 6 mm thickness keeping 3mm wide joints between tiles including grouting of the joints using epoxy grout mix of 0.70 kg of organic coated filler of desired shade (0.10 kg of hardener and 0.20 kg of resin per kg), including filling / grouting and finishing as per direction of Engineer-in-charge.

**REFERENCE STANDARDS:**

<table>
<thead>
<tr>
<th>Code /Parameters</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>I.S. 383 -1970</td>
<td>Specification for coarse and fine aggregates</td>
</tr>
<tr>
<td>I.S. 2250 :1981</td>
<td>Tests for mortar</td>
</tr>
<tr>
<td>I.S. 2386 -1963</td>
<td>Method of test of aggregates in concrete</td>
</tr>
<tr>
<td>I.S. 8042 -1989</td>
<td>Specification for white port land cement</td>
</tr>
<tr>
<td>I.S. 8112 -1989</td>
<td>Ordinary Portland cement 43 grade</td>
</tr>
<tr>
<td>I.S. 456 &amp; I.S.3025</td>
<td>Water</td>
</tr>
<tr>
<td>IS : 15622</td>
<td>Pressed Ceramic Tiles – Specification (<a href="#">Vitrified tiles shall confirm to Table-12 of IS :15622</a>)</td>
</tr>
<tr>
<td>Antiskid Vitrified Tiles</td>
<td>Shall conform to EN-176 Group B1a and ISO 13006 stds.</td>
</tr>
<tr>
<td>Deviation in length</td>
<td>Method of testing shall be as per EN98</td>
</tr>
<tr>
<td>Deviation in thickness</td>
<td>Method of testing shall be as per EN98</td>
</tr>
<tr>
<td>Straightness of sides</td>
<td>Method of testing shall be as per EN98</td>
</tr>
<tr>
<td>Rectangularity</td>
<td>Method of testing shall be as per EN98</td>
</tr>
<tr>
<td>Surface flatness</td>
<td>Method of testing shall be as per EN98</td>
</tr>
<tr>
<td>Water absorption</td>
<td>Shall not be greater than 0.05 % (Method of testing shall be as per EN99)</td>
</tr>
<tr>
<td>Moh's hardness</td>
<td>Shall not be less than 6 (Method of testing shall be as per EN101)</td>
</tr>
<tr>
<td>Flexural strength</td>
<td>Shall not be less than 27N/sqmm. (Method of testing shall be as per EN100)</td>
</tr>
<tr>
<td>Abrasion resistance</td>
<td>(Method of testing shall be as per EN102)</td>
</tr>
<tr>
<td>Skid resistance (coefficient of friction)</td>
<td>0.6 (Method of testing shall be as per ASTM C-1028)</td>
</tr>
<tr>
<td>Property</td>
<td>Requirement</td>
</tr>
<tr>
<td>--------------------------</td>
<td>-----------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Breaking strength</td>
<td>Shall not be less than 2500 N (Method of testing shall be as per ASTMC-678)</td>
</tr>
<tr>
<td>Density</td>
<td>Shall not be less than 2 gm/cm³ (Method of testing shall be as per DIN 51082)</td>
</tr>
<tr>
<td>Frost resistance</td>
<td>Shall be frost proof (Method of testing shall be as per EN -202)</td>
</tr>
<tr>
<td>Chemical resistance</td>
<td>Shall be resistant to chemicals (Method of testing shall be as per EN -106)</td>
</tr>
<tr>
<td>Thermal shock resistance</td>
<td>Shall be resistant to thermal shocks (Method of testing shall be as per EN -104)</td>
</tr>
<tr>
<td>Colour resistance</td>
<td>No damage (Method of testing shall be as per DIN -51094)</td>
</tr>
<tr>
<td>Thermal expansion</td>
<td>Shall not be more than $9 \times 10^{-6}$ (Method of testing shall be as per EN -103)</td>
</tr>
<tr>
<td>Stain resistance</td>
<td>Shall be stain resistant (Method of testing shall be as per ISO 10545-14)</td>
</tr>
<tr>
<td>Glossiness</td>
<td>Desired reflection effect as required by AAI/PMC (Method of testing shall be with the use of glossometer)</td>
</tr>
</tbody>
</table>

**MATERIAL:**

The tiles shall be unchamfered, double charged, unglazed, ceramic satin matt finished tiles of nominal size of premium quality. The tiles shall be of approved make and confirming to the standards. The size and thickness of tiles shall be as per the architectural requirements. They shall be flat, and true to shape and free from blisters, crazing, welts, crawling or other imperfection detracting from their appearance. The tiles shall be tested as per standard acceptance criteria mentioned.

The tiles shall be square of nominal size as per architectural drawings and approved by the engineer-in-Charge. The thickness shall be minimum 9.8mm as specified.

The underside of the tiles shall not have any finish in order that the tiles may adhere properly to the base. The edges of the tiles shall be preferably free from shine or polish. However any finish, if unavoidable shall be permissible on only upto to 50 percent of the surface area of the edges.
PREPARATION OF SURFACE AND LAYING OF FLOORS:

Base concrete or the RCC slab on which the tiles are to be laid shall be cleaned, wetted and mopped. The bedding for the tiles shall be with cement mortar 1:4 (1 cement: 4 coarse sand) or as specified. The average thickness of bedding shall be 15mm. Mortar shall be spread, tamped and corrected to proper levels and allowed to harden sufficiently to offer a fairly rigid cushion for the tiles to be set and to enable the mason to place wooden plank across and squat on it.

Over this mortar bedding laying and fixing with high polymer modified quick set adhesive Type II, as per IS: 15477, with average 6 mm thickness Tiles shall be soaked in water washed clean and shall be fixed in this grout one after another, each tile gently being tapped with a wooden mallet till it is properly bedded and in level with the adjoining tiles. The joints shall be 3mm thick and in straight lines or to suit the required pattern.

The surface of the flooring during laying shall be frequently checked with a straight edge about 2m long, so as to obtain a true surface with the required slope. Where full size tiles cannot be fixed these shall be cut (sawn) to the required size, and their edge rubbed smooth to ensure straight and true joints. Tiles, which are fixed in the floor adjoining the wall, shall enter not less than 10mm under the plaster, skirting or dado. After tiles have been laid, the surplus adhesive shall be cleaned off.

POINTING AND FINISHING:

The joint shall be cleaned off the surplus adhesive with wire/coir brush or trowel and all dust and loose mortar removed. The joint shall be grouted using epoxy grout mix of 0.70 kg of organic coated filler of desired shade (0.10 kg of hardener and 0.20 kg of resin per kg) of approved make.

After fixing the tiles finally in an even plane, the flooring laid shall be kept moist and allowed to mature undisturbed for 10 days to allow the bedding and flooring to set properly.

The finished surface shall be kept protected by laying Plaster of Paris @ 2kg / Sqm over 200mm micron polyethylene sheet till commissioning after laying of tiles.

The finished floor shall not sound hollow when tapped.

Testing: Tile of each size shall be tested one test per 1000 Sqm or part thereof.
5. **VACCUM DEWATERED FLOORING (VDF)**

The vacuum dewatering process consists of leveling, compacting and vacuum dewatering the concrete flooring by using vibrating screed, vacuum pumps, suction mats, filter pads, accessories etc. The sequence of operation shall be placing of concrete, vibration, vacuum treatment and floating and the operations shall follow immediately behind each other.

**GENERAL REQUIREMENTS**

All concrete work, reinforcement and formwork shall be done as per specification.

The Contractor shall furnish all skilled and unskilled labour, plant, tools, tackle, equipment, men, materials etc., required for complete execution of the work in accordance with the drawings and as described herein / or as directed by AAI/PMC.

The Contractor shall have persons well experienced in the vacuum dewatering process, and in the operation of all related equipments. All process equipment to be used shall be in good working condition and shall be subject to the approval of AAI/PMC.

The Contractor shall strictly follow, at all stages of work, the stipulations contained in the Indian Standard Safety Code and the provisions of the safety code and the provision of the safety rules as specified in the General Conditions of the Contract for ensuring safety of men and materials.

Any approval, instructions, permission, checking, review, etc. whatsoever by AAI/PMC shall not relieve the Contractor of his responsibility and obligation regarding adequacy, correctness, completeness, safety, strength, workmanship etc.

**MATERIAL**

Generally, the materials shall be in accordance with their respective Indian Standard Codes and as specified in similar works, which shall be deemed to form a part of this specification.

Cement: Ordinary Portland cement of 43 / 53 Grade conforming to IS 8112 and as specified under concrete works.

Fine aggregates: As specified under concrete works and conforming to IS 383.

Coarse aggregate: As specified under concrete works and conforming to IS 383.

Water: As specified under concrete works and conforming to IS 456 - Clause 4.3.
Concrete: Batching, mixing, conveying, placing etc. as specified under concrete works.

Reinforcement: Fabricating, placing, tying etc. as specified under reinforcement.

**PROCEDURE**

The work should be planned well in advance with a view to determine areas to be concreted daily, the required number of equipment, size of vacuum mats, length of vacuum hoses, arrangement of rails, screeds etc.

The area to be concreted shall be thoroughly cleaned, reinforcement checked and got approved by AAI/PMC. Then the specified grade of concrete shall be placed in position without any segregation and properly vibrated.

**COMPACTING AND LEVELLING**

Immediately after placement of concrete, the vibrating screed, fixed at the proper position to achieve the required specified finished level, shall be allowed to run over the concrete on a true surface to level the concrete. For better consolidation proper surcharge of concrete should be maintained in front of the leading edge of the screed and the vibrating screed shall be allowed to move forward rapidly.

The concrete surface shall be screeded high by 2\% of the slab's thickness to compensate for the compaction caused by the Vacuum dewatering process. (Slabs which have an aggregate hardener shall have compensation made to maintain elevation).

**DEWATERING**

Immediately after leveling, the concrete shall be covered with filter pads and suction mats in strict accordance with the recommendation of the Manufacturer to have the slab fully dewatered. The suction mat shall extend 100 mm beyond the edge of the filter pad on all sides. The pads shall extend to within 100 mm of the edges of concrete slab, and the mats shall cover entire slab. Before connecting the hose on the suction mat to the vacuum pump, the edges of the mat shall be smoothed to enable an airtight seal to be created. A vacuum shall then be applied to the mat. After a minute the gauge on the vacuum pump should indicate a minimum vacuum of 0.70 atmospheres (24.0 in Hg) and if not, the mat must be checked for leakage. For concrete that dewaters readily the vacuum should then be maintained at 0.70 - 0.80 atmosphere (24.0 - 25.5 in Hg). For concrete which dewaters less efficiently (eg. air-entrained concrete) the vacuum shall then be reduced to 0.50 - 0.60 atmospheres (15.0 - 18.0 in Hg). After approximately 10 minutes the vacuum can then be increased to 0.80 atmospheres.
The vacuum shall be maintained for at least 3 minutes per 25 mm of concrete thickness at 0.80 atmospheres. (Where aggregate hardeners are specified, sufficient moisture shall be maintained to meet Manufacturer's requirements). The suction mats and filter pads shall then be removed and moved to the next section in a leapfrog manner.

Stop the vacuum dewatering when light foot prints only are left in the concrete when stepped upon. A suitable suction time can also be checked with a Proctor apparatus which should show 1.5 – 2Kp/Sqcm.

**FLOATING**

Upon removal of the suction mats and filter pads the concrete shall be power floated without delay until all imprints from the vacuum process are removed. If crusting occurs, the floating operation must be delayed till the concrete carries the machine. The higher speed is recommended for the floating operation. The passes with the floating disc should be made in the junction of two mats in order to avoid risk of cracking.

The waiting time after the floating operation depends on concrete temperature and humidity and varies from 10 minutes to 2 hours. Sub-base course of crusher run for a consolidated thickness of 300 mm thick (in two layers of 150 mm thick) using 1 Cum of 63 mm to 45 mm size Coarse graded coarse graded aggregate with 0.48 Cum of approved earth for bondage and filler material for 10 sqm area of each layer etc. complete, including preparation of sub-Grade, cost and conveyance of all materials from any source to work site, stacking to standard gauge for pre-measurement, labor charges for spreading and packing to level, watering with all leads for water, forming edge bund and consolidation by suitable capacity power roller including all labour, hire and fuel charges for all tools and plants employed and all other incidental charges etc. all complete, as directed. 200 microns thick low density polythene sheet in rolls over sub base. A minimum lap of 150 mm shall be provided at all junctions and wherever required.

**SURFACE FLOOR HARDENER**

**Epoxy Floor Topping**

Flow applied epoxy floor topping. The designated floor area shall be surfaced with a 3 mm thick flow-applied epoxy resin floor topping. The topping shall achieve a compressive strength of 60 N/mm² and a flexural strength of 30 N/mm² at 7 days when tested to BS 6319. At 20°C, it shall be capable of accepting foot traffic at 24 hours and vehicular traffic at 48 hours.

**Surface Preparation:** It is essential that the floor topping is applied to sound, clean and dry surfaces in order that maximum bond strength is achieved between the substrate and the flooring system. All dust and debris should be removed prior to application of the product or
its primer. New concrete floors, or cementations substrates, should be at least 28 days old and have a moisture content not exceeding 5%. Laitance deposits on new concrete are best removed by light grit blasting, mechanical scrubbling or grinding. Old concrete floors, Existing concrete floors which require refurbishment must be prepared to ensure a strong adhesive bond between the flooring system and the existing floor. Mechanical cleaning methods are strongly recommended particularly where heavy contamination by oil and grease has occurred or existing coatings are present. To ensure adhesion, all contamination should be removed. Alternatively, blasting techniques can be used to provide the required substrate. Steel surfaces, Steel surfaces should be degreased and grit blasted to SA2½ immediately prior to application. The prepared surface should then be primed with one coat of Nitoprime 25.

**Application:** The applicator should ensure that there are sufficient supplies of plant, labor and materials to make the mixing and subsequent application process a continuous one for any given, independent floor area. Once mixed, the material must be used within its specified pot life. The material should be poured onto the prepared and primed substrate as soon as mixing is complete. It should be spread to the required thickness preferably using a serrated trowel; with care taken not to overwork the resin, spreading evenly and slowly. Immediately after laying, the material should be rolled, using a spiked nylon roller, to remove slight trowel marks, and to assist air release. The rolling should be carried out using a ‘back and forth’ technique along the same path. An overlap of 50% with adjacent paths is recommended. The rolling process should continue for a minimum of 5 times on the same path, but should be prior to setting of the product.

**Nitoflor SL Conductive**

**Surface preparation:** All floors to receive Nitofl or SL Conductive / Nitofl or SL Dissipative topping should be protected by means of a damp-proof membrane. The absence of such membranes could lead to the problem of osmosis/rising dampness where soluble salts have concentrated. New concrete or cementations substrates should have been placed at least 28 days earlier and have a moisture content of less than 5% before topping with Nitofl or SL Conductive / Nitofl or SL Dissipative system. This can be checked by using a Thermo Hygrometer. With non-self supporting concrete floors transfer of moisture from the soil might occur, resulting in adhesion failures of the flooring system. The long term durability of the applied Nitofl or SL Conductive / Nitofl or SL Dissipative topping is dependent upon the adhesive bond achieved between the flooring material and substrate. It is most important therefore, that substrate surfaces are correctly prepared prior to application.
All substrates should be sound and free from contamination such as mortar and paint splashes, curing compound residue, oil or grease. Excessive laitance should be removed by light mechanical scabbling, grinding or grit blasting. Oil and grease contamination must be completely removed by grinding down to sound, clean concrete. Alternatively, blasting techniques can be used to provide the required substrate. Old concrete floors with deep seated contamination and substrate damage must be prepared by any of the mechanical methods as previously described. Major discrepancies in the substrate should be repaired with Nitomortar S*. Where these methods are considered impracticable, alternative methods may be considered, but it is essential that a sound, clean substrate be provided. For further advice, Fosroc may be consulted.

For undercoat curing to be complete, adequate ventilation and air movement are necessary. Thorough covering of earthing connections is essential. The conductivity of the undercoat needs to be measured before applying the Top coat. The surface resistance should be : Nitofl or SL Conductive : approx. 3x10³ - 9 x10³ Ohm.

**Applying Topcoat:** When mixed, Nitofl or SL Conductive/Nitofl or SL Dissipative Topcoat should be poured immediately on to the surface and spread at 2mm with a steel trowel or a float. Immediately after application the surface should be firmly rolled in perpendicular directions with any lon spiked roller to help release any entrapped air in the material and help level any slight trowel marks.

150 mm thick PCC 1:3:6 with 25 and down size HBG stone and finish the top surface smooth to receive the water proof coating.

Application of two coats of CICO Tapacrete, Acrylic Polymer Modified cementious Coating and plastering over the treated area with C.M 1:4 12mm thick admixed with CICO no 1 @ 2% by weight of cement.

Controlled reinforced cement concrete of M-25 grade to the specified thickness as per drawing using 20mm and down size course graded machine crushed hard stone aggregate including shuttering, formwork etc. all complete.

High yield strength deformed bars as per details mentioned below of Fe 500 grade conforming to IS : 1786 for reinforcement.

Vacuum dewatering the surface when concrete is in wet condition by approved, vacuum dewatering method using specialized equipments and finishing the surface with electrical skin floaters and power trowels and finishing the surface neat and smooth.
Non-metallic monolithic floor hardening compound with very hard granulates of mineral origin like NITOFLO HARDSOP STANDARD (FOSROC) or approved equivalent over vacuum dewatered RCC floor when the concrete in green and touch dry condition at the rate of 7 Kg/Sqm.

Expansion joints, construction joints, control joints, isolation joints and other joints wherever required using Fosroc Hydrocell XL, high density polyethylene filler board to the joints covered with Fosroc Expancell and sealed with Non shrink grout Fosroc Nitoseal HP40. This includes shuttering formwork cutting grooves and floor with mechanically operated floor sawing machine, Any damaged / worn-out edges shall be repaired using Fosroc Nitomortar S before starting the joints treatment.

"Normal shear connectors using rod anchorage for the VDF flooring”
Providing, supplying and installing Speed Plate Dowel comprised of high density plastic sleeve pocket former to position load plate dowel for axial and lateral shrinkage capability. Speed Plate assembly complete with steel load plate dowel from hot rolled steel plate meeting ASTM A 36.Speed Plate shall have dimensions of 6mm thick to suit applications and having further dimensions of 100mm x 150mm load plate dowel and Speed Plate.

FINISHING

The trowelling operation cannot take place before the concrete has hardened enough to carry the machine ie. the trowelling blades will not leave any marks on the concrete. Repeated trowelling, with intervals between the passes which are adapted to the setting of the concrete, greatly improves the surfaces characteristics. The surface will be more wear resistant and less dusty.

At least two passes are recommended for floors which are not to be covered.

CURING

Vacuum dewatered concrete should be cured like any quality concrete in order to achieve a good final result. Use curing compounds, plastic sheets or wet burlap.

The contractor has the responsibility for achieving the quality of concrete specified by controlling the concrete mixes, placing, vacuum process finishing and curing. The concrete technician in charge must be present at the site when work is in progress.

The contractor shall be responsible for mix adjustments, performing necessary tests, correcting deficiencies and trouble shooting in general. The contractor shall be required to
maintain control charts showing individual test results for aggregate gradation, slump, air content, cement content and compressive strength.

**CONTROL JOINTS, GROOVES, FILLER**

The Contractor shall provide grooves of size 6 mm wide and 20 mm deep on floor surface at every 10sqm area or as specified or as shown drawings and / or as directed by AAI/PMC. Grooves shall be made with groove cutting machine using diamond cutting wheel.

The groove shall be filled in two layers “bottom with bituminous expansion joint filler 6 mm x 10 mm and top layer 6 mm x 10 mm with polyurethane based elastomeric joint filler of SIKAFLEX (la) one component high performance joint sealant or approved equivalent make. All the edges of the grooves shall be finished neatly with epoxy floor hardener mortar.
Part B: FALSE CEILING WORKS

A. SCOPE OF WORKS
The works described in this Specification relates to but is not limited to, the completion of detail design, manufacture, and execution of Suspended Ceiling works to achieve the Suspended false ceiling works as per the specification requirements for the New Integrated airport terminal building areas in the facilities arrangement.

The suspended ceiling types suggested in the preliminary design are intent to define ceiling surfaces for terminal areas which provides the performance and aesthetic quality. This specification shall be read in conjunction with General Specifications and other related sections of the Specification, Preliminaries and Contract Conditions.

B. TECHNICAL SPECIFICATIONS
1. METAL CEILINGS HOOK-ON (INTERIOR)

- Flat Hook-On Ceilings (Interior) Plain

Suspended Metal Ceilings manufactured in Hook-on system with Rectangular panels (flat / curved) made out of 0.7mm thick GI. The entire system to be designed for Interior applications, and concealed Grids with butt joint panels. The double grid system has to have fully accessible panels, with system height of around 100mm.

PANEL SPECIFICATIONS:

Material: The rectangular Hook-On panels to be made of Galvanized Steel (zero spangle – suitable for architectural finishes), minimum thickness 0.7mm, 120gsm hot dipped galvanization (both sides). The panels shall have 3mm(W) x 8mm(H) black foam gasket, glued at the edges, and 3mm PVC spacer.

Sizes: The panel length shall be up to 3000mm (based on the design), while the panel width shall be 400mm. The panels shall have long side upturn of minimum 50mm (vertical) and inside bends of 8mm (horizontal) for rigidity, and short side upturns of 30mm (vertical) and shall be bent appropriately as per the manufacturer’s specifications for providing hook-on ends.
Edge Detail: The panels shall be with Square Edge, having butt joint between consecutive panels, along with 3mm reveal.

Sag Limits: To be measured at the center in accordance with TAIM standards.

Dimensional Tolerances: For panel Thickness / panel width /panel length - To be measured in accordance with TAIM standards.

Panel Finish: The panels shall be in plain finish.

Coating: The panel surface to be polyester powder coated to 60-80µ (pure polyester) on visible side after panel production, low gloss (degree of gloss approx. 20%). The coating shall be architectural-quality, electrostatically applied polyester powder coat paint. The color to be plain RAL color shades as approved by AAI/PMC. The paint to conform to 1000 hours of salt spray for durability (as per ASTM B117 Norms), 250 hours of condensation test (as per DIN 50017 or DIN EN ISO 6270-1 Norms), UV resistance of 500 hours and 50% gloss retention(as per ASTM G 154 UVB-313 Norms). Paint tolerance (∆e) shall be ≤ 1.0. Pre-coated panels shall not be acceptable.

Fire Classification: The GI panels must conform to Fire Performance of Class 0/Class 1 as per BS476 Part 6 & 7 test standard.

**SUSPENSION SYSTEM SPECIFICATIONS:**

Primary Runners: would be Galvanized steel (minimum galvanization 120gsm) U-shaped Profile of 30mm(H) x 3746mm(L) x 20mm(W) x 1.5mm(T), roll formed slotted profile (Steel Material Grade : S280GD). The slots shall be alternate square and rectangular shapes with dimensions 6.5x6.5mm & 6.5x28mm. Torsion< 2° / 1000mm L, Flatness≤ 0.5mm/length, Straightness ≤6mm/ length. Weight of profile to be 0.77kgs per LM (minimum).

Secondary Runners: would be Galvanized steel (minimum galvanization 120gsm) J-shaped roll formed ribbed profile of 45mm(H) x 3000mm (L) x 31mm(W) x 1.0mm(T),in GI(S280GD+Z140 NAC). Weight of profile to be 0.63kg/LM (minimum). Flatness/ Straightness to be within 0.2mm/length.

**ACCESSORIES:**

- Galvanized Steel Hangers (for J-shaped profile) 1.25mm thick, galvanization 120 gsm
- U-shape Profile Splice (Galvanized steel, DX51D) 1.5mm Thick, minimum galvanization 120gsm
- J-shape Profile Splice (Galvanized steel, S250GD) 1.5mm thick, minimum galvanization 120gsm
Wall Anchor (Galvanized steel, S250GD) 2mm thick, minimum galvanization 120gsm
Plug-in Clip (spring steel), 0.8mm thick, spring steel
Pressure Spring (St. Steel), 0.3mm thick, spring steel
Clamping Bracket (Galvanized steel, CK60 42HRC) 1mm thick, (with galvanized fasteners)

Perimeter Trims: These would include 25mmx25mmx4000mm Aluminum extruded profile (Al 6xxx), post-coated to RAL color, shade approved by AAI/PMC.

Suspension would be M6 GI threaded rod (max. 2000mm L).

**INSTALLATION:**

Primary and secondary runners Installation:

U-shaped Profiles, spaced at 1200mm, to be suspended from ceiling using clamping brackets and GI threaded rods. The J-shape profiles (directional) shall intersect the U-profile at 90° at every module dictated by the panel length. The J-shape profile is connected to the U-shaped profile with a J-shape profile hanger and secured to the matching square U-Profile slots using plug-in clips. Self-tapping screws to be used when square U-shaped Profile slots do not match the hangers. The U-profiles and J-shape profiles be fastened to two adjacent walls using the wall anchor and bolts. U-Profiles and J-shape profiles to be at a maximum distance of 450mm (max.) to a perimeter wall or outside edge of a floating module. To join two pieces of continuous U-shaped profiles and J-shape profiles, a U-Profile splice and J-shape profile splice to be used respectively.

Panel Installation:

Full size metal Hook-On panels (directional) to be hooked on to the J-shape profiles (in accordance with the shop drawings) along the short side (typical).

Field-cut Panels:

Perimeter panels that require field cutting to fit on a wall trim option must have a minimum of 12mm edge resting on the horizontal surface of the wall moldings.

Wall Moldings: Aluminum extruded grooved wall molding to be fastened to the perimeter using screws, at every 450mm to 600mm L. All perimeter field cut panels to be fixed to the Aluminum wall molding using two pressure springs.
Provides and Fixing Suspended Metal Ceilings manufactured in Hook-on system with Rectangular panels (flat / curved) made out of 0.7mm thick GI. The entire system to be designed for Interior applications, and concealed Grids with butt joint panels. The double grid system has to have a fully accessible panel, with system height of around 100mm.

**PANEL SPECIFICATIONS:**

Material: Curved Hook-on ceilings with fishnet profile (HYPAR): The Hook-On panels to be made of Galvanized Steel (zero spangle – suitable for architectural finishes), minimum thickness 1.0mm, 120gsm hot dipped galvanization (both sides). The panels shall have 3mm(W) x8mm(H) black foam gasket, glued at the edges. The panels shall have a custom Fishnet profile (HYPAR), manufactured as per approved design.

Sizes: Curved Hook-on ceilings with fishnet pattern: The curved panel shall have length of 1800mm, while the panel width shall be 600mm. The panels shall have long side upturns of minimum 40mm H, 2mm thickness and (vertical) for rigidity, and short side upturns of 30mm (vertical) and shall be bent appropriately as per the manufacturer’s specifications for providing hook-on ends.

Edge Detail: The panels shall be with Square Edge, having butt joint between consecutive panels, along with 3mm reveal.

Sag Limits: To be measured at the center in accordance with TAIM standards.

Dimensional Tolerances: For panel Thickness / panel width / panel length - To be measured in accordance with TAIM standards.

Panel Finish: The panels shall be in plain finish.

Coating: The panel surface to be polyester powder coated to 60-80µ (pure polyester) on visible side after panel production, low gloss (degree of gloss approx. 20%). The coating shall be architectural-quality, electrostatically applied polyester powder coat paint. The color to be plain RAL color shades as approved by AAI/PMC. The paint to conform to 1000 hours of salt spray for durability (as per ASTM B117 Norms), 250 hours of condensation test (as per DIN 50017 or DIN EN ISO 6270-1 Norms), UV resistance of 500 hours and 50% gloss retention (as per ASTM G 154 UVB-313 Norms). Paint tolerance (Δe) shall be ≤ 1.0. Pre-coated panels shall not be acceptable.
Fire Classification: The GI panels must conform to Fire Performance of Class 0/Class 1 as per BS476 Part 6 & 7 test standard.

**SUSPENSION SYSTEM SPECIFICATIONS:**

Primary Runners: would be Galvanized steel (minimum galvanization 120gsm) U-shaped Profile of 30mm(H) x 3746mm(L) x 20mm(W) x 1.5mm(T), roll formed slotted profile (Steel Material Grade : S280GD). The slots shall be alternate square and rectangular shapes with dimensions 6.5x6.5mm & 6.5x28mm. Torsion< 2° / 1000mm L, Flatness≤ 0.5mm/length, Straightness ≤6mm/length. Weight of profile to be 0.77kgs per LM (minimum).

Secondary Runners: would be Galvanized steel (minimum galvanization 120gsm) J-shaped roll formed ribbed profile of 45mm(H) x 3000mm (L) x 31mm(W) x 1.0mm(T), in GI (S280GD+Z140 NAC). Weight of profile to be 0.63kg/LM (minimum). Flatness/ Straightness to be within 0.2mm/length.

**ACCESSORIES:**

- Galvanized Steel Hangers (for J-shaped profile) 1.25mm thick, galvanization 120 gsm
- U-shape Profile Splice (Galvanized steel, DX51D) 1.5mm Thick, minimum galvanization 120gsm
- J-shape Profile Splice (Galvanized steel, S250GD) 1.5mm thick, minimum galvanization 120gsm
- Wall Anchor (Galvanized steel, S250GD) 2mm thick, minimum galvanization 120gsm
- Plug-in Clip (spring steel), 0.8mm thick, spring steel
- Pressure Spring (St. Steel), 0.3mm thick, spring steel
- Clamping Bracket (Galvanized steel, CK60 42HRC) 1mm thick, (with Galvanized fasteners)

Suspension would be M6 GI threaded rod (max. 2000mm L).

**INSTALLATION:**

Primary and secondary runners Installation: U-shaped Profiles, spaced at 1200mm, to be suspended from ceiling using clamping brackets and GI threaded rods. The J-shape profiles (directional) shall intersect the U-profile at 90° at every module dictated by the panel length. The J-shape profile is connected to the U-shaped profile with a J-shape profile hanger and secured to the matching square U-Profile slots using plug-in clips. Self-tapping screws to be used when square U-shaped Profile slots do not match the hangers. The U-profiles and J-shape profiles be fastened to two adjacent walls using the wall anchor and bolts. U-Profiles and J-
shape profiles to be at a maximum distance of 450mm (max.) to a perimeter wall or outside edge of a floating module. To join two pieces of continuous U-shaped profiles and J-shape profiles, a U-Profile splice and J-shape profile splice to be used respectively.

Panel Installation: Full size metal curved Hook-On panels (directional) to be hooked on to the J-shape profiles (in accordance with the shop drawings) along the short side (typical). The J-shaped profiles shall be indirectly fixed to the primary runner or using threaded rods and clamping bracket.

• Flat Hook-on Ceilings (Interior) with Custom Pattern

Suspended Metal Ceilings manufactured in Hook-on system with Rectangular panels (flat / curved) made out of 0.7mm thick GI. The entire system to be designed for Interior applications, and concealed Grids with butt joint panels. The double grid system has to have fully accessible panels, with system height of around 100mm.

**PANEL SPECIFICATIONS:**

Material: Flat Hook-on ceilings with custom pattern: The rectangular Hook-On panels to be made of Galvanized Steel (zero spangles – suitable for architectural finishes), minimum thickness 1.0mm, 120 gsm hot dipped galvanization (both sides). The panels shall have 3mm(W) x8mm(H) black foam gasket, glued at the edges, and 3mm PVC spacer. The panels shall have a custom design Pattern, machine cut as per approved design.

Sizes: Flat Hook-on ceilings with custom pattern: The panel length shall be 1500mm (based on the design), while the panel width shall be 475mm. The panels shall have long side upturns of minimum 40mm (vertical) and inside bends 8mm (horizontal), and short side upturns of 30mm (vertical) and shall be bent appropriately as per the manufacturer’s specifications for providing hook-on ends.

Edge Detail: The panels shall be with Square Edge, having butt joint between consecutive panels, along with 3mm reveal.

Sag Limits: To be measured at the center in accordance with TAIM standards.

Dimensional Tolerances: For panel Thickness / panel width / panel length - To be measured in accordance with TAIM standards.

Panel Finish: The panels shall be in plain finish.

Coating: The panel surface to be polyester powder coated to 60-80µ (pure polyester) on visible side after panel production, low gloss (degree of gloss approx. 20%). The coating shall
be architectural-quality, electrostatically applied polyester powder coat paint. The color to be plain RAL color shades as approved by AAI/PMC. The paint to conform to 1000 hours of salt spray for durability (as per ASTM B117 Norms), 250 hours of condensation test (as per DIN 50017 or DIN EN ISO 6270-1 Norms), UV resistance of 500 hours and 50% gloss retention (as per ASTM G 154 UVB-313 Norms). Paint tolerance (Δe) shall be ≤ 1.0. Pre-coated panels shall not be acceptable.

Fire Classification: The GI panels must conform to Fire Performance of Class 0/Class 1 as per BS476 Part 6 & 7 test standard.

**SUSPENSION SYSTEM SPECIFICATIONS:**

Primary Runners: would be Galvanized steel (minimum galvanization 120gsm) U-shaped Profile of 30mm(H) x 3746mm(L) x 20mm(W) x 1.5mm(T), roll formed slotted profile (Steel Material Grade : S280GD). The slots shall be alternate square and rectangular shapes with dimensions 6.5x6.5mm & 6.5x28mm. Torsion< 2° / 1000mm L, Flatness≤ 0.5mm/length, Straightness ≤6mm/ length. Weight of profile to be 0.77kgs per LM (minimum).

Secondary Runners: would be Galvanized steel (minimum galvanization 120gsm) J-shaped roll formed ribbed profile of 45mm(H) x 3000mm (L) x 31mm(W) x 1.0mm(T), in GI (S280GD+Z140 NAC). Weight of profile to be 0.63kg/LM (minimum). Flatness/ Straightness to be within 0.2mm/length.

**ACCESSORIES:**

- Galvanized Steel Hangers (for J-shaped profile) 1.25mm thick, galvanization 120 gsm
- U-shape Profile Splice (Galvanized steel, DX51D) 1.5mm Thick, minimum galvanization 120gsm
- J-shape Profile Splice (Galvanized steel, S250GD) 1.5mm thick, minimum galvanization 120gsm
- Wall Anchor (Galvanized steel, S250GD) 2mm thick, minimum galvanization 120gsm
- Plug-in Clip (spring steel), 0.8mm thick, spring steel
- Pressure Spring (St. Steel), 0.3mm thick, spring steel
- Clamping Bracket (Galvanized steel, CK60 42HRC) 1mm thick, (with Galvanized fasteners)

Perimeter Trims: These would include 25mmx25mmx4000mmx1.2mm thick Aluminum extruded profile (Al 6xxx), post-coated to RAL color, shade approved by AAI/PMC.

Suspension would be M6 GI threaded rod (max. 2000mm L).
INSTALLATION:

Primary and secondary runners Installation: U-shaped Profiles, spaced at 1200mm, to be suspended from ceiling using clamping brackets and GI threaded rods. The J-shape profiles (directional) shall intersect the U-profile at 90° at every module dictated by the panel length. The J-shape profile is connected to the U-shaped profile with a J-shape profile hanger and secured to the matching square U-Profile slots using plug-in clips. Self-tapping screws to be used when square U-shaped Profile slots do not match the hangers. The U-profiles and J-shape profiles be fastened to two adjacent walls using the wall anchor and bolts. U-profiles and J-shape profiles be at a maximum distance of 450mm (max.) to a perimeter wall or outside edge of a floating module. To join two pieces of continuous U-shaped profiles and J-shape profiles, a U-Profile splice and J-shape profile splice to be used respectively.

Panel Installation: Full size metal Hook-On panels (directional) to be hooked on to the J-shape profiles (in accordance with the shop drawings) along the short side (typical).

Wall Moldings: Aluminum extruded grooved wall molding to be fastened to the perimeter using screws, at every 450mm to 600mm L. All perimeter panels to be fixed to the Aluminum wall molding using two pressure springs.

2. METAL CEILINGS HOOK-ON (EXTERIOR)

• Flat, Inclined Hook-on Ceilings (Exterior)

Suspended Metal Ceilings manufactured in Hook-on system with Rectangular panels made out of 1.0mm thick Aluminum and curved panels made out of 0.7mm thick GI. The entire system to be designed for Exterior applications, and concealed Grids with butt joint panels. The double grid system to have fixed panels, with system height of around 100mm.

PANEL SPECIFICATIONS:

Material: Flat / inclined hook-on ceilings (plain): The rectangular Hook-On panels to be made of Aluminum alloy of 3xxx series (A3003 H14), minimum thickness 1.0mm. The panels shall have 3mm(W) x 8mm(H) black foam gasket, glued at the edges, and 3mm PVC spacer.

Sizes: Flat / Inclined hook-on ceilings (plain): The panel length shall be up to 3000mm (based on the design), while the panel width shall be 400mm. The panels shall have long side upturns of minimum 50mm (vertical) and inside bends of 8mm (horizontal) for rigidity, and short side
upturns of 30mm (vertical) and shall be bent appropriately as per the manufacturer’s specifications for providing hook-on ends.

Edge Detail: The panels shall be with Square Edge, having butt joint between consecutive panels, along with 3mm reveal.

Sag Limits: To be measured at the center in accordance with TAIM standards.

Dimensional Tolerances: For panel Thickness / panel width / panel length - To be measured in accordance with TAIM standards.

Panel Finish: The panels shall be in plain finish.

Coating: The panel surface to be polyester powder coated to 60-80µ (pure polyester) on both visible and non-visible sides after panel production, low gloss (degree of gloss approx. 20%). The coating shall be architectural-quality, electrostatically applied polyester powder coat paint. The color to be plain RAL color shades as approved by AAI/PMC. The paint to conform to 1000 hours of salt spray for durability (as per ASTM B117 Norms), 250 hours of condensation test (as per DIN 50017 or DIN EN ISO 6270-1 Norms), UV resistance of 500 hours and 50% gloss retention (as per ASTM G 154 UVB-313 Norms). Paint tolerance (Δe) shall be ≤ 1.0. Pre-coated panels shall not be acceptable.

Fire Classification: The GI panels must conform to Fire Performance of Class 0/Class 1 as per BS476 Part 6 & 7 test standard.

**SUSPENSION SYSTEM SPECIFICATIONS:**

Primary Runners: would be Galvanized steel (minimum galvanization 120gsm) U-shaped Profile of 30mm(H) x 3746mm(L) x 20mm(W) x 1.5mm(T), roll formed slotted profile (Steel Material Grade : S280GD). The slots shall be alternate square and rectangular shapes with dimensions 6.5x6.5mm & 6.5x28mm.Torsion< 2° / 1000mm L, Flatness≤ 0.5mm/length, Straightness ≤6mm/ length. Weight of profile to be 0.77kgs per LM (minimum).

Secondary Runners: would be Galvanized steel (minimum galvanization 120gsm) J-shaped roll formed ribbed profile of45mm(H) x 3000mm (L) x 31mm(W) x 1.0mm(T),in GI (S280GD+Z140 NAC). Weight of profile to be 0.63kg/LM (minimum).Flatness/ Straightness to be within 0.2mm/length.

**ACCESSORIES:**

Galvanized Steel Hangers (for J-shaped profile), minimum 1.25mm thick, galvanization 120 gsm
U-shaped Profile Splice (Galvanized steel, DX51D) 1.5mm Thick, minimum galvanization 120gsm

J-shaped Profile Splice (Galvanized steel, S250GD) 1.5mm thick, minimum galvanization 120gsm

Wall Anchor (Galvanized steel, S250GD) 2mm thick, minimum galvanization 120gsm

Plug-in Clip (spring steel) 0.8mm thick, spring steel

Pressure Spring (St. Steel) 0.3mm thick, spring steel

Clamping Bracket (Galvanized steel, CK60 42HRC) 1mm thick, (with Galvanized fasteners)

Security Bracket (Galvanized steel, S250GD) 1.5mm thick, minimum galvanization 120gsm

All above accessories shall be powder coated with exterior grade coating.

Perimeter Trims: These would include 25mmx25mmx4000mm Aluminum extruded profile (Al 6xxx), post-coated to RAL color, shade approved by AAI/PMC.

Suspension would be M6 GI threaded rod (2000mm L) & GI Compression studs (C-profiles) as required.

**INSTALLATION:**

Primary and secondary runners Installation: U-Profiles, spaced at 1200mm, to be suspended from ceiling using clamping brackets and threaded rods OR hanger wires. Hanger wires must be wrapped tightly with 3 full wraps. The J-shape profiles (directional) shall intersect the U-profile at 90° at every module dictated by the panel length. The J-shape profile is connected to the U-profile with a J-shape profile hanger and secured to the matching square U-Profile slots using plug-in clips. Self-tapping screws to be used when square U-Profile slots do not match the hangers. The U-profiles and J-shape profiles be fastened to two adjacent walls using the wall anchor and bolts. U-Profiles and J-shape profiles to be at a maximum distance of 450mm (max.) to a perimeter wall or outside edge of a floating module. To join two pieces of continuous U-profiles and J-shape profiles, a U-Profile splice and J-shape profile splice to be used respectively. For Inclined installation, the J-shape profiles shall be indirectly fixed to U-shape profiles using appropriate accessories.

Panel Installation: Full size flat metal works Hook-on panels (directional) to be hooked on to the J-shape profiles (in accordance with the shop drawings) along the short side (typical).

Field-cut Panels: Perimeter panels that require field cutting to fit on a wall trim option must have a minimum of 12mm edge resting on the horizontal surface of the wall moldings.
Wall Moldings: Aluminum extruded grooved wall molding to be fastened to the perimeter using screws, at every 450mm to 600mm L. All perimeter fields cut panels to be fixed to the Aluminum wall molding using two pressure springs.

Exterior Installation: For Exterior Installation, the U-shaped Profile and J-shape profile must be attached to two adjacent perimeter walls using wall anchors. An appropriate system restraint with lateral force bracing using compression posts / studs and 4 splay hanger wire cluster to be made at the intersection of each J-shape profile and U-shape Profile. The J-shaped profiles to run along the long side (in accordance with the shop drawings). A compression post to be fastened to the U-Profile using self-drilling screws. Panels without access to be attached to the J-shaped profile using self-tapping screws. J-shaped profile Security Brackets must be attached to all Hook-on Panels to maintain secure engagement on the J-shaped profile at an interval of around 600mm (or as per shop drawings).

• Curved Hook-on Ceilings (Exterior)

Providing and Fixing Suspended Metal Ceilings manufactured in Hook-on system with Rectangular panels made out of 1.0mm thick Aluminum and curved panels made out of 0.7mm thick GI. The entire system to be designed for Exterior applications, and concealed Grids with butt joint panels. The double grid system to have fixed panels, with system height of around 100mm.

PANEL SPECIFICATIONS:

Material: The curved hook-on ceilings (plain): The Curved Hook-On panels (rectangular or radial as per design requirements) to be made of Galvanized Steel (zero spangle – suitable for architectural finishes), minimum thickness 0.7mm, 120gsm hot dipped galvanization (both sides). The panels shall have 3mm(W) x 8mm(H) black foam gasket, glued at the edges. The panels shall have a custom curved profile, manufactured as per approved design.

Sizes: The curved hook-on ceilings (plain): The curved panel shall have length up to 1500mm, while the panel width shall be up to 600mm. The panels shall have long side upturns of minimum 40mm H, 2mm thickness (vertical) for rigidity, and short side upturns of 30mm (vertical) and shall be bent appropriately as per the manufacturer’s specifications for providing hook-on ends.

Edge Detail: The panels shall be with Square Edge, having butt joint between consecutive panels, along with 3mm reveal.

Sag Limits: To be measured at the center in accordance with TAIM standards.
Dimensional Tolerances: For panel Thickness / panel width / panel length - To be measured in accordance with TAIM standards.

Panel Finish: The panels shall be in plain finish.

Coating: The panel surface to be polyester powder coated to 60-80µ (pure polyester) on both visible and non-visible sides after panel production, low gloss (degree of gloss approx. 20%). The coating shall be architectural-quality, electrostatically applied polyester powder coat paint. The color to be plain RAL color shades as approved by AAI/PMC. The paint to conform to 1000 hours of salt spray for durability (as per ASTM B117 Norms), 250 hours of condensation test (as per DIN 50017 or DIN EN ISO 6270-1 Norms), UV resistance of 500 hours and 50% gloss retention (as per ASTM G 154 UVB-313 Norms). Paint tolerance (Δe) shall be ≤ 1.0. Pre-coated panels shall not be acceptable.

Fire Classification: The GI panels must conform to Fire Performance of Class 0/Class 1 as per BS476 Part& 7 test standard.

**SUSPENSION SYSTEM SPECIFICATIONS:**

Primary Runners: would be Galvanized steel (minimum galvanization 120gsm) U-shaped Profile of 30mm(H) x 3746mm(L) x 20mm(W) x 1.5mm(T), roll formed slotted profile (Steel Material Grade : S280GD). The slots shall be alternate square and rectangular shapes with dimensions 6.5x6.5mm & 6.5x28mm.Torsion< 2° / 1000mm L, Flatness≤ 0.5mm/length, Straightness ≤6mm/ length.Weight of profile to be 0.77kgs per LM (minimum).

Secondary Runners: would be Galvanized steel (minimum galvanization 120gsm) J-shaped roll formed ribbed profile of45mm(H) x 3000mm (L) x 31mm(W) x 1.0mm(T),in GI (S280GD+Z140 NAC). Weight of profile to be 0.63kg/LM (minimum).Flatness/ Straightness to be within 0.2mm/length.

**ACCESSORIES:**

Galvanized Steel Hangers (for J-shaped profile), minimum 1.25mm thick, galvanization 120 gsm

U-shaped Profile Splice (Galvanized steel, DX51D) 1.5mm Thick, minimum galvanization 120gsm

J-shaped Profile Splice (Galvanized steel, S250GD) 1.5mm thick, minimum galvanization 120gsm

Wall Anchor (Galvanized steel, S250GD) 2mm thick, minimum galvanization 120gsm
Plug-in Clip (spring steel), 0.8mm thick, spring steel

Pressure Spring (St. Steel), 0.3mm thick, spring steel

Clamping Bracket (Galvanized steel, CK60 42HRC) 1mm thick, (with Galvanized fasteners)

Security Bracket (Galvanized steel, S250GD) 1.5mm thick, minimum galvanization 120gsm

All above accessories shall be powder coated with exterior grade coating.

Suspension would be M6 GI threaded rod (2000mm L) & GI Compression studs (C-profiles) & 2.5mm hanger wires (splay wires).

**INSTALLATION:**

Primary and secondary runners Installation: U-Profiles, spaced at 1200mm, to be suspended from ceiling using clamping brackets and threaded rods. The J-shape profiles (directional) shall intersect the U-profile at 90° at every module dictated by the panel length. The J-shape profile is connected to the U-profile with a J-shape profile hanger and secured to the matching square U-Profile slots using plug-in clips. Self-tapping screws to be used when square U-Profile slots do not match the hangers. The U-profiles and J-shape profiles be fastened to two adjacent walls using the wall anchor and bolts. U-Profiles and J-shape profiles to be at a maximum distance of 450mm (max.) to a perimeter wall or outside edge of a floating module. To join two pieces of continuous U-profiles and J-shape profiles, a U-Profile splice and J-shape profile splice to be used respectively.

Panel Installation: Full size metal curved Hook-On panels (directional) to be hooked on to the J-shape profiles (in accordance with the shop drawings) along the short side (typical). The J-shaped profiles shall be indirectly fixed to the primary runner or directly fixed on the curved metal structure (by others) grouted on the rigid ceiling structure.

Wall Moldings: Aluminum extruded grooved wall molding to be fastened to the perimeter using screws, at every 450mm to 600mm L. All perimeter field cut panels to be fixed to the Aluminum wall molding using two pressure springs.

Exterior Installation: For Exterior Installation, the U-shaped Profile and J-shape profile must be attached to two adjacent perimeter walls using wall anchors. An appropriate system restraint with lateral force bracing using compression posts / studs and 4 splay hanger wire cluster to be made at the intersection of each J-shape profile and U-shape Profile. The J-shaped profiles to run along the long side (in accordance with the shop drawings). A compression post to be fastened to the U-Profile using self-drilling screws. Panels without
access to be attached to the J-shaped profile using self-tapping screws. J-shaped profile Security Brackets must be attached to all Hook-on Panels to maintain secure engagement on the J-shaped profile at an interval of around 600mm (or as per shop drawings).

3. METAL CEILINGS BAFFLES (INTERIOR)

• Baffles (Rectangular)

Suspended Metal Baffle Ceilings manufactured in Vertical Linear Rectangular Pattern, with Baffles made out of Aluminum Extrusion. The entire system to be designed for Interior applications, and visible grids.

Baffle Material: The baffles shall be manufactured in Aluminum (alloy and temper: 6063 – T6).

Baffle Size: The baffle blade shall be in size of 150mm(H) x 25mm(W) x 3600mm(L) x 1.6mm(T).

Coating: The Baffles shall be powder coated to Wood grain finish shade approved by AAI/PMC.

Primary Runners: would be Galvanized steel (minimum galvanization 120gsm) U-shaped Profile (black powder coated) of 30mm(H) x 3746mm(L) x 20mm(W) x 1.5mm(T), roll formed slotted profile (Steel Material Grade : S280GD). The slots shall be alternate square and rectangular shapes with dimensions 6.5x6.5mm & 6.5x28mm. Torsion< 2° / 1000mm L, Flatness≤ 0.5mm/length, Straightness ≤6mm/ length. Weight of profile to be 0.77kgs per LM (minimum).

ACCESSORIES:

Galvanized Steel Hangers (for Baffle profile) 1.0mm thick, galvanization 120 gsm

U-shaped Profile Splice (Galvanized steel, DX51D) 1.5mm Thick, minimum galvanization 120gsm

Wall Anchor (Galvanized steel, S250GD) 2mm thick, minimum galvanization 120gsm

Plug-in Clip (spring steel) - black 0.8mm thick, spring steel

Clamping Bracket (Galvanized steel, CK60 42HRC) black 1mm thick, (with Galvanized fasteners)

End caps (Stainless steel) coated to matching baffle shade 0.7mm thick, SS-304

INSTALLATION:

U-shaped profiles:
Rectangular: The GI slotted U profile to be suspended at every 1200mm on-centre using 6mm threaded rod from the structural soffit using U-profile hanger. U-profile splice to be used to join more than one U profiles of length 3.75M. 1st U-Grid Channel must be no more than 400mm from the perimeter.

Installation of Baffles

Rectangular Installation: The baffle blade shall be suspended using Slotted U-shape profile of 20 x 30mm at on-center spacing in multiples of 25mm. Longer lengths of Baffles to be connected by Baffle Joiner and the ends to be fixed with End caps.

Rectangular Installation: Locate the slot for Baffle Hangers in U Profile section at 1200mm centers. Hangers are inserted into the slot, then rotated 90° and fixed into position by tightening the grub screw. Baffle to be lifted into position and hangers engage over lip of U-Grid Channel. Each Hanger to be secured into position by inserting the Locking Clip.

When doing continuous installation, Baffles blades are to be connected at ends with Baffle Joiner, which are inserted into the top and bottom slots of the Baffle closed profile for alignment only. The bottom Joiner to be located first and fastened on one side only. The top Joiner to be fitted then and secured with grub screws on one side. Then the two Baffle sections shall be joined and the top Joiner is screw fastened on the 2nd Baffle profile.

End Caps to be located by pushing the End Cap tongues into open Baffle slots.

Installation to be carried out by trained Installation team & Installation should be carried out as per recommended procedure.

• Baffles (Radial)

Suspended Metal Baffle Ceilings manufactured in Vertical Linear Radial Pattern, with Baffles made out of Aluminum Extrusion. The entire system to be designed for Interior applications, and visible Grids.

Baffle Material: The baffles shall be manufactured in Aluminum (alloy and temper: 6063 – T6).

Baffle Size: The baffle blade shall be in size of 150mm(H) x25mm(W) x3600mm(L) x 1.6mm(T).

Coating: The Baffles shall be powder coated to Wood grain finish shade approved by AAI/PMC.

Primary Runners: would be Galvanized steel (minimum galvanization 120gsm) U-shaped Profile (black powder coated)of 30mm(H) x 3746mm(L) x 20mm(W) x 1.5mm(T), roll formed slotted profile (Steel Material Grade : S280GD). The slots shall be alternate square and
rectangular shapes with dimensions 6.5x6.5mm & 6.5x28mm. Torsion< 2° / 1000mm L, Flatness≤ 0.5mm/length, Straightness ≤6mm/ length. Weight of profile to be 0.77kgs per LM (minimum).

ACCESSORIES:

Galvanized Steel Hangers (for Baffle profile)  1.0mm thick, galvanization 120 gsm

U-shaped Profile Splice (Galvanized steel, DX51D)  1.5mm Thick, minimum galvanization 120gsm

Wall Anchor (Galvanized steel, S250GD)  2mm thick, minimum galvanization 120gsm

Plug-in Clip (spring steel) - black  0.8mm thick, spring steel

Clamping Bracket (Galvanized steel, CK60 42HRC) black  1mm thick, (with Galvanized fasteners)

End caps (Stainless steel) coated to matching baffle shade  0.7mm thick, SS-304

INSTALLATION:

U-shaped profiles: Radial: The GI slotted U profile of size 30mm(H) x 20mm(W) x (3750/1875)mm(L) x 1.5mm(T), to be suspended at the on-centre spacing dictated by the shop drawings, using 6mm threaded rod from the structural soffit using U-profile hanger. U-profile splice to be used to join more than one Straight U profiles in linear directions. 1st U-Grid Channel must be no more than 400mm from the perimeter. For connecting U-Profiles at non-linear, special angular splice to be used. U-Profiles to be suspended at around 700mm spacing to each other. The suspension points to be at around 700-800mm spacing.

Installation of Baffles:-

Radial Installation: Locate the slot for Baffle Hangers in U Profile section at 700mm centres. Baffle Hangers are inserted into the slot, to the specific location (in accordance with the shop drawing) and fixed into position by tightening the grub screw. Baffle to be lifted into position and hangers engage over lip of U-Grid Channel. Each Hanger to be secured into position by inserting the Locking Clip or Plug-in clip. A module of Baffles is created and then the subsequent module is rotated to specific degree (in accordance to the shop drawings).

When doing continuous installation, Baffles blades are to be connected at ends with Baffle Joiner, which are inserted into the top and bottom slots of the Baffle closed profile for alignment only. The bottom Joiner to be located first and fastened on one side only. The top Joiner to be fitted then and secured with grub screws on one side. Then the two Baffle sections shall be joined and the top Joiner is screw fastened on the 2nd Baffle profile.
End Caps to be located by pushing the End Cap tongues into open Baffle slots.

Installation to be carried out by trained Installation team & Installation should be carried out as per recommended procedure.

4. **METAL CEILINGS LAY-IN (INTERIOR)**

- **Metal Lay-in Ceilings**

GI Microlook Lay-in Micro Perforated metal ceiling consisting of 600x600mm Lay-in tiles of pre-coated galvanized steel in 0.5 mm thickness in approved white color.

Panel Material: The material shall be Galvanized steel (zero spangle – suitable for architectural finishes), 0.5mm thick in pre-coated finish

Panel sizes: The panel sizes shall be 600x600 (nominal).

Sag Limits: To be measured at the center in accordance with TAIM standards.

Dimensional Tolerances: For panel Thickness / panel width / panel length - To be measured in accordance with TAIM standards.

Perforations: The perforation shall have Micro Perforation having hole diameter as 1.5mm and open area as 18%. Back side of the tile will have Soundtex fleece hot pressed to achieve NRC upto 0.7

Coating: The panel surface to be pre-coated finish having 5μ primer coat on the back and front side of the panel, and 25μ top coat on visible side, with low gloss (degree of gloss approx. 20%). The color to be white shade as approved by AAI/PMC. The paint to conform to 1000 hours of salt spray for durability.

Paint tolerance (∆e) shall be ≤ 0.6.

Fire performance: shall be of Class 0/Class 1 as per BS476 Part 6 &7 in module size of 600x600mm.

Acoustic performance: The sound absorption shall be 0.7NRC.

Grids and accessories: The tile shall be laid on T-Grid having 38mm web height with 15 mm wide T-section flanges (colour: approved white) having rotary stitching on all T sections i.e. the Main Runner, 1200 mm & 600 mm Cross Tees with a web height of 38mm and a load carrying capacity of 12.5 Kgs/M2 (as per standard installation layout mentioned below) & pull
out strength of 100Kgs. The T Sections have a Galvanizing of 90 grams per M2 and need to be installed with Suspension system of make.

Installation: To comprise main runner spaced at 1200mm securely fixed to the structural soffit using suspension system (specifications below) at 1200mm maximum. The First/Last suspension system at the end of each main runner should not be greater than 450mm from the adjacent wall.

Flush fitting 1200mm long cross tees to be interlocked between main runners at 600mm to form 1200 x 600 mm module. Cut cross tees longer than 600mm require independent support. 600 x 600mm module to be formed by fitting 600mm long flush fitting cross tees centrally between the 1200 mm cross tees.

Perimeter trim to be wall angles of size 3000x19x19mm, secured to walls at 450 mm maximum. In case of end tiles lesser than 600mm, use lay-in end cap for installation to have a Microlook effect on perimeters.

Installation to be carried out by trained Installation team & Installation should be carried out as per recommended procedure.

Suspension System: These accessories shall consist of M6 Anchor Fasteners with hanger hole, pre straightened Hanger wire of dia – 2.5 mm of 1.80 m length having a tensile strength of 344-413 MPa and a minimum pull strength of 110 kgs. (Adjustable hook clips of 0.7mm thick, galvanized spring steel can also be used for installation purpose as an additional accessory. The adjustable clip also consists of a 4 mm aquiline wire to be used with the main runner).

• **Metal Open Cell Ceilings**

Providing and fixing in true horizontal level Open cell GI lay-in ceiling tiles with border panels forming flush-regular edge of size 600x600x38mm. The tile shall be powder coated to White color having powder coat thickness ranging from 60-80 microns.

Panel Material: The material shall be Galvanised steel (zero spangle – suitable for architectural finishes), of 0.35mm thick in powder coated finish

Panel sizes: The panel sizes shall be 600x600 (nominal). The cell size shall be 200mm x 200mm.

Sag Limits: To be measured at the center in accordance with TAIM standards.

Dimensional Tolerances: For panel Thickness / panel width / panel length - To be measured in accordance with TAIM standards.
Coating: The panel surface to be polyester powder coated to 60-80µ (pure polyester) on visible side after panel production, low gloss (degree of gloss approx. 20%). The coating shall be architectural-quality, electrostatically applied polyester powder coat paint. The color to be white shade as approved by AAI/PMC. The paint to conform to 1000 hours of salt spray for durability (as per ASTM B117 Norms), 250 hours of condensation test (as per DIN 50017 or DIN EN ISO 6270-1 Norms), UV resistance of 500 hours and 50% gloss retention (as per ASTM G 154 UVB-313 Norms). Paint tolerance (Δe) shall be ≤ 1.0. Pre-coated panels shall not be acceptable.

Fire performance: This shall be having Fire Performance CLASS A1 as per EN-13964

Grids: The tile shall be laid on T-Grid of 38mm webheight with 15 mm wide T-section flanges (colour: approved white) having rotary stitching on all T sections i.e. the Main Runner, 1200 mm & 600 mm Cross Tees with a web height of 38mm and a load carrying capacity of 12.5 Kgs/M2 & pull out strength of 100Kgs. The T-sections have a Galvanizing of 90 grams per M2 and need to be installed with Suspension system of make.

Installation: To comprise main runner spaced at 1200mm securely fixed to the structural soffit using suspension system (specifications below) at 1200mm maximum. The First/Last suspension system at the end of each main runner should not be greater than 450mm from the adjacent wall.

Flush fitting 1200mm long cross tees to be interlocked between main runners at 600mm to form 1200 x 600 mm module. Cut cross tees longer than 600mm require independent support.

600 x 600mm module to be formed by fitting 600mm long flush fitting cross tees centrally between the 1200 mm cross tees.

Perimeter trim to be wall angles of size 3000x19x19mm, secured to walls at 450 mm maximum.

Installation to be carried out by trained Installation team & Installation should be carried out as per recommended procedure.

Suspension System: These accessories shall consist of M6 Anchor Fasteners with hanger hole, pre Straightened Hanger wire of dia – 2.5 mm of 1.80 m length having a tensile strength of 344-413 MPa and minimum pull strength of 110 kgs. (Adjustable hook clips of 0.7mm thick, galvanized spring steel can also be used for installation purpose as an additional accessory. The adjustable clip also consists of a 4 mm aquiline wire to be used with the main runner).
5. METAL BULKHEADS (INTERIOR)

• Vertical Bulkheads

Vertical bulkheads manufactured in Rectangular panels, made out of 1.0mm thick GI. The entire system to be designed for Interior and exterior applications with butt joint panels.

Material: The rectangular Hook-On panels to be made of Galvanized Steel (zero spangle – suitable for architectural finishes), minimum thickness 1.0mm, 120gsm hot dipped galvanization (both sides).

Size: The panel length shall be up to 1500mm, while the panel width shall be 475mm. The panels shall have long side upturn of minimum 25mm (horizontal) and inside bends of 25mm (vertical) for rigidity, and short side upturns of 30mm (vertical) and the panel shall be bent appropriately as per the manufacturer’s specifications for providing connections.

Sag Limits: To be measured at the center in accordance with TAIM standards.

Dimensional Tolerances: For panel Thickness / panel width / panel length - To be measured in accordance with TAIM standards.

Panel Finish: The panels shall be in plain finish.

Coating: The panel surface to be polyester powder coated to 60-80µ (pure polyester) on both visible and non-visible sides after panel production, low gloss (degree of gloss approx. 20%). The coating shall be architectural-quality, electrostatically applied polyester powder coat paint. The color to be plain RAL color shades as approved by AAI/PMC. The paint to conform to 1000 hours of salt spray for durability. Pre-coated panels shall not be acceptable. Paint tolerance (Δe) shall be ≤ 0.6.

Installation: GI bulkheads: The GI Bulkheads shall be suspended from ceiling soffit, M6 GI threaded rods and fasteners. The bulkheads shall be transitions and floating conditions and the transition panels to be rested on the bulkheads.

• Curved Bulkheads

Bulkhead profiles made of Aluminum extrusions in curved shape for ceilings, having 200mm height, suitable for interior applications.

Material: The bulkheads shall be made of Extruded Aluminum profiles of grade 6006-T6.
Size: The bulkheads shall have 200mm height and length of 4000mm, with minimum 1.6mm thickness. This profile shall be assembled in circular or elliptical shape, as approved by AAI/PMC.

Edge: The Edge of the Bulkhead profile shall have radius of suitable dimensions.

Coating: The panel surface to be polyester powder coated to 60-80µ (pure polyester) on visible side after panel production, low gloss (degree of gloss approx. 20%). The coating shall be architectural-quality, electrostatically applied polyester powder coat paint. The color to be white shade as approved by AAI/PMC. The paint to conform to 1000 hours of salt spray for durability. Paint tolerance (∆ε) shall be ≤ 0.6.

Installation: Special extruded Aluminum bulkhead assembly shall be curved to desired circular or elliptical shape and shall act as transition for Lower level and upper level Hook-on ceilings. These bulkheads to be fastened to U-shape Profiles using hangers or fasteners. The Hook-on panels rested on the bulkheads shall be field cut and locked to the bulkheads using pressure springs.

These would include 200mmx25mm Aluminum extruded profile having edge with radius, post-coated to approved RAL color / shades.

6. SOFT FIBER CEILINGS (INTERIOR)

• Shapes (at multiple levels)

Soft fiber - Acoustical clouds which are 30 mm thick, flat glass fiber panels with Humidity Resistance RH 90% & Recycled Content of minimum 30%, having in hexagon shape.

Material: The shapes shall be of pre-formed fiberglass core with laminated scrim finish on all sides and edges.

Size: The size and sound absorption details of multiple level Shapes are as below:

<table>
<thead>
<tr>
<th>Sr. No</th>
<th>Shape</th>
<th>Nominal Size</th>
<th>Actual Size</th>
<th>Sound Absorption – Metric Sabin</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Hexagon (Std.)</td>
<td>1200x1200mm</td>
<td>1168x1011mm</td>
<td>1.61</td>
</tr>
</tbody>
</table>
The back of each of the above panel to have embedded square frame bracket system of 610x610mm (or min 4 sleeves, based on custom size if any) in which provisions are already made for integration of installation system for suspension of grouped panels. Individual suspension shall not be accepted.

Fire performance: This shall be Class A2 -s1, d0 as per GB 8624-2006.

Color: The color shall be approved White color in the color specified by AAI/PMC with LR 90%.

Installation: Shapes at multiple levels: The panels to be suspended at three different levels, with each subsequent level offset from other by 50mm. These panels to be suspended in a specifically designed linear group arrangement using the Deck hanging kit (consisting of gripper structure anchors with an outer diameter of 16mm and height 23mm, aircraft cables of 1.5mm dia 2.44 LM in length and bottom end cable adjusters of 8.9mm outer diameter), 3.66 mtrs Aluminum group carrier frames, frame alignment spacers and panel hooks of sizes: Upper level 115mm (High Hooks) & 90mm (Low hooks); Middle level 169mm (High Hooks) & 144mm (Low hooks); Middle level 219mm (High Hooks) & 194mm (Low hooks). Aluminum group frames needs to be cut in size of 1931mm (2nos) and 712mm (4nos) for installation purpose.

Two Aluminum carrier frames to be placed parallel to each other and at a distance of 559 mm with their open face down and would form the ‘lower’ frame. The upper Frame carrier bar to be placed parallel to each other at every 970mm with their open face up and should be placed on top and perpendicular to the ‘lower’ frame thus forming the ‘upper’ frame using the frame alignment spacers with the first and the last ‘upper’ frame pieces to be placed at a distance guided by the shop drawings, from the ends and the assembly is secured with nut and bolts passing through the ‘upper’, ‘lower’ and the frame alignment spacers at every intersection.

The assembly to be suspended to the soffit using the deck hanging kit and the levels to be adjusted using the bottom end cable adjuster. 4 panel hooks to be screwed on the embedded square frame bracket at the back of each panel such that the two ‘High’ hooks are opposite to each other and are at the 305mm off centre mark of the embedded square frame bracket and the two ‘Low’ hooks are opposite to each other at the centre mark of the embedded square frame bracket. The Panels to be suspended on the Aluminum group frames by engaging the High hooks to the ‘upper’ frame and the Low hooks to the ‘lower’ frame.

Installation to be carried out by trained Installation team & Installation should be carried out as per recommended procedure.
• **Shapes (Mega Size Clouds)**

Soft fiber - Acoustical clouds which are 30 mm thick, flat glass fiber panels with Humidity Resistance RH 90% & Recycled Content of minimum 30%, come in custom odd size shapes (6 types as tabulated below).

Material: The shapes shall be of pre-formed fiberglass core with laminated scrim finish on all sides and edges.

Size: The Mega size shapes shall have various sizes as given below:

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Shape</th>
<th>Area per shape</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Shape-01</td>
<td>3.40 m²</td>
</tr>
<tr>
<td>2.</td>
<td>Shape-02</td>
<td>7.50 m²</td>
</tr>
<tr>
<td>3.</td>
<td>Shape-03</td>
<td>11.00 m²</td>
</tr>
<tr>
<td>4.</td>
<td>Shape-04</td>
<td>9.00 m²</td>
</tr>
<tr>
<td>5.</td>
<td>Shape-05</td>
<td>10.50 m²</td>
</tr>
<tr>
<td>6.</td>
<td>Shape-06</td>
<td>4.10 m²</td>
</tr>
</tbody>
</table>

The back of each of the above panel to have embedded square frame bracket system of 610x610mm (or min 4 sleeves, based on custom size if any) in which provisions are already made for integration of installation system for suspension of grouped panels. Individual suspension shall not be accepted.

Fire performance: This shall be Class A2 -s1, d0 as per GB 8624-2006.

Color: The color shall be approved White color in the color specified by AAI/PMC with LR 90%.

Installation: Mega Size clouds: These panels to be suspended in a specifically designed grouping arrangement (each type of shape shall have individual grouping design – in accordance with the shop drawings) using the Soft FiberDeck hanging kit (consisting of gripper structure anchors with an outer diameter of 16mm and height 23mm, aircraft cables of 1.5mm dia 2.44 LM in length and bottom end cable adjusters of 8.9mm outer diameter), 3.66 mtrs Aluminum group carrier frames, frame alignment spacers and panel hooks of sizes 115mm (High Hooks) & 90mm (Low hooks). Aluminum group frames needs to be cut in custom sizes as per shop drawings for installation purpose.

Two Aluminum carrier frames to be placed parallel to each other and at a specified distance with their open face down and would form the ‘lower’ frame. The upper Frame carrier bar to
be placed parallel to each other at specified distance with their open face up and should be placed on top and perpendicular to the ‘lower’ frame thus forming the ‘upper’ frame using the frame alignment spacers with the first and the last ‘upper’ frame pieces to be placed at a distance guided by the shop drawings, from the ends and the assembly is secured with nut and bolts passing through the ‘upper’, ‘lower’ and the frame alignment spacers at every intersection.

The assembly to be suspended to the soffit using the deck hanging kit and the levels to be adjusted using the bottom end cable adjuster. 4 panel hooks to be screwed on the embedded square frame bracket at the back of each panel such that the two ‘High’ hooks are opposite to each other and are at the specified off centre mark of the embedded square frame bracket and the two ‘Low’ hooks are opposite to each other at the centre mark of the embedded square frame bracket. The Panels to be suspended on the Aluminum group frames by engaging the High hooks to the ‘upper’ frame and the Low hooks to the ‘lower’ frame. Multiple shaped shall be joined to each other using special connectors from the sides and the top.

Installation to be carried out by trained Installation team & Installation should be carried out as per recommended procedure.

- **Blades (curved)**

Soft Fiber – Blades having Curved profile which are 40 mm thick, pre-formed fiberglass blades, with acoustic properties and having a recycled content of 80%, having shapes as per the design approved by AAI/PMC.

Material: The blades shall be of pre-formed fiberglass core with laminated scrim finish on all sides and edges.

Blade size: The Blades shall be 40mm thick having curved profile edges, with length of panels up to 2400mm, and height up to 400mm.

Fire Performance: This shall be Class B – s1, d0 as per EN 13501-1

Acoustic performance: Acoustical performance of 0.65 NRC

Color: The color shall be standard White color with Light reflectance 87%, or in the color specified by AAI/PMC.

Installation with Deck Hanging Kit: The Soft Fiber Blades Curved shall be factory fitted with “female inserts” on both sides. The blades to be suspended individually using the Deck Hanging kit comprising of gripper structure anchors with an outer diameter of 16mm and
height 23mm, aircraft cables of 1.5mm dia 2.44 LM in length and bottom end cable adjusters of 8.9mm outer diameter. Blades must be installed with minimum 100 mm on-centre spacing.

Hanger Wire Attachment to Structure: Attach the gripper structure anchor to the structure with a fastener that will carry the full weight of the blades. Insert the end of the cable into the gripper anchor cap. Screw the gripper anchor cap completely into the gripper structure anchor.

Insert Suspension Cables: The panel is to be suspended using the aircraft cables which are suspended from the soffit using the gripper structure anchors and its other end passing through the bottom end cable adjuster. The height & level of the panels can be adjusted using the bottom end cable adjusters.

Suspend the Blade: Locate the two factory fitted female inserts on the blades. Suspend the Blades by screwing the bottom end of the cable adjuster into the female inserts.

Installation to be carried out by trained Installation team & Installation should be carried out as per recommended procedure.

7. LIGHT WEIGHT CALCIUM SILICATE GRID CEILING:

The true horizontal level imported false ceiling grid using hot dipped galvanized steel section exposed surface chemically cleaned capping pre-finished in baked polyester paint main tee size of 24 x 38 x 033mm at every 1200mm c/c maximum and rotary stitched cross ‘T’ of size 24 x 30 x 0.284mm at every size of 600mm c/c max and 22 x 22 x 0.457mm Wall angle all round the wall to form a grid of size 600mm x 600mm and suspending the grid using suitable support system of 4mm dia galvanized wire rod with butterfly clip for leveling made out of spring steel spaced at a distance of 1200 mm centers intervals at the main T and laying Light Weight Calcium Silicate board Ceilings as per the manufactures specification.

TECHNICAL DATA:

- Humidity Resistance : 100% RH
- Noise Reduction coefficient : 0.10 to 0.50
- Fire Resistance : Class 2 / Class 1
- Light Reflectance : >85%
- Lightweight : 5 Kg/Sq.mt.
- Size : 600 x 600mm
8. WOODCEILINGS (INTERIOR)

Wooden grille with dowel made of natural bamboo with 24mm W, 43mm H black exposed grid, and relative humidity or RH 90%.

Size: The Wooden Grille panel of nominal size 57x300x2400mm comprising 6 blades of 57x16x2376mm with on center spacing of 50mm fixed thru dowel of dia-12mm x 300mm with on center spacing of 300mm and additional end dowels at 150mm from both the edges. Ledger of 6.5x24x2400mm to be used for covering face of wall angle.

Standards: Wood Grille should comply with ASTM-E84: Class A and have Relative Humidity of RH70.

Shade: The panels are UV coated to Natural or Carbonized shades as approved by AAI/PMC.

Edge: Open edges may be covered using “Edge Caps” of 66x19x2400mm and “Blade Junction” of 66x38x2400mm to be used along the connection of two WW Grille Panels.

Fire Performance: This shall be Class A as per ASTM-E84

Grids and accessories: The grid should be of 43mm H, with 24mm wide T - section flanges Black powder coating having rotary stitching on all T sections i.e. the Main Runner, 1200 mm & 600 mm Cross Tees with a web height of 43mm for the main runner & the Cross Tees and with a load carrying capacity of 20 Kgs/M2. Black dowel clips of spring steel to be used for fixing panel to suspension system.

INSTALLATION:

To comprise main runner spaced at 1200mm centers securely fixed to the structural soffit using suspension system (specifications below) at 1200mm maximum center. The First/Last suspension system at the end of each main runner should not be greater than 450mm from the adjacent wall.

Flush fitting 1200mm long cross tees to be interlocked between main runners at 600mm center to form 1200 x 600 mm module. Cut cross tees longer than 600mm require independent support. 600 x 600mm module to be formed by fitting 600mm long flush fitting cross tees centrally between the 1200 mm cross tees.

Perimeter trim to be wall angles of size 19x19x3000mm, secured to walls at 450 mm maximum centers.

Dowel clips are used to fix the panel to suspension with a grid formation of 600mm along the slat and 2 pieces along each dowel for every individual panel.
SUSPENSION SYSTEM:

These accessories shall consist of M6 Anchor Fasteners with hanger hole, pre Straightened Hanger wire of diameter – 2.5 mm of 1.80 m length having a tensile strength of 344-413 MPa, along with Adjustable hook clips of 0.8mm thick, galvanized spring steel for 2.5 mm wire with a minimum pull strength of 110 kg. The adjustable clip also consists of a 4 mm aquiline wire to be used with the main runner.
Part C: ELEVATIONAL WORKS

1. MDF PANELS

Medium density fiberboard or MDF is an engineered composite wood panel product, made out of wood fibers glued together with synthetic resin, heat and pressure. It is also termed as dry process fiber board in technical parlance. The term ‘dry process fiber board is a generic term so called by virtue of the manufacturing process. In common parlance, Medium Density Fibreboard (MDF) is a generic term.

Trade practice classifies MDF Panels in to different types, chiefly by its constituent fibers, density, resin and usage, i.e. Medium Density MDF (MDF)

INSTALLATION & APPLICATION:

Surface Preparation: The surfaces to be finished should be free from dust or sanding marks. An additional light sanding with 320 grit will be beneficial for applications where a high level of smoothness is required without the necessity of using additional coats of paint.

Sealing: Fill up all nail holes with solvent-based wood filler and lightly sand. To prevent excessive absorption of resins and solvents from paint or lacquer finishes, seal the Custom wood surfaces with a solvent borne sealer. Solvent-borne wood primers or undercoats may also be used depending on the type of finish coating and the quality of finish required. Sealers should be applied soon after sanding to prevent raising of the fibers, especially in areas of high relative humidity.

Low Pressure Melamine: MDF can be laminated with Melamine impregnated papers following the procedures adopted in either short cycle or continuous belt presses. It may however, be noted that every other type or grade of MDF is not suitable to LPM application as results vary in terms of density profile of the Panel.

The light Colour of the MDF surface works well even with light weight white color resonated papers. To ensure stability and flatness of panel after melamine application, same type of resonated paper need to be used in varying environmental conditions. Grain direction of the paper on both faces should also be matched for a balanced lamination.
Pressing temperature and time should be at the minimum levels consistent with full cure of the melamine resin. The following short cycle press conditions have been found to be satisfactory depending upon the type of resin.

Temperature 100 - 200 °C
Pressure 2000 - 2500 kN/M2
Time 40 - 60 Seconds
Moisture Content in Panel 6 - 9 %

(Note: Excessive dry weather or loss of moisture content in the panel is likely to loss of thickness in the process of pressing).

It is necessary that the process of loading and closing the press is fast enough to allow more or less equal heating of both faces to ensure flatness.

After pressing, the Panels must be stored on uniform flat surface until its cooling to room temperature conditions.

**FIXING OF MDF**

**Lipping & Edge Jointing:**

Joining techniques for MDF are similar to those used for solid wood and other wood based panel products. The following recommendations will ensure satisfactory results:

Edges must be accurately machined, parallel to each other and perpendicular to the, boards surface.

Use a high solids content adhesive with gap filling and good machining qualities. Glue lines should accept stains, paints and lacquers.

Mating pieces should be accurately located and held under pressure whilst adhesive sets.

Adhesive bonded joints should be allowed to condition for at least 48 hours before finishing to avoid the appearance of sunken joints which may later become noticeable particularly when using high gloss finishes when attaching lippings, the tongue should be machined on the main piece of board.

Machined grooves should be limited to about one-third the board thickness and to a depth of about half the thickness.

Dowels or tongues should fit firmly but easily as tight-fitting joints may result in splitting or de-lamination.
MDF is produced in large number of thickness ranging from 2.3mm to 32.8mm. The most commonly available sheet dimension is 2440mm x 1220mm, there are several customized dimensions depending on end-users requirement to eliminate wastages in the product application. For any specialized requirement, prior arrangement is necessary.

### Table 1: Physical Properties of THIN Standard Density MDF Panels

<table>
<thead>
<tr>
<th>Panel density variants</th>
<th>Physical Properties</th>
<th>Thickness Range</th>
<th>Low</th>
<th>25</th>
<th>25</th>
<th>30</th>
<th>30</th>
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<tbody>
<tr>
<td></td>
<td>Density (kg/m³)</td>
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<td></td>
<td>Typical Low High</td>
<td>&lt;2.7m m</td>
<td>790</td>
<td>800</td>
<td>80</td>
<td>800</td>
<td>80</td>
<td>76</td>
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<td></td>
<td></td>
<td>3mm m</td>
<td>725</td>
<td>745</td>
<td>75</td>
<td>750</td>
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<td>71</td>
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<td></td>
<td></td>
<td>4m m</td>
<td>75</td>
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<td>5.5m m</td>
<td>80</td>
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<td>6m m</td>
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<td>7m m</td>
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<td></td>
<td>Modulus of Rupture (MPa)</td>
<td>Typical Low</td>
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<td></td>
<td>Modulus of Elasticity (MPa)</td>
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<td>3700</td>
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<td></td>
<td>Internal Bond Strength (kPa)</td>
<td>Typical Low</td>
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<td></td>
<td>Moisture Content (%)</td>
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<td>6 to 11</td>
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<td>5</td>
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<td>Surface Water Absorption (g/m²)</td>
<td>Low</td>
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<td></td>
<td>Thickness Swell (20°C, 24 hours) (%)</td>
<td>Typical Low</td>
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<tr>
<td>Hygroexpansivity (Change in face dimensions over 30% to 90% relative humidity)</td>
<td>%</td>
<td>Typical 0.3</td>
<td>0.3</td>
<td>0.3</td>
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</table>

Physical Properties of Medium Density Fibreboard

**Thermal properties**: The thermal conductivity of MDF varies slightly with thickness with usual range being 0.05 to 0.08 kcal/mh0 C (0.12 - 0.15 W/m0 K).

2. **PAINTING WORKS**

**GENERAL REQUIREMENTS:**

Before commencing painting, the Contractor shall obtain the approval of AAI/PMC in writing regarding the scheduling of work to minimize damage, disfiguration or staining by other trades. He shall also undertake necessary precautions to prevent damage, disfiguration or staining of other trades or other installations.

Contractor shall protect not only his own work at all times but also all the adjacent work and materials by suitable covering, protection or other methods acceptable to AAI/PMC during progress of painting. It is the responsibility of the contractor upon completion of painting work to remove all paint and varnish spots from floors, walls, glass panes and other surfaces and restore them to the original conditions. The work generally to be touched up shall be attended to after all other workmen have left. All accumulated material, rubbish etc. have to be cleared and the premises left in clean, orderly and acceptable conditions.

Contractor shall provide scaffolding wherever necessary erected on double supports tied together by horizontals, no ballies, bamboos or planks shall rest on or touch the surface which is being painted. Contractor is deemed to have considered the following while tendering and no extra claim on account of these will be entertained.

a) Supplying the paint and other materials required of approved colour and brand.
b) Preparing the surface to be painted.
c) Providing and erecting scaffolding and removing the same after completion of the work.
d) Lifting of materials to any height and painting at all levels.
e) Application of paint as per the specification and to Manufacturer’s instructions.
f) Curing, protecting the painted surface, adjacent work and thoroughly cleaning of the premises.

The Contractor shall furnish all skilled and unskilled labour, plant, equipment, scaffolding, all materials etc. required for complete execution of the work in accordance with the drawings and as described herein and / or as directed by AAI/PMC.

Any approval, instructions, permission, checking, review etc. whatsoever by AAI/PMC shall not relieve the Contractor of his responsibility and obligation regarding adequacy, correctness, completeness, safety, strength, workmanship etc.

CODES AND STANDARDS

All standards, specifications, acts, and codes of practice referred to herein shall be the latest editions including all applicable official amendments and revisions.

List of certain important Indian Standards, Acts and Codes applicable to this work is given below. However, the applicable standards and codes shall be as per but not limited to the list given below:

IS : 157 : Chemical resistant paint.
IS : 161 : Oil resistant paint
IS : 162 : Ready mixed paint, brushing, fire resisting, silicate type for use on wood, color as required
IS : 348 : French Polish
IS : 423 : Plastic wood for joiners filter.
IS : 427 : Distemper, dry, colour as required
IS : 428 : Distemper, oil emulsion, colour as required
IS : 712 : Building limes
IS : 1200: Method of measurement of building and civil Engineering works.
IS : 2074: Ready mixed paint, air drying, red oxide – zinc chrome priming.
IS : 2922: Specification for wooden tentmallets
IS : 2932: Enamel, synthetic, exterior (a) undercoating, (b) finishing
IS : 2933: Enamel exterior (a) undercoating, (b) finishing
IS : 5410: Cement paint
MATERIALS

i. General

Paint shall be ready mixed and of first quality of the approved brand and manufacturer. The paint shall generally conform to the chemical composition and other characteristics laid down in the relevant Indian standard specification. Mixing of paint by the Contractor at site will not be allowed. However, in the case of selection of special shades and colours (not available standard shades) the Contractor shall mix different shades of ready mixed paints as per Manufacturer’s instructions and as directed by the AAI/PMC.

Materials shall be the highest grade products of well known approved manufacturers and shall be delivered to the site in original sealed containers, bearing brand name, manufacturer’s name and colour shade, with labels intact and seals unbroken. All materials shall be subject to inspection and approval by AAI/PMC. It is desired that materials of one manufacturer only shall be used as far as possible and paint of one shade be obtained from the same manufacturing batch. All paints shall be subjected to analysis from random samples taken at site from the painter’s bucket, if so desired by AAI/PMC.

All unspecified materials shall be of the highest quality available and shall conform to the latest IS standards. All such materials shall be made by reputable recognized manufacturers and shall be approved by AAI/PMC. Any materials found not conforming to the relevant specification shall have to be removed by the Contractor from the site at his own expenses.

All colours shall be as per the painting schedule and tinting and matching shall be done to the satisfaction of AAI/PMC. In such cases, where samples are required, they shall be executed in advance with the specified materials for the approval of the AAI/PMC.

All primer coats shall be compatible to the material of the surface to be finished as well as to the finishing coats to be applied.

ii. Dry Distemper

Dry distemper of required colour conforming to IS:427 and of approved brand and manufacturer shall be used. The primer where used shall be cement primer or distemper primer. These shall be of same manufacturer as that of distemper.

iii. Acrylic Emulsion Paint

Shall be water based acrylic copolymer emulsion with rutile titanium dioxide and other
selected pigment and fungicide. It shall exhibit excellent adhesion to plaster and cement surface and shall resist deterioration by alkali salts. The paint film shall allow the moisture in wall to escape without peeling or blistering the paint. After it is dried, the paint should be able to withstand washing with mild soap and water without any deterioration in colour or without showing flaking, blistering or peeling.

**OIL EMULSION (OIL BOUND) WASHABLE DISTEMPERING**

**Materials:** Oil emulsion (Oil Bound) washable distemper (IS 428) of approved brand and manufacture shall be used. The primer where used as on new work shall be cements primer or distemper primer as described in the item. These shall be of the same manufacture as distemper. The distemper shall be diluted with water or any other prescribed thinner in a manner recommended by the manufacturer. Only sufficient quantity of distemper required for day’s work shall be prepared.

The distemper and primer shall be brought by the contractor in sealed tins in sufficient quantities at a time to suffice for a fortnight’s work, and the same shall be kept in the joint custody of the contractor and AAI/PMC. The empty tins shall not be removed from the site of work, till this item of work has been completed and passed by AAI/PMC.

**Preparation of the Surface:** For new work the surface shall be thoroughly cleaned of dust, old white or colour wash by washing and scrubbing. The surface shall then be allowed to dry for at least 48 hours. It shall then be sand papered to give a smooth and even surface. Any unevenness shall be made good by applying putty, made of plaster of paris mixed with water on the entire surface including filling up the undulations and then sand papering the same after it is dry.

In the case of old work, all loose pieces and scales shall be removed by sand papering. The surface shall be cleaned of all grease, dirt etc.

Pitting in plaster shall be made good with plaster of paris mixed with the colour to be used. The surface shall then be rubbed down again with a fine grade sand paper and made smooth. A coat of the distemper shall be applied over the patches. The patched surface shall be allowed to dry thoroughly before the regular coat of distemper is applied.

**Application:**
Priming Coat: The priming coat shall be with distemper primer or cement primer, as required in the description of the item. The application of the distemper primer shall be as described in CPWD specifications.

Note: If the wall surface plaster has not dried completely, cement primer shall be applied before distempering the walls. But if distempering is done after the wall surface is dried
completely, distemper primer shall be applied.

Oil bound distemper is not recommended to be applied, within six months of the completion of wall plaster. However, newly plastered surfaces if required to be distempered before a period of six months shall be given a coat of alkali resistant priming Paint conforming to IS 109 and allowed to dry for at least 48 hours before distempering is commenced.

For old work no primer coat is necessary.

**Distemper Coat**: For new work, after the primer coat has dried for at least 48 hours, the surface shall be lightly sand papered to make it smooth for receiving the distemper, taking care not to rub out the priming coat. All loose particles shall be dusted off after rubbing. One coat of distemper properly diluted with thinner (water or other liquid as stipulated by the manufacturer) shall be applied with brushes in horizontal strokes followed immediately by vertical ones which together constitutes one coat.

The subsequent coats shall be applied in the same way. Two or more coats of distemper as are found necessary shall be applied over the primer coat to obtain an even shade.

A time interval of at least 24 hours shall be allowed between successive coats to permit proper drying of the preceding coat.

For old work the distemper shall be applied over the prepared surface in the same manner as in new work. One or more coats of distemper as are found necessary shall be applied to obtain an even and uniform shade.

15 cm double bristled distemper brushes shall be used. After each days work, brushes shall be thoroughly washed in hot water with soap solution and hung down to dry. Old brushes which are dirty and caked with distemper shall not be used on the work.

The specifications in respect of scaffolding, protective measures and measurements shall be as described under CPWD specifications.

**Rate**: The rate shall include the cost of all labour and materials involved in all the above operations (including priming coat) described above.

**CEMENT PRIMER COAT**: Cement primer coat is used as a base coat on wall finish of cement, lime or lime cement plaster or on non-asbestos cement surfaces before oil emulsion distemper Paints are applied on them. The cement primer is composed of a medium and pigment which are resistant to the alkalies present in the cement, lime or lime cement in wall finish and provides a barrier for the protection of subsequent coats.
of oil emulsion distemper Paints.

Primer coat shall be preferably applied by brushing and not by spraying. Hurried priming shall be avoided particularly on absorbent surfaces. New plaster patches in old work should also be treated with cement primer before applying oil emulsion Paints etc.

Preparation of the Surface: The surface shall be thoroughly cleaned of dust, old white or colour wash by washing and scrubbing. The surface shall then be allowed to dry for at least 48 hours. It shall then be sand papered to give a smooth and even surface. Any uneveness shall be made good by applying putty, made of plaster of paris mixed with water on the entire surface including filling up the undulations and then sand papering the same after it is dry.

Application: The cement primer shall be applied with a brush on the clean dry and smooth surface. Horizontal strokes shall be given first and vertical strokes shall be applied immediately afterwards. This entire operation will constitute one coat. The surface shall be finished as uniformly as possible leaving no brush marks. It shall be allowed to dry for at least 48 hours, before oil emulsion Paint is applied.

The Specifications in respect of scaffolding, protective measures, measurements and rate shall be as described under CPWD specifications.

CEMENT PAINT: The cement Paint shall be (conforming to IS 5410) of approved brand and manufacture.
The cement Paint shall be brought to the site of work by the contractor in its original containers is sealed condition. The material shall be brought in at a time in adequate quantities to suffice for the whole work or at least a fortnight’s work. The materials shall be kept in the joint custody of the Contractor and AAI/PMC. The empty containers shall not be removed from the site of work till the relevant item of the work has been completed and permission obtained from AAI/PMC.

Preparation of Surface: For New Work, the surface shall be thoroughly cleaned of all mortar dropping, dirt dust, algae, grease and other foreign matter by brushing and washing. Pitting in plaster shall be made good and a coat of water proof cement Paint shall be applied over patches after wetting them thoroughly.

Preparation of Mix: Cement Paint shall be mixed in such quantities as can be used up within an hour of its mixing as otherwise the mixture will set and thicken, affecting flow and finish. Cement Paint shall be mixed with water in two stages. The first stage shall comprise of 2 parts of cement Paint and one part of water stirred thoroughly and allowed to stand for 5 minutes. Care shall be taken to add the cement Paint gradually to the water and not vice versa. The second stage shall comprise of adding further one part of water to the mix and stirring thoroughly to obtain a liquid of workable and uniform consistency.
In all cases the manufacturer’s instructions shall be followed meticulously.

The lids of cement Paint drums shall be kept tightly closed when not in use, as by exposure to atmosphere the cement Paint rapidly becomes air set due to its hygroscopic qualities.

In case of cement Paint brought in gunny bags, once the bag is opened, the contents should be consumed in full on the day of its opening. If the same is not likely to be consumed in full, the balance quantity should be transferred and preserved in an airtight container to avoid its exposure to atmosphere.

Application: The solution shall be applied on the clean and wetted surface with brushes or spraying machine. The solution shall be kept well stirred during the period of application. It shall be applied on the surface which is on the shady side of the building so that the direct heat of the sun on the surface is avoided. The method of application of cement Paint shall be as per manufacturer’s specification. The completed surface shall be watered after the day’s work.

The second coat shall be applied after the first coat has been set for at least 24 hours. Before application of the second or subsequent coats, the surface of the previous coat shall not be wetted.

For new work, the surface shall be treated with three or more coats of water proof cement Paint as found necessary to get a uniform shade.

For old work, the treatment shall be with one or more coats as found necessary to get a uniform shade.

Precaution: Water proof cement Paint shall not be applied on surfaces already treated with white wash, colour wash, distemper dry or oil bound, varnishes, Paints etc. It shall not be applied on gypsums, wood and metal surfaces.

If water proofing cement is required to be applied on existing surface, previously treated with white wash, colour wash etc., the surface shall be thoroughly cleaned by scrapping off all the white wash, colour wash etc. completely. Thereafter, a coat of cement primer shall be applied followed by two or more coat of water proof cement.

The specifications in respect of scaffolding, protective measures, measurements and rate shall be as described under 13.14. The coefficient for cement Paint on RCC Jalli shall be the same as provided in Sl. No. 7 of Table 1 under para 13.23.6.4 for painting trellis for Jaffri work.
• TEXUTRED EXTERIOR PAINT/ ACRYLIC SMOOTH EXTERIOR PAINT/ PREMIUM ACRYLIC SMOOTH EXTERIOR PAINT

**Material:** The paint shall be (Textured exterior paint/Acrylic smooth exterior paint/premium acrylic smooth exterior paint) of approved brand and manufacture.

This paint shall be brought to the site of work by the contractor in its original containers in sealed condition. The material shall be brought in at a time in adequate quantities to suffice for the whole work or at least a fortnight’s work. The materials shall be kept in the joint custody of the contractor and AAI/PMC. The empty containers shall not be removed from the site of work till the relevant item of work has been completed and permission obtained from AAI/PMC.

**Preparation of Surface:** For new work, the surface shall be thoroughly cleaned off all mortar dropping, dirt dust, algae, fungus or moth, grease and other foreign matter of brushing and washing, pitting in plaster shall make good, surface imperfections such as cracks, holes etc. should be repaired using white cement. The prepared surface shall have received the approval of AAI/PMC after inspection before painting is commenced.

**Application:** Base coat of water proofing cement paint or as per manufacturer’s instructions. All specifications in respect of base coat of water proofing cement paint shall be as described under CPWD specifications.

Before pouring into smaller containers for use, the paint shall be stirred thoroughly in its container, when applying also the paint shall be continuously stirred in the smaller containers so that its consistency is kept uniform. Dilution ratio of paint with potable water can be altered taking into consideration the nature of surface climate and as per recommended dilution given by manufacturer. In all cases, the manufacturer’s instructions & directions of AAI/PMC shall be followed meticulously.

The lids of paint drums shall be kept tightly closed when not in use as by exposure to atmosphere the paint may thicken and also be kept safe from dust.

Paint shall be applied with a brush on the cleaned and smooth surface. Horizontal strokes shall be given, First and vertical strokes shall be applied immediately afterwards. This entire operation will constitute one coat. The surface shall be finished as uniformly as possible leaving no brush marks.

The specifications in respect of scaffolding, protective measures, measurements and rate shall be as described under CPWD specifications.

**Painting:** Materials: Paints, oils, varnishes etc. of approved brand and manufacture shall be used. Only ready mixed Paint (Exterior grade) as received from the manufacturer without any admixture shall be used.
If for any reason, thinning is necessary in case of ready mixed Paint, the brand of thinner recommended by the manufacturer or as instructed by AAI/PMC shall be used.

Approved Paints, oil or varnishes shall be brought to the site of work by the contractor in their original containers in sealed condition. The material shall be brought in at a time in adequate quantities to suffice for the whole work or at least a fortnight’s work. The materials shall be kept in the joint custody of the contractor and AAI/PMC. The empties shall not be removed from the site of work, till the relevant item of work has been completed and permission obtained from AAI/PMC.

**Commencing Work:** Painting shall not be started until AAI/PMC has inspected the items of work to be painted, satisfied himself about their proper quality and given his approval to commence the painting work. Painting of external surface should not be done in adverse weather condition like hail storm and dust storm. Painting, except the priming coat, shall generally be taken in hand after practically finishing all other building work. The rooms should be thoroughly swept out and the entire building cleaned up, at least one day in advance of the Paint work being started.

**Preparation of Surface:** The surface shall be thoroughly cleaned and dusted off. All rust, dirt, scales, smoke splashes, mortar droppings and grease shall be thoroughly removed before painting is started. The prepared surface shall have received the approval of AAI/PMC after inspection, before painting is commenced.

**Application:** Before pouring into smaller containers for use, the Paint shall be stirred thoroughly in its containers, when applying also, the Paint shall be continuously stirred in the smaller containers so that its consistency is kept uniform.

The painting shall be laid on evenly and smoothly by means of crossing and laying off, the latter in the direction of the grains of wood. The crossing and laying off consists of covering the area over with Paint, brushing the surface hard for the first time over and then brushing alternately in opposite direction, two or three times and then finally brushing lightly in a direction at right angles to the same. In this process, no brush marks shall be left after the laying off is finished. The full process of crossing and laying off will constitute one coat.

Where so stipulated, the painting shall be done by spraying. Spray machine used may be (a) high pressure (small air aperture) type, or (b) a low pressure (large air gap) type, depending on the nature and location of work to be carried out. Skilled and experienced workmen shall be employed for this class of work. Paints used shall be brought to the requisite consistency by adding a suitable thinner.

Spraying should be done only when dry condition prevails. Each coat shall be allowed to dry out thoroughly and rubbed smooth before the next coat is applied. This should be facilitated by thorough ventilation. Each coat except the last coat, shall be lightly rubbed
down with sand paper or fine pumice stone and cleaned off dust before the next coat is laid.

No left over Paint shall be put back into the stock tins. When not in use, the containers shall be kept properly closed.

No hair marks from the brush or clogging of Paint puddles in the corners of panels, angles of mouldings etc. shall be left on the work.

In painting doors and windows, the putty round the glass panes must also be painted but care must be taken to see that no Paint stains etc. are left on the glass. Tops of shutters and surfaces in similar hidden locations shall not be left out in painting. However, bottom edge of the shutters where the painting is not practically possible, need not be done nor any deduction on this account will be done but two coats of primer of approved make shall be done on the bottom edge before fixing the shutters.

On painting steel work, special care shall be taken while painting over bolts, nuts, rivets overlaps etc.

The additional specifications for primer and other coats of Paints shall be as according to the detailed specifications under the respective headings.

**Brushes and Containers:** After work, the brushes shall be completely cleaned of Paint and linseed oil by rinsing with turpentine. A brush in which Paint has dried up is ruined and shall on no account be used for painting work. The containers when not in use, shall be kept closed and free from air so that Paint does not thicken and also shall be kept safe from dust. When the Paint has been used, the containers shall be washed with turpentine and wiped dry with soft clean cloth, so that they are clean, and can be used again.

**Measurements:** The length and breadth shall be measured correct to a cm. The area shall be calculated in sqm (correct to two places of decimal), except otherwise stated.

Small articles not exceeding 10 sq. decimeter (0.1 sqm) of painted surfaces where not in conjunction with similar painted work shall be enumerated.

Painting upto 10 cm in width or in girth and not in conjunction with similar painted work shall be given in running metres and shall include cutting to line where so required.

Components of trusses, compound girders, stanchions, lattices and similar work shall, however, be given in sq. metres irrespective of the size or girth of members. Priming coat of painting shall be included in the work of fabrication.

In measuring painting, varnishing, oiling etc. of joinery and steel work etc. The coefficients as indicated in following tables shall be used to obtain the area payable. The coefficients shall be applied to the areas measured flat and not girthed.
Width of moulded work of all other kinds, as in hand rails, cornices, architraves shall be measured by girth.

For trusses, compound girders, stanchions, lattice girders, and similar work, actual areas will be measured in sq. metre and no extra shall be paid for painting on bolt heads, nuts, washers etc. even when they are picked out in a different tint to the adjacent work.

Painting of rain water, soil, waste, vent and water pipes etc. shall be measured in running metres of the particular diameter of the pipe concerned. Painting of specials such as bends, heads, branches, junctions, shoes, etc. shall be included in the length and no separate measurements shall be taken for these or for painting brackets, clamps etc.

Measurements of wall surfaces and wood and other work not referred to already shall be recorded as per actual. Flag staffs, steel chimneys, aerial masts, spires and other such objects requiring special scaffolding shall be measured separately.

**Precautions:** All furnitures, fixtures, glazing, floors etc. shall be protected by covering and stains, smears, splashings, if any shall be removed and any damages done shall be made good by the contractor at his cost.

**Rate:** Rates shall include cost of all labour and materials involved in all the operations described above and in the particular specifications given under the several items.

### • PAINTING PRIMING COAT ON WOOD, IRON OR PLASTERED SURFACES

Primer: The primer for wood work, iron work or plastered surface shall be as specified in the description of item.

Primer for plaster/wood work/Iron & Steel/Aluminum surfaces shall be as specified below:

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<thead>
<tr>
<th>S. No.</th>
<th>Surfaces</th>
<th>Primer to be used</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Wood work (hard and soft wood)</td>
<td>Pink conforming to IS 3536</td>
</tr>
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<td>2.</td>
<td>Resinour wood and plywood</td>
<td>Aluminum primer conforming to IS 3585</td>
</tr>
<tr>
<td>3.</td>
<td>(A) Aluminum and light alloys</td>
<td>Zinc chromate primer conforming to IS 104</td>
</tr>
<tr>
<td></td>
<td>(B) Iron, Steel and Galvanized steel</td>
<td>Red Oxide Zinc chromate Primer conforming IS 2074</td>
</tr>
<tr>
<td>4.</td>
<td>Cement/Conc/RCC/brick work, Plastered surfaces, non-asbestos surfaces to receive Oil bound distemper or Paint finish.</td>
<td>Cement primer conforming to IS 109</td>
</tr>
</tbody>
</table>
The primer shall be ready mixed primer of approved brand and manufacture.

Where primer for wood work is specified to be mixed at site, it shall be prepared from a mixture of red lead, white lead and double boiled linseed oil in the ratio of 0.7 kg: 0.7 kg: 1 litre.

Where primer for steel work is specified to be mixed at site, it shall be prepared from a mixture of red lead, raw linseed oil and turpentine in the ratio of 2.8 kg : 1 litre : 1 litre.

The specifications for the base vehicle and thinner for mixed on site primer shall be as follows:

White Lead: The White lead shall be pure and free from adulterants like barium sulphate and whiting. It shall conform to IS 103.

Red Lead: This shall be in powder form and shall be pure and free from adulterants like brick dust etc. It shall conform to IS 102.

Raw Linseed Oil: Raw linseed oil shall be lightly viscous but clear and of yellowish colour with light brown tinge. Its specific gravity at a temperature of 30 degree C shall be between 0.923 and 0.928.

The oil shall be mellow and sweet to the taste with very little smell. The oil shall be of sufficiently matured quality. Oil turbid or thick, with acid and bitter taste and rancid odour and which remains sticky for a considerable time shall be rejected. The oil shall conform in all respects to IS 75. The oil shall be of approved brand and manufacture.

Double Boiled Linseed Oil: This shall be more viscous than the raw oil, have a deeper colour and specific gravity between 0.931 and 0.945 at a temperature of 30 degree C. It shall dry with a glossy surface. It shall conform in all respects to IS 77. The oil shall be of approved brand and manufacture.

Turpentine: Mineral turpentine i.e. petroleum distillate which has the same rate of evaporation as vegetable turpentine (distillate product of oleoresin of conifers) shall be used. It shall have no grease or other residue when allowed to evaporate. It shall conform to IS 533.

All the above materials shall be of approved manufacture and brought to site in their original packing in sealed condition.

**Preparation of Surface:**
Wooden Surface: The wood work to be painted shall be dry and free from moisture.

The surface shall be thoroughly cleaned. All unevenness shall be rubbed down smooth with sand paper and shall be well dusted. Knots, if any shall be covered with preparation
of red lead made by grinding red lead in water and mixing with strong glue sized and used hot. Appropriate filler material conforming to IS 345 with same shade as Paint shall be used where specified. The surface treated for knotting shall be dry before Paint is applied. After obtaining approval of AAI/PMC for wood work, the priming coat shall be applied before the wood work is fixed in position. After the priming coat is applied, the holes and indentation on the surface shall be stopped with glazier’s putty or wood putty. Stopping shall not be done before the priming coat is applied as the wood will absorb the oil in stopping and the latter is therefore liable to crack.

Iron & Steel Surface: All rust and scales shall be removed by scrapping or by brushing with steel wire brushes. Hard skin of oxide formed on the surface of wrought iron during rolling which becomes loose by rusting, shall be removed.

All dust and dirt shall be thoroughly wiped away from the surface.

If the surface is wet, it shall be dried before priming coat is undertaken.

Plastered Surface: The surface shall ordinarily not be painted until it has dried completely. Trial patches of primer shall be laid at intervals and where drying is satisfactory, painting shall then be taken in hand. Before primer is applied, holes and undulations shall be filled up with plaster of paris and rubbed smooth.

Application: The primer shall be applied with brushes, worked well into the surface and spread even and smooth. The painting shall be done by crossing and laying off as described in CPWD specifications.

Treatment on Steel for Aggressive Environment: A second coat of ready mixed red oxide zinc chromate primer may be applied where considered necessary in aggressive environment such as near Industrial Establishment and Coastal regions where the steel members are prone to corrosion. The second coat (which shall be paid for separately) is to be applied after placing the member in position and just before applying Paint. The second coat of primer is not necessary in case of painting with synthetic enamel Paint as it is applied over an under coat of ordinary Paint.

The specifications described under CPWD specifications shall hold good so far as they are applicable.

PAINTING SYNTHETIC ENAMEL PAINT OVER G.S. SHEETS
Synthetic enamel: Paint, suitable for painting over G.S. sheets, of approved brand and manufacture and of the required shade shall be used. New or weathered G.S. sheets shall be painted with a priming coat of one coat of redoxide zinc chromate Paint. Primer shall be applied before fixing sheets in place.

Preparation of Surface:
Painting New Surface: The painting of new G.S. sheets shall not usually be done till the
sheets have weathered for about a year. When new sheets are to be painted before they
have weathered they shall be treated with a mordant solution prepared by mixing 38 gm
of copper acetate in a litre of soft water or 13 gm hydrochloric acid in a solution of 13 gm
each of copper chloride, copper nitrate and ammonium chloride dissolved in a litre of soft
water. This quantity of solution is sufficient for about 235 sqm. to 280 sqm of area and is
applied for ensuring proper adhesion of Paint. The painting with the mordant solution
will be paid for separately.

Before painting on new or weathered G.S. sheets, rust patches shall be completely
cleaned with coarse emery paper and brush. All grease marks shall also be removed and
the surface washed and dried and rusted surface shall be touched with synthetic enamel
paint of approved brand, manufacturer and shade.

Painting Old Surface: If the old Paint is firm and sound, it shall be cleaned of grease, smoke
etc. The surface shall then be rubbed down with sand paper and dusted. Rusty patches
shall be cleaned up and touched with synthetic enamel paint.

If the old Paint is blistered and flaked, it shall be completely removed as described in
CPWD specifications. Such removal shall be paid for separately and painting shall be
treated as on new work.

**Application:** The number of coats to be applied shall be as in the description of item. In
the case of C.G.S. sheets, the crowns of the corrugations shall be painted first and when
these get dried the general coat shall be given to ensure uniform finish over the entire
surface without the crowns showing signs of thinning.

The second or additional coats shall be applied when the previous coat has dried.

The specifications described in CPWD specifications shall hold well so far as they are
applicable.

**PAINTING WITH SYNTHETIC ENAMEL PAINT**

Synthetic Enamel Paint (conforming to IS 2933) of approved brand and manufacture and
of the required colour shall be used for the top coat and an undercoat of ordinary Paint
of shade to match the top coat as recommended by the same manufacturer as far the top
color shall be used.

**Painting on New Surface:** Preparation of surface shall be as specified in CPWD
specifications as the case may be.
Application: The number of coats including the undercoat shall be as stipulated in the
item.

Under Coat: One coat of the specified ordinary Paint of shade suited to the shade of the
top coat, shall be applied and allowed to dry overnight. It shall be rubbed next day with
the finest grade of wet abrasive paper to ensure a smooth and even surface, free from
brush marks and all loose particles dusted off.

Top Coat: Top coats of synthetic enamel Paint of desired shade shall be applied after the
undercoat is thoroughly dry. Additional finishing coats shall be applied if found necessary
to ensure properly uniform glossy surface.

Other details shall be as specified in CPWD specifications as far as they are applicable.

Painting on Old Surface:
Preparation of Surface: Where the existing Paint is firm and sound it shall be cleaned of
grease, smoke etc. and rubbed with sand paper to remove all loose particles dusted off.
All patches and cracks shall then be treated with stopping and filler prepared with the
specified Paint. The surface shall again be rubbed and made smooth and uniform.

If the old paint is blistered and flaked it will be necessary to completely remove the same
as described in CPWD specifications. Such removal shall be paid for separately and the
painting shall be treated as on new surface.

Painting: The number of coats as stipulated in the item shall be applied with synthetic
enamel Paint. Each coat shall be allowed to dry and rubbed down smooth with very fine
wet abrasive paper, to get an even glossy surface. If however, the surface is not
satisfactory additional coats as required shall be applied to get correct finish.

Other details shall be specified in CPWD specifications as far as they are applicable.

• VARNISHING

Ordinary copal varnish or superior quality spray varnish shall be used. The work includes
sizing of transparent wood filler.

Varnish (conforming to IS 347 for the finishing and undercoats shall be of the approved
manufacturer.

Varnishing on New Surfaces:
Preparation of Surface: New wood work to be varnished shall have been finished smooth
with a carpenter’s plane. Knots shall be cut to a slight depth. Cracks and holes shall be
cleaned of dust. The knots, cracks etc. shall then be filled in with wood putty made as
follows:

On a piece of wood say 20 x 15 cm face and on the side where cross grains appear, a small
quantity of glue size shall be poured and the surface scraped with the edge of a fine
carpenter’s chisel. Very fine wood powder shall be mixed with the glue and the stiff paste
thus formed shall be used for the filling.

The fillings when dry shall be rubbed down with a carpenter’s file and then the entire surface shall be rubbed down perfectly smooth with medium grained and fine sand papers and wiped with dry clean cloth so that it presents uniform appearance. In no case shall sand papers be rubbed across the grains, as in this case even the finest marks will be visible when the varnishing is applied.

Sizing or Transparent Wood Filler Coat: The surface shall then be treated with either glue sizing or with transparent wood filler coat as stipulated in the description of item.

Sizing: When sizing is stipulated, an application of thin clean size shall be applied hot on the surface. When dry, the surface shall be rubbed down smooth with sand paper and cleaned. It shall then be given another application of glue size nearly cold. The sized wood work shall again be rubbed down smoothly with fine sand paper and cleaned. The surface shall be perfectly dry and all dust shall be removed not only from the surface but also from the edges and joints before varnishing is commenced. If the wood work is to be stained, the staining colour shall be mixed with the second coat of the size which must be applied evenly and quickly keeping the colour on the flow.

Any joining up with work already dry will show badly. The object of application of the glue size is to seal the pores in wood to prevent absorption of the oil in the varnish.

Glue sizing is inadvisable on floors, table tops and other horizontal surfaces likely to carry wet household utensils which are likely to disturb the size coatings and thus expose bare wood.

Where glue sizing is omitted to be done the rate for the work shall be suitably reduced.

Transparent Wood Filler Coat: Where instead of glue sizing, transparent wood filler application is stipulated in the item, then the surface prepared as described in CPWD specifications shall be given as application of the filler with brush or rag in such a way that the filler fills up all the pores and indentations and levels up the surface. It shall be allowed to dry for 24 hours. Then it shall be cut and rubbed with emery paper so that the surface of the wood is laid bare, with the filler only in the pores and crevices of the wood.

Application of Varnish: The number of coats to be applied shall be as stipulated in the description of the item.

The undercoat shall be with a flating varnish. This dries hard and brittle and when cut and rubbed down to produce a smooth surface enhances the gloss of the finishing varnish. The top coat shall be given with stipulated brand of finishing varnish.

The varnish shall be applied liberally with a full brush and spread evenly with short light strokes to avoid frothing. If the work is vertical the varnish shall be crossed and recrossed.
and then laid off, latter being finished on the upstrokes so that varnish, as it sets, flows down and eliminates brush marks, the above process will constitute one coat. If the surface is horizontal, varnish shall be worked in every direction, with light quick strokes and finish in one definite direction so that it will set without showing brush marks, in handling and applying varnish care should be taken to avoid forming froth or air bubbles. Brushes and containers shall be kept scrupulously clean.

Rubbing down and flating the surface shall be done after each coat except the final coat with fine sand paper.

The work shall be allowed to dry away from droughts and damp air. The finished surface shall then present a uniform appearance and fine glossy surface free from streaks, blister etc.

Any varnish left over in the small container shall not be poured back into the stock tin, as it will render the latter unfit for use.

Special fine haired varnishing brushes shall be used and not ordinary Paint brushes. Brushes shall be well worn and perfectly clean.

Other details shall be as specified in CPWD specifications as far as they are applicable.

**Varnishing on Old Surface**:
Preparation of Surface : If the old varnished surface is firm and sound it shall be cleaned of grease and dirt with turpentine and then rubbed with wet sand paper until the surface is clean and smooth. It shall be dried and wiped clean with a soft cloth. Knots, holes and cracks shall be stopped as specified in CPWD specifications. The entire surface shall then be rubbed down smooth with sand paper and wiped clean.

If the old varnished surface is peeled or cracked then it will be necessary to remove the entire varnish as described in para 13.41 and such removal shall be paid for separately outside the rate for varnishing. Further the varnishing itself will have to be done like new work and will be paid for as such.

Application : The specification shall be same as described in CPWD specifications as far as applicable except that the coats to be applied will be with the stipulated quality of varnish for finishing coat.

Other details shall be as specified in CPWD specifications as far as they are applicable.

**FRENCH SPIRIT POLISHING**

Pure shellac conforming to IS 16 varying from pale orange to lemon yellow colour, free from resin or dirt shall be dissolved in methylated spirit at the rate of 140 gm of shellac to 1 litre of spirit. Suitable pigment shall be added to get the required shade. Readymade
polish conforming to IS 348 can also be used.

**Polishing New Surface:**
Preparation of Surface: The surface shall be cleaned. All unevenness shall be rubbed down smooth with sand paper and well dusted. Knots if visible shall be covered with a preparation of red lead and glue size laid on while hot. Holes and indentations on the surface shall be stopped with glazier's putty. The surface shall then be given a coat of wood filler made by mixing whiting (ground chalk) in methylated spirit at the rate of 1.5 Kg of whiting per litre of spirit. The surface shall again be rubbed down perfectly smooth with glass paper and wiped clean.

Application: The number of coats of polish to be applied shall be as described in the item.

A pad of woolen cloth covered by a fine cloth shall be used to apply the polish. The pad shall be moistened with the polish and rubbed hard on the wood, in a series of overlapping circles applying the mixture sparingly but uniformly over the entire area to give an even level surface. A trace of linseed oil on the face of the pad facilitates this operation. The surface shall be allowed to dry and the remaining coats applied in the same way. To finish off, the pad shall be covered with a fresh piece of clean fine cotton cloth slightly damped with methylated spirit and rubbed lightly and quickly with circular motions. The finished surface shall have a uniform texture and high gloss.

Measurements, Rate and other details shall be as specified in CPWD specifications as far as they are applicable.

**Polishing Old Surface:**
Preparation of Surface: If the old polished surface is not much soiled it shall be cleaned of grease and dirt by rubbing with turpentine and then rubbed with fine sand paper.

If the old polished surface is much soiled then it will be necessary to remove the entire polish as described in CPWD specifications and such removal shall be paid for separately outside the rate of polishing. Further the polishing itself will have to do done like new work and will be paid for as such.

Application: The specifications shall be same as described in CPWD specifications as far as applicable.

Measurements, Rate and other details shall be as specified in CPWD specifications as far as they are applicable.

3. **BAMBOO WOOD PRODUCTS**

Following tests are to be performed to find out the characteristics of Bamboo wood:
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<th>Test Method</th>
<th>Criteria</th>
<th>Specification</th>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Density</td>
<td>IS: 1708 (Part 2) 1986</td>
<td>$\geq 1100$ Kg/m$^3$</td>
<td>1156.9 Kg/m$^3$</td>
</tr>
<tr>
<td>Modulus of Rupture (MOR)</td>
<td>IS: 1708 (Part 5) 1986</td>
<td>$\geq 150$ N/mm$^2$</td>
<td>215.2 N/mm$^2$</td>
</tr>
<tr>
<td>Modulus of Elasticity (MOE)</td>
<td>IS: 1708 (Part 5) 1986</td>
<td>$\geq 17500$ N/mm$^2$</td>
<td>23216 N/mm$^2$</td>
</tr>
<tr>
<td>Hardness Test</td>
<td>IS 1708 (Part 10), ASTM D 1037</td>
<td>$\geq 800$ Kg</td>
<td>1287Kgf</td>
</tr>
<tr>
<td>Moisture Content</td>
<td>IS: 1708 (Part 1) 1986, ASTM D 4442</td>
<td>$\leq 12%$ (oven dry method)</td>
<td>7.08%</td>
</tr>
<tr>
<td>Specialized Test</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Thermal Conductivity</td>
<td>IS: 3346Y1980</td>
<td>$\leq 0.50$ W/ mYK</td>
<td>0.354 W/ mYK</td>
</tr>
<tr>
<td>Volatile organic compound</td>
<td>IS: 13745–1993</td>
<td>$\leq 6.00$ mg/ 100gm (oven dry method)</td>
<td>0.4309 mg/ 100gm</td>
</tr>
<tr>
<td>Termite Test</td>
<td>Laboratory Test</td>
<td>6month in Termite Mound</td>
<td>No Termite Attack</td>
</tr>
<tr>
<td>Borer Test</td>
<td>Laboratory Test</td>
<td>6month in Borer Box</td>
<td>No Borer Attack</td>
</tr>
<tr>
<td>Flame penetration</td>
<td>IS:1734(ParY3)1 983</td>
<td>$\geq 30$min</td>
<td>38min</td>
</tr>
<tr>
<td>Water Absorption</td>
<td>IS 2380Y 1981</td>
<td>$\leq 4%$ (2hrs), $\leq 8%$ (24hrs)</td>
<td>1.17% (2hrs), 3.42% (24hrs)</td>
</tr>
<tr>
<td>Swelling due to general absorption</td>
<td>IS 2380Y 1981</td>
<td>$\leq 8%$</td>
<td>3.22%</td>
</tr>
<tr>
<td>Swelling due surface absorption</td>
<td>IS 2380Y 1981</td>
<td>$\leq 4%$ (2hrs), $\leq 8%$ (24hrs)</td>
<td>1.2% (2hrs), 3.2% (24hrs)</td>
</tr>
<tr>
<td>Test Type</td>
<td>Standard/Code</td>
<td>Requirement</td>
<td>Result</td>
</tr>
<tr>
<td>---------------------------------</td>
<td>------------------------------------</td>
<td>------------------------------------------------------------------------------</td>
<td>---------</td>
</tr>
<tr>
<td>Flammability</td>
<td>IS: 1734 (PartY3) 1983</td>
<td>≥ 5min (time taken for second ignition)</td>
<td>5min</td>
</tr>
<tr>
<td>Rate of burning</td>
<td>IS: 1734 (PartY3) 1983</td>
<td>≥ 10min (time taken to lose weight from 70% to 30%)</td>
<td>11min</td>
</tr>
<tr>
<td>Screw Withdrawal Resistance</td>
<td>IS:2380Y 1981</td>
<td>≥ 250 Kg (Flat Face)</td>
<td>439Kg</td>
</tr>
<tr>
<td>Screw Withdrawal Resistance</td>
<td>IS:2380Y 1981</td>
<td>≥ 200 Kg (Edge)</td>
<td>349Kg</td>
</tr>
<tr>
<td>Sound Absorption Coefficient</td>
<td>IS:10420Y 1982</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Bamboo Wood Wall Cladding</td>
<td></td>
</tr>
<tr>
<td>FLOORING/ WALL CLADDING FINISH (Specialized Test)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cross Cut Test</td>
<td>DIN EN ISO 2409</td>
<td>≤ GT 2</td>
<td>GT 0</td>
</tr>
<tr>
<td>Scratch Resistance Coin Test</td>
<td>Hamburger planner</td>
<td>≥ 20 Newton</td>
<td>39 Newton</td>
</tr>
<tr>
<td>Abrasion Resistance</td>
<td>DIN EN 438Y2 (500g load per wheel S 33)</td>
<td>Initial Point &gt;100 cycle</td>
<td>Initial Point – 260 cycle</td>
</tr>
</tbody>
</table>

<p>| Freq uency Hz                  | Bamboo Wood Wall Cladding          | Abs orption Coefficient                                                     |         |
| 250                             | 0.0                                |                                                                              |         |
| 500                             | 1                                  |                                                                              |         |
| 1000                            | 0.01                               |                                                                              |         |
| 2000                            | 0.02                               |                                                                              |         |
| 3000                            | 0.07                               |                                                                              |         |
| 4000                            | 0.12                               |                                                                              |         |
| NA                              |                                    |                                                                              |         |</p>
<table>
<thead>
<tr>
<th>Test</th>
<th>Method</th>
<th>Initial Point &gt;6000 cycle</th>
<th>Initial Point &gt;15000 cycle</th>
<th>Initial Point &gt;15000 cycle</th>
<th>Initial Point &gt;15000 cycle</th>
<th>NA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abrasion Resistance</td>
<td>ASTM D 4060 (500 g load per wheel CS 17)</td>
<td>≥ 1 H</td>
<td>7 H</td>
<td>7 H</td>
<td>7 H</td>
<td>NA</td>
</tr>
<tr>
<td>Scratch Resistance Pencil Hardness</td>
<td>ISO 15184</td>
<td></td>
<td>7 H</td>
<td>7 H</td>
<td>7 H</td>
<td></td>
</tr>
<tr>
<td>Scratch Resistance Surface</td>
<td>Steel wool test, Type 2</td>
<td>No Scratch</td>
<td>No Scratch</td>
<td>No Scratch</td>
<td>No Scratch</td>
<td></td>
</tr>
<tr>
<td>Impact Resistance</td>
<td>DIN EN 438 Part 2 – 12</td>
<td>≥ 2 Newton</td>
<td>3 Newton</td>
<td>3 Newton</td>
<td>3 Newton</td>
<td>3 Newton</td>
</tr>
<tr>
<td>Chemical Resistance</td>
<td>DIN 68861 Part 1</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>Inflammability</td>
<td>DIN 4102 Part 14</td>
<td>B1</td>
<td>B1</td>
<td>B1</td>
<td>B1</td>
<td>B1</td>
</tr>
</tbody>
</table>

Following is the procedure followed in performing above mentioned test:

1. **Moisture content of the board:**

   Procedure: Each specimen was weighed to accuracy not less than ±0.2%. The specimens were dried in an oven at a temperature 103 ±20°C, until the mass is constant to ±0.2% between two successive weightings made at an interval of not less than one hour.

   Calculation: The moisture content expressed as percentage of the oven dry mass is given by the formula:

   \[
   \text{Moisture content} \% = \frac{M_1 - M_0}{M_0} \times 100
   \]

   Where, \( M_1 \) = initial mass \( M_0 \) = oven dry mass

2. **Density of the board:**
Procedure: The dimensions of each test specimen were measured to an accuracy of not less than ±0.3 % & each specimen was weighed to an accuracy of ±0.2 %.

Calculation:
Mass of the test specimen in gm
Density (gm/cm³) = \frac{\text{Length (cm) x Width (cm) x Thickness (cm)}}{\text{Mass of the test specimen in gm}}

3. Water Absorption:
Procedure: Each test specimen must be edge insulated and weighed to an accuracy of not less than ±0.2% & the width, thickness & length were measured to accuracy not less than ±0.3%. Then the specimens were submerged under 25 mm fresh clean water maintained at a temperature of 27±20°C. The test specimens were separated by at least 15 mm from each other & from the bottom & the sides of the container. After a 2 hours submersion, the specimens were suspended to drain for 10 minutes, at the end of which time the excess surface water was removed & then specimens were immediately weighed. The specimens were then submerged for an additional period of 22 hours & the above weighing procedure was repeated.

Calculation: The amount of water absorbed by each test specimen after 2 hours & 24 hours was calculated from the increase in of the specimen during the submersion. It is expressed as follows:

\[
\text{Water absorption %} = \frac{M_2 - M_1}{M_1} \times 100
\]

Where, \( M_1 \) = Mass of the test specimen before experiment \( M_2 \) = Mass of the test specimen after the experiment

4. Swelling due to General Absorption:
Procedure: The thickness at the edge of each test specimen must be insulated and measured to an accuracy of 0.01mm at three places along one long edge. The points at which the thickness was measured were clearly marked. Each test specimen was immersed in fresh clean water having a temperature of 27 ±20°C. The short edge of the lower most, & the test specimen was separated by at least 15mm from each other & from bottom & sides of the container. They were covered by 25mm of water. At the end of 2 hours each test specimen was withdrawn from the water, wiped with a damp cloth & was allowed to stand under normal room conditions for 1 hour with its bottom edge on a non-absorbent surface. The
thickness of each test specimen was measured at the same points as before and to the same degree of accuracy. The increase in thickness was measured.

Calculation: The average of three values obtained for the changes in thickness expressed as a percentage of the original average thickness was reported as the swelling value.

\[
\text{Swelling in thickness \%} = \frac{T2 - T1}{X} \times 100
\]

Where, \( T1 \) = Average thickness before experiment \( T2 \) = Average thickness after the experiment

5. **Swelling due to Surface Absorption:**

Procedure: The thickness of each test specimen was measured to an accuracy of ±0.03mm at four places. The average of four readings was recorded. The edges of each test specimen was then sealed by quickly dipping them in turn to a depth of 5mm into a shallow bath of molten paraffin wax having a melting point about 550°C, the temperature of both bath was being about 900°C. The procedure was repeated until the pickup of wax for each specimen was of the order of 5gm for each 10mm thickness of the board. Each test specimen was then immersed in fresh clean water having a temperature of 21 ±2°C, the water being renewed for each test. The face being tested was immersed to a depth of approximately 3mm. Care was taken not to wet the top surface of the test specimen. At the end of the 2 hrs each test specimen was withdrawn from water & the wet surface was wiped with a damp cloth, the test specimen was then laid, wet surface down, for one hour on a glass sheet. The thickness of each test specimen was re measured at the same points as before & to the same degree of accuracy & the increase in thickness was recorded.

6. **Janka Hardness Test:**

The Janka hardness test measures force requires to embedded in Bamboo wood measured in the Kilogram required to embed a 0.444-inch (11.28mm) steel ball to half its diameter in Bamboo wood. It is one of the best measures of the ability of a Bamboo wood to withstand denting and wear. It is also a good indicator of how hard or easy a species is to saw or nail.

Sample size: The specimen for Janka hardness test shall be 13cm in length and 13cm in width and for either 1.4cm thickness or 2cm thickness.

Test procedure: Loading attachment, attached to the heads of the testing machine, shall engage the blocks attached to the specimen. The specimen shall be fixing to the testing attachment and start loading 1mm/ minute until half ball penetration
Calculation: Load required to penetrate half ball = in Kgf or Newton

7. **Static Bending Test (Modulus of Rupture and Modulus of Elasticity)**

Sample size: The specimen for static bending test shall be 5 X 5 cm in cross-section and 75 cm in length or 2 X 2 cm in cross-section and 30 cm in length.

Test procedure: Loading fixtures, attached to the heads of the testing machine, shall engage the blocks attached to the specimen. The specimen shall be stressed by separation of the heads of the testing machine until failure occurs. The direction of loading shall be as nearly.

Rate of loading: The load shall be applied continuously throughout the test at a uniform rate of motion of the movable crosshead of the testing machine as calculated by the following formula:

\[
Z \frac{L^2}{N} = \frac{6 t}{L}
\]

Where, \( N \) = Rate of loading in cm / min.
\( Z \) = Unit rate of fiber strain of outer fiber length/minute = 0.005 \( L \) = Span in cm.
\( t \) = Thickness of the specimen in cm.

Calculation:
\[
3P'L
MOR = \frac{L}{2 bd^2} \times 9.8
\]

\[
PL3
MOE = \frac{L}{4 Dbd^3} \times 9.8
\]

Where, \( MOR \) = Modulus of Rupture N/mm² \( MOE \) = Modulus of elasticity
\( P' \) = Maximum load in kg
\( P \) = load in kg at the limit of proportionality which shall be taken as the point in load – deflection curve above which the graph deviate from straight line.
\( L \) = Span length mm
\( b \) = Width of the specimen in mm
\( d \) = Thickness of the specimen in mm \( D \) = deflection

a. **Test For Screw Withdrawal Resistance:**
Sample size: The length & width of the test specimen shall be 150mm & 75mm respectively. The thickness shall not be less than 30 mm. if the thickness of the board is less than 30mm, two or more specimen may be bonded with suitable adhesives.

Two wood screws no. 8 & 50 mm in length shall be threaded into the specimen at right angle to the face up to half of their length in a pre-bore of 2.5 mm. the hole should be preferably at mid width about 5 cm from the ends of the specimen.

Test procedure: The specimen holding fixture shall be attached to the lower platen of the testing machine. The specimen shall be inserted in the fixture, which is equipped with a slot to easy engagement of the head of the screw of nail, shall be attached to the upper platen of the testing machine.

Rate of loading: Load shall be applied to the specimen throughout the test by a uniform motion of the movable head of the testing machine at a rate of 1.5mm per minute.

8. **Accelerated Water Resistance Test:**

The exterior grade sample is put in boiling water for 2 hours. After that dry it in open atmosphere for 24 hours and then check the internal bonding strength of the sample by similar method as describe above. For passing the IS standard the IB should not be less than 0.15 N.

9. **Termite Resistance Test:**

The sample was kept in termite mound for six months. Result – sample checked thereafter for termite attack. There was no attack seen.

10. **Borer Resistance test:**

The sample was kept in borer box for six months. Result – sample checked thereafter for borer attack. There was no attack seen.

**FINISH TESTS**

Following is the procedure followed in performing above mentioned Finish Test: -

1. **Gloss Value:**

According to ISO 2813, 60° geometry Radiation from a light source is reflected off the surface of the floor at a defined angle (normally 60° for coated parquet surfaces) and measured by a sensor. The more glossy the surface, the less light gets reflected from its surface, and the lower the specular gloss. The specular gloss readings are too imprecise for very matt surfaces meaning that surfaces with identical gloss value may look considerably different. In the gloss
value test it is therefore necessary to carry out a visual inspection of the test surfaces against a master sample.

2. **Cross cut Test:**

Purpose: To test the adhesive properties of the coating to the substrate using a multiple blade cutter and tape.

Standard: DIN EN ISO 2409

<table>
<thead>
<tr>
<th>Grid Cut Classification</th>
<th>Description</th>
<th>Appearance of surface in area of grid-cut where flaking has occurred (Example for six parallel cut)</th>
</tr>
</thead>
<tbody>
<tr>
<td>GT 0</td>
<td>The edges of the cuts are completely smooth, none of the lattice squares is detached.</td>
<td></td>
</tr>
<tr>
<td>GT 1</td>
<td>Small flakes of coating have detached at the intersections of the cuts. The area affected is not significantly greater than 9% of the cross cut area.</td>
<td><img src="example1.png" alt="Image" /></td>
</tr>
<tr>
<td>GT 2</td>
<td>The coating has flaked along the edges and/or the intersections of the cuts. Area of the cross-cut considerably greater than 9% but not significantly greater than 15% of the total cross-cut area.</td>
<td><img src="example2.png" alt="Image" /></td>
</tr>
<tr>
<td>GT 3</td>
<td>The coating has flaked along the edges of the cuts in wide strips partly/completely and/or partial complete flaking on some of the squares. A cross-cut area considerably greater than 15% but not significantly greater than 35% is affected.</td>
<td><img src="example3.png" alt="Image" /></td>
</tr>
<tr>
<td>GT 4</td>
<td>The coating has flaked along the edges of the cuts in wide strips and/or partial/complete flaking on some of the squares. A cross-cut area considerably greater than 35% but not significantly greater than 65% is affected.</td>
<td><img src="example4.png" alt="Image" /></td>
</tr>
<tr>
<td>GT 5</td>
<td>Any flaking that cannot be classified under Category 4.</td>
<td></td>
</tr>
</tbody>
</table>

The surface is rated according to the table, as follows:
Abrasive Resistance:

Purpose: The Taber abraser is commonly used to provide comparative data regarding the abrasive resistance of a coating.

Standard:
S33 sandpaper (EN 438-2): Test according to EN 438-2, S 33 strips of sandpaper are attached to the abrading wheels.

CS17 (ASTM D4060): Test according to ASTM D 4060, CS 17 wheels. Specially defined abrading wheels are used for this test.

Expression of Results: Evaluate visual Initial Point, at the first sign that the wheels have worn through the coating from the substrate. (S 33 sand paper is more rough compare to CS 17 wheels. So the result of S 33 is less compare with CS 17)

3. Pencil Hardness:

Purpose: To determine the surface hardness of coating with regard to stresses inflicted by scratching with sharp edges, or other rough surfaces.

Standard: ISO 15184

Expression of Results: The number of the first pencil that you use after you have made a scratch in the coating that doesn’t leave a mark is considered the "pencil hardness" of the coating.

4. Scratch Resistance Coin Test- Hamburger Planer:

Purpose: To check the adhesion between lacquer film and substrate on one hand and to check the adhesion between different lacquer layers on the other hand.

Expression of Results: The test result is the applied force in Newton just before damage becomes visible on the test surface (white mark). It is essential that you move towards this point incrementally. Use the above method to test each specimen in at least three separate areas in order to relativise the vibrations from the base. We recommend you calculate an average from the test results. 20N and above is considered as a passed result.

5. Scratch Resistance Coin Test- Coin Test:

Purpose: To check on spot the adhesion between lacquer film and substrate on one hand and to check the adhesion between different lacquer layers on the other hand.
Expression of Results: Resistance to scratch by manual force on finished surface. It is recommend to use standard coin for this test. Apply standard uniform force for scratch resistance.

6. **Scratch Resistance Surface:**

Purpose: Resistance to fine scratches is tested by rubbing on the surface with steel wool, applying normal pressure.

7. **Impact test:**

Standard: DIN EN 438 Part 2 – 12

Purpose: To determine the minimum spring force to cause damage on the coating film and its substrate. In the impact test a metal ball applies a force to a varnished surface at a pre-defined spring tension/weight. The ball leaves behind a dent which is largely dependent on the hardness of wooden substrate. The test measures the weight at which the first continuous cracks appear in the varnish in the form of concentric rings along the edge of the dent. These cracks are marked with a felt-tip pen before being wiped off with solvent. The cracks in the varnish are made visible by the residue from the pen at the point of impact. The drop-weight test is thus a method of measuring the elasticity of a varnish film. Due to the qualities of different woods, it only makes sense to compare measurements for one and the same wooden substrate.

Expression of Results: The test result is the value in Newton at which no residue of pen colour remains after having it wiped off with solvent.

8. **Resistance to Indentation:**

Purpose: To determine the minimum load by applying successively decreasing loads to the diamond point and examine the indentation or cut on the surface.

Standard: DIN EN 438 Part 2 – 25

The test specimen is tested during one revolution of a defined diamond point at a pre-defined load (Newton). Several scratch tests are carried out side by side at different levels of pressure during which the pressure on the surface is changed on a scale from high to low. With each revolution, the pressure on the specimen is adjusted to a different part of the surface.

Expression of Result: The test result is the value in Newton at which an indentation on the surface is no longer visible.

9. **Heat resistance (Cigarette test):**
Purpose: To determine the surfaces behavior on exposure to glowing cigarette.

Standard: DIN 68861 Part 6
3 cigarettes from different brands are used for this test. The first 10mm of each cigarette is smoked before being placed on the coated surface. The cigarette is removed from the test surface once the cigarette has burned down a further 40mm.
If any changes to the surface arise, either in its colour or other visible changes, the surface will need to be cleaned as thoroughly as possible with a defined cleaning agent.

Rating of the test results from the cigarette test:
6A No change
6B Change in gloss visible to naked eye
6C Gloss and/or colour change
6D Colour change
6E Destroyed

10. In flammability Test:

Purpose: Determination of the burning behavior of floor covering systems using a radiant heat source.

Standard: DIN 4102 Part 14
This standard is for measuring the critical radiant flux of horizontally mounted floor-covering systems exposed to a graded radiant heat energy environment in a test enclosure, when ignited with a pilot flame.

Building Material Classes:
B1. Not easily flammable
B2. Flammable
B3. Easily flammable

11. Chemical resistance:

Standard DIN 68861:
In the following table you can find a list of the chemicals used to measure chemical resistance in accordance with DIN 68861:
### Chemicals/substances

<table>
<thead>
<tr>
<th>Chemicals/substances</th>
<th>Beginning temperature of substances (± 5) °C</th>
<th>Duration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Distilled water</td>
<td>20</td>
<td>(24 ± 1) h</td>
</tr>
<tr>
<td>Cleaning agent (def. mixture)</td>
<td>20</td>
<td>(24 ± 1) h</td>
</tr>
<tr>
<td>Acetone, min. 95 %</td>
<td>20</td>
<td>(120 ± 10) s</td>
</tr>
<tr>
<td>Ethanol, clean, not denaturated, 50 % in distilled water</td>
<td>20</td>
<td>(24 ± 1) h</td>
</tr>
<tr>
<td>Red wine, alcohol content 10 % to 12 % vol.</td>
<td>20</td>
<td>(24 ± 1) h</td>
</tr>
<tr>
<td>Red wine vinegar, acetic acid solution 3 % to 5 % vol.</td>
<td>20</td>
<td>(24 ± 1) h</td>
</tr>
<tr>
<td>Olive oil</td>
<td>20</td>
<td>(24 ± 1) h</td>
</tr>
<tr>
<td>Milk, 3 % to 5 % fat</td>
<td>80</td>
<td>(24 ± 1) h</td>
</tr>
<tr>
<td>Coffee, 40 g dehydrofrozen instant coffee per l cooking water</td>
<td>80</td>
<td>(24 ± 1) h</td>
</tr>
<tr>
<td>Black tea, 10 g tea leafs brewed with 1 l cooking water.</td>
<td>80</td>
<td>(24 ± 1) h</td>
</tr>
<tr>
<td>Brewing time 5 min</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10%, ammonia solution</td>
<td>20</td>
<td>(8 ± 1) h</td>
</tr>
<tr>
<td>Blue/black ink</td>
<td>20</td>
<td>(24 ± 1) h</td>
</tr>
</tbody>
</table>

### CLASSIFICATION:

5: No visible changes (no damages).

4: Slight changes in gloss and colour, only visible when light sources are reflecting on or next to the marks to the eyes of the observer, or single just visible marks.

3: Light marks, visible from different directions, for example the visibility of nearly complete form of filter paper.

2: Strong marks, but the structure of the surface is broadly unchanged.

1: Strong marks, the structure of surface has changed or the sealer is completely or partially worn off, or the filter paper inheres to the surface.

**Baffle Paneling:** Phenol bonded customize bamboo wood baffle tile of length 1900 mm, width 100 mm and having thickness of 30 mm in AAI/PMC approved colour/texture/finish. Bamboo
wood (Made in India) baffle tile to be made from Bamboo wood having Performance Appraisal Certificate (PAC) from Building Material Technology Promotion Council (BMTPC). The bamboo wood shall have minimum density of 1000 Kg/Cum and minimum hardness of 1000 kgf. Bamboo wood baffle tile shall be installed as per attached drawings along with all engineering material and accessories specified in the drawings as per direction of engineer in charge.

**Column Cladding:** Phenol bonded customized bamboo wood hollow pole having outer dia of 80 mm in AAI/PMC approved colour/texture/finish. Bamboo wood (Made in India) hollow pole to be made from Bamboo wood having Performance Appraisal Certificate (PAC) from Building Material Technology Promotion Council (BMTPC). The bamboo wood shall have minimum density of 1000 Kg/Cum and minimum hardness of 1000 kgf. Bamboo wood hollow pole shall be cladded to the column as per attached drawings along with all engineering material and accessories specified in the drawings as per direction of engineer in charge.

**Boat Wall:** Phenol bonded customize bamboo wood boats and customized bamboo wood hollow poles with an outer dia of 80 mm in AAI/PMC approved colour/texture/finish on wall of size 20 mtr (lnth) x 4 mtr (ht). Bamboo wood (Made in India) boats and customized bamboo wood hollow poles of 80 mm to be made from Bamboo wood having Performance Appraisal Certificate (PAC) from Building Material Technology Promotion Council (BMTPC). The bamboo wood shall have minimum density of 1000 Kg/Cum and minimum hardness of 1000 kgf. Bamboo wood boats and bamboo wood hollow poles shall be installed as per attached drawings along with all engineering material and accessories specified in the drawings as per direction of engineer in charge.

The drawings to be referred for this item are as follows:

DP 974 DRG ID 01 058, DP 974 DRG ID 01 059, DP 974 DRG ID 01 060, DP 974 DRG ID 01 061, DP 974 DRG ID 01 062, DP 974 DRG ID 01 063, DP 974 DRG ID 01 064, DP 974 DRG ID 01 065, DP 974 DRG ID 01 066, DP 974 DRG ID 01 067, DP 974 DRG ID 01 068, DP 974 DRG ID 01 069, DP 974 DRG ID 01 070, DP 974 DRG ID 01 071, DP 974 DRG ID 01 072, DP 974 DRG ID 01 073, DP 974 DRG ID 01 074, DP 974 DRG ID 01 075, DP 974 DRG ID 01 076, DP 974 DRG ID 01 077, DP 974 DRG ID 01 078, DP 974 DRG ID 01 079, DP 974 DRG ID 01 080, DP 974 DRG ID 01 081, DP 974 DRG ID 01 082

4. **STONE CLADDING**

The scope of work for the Indian stone work contractor will include:

a) Procuring various types of specified Indian stones.

b) Processing these various types of stones and providing them (with & without art/craft work) in different sizes, shapes & textures.
c) Wooden packaging of stones, getting tax clearances and transporting the processed/ carved stones from source to site at Imphal (Manipur).

d) Deputing craftsmen on site for unloading, check the site conditions, liaise with authorities, guide & oversee the installation of processed/ carved stones at site, and carry out adjustments/ grinding/ jointing, etc. for perfect.

e) Specifications suggested by the manufacturers for the materials, surface preparation, workmanship and all other bye works etc., shall be strictly followed. In addition to this the entire job will have to be carried out as per direction of AAI/PMC, which shall be final.

**BLACK GRANITE:**

Wall cladding of granite in color as per selection of AAI/PMC as per Indian standard 1121, 1122, 1124-1974.

Minimum 20mm thickness

Tolerance- In length & breadth shall be +/- 2mm and thickness +/-1mm.

Technical Specifications-The compressive strength when tested according to IS : 1121-1974 shall be not less than 1 000 kg/cm². 3.2 The specific gravity when tested according to IS : 1122-1974 shall not be less than 2’6. 3.3 The water absorption when tested according to IS : 1124-19749 shall not be more than 0’50 percent.

Texture- Polish finished with paper joints.

Fixing- Fixing with cement mortar 1:4 using Black cement and colour pigments to match the colour of the slab making through jointing with sealant. Dry fixing shall also be considered if usage of cement mortar is not appropriate for large size panels.

**SANDSTONE:**

Wall cladding of natural sandstone in color as per selection of AAI/PMC as per Indian standard 1121-1974, 1122-1974, 1124-1974, 1126-1974.

Minimum 30mm thickness.

Tolerance- Variance +/-2mm. Natural variance in shade and marking is natural criteria of the natural stones.

Technical Specifications- Water absorption 4.09%, comprehensive strength dry 66.40MPa, wet 57.00MPa in parallel as per ASTM standard.

Texture- Rough rack finish
Fixing- Fixing with cement mortar 1:4 using Black cement and colour pigments to match the colour of the slab making through jointing with sealant. Dry fixing shall also be considered if usage of cement mortar is not appropriate for large size panels.

5. **GLASS WORKS**

- **Lacquered Glass**

  **Glass Thickness:** 4mm, 6mm & 8mm

  **Substrate:** Marine PlywoodBWP grade/cement boards

Marine ply/cement boards are extremely good in water/moisture resistance and give enough strength to hold the glass upto 8mm thickness. Also it does not adopt the wall undulations easily and helps to get a flat surface for glass installation. It is always recommended to make a dummy wall of plywood/cement board 100 to 200mm away from the brick wall surface to avoid any direct contact from moisture and allow air to pass in between. This procedure also helps to prevent any direct vibration of building to glass wall which may cause breakage in glass later. If aluminum fabrication is not possible, do the POP in the raw wall and screw ply/cement board with the help of flex sheet as a backing material to avoid moisture attack on the substrate directly.

<table>
<thead>
<tr>
<th>Substrate</th>
<th>Min. Thickness</th>
<th>Glass Thickness</th>
<th>Adhesive</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ply Wood</td>
<td>12mm</td>
<td>4mm</td>
<td>Silicon</td>
</tr>
<tr>
<td></td>
<td>15mm</td>
<td>6mm</td>
<td>Silicon</td>
</tr>
<tr>
<td></td>
<td>19mm</td>
<td>8mm</td>
<td>Silicon</td>
</tr>
<tr>
<td>Cement boards</td>
<td>12mm</td>
<td>4mm</td>
<td>Silicon</td>
</tr>
<tr>
<td></td>
<td>12mm</td>
<td>6mm</td>
<td>Silicon</td>
</tr>
<tr>
<td></td>
<td>12mm</td>
<td>8mm</td>
<td>Silicon</td>
</tr>
</tbody>
</table>

**Tool list:**

1. Drill machine
2. Drill bits 4mm to 10mm
3. PVC plugs and CSK screws
4. Metal scraper
5. Emery paper
6. Hammer & Chisel
7. Silicon tubes 280ml cartridges
8. Silicon Gun
9. Masking tapes
10. Tile spacers (cross T & L shape)
11. Wood nails
12. Marine plywood/cement boards
13. Aluminum channels, L angles etc. (as per site requirements)
14. Hack Saw or Ply Cutter
15. Safety Gloves, Safety Helmet, Safety Shoes, Safety goggles

Method of Installation:

1. Check the position of wall and surroundings as shown in the picture below:
2. Prepare a dummy wall of 19mm marine plywood (keep a distance of atleast 100 to 150mm from brick wall) with the help of Aluminum/wood frames.

3. Make sure that there should be no any surface undulation (verticality, horizontalness and flatness) on the ply wall. Ideally this wall should be perfectly flat and vertical WRT to floor and roof otherwise it may lead in glass breakage during or after installation
4. It is always recommended to screw the nails instead of hammering it.

5. Make sure there should be no any foreign material sticking on the ply wall (eg. No nails extruding from the wall, no POP/plaster/paints or any other debri is allowed).
6. Clean the surface with the help of metal scraper and cotton cloth before installing the glass
7. Always prefer to start the installation of glass from bottom most surface
8. While taking the glass measurement, always consider a gap of 2mm to 3mm to avoid any direct contact of glass to glass or glass to any other material.
9. Do not start the glass installation if AC is on.
10. Prepare some strong wooden blocks to hold the glass.
11. Put the glass in respective location (do not put the silicon at this stage) and check the dimensions of glass and surroundings WRT to approved drawings.
12. If everything is OK, apply the recommended silicon on the coated surface of glass and put the glass in respective location with the help of vacuum chucks.
13. Press the glass surface firmly with hands or rollers to spread the silicon uniformly to get fast and better adhesion.
14. Make arrangements to hold the glass in installed location with the help of small nails & making tapes. During this procedure care to be taken to avoid glass chipping, use some cushioning material in between glass and nail.
15. With the help of tile spacer install the other glass creating a gap 2 to 3mm.
16. Remove all supports after 48 hrs (wooden blocks, nails, masking tapes etc.) as silicon will get its initial strength after 48hrs only.
17. Clean the grooves with the help of vacuum cleaner and avoid any dusty atmosphere after cleaning.
18. Put the masking tapes at the edges of glass and carefully fill the neutral silicon, remove the masking tape immediately after filling the silicon in gaps.
19. Allow silicon to get dry for at least 24 hrs and after that put protection covers on the glass surface.
20. Site is ready for handover.

**Digitally Printed Laminated Glass**

**STANDARDS:**

The contractor must comply with all the relevant Indian and British Standards of Code of practice and technical literature relating to best practice pertaining to Decorative Glass Glazing. Nothing in this clause shall relieve the contractor of his obligations to provide a higher standard where required and directed.

Summary:
A. Section Includes: Laminated glass with image interlayer(s).
B. Related Sections:
1. Section 09770 – Special Wall Surfaces
2. Section 07 90 00 – Joint Protection
3. Section 08 11 00 – Metal Doors and Frames
4. Section 08 30 00 – Specialty Doors and Frames
5. Section 08 41 00 – Entrances and Storefronts
6. Section 08 81 00 – Glass Glazing
7. Section 08 44 00 – Curtain Wall and Glazed Assemblies

References:

ASTM International:
ASTM C 1036 Specification for Flat Glass:
• ASTM C 1048 Specification for Heat-Treated Flat Glass-Kind HS, Kind FT Coated and Uncoated Glass
• ASTM C 1172 Specification for Laminated Architectural Flat Glass
• ASTM E-774-Specification for Sealed Insulating Glass Units where insulating glass is specified

ANSI - American National Standards Institute:
• ANSI Z-97.1 Safety Performance Specifications and Methods of Test Used in Buildings.
• CPSC 16 CFR 1201 Safety Standard for Architectural Glazing Materials, Category I and II.

Submittals:
• Provide submittals in accordance with Section 01305 – Submittal Procedures.
• Submit manufacturer’s shop drawings, installation drawings, installation instructions and maintenance instructions.
• Submit environmental impact data for all materials.
• Submit samples no less than 6" x 6" for all specified glass configurations.
• Manufacturer information:
  • Provide overview literature describing manufacturer’s overall scope of products and manufacturing capabilities.
  • Provide URL for manufacturer’s web site; web site must provide access to technical data, images and general product information.

Quality Assurance:
• Manufacturer Qualifications:
  • Minimum 10 years experience in the manufacture of laminated glass.
  • Minimum 10 years experience in the fabrication of laminated glass.
  • Provide test reports indicating products meet or exceed specified requirements.
Delivery, Storage and Handling:
A. Deliver materials to installation site in manufacturer’s original packaging. Handle products in accordance with manufacturer’s instructions. Store in dry, secure location, protected against direct sunlight and excessive heat. Protect finished surfaces with strippable film.

Warranty
A. Provide manufacturer’s standard warranty.
1. Warranty terms: one year against defects in materials and workmanship.

SCOPE OF WORK:
The contractor shall be responsible for supply, installation, test and guarantee of all items including taking all measures that may be required to complete the work as per Architectural concept drawings and specifications details. Contractor must provide all materials, tools, consumables required for unloading the material and installing the Architectural Laminated Flat Glass.

MATERIAL AND FINISHES:
Digitally Printed Laminated Glass -
Material:
Pattern: Pattern from detail drawings submitted by AAI/PMC.
Color: As per approval of AAI/PMC
Finish: As per approval of AAI/PMC
Processing: Polished edges, holes, cutouts, pattern cuts, none
Overall Nominal Thickness: 8.0 mm or 14.0 mm.

Fire rating: The laminated glass is Class A fire rated glass in accordance with ASTM designation E84-09, standard test method of surface burning characteristics of building materials. The foregoing test procedure is comparable to UL 723, ANSI/NFPA No. 255, and UBC No. 8-1.

Associated Components -
Top Lite:
Type: It should be Annealed/ Heat-Strengthened/ Tempered.
Thickness: 3.0 mm/ 6.0 mm.
Bottom Lite:
Type: It should be Annealed/ Heat-Strengthened/ Tempered.
Thickness: 3.0 mm/ 6.0 mm.
Interlayer
1. Design: Pattern from detail drawings submitted by AAI/PMC.
2. Thickness: 2 mm.
WORKMANSHIP:

• General:
  • No materials, equipment or practices shall be used that may adversely affect the functioning, appearance and durability of the digitally printed laminated glass installation. The work shall be accomplished in compliance with the specified criteria without bucking, opening of welds, cracking of glass, leakage or other harmful effects.
  • The materials used must be capable of withstanding the effects of in site installation and allow sufficient tolerance to prevent damage to the finished surface.
  • Install the digitally printed laminated glass in accordance with manufacturer’s instructions at locations indicated on the drawings.
  • Materials, finishes, shapes, sizes, thickness, and joint locations shall conform strictly to those required by the drawings and specifications.
  • All work shall be of the highest quality, in accordance with best trade practices, and performed by skilled workmen.
  • All components exposed in the finished work shall be free from warping & oil-cleaning effects.

• Manufacturer’s Standards:
  Materials, components and system incorporated in the work shall be in compliance with the standards and procedures of the appropriate manufacturers and the standards and codes referred to in this specification.

• Storage and Handling:
  • Store all materials indoors at moderate temperature (above the dew point).
  • Support both sides of vertically stored cases.
  • Wet glass must be towel dried prior to storage as prolonged moisture exposure can cause permanent surface staining.

INSPECTION:
All shop and field materials and workmanship shall be subject to inspection by the in charge architect at all the times. These inspections shall not relieve the contractor from the obligation to provide materials conforming to all requirements of the contract Document and matching approved samples.

TESTING:
The contractor shall be required to perform necessary test at site. Following 3 tests shall be done at site using Spectrophotometer. Lux Level, Delta E and Kelvin. The results of these tests shall fall within the criteria defined by the Manufacturer. The values differ from one material finish to another. Manufacturer will provide the criteria once the product is shortlisted.

CLEANING:
• Remove strippable film. Clean exposed surfaces in accordance with manufacturer’s instructions.
• Protect exposed surfaces from damage by subsequent construction.
• The digitally printed laminated glasses should be maintained using standard commercial, non-streaking cleaners and polishes formulated for use on glass.
• Do not let liquid sit on or near the glass for an extended period of time. Avoid puddling near the base of the panels.

Integrate Light Panels

STANDARDS

The contractor must comply with all the relevant Indian and British Standards of Code of practice and technical literature relating to best practice pertaining to Light panels. Nothing in this clause shall relieve the contractor of his obligations to provide a higher standard where required and directed.

Summary: Section Includes: Engineered, edge-lit LED panel integrated with Pre-approved glass as per AAI/PMC, Kiln Cast Glass, power source with dimming controls and wiring and mounting cleat extrusion.

Related Sections: 1. Section 14 27 00 – Elevators

2. Section 10 14 33 – Illuminated Panel Signage


Submittals:

• Provide submittals in accordance with Section 01 30 50 – Submittal Procedures.
• Submit manufacturer’s shop drawings, installation drawings, installation instructions and maintenance instructions.
• Submit samples no less than 4” x 4” for all specified material finishes.
• Submit panel edge extrusion samples no less than 4” of specified finish.

Manufacturer Information:

• Provide overview literature describing manufacturer’s overall scope of products and manufacturing capabilities.
• Provide URL for manufacturer’s website; website must provide access to technical data, images and general product information.

Quality Assurance:

• Manufacturer Qualifications-
  1. Minimum 10 years experience in the manufacture of architectural surface materials.
  2. Minimum 10 years experience in the fabrication of wall systems.

Delivery, Storage and Handling: Deliver materials to installation site in manufacturer’s original packaging. Handle products in accordance with manufacturer’s instructions. Store in dry, secure location, protected against direct sunlight and excessive heat. Protect finished surfaces with strippable film.
Warranty: Provide manufacturer’s standard warranty.
Warranty terms: one year against defects in materials and workmanship.

SCOPE OF WORK

The contractor shall be responsible for supply, installation, test and guarantee of all items including taking all measures that may be required to complete the work as per Architectural concept drawings and specifications details. Contractor must provide all materials, tools, consumables required for unloading the material and installing the Light panels.

Contractor shall also provide below things in addition:
1. An accessible mounting surface or vented enclosure for the supplied power box within 25-30 running feet of the final Light panel location.
2. Provide a 100-277 VAC power feed and electrical hook up to each supplied power box.
3. If customer desired to switch the panels on and off, contractor must supply a switch with a dry contract and add a separate wire to run the switch connection provided in the box.

MATERIAL AND FINISHES

• The material must be purchased from pre approved Manufacturer to ensure compliance of design as per AAI/PMC.

• Light Panels
1. General
2. Panel configuration: Illuminated Light panels. See drawings for panel layout and sizes.
3. Provide panels in the finishes specified.

2. Inset Materials
   Laminated Glass Panels (choose one): Made using 3mm Low Iron Annealed Glass + Interlayer + 3mm Low Iron Annealed Glass.
   Material: Pre approved glass as per instructions of AAI/PMC
   Material: Kiln Cast Glass

3. Panel Frames
   Material: Extruded, anodized aluminum (Grade 6063)
   Finish: Clear Anodized, Black Anodized, Antique Bronze Anodized (choose one).
   Bezel Width: 0.23 in (5.8 mm)
Panel Thickness: 1.344 in (34.1 mm)

4. Illuminated Element
   1. LED: Lamp type - As per pre approved or equivalent as per the design intent, instructions of AAI/PMC.
      - Wattage: 0.25 watts/LED.
      - Color temperature: 5,000K.
      - Rated life: 100,000 hours at recommended illumination.
      - Running temperature: 72° F (22.2 degrees Celsius)

2. Power Source:
   - Single panel power box: 100-277 VAC/ 10-24V DC output, dimmable, constant current, 5 amp power supply; quick disconnect; maximum wattage: 60 watts per panel.
   - Multiple panel power box: 100-277 VAC/ 16-24V DC output, dimmable constant current, 5 amp power supply with internal forward-phase dimming controls; quick disconnect; maximum wattage: 60 watts per panel.
      - Input voltage: AC 100-277 VAC
      - Output voltage: 12 V

3. Safety Certification:
   - UL 8750 - UL Standard for Safety for Light Emitting Diodes (LED)
   - CSA C22.2 - Canadian Standard for (Interior) Portable and Stationary Electric Signs and Displays.

WORKMANSHIP

General:
- No materials, equipment or practices shall be used that may adversely affect the functioning, appearance and durability of the completed Light panels installation. The work shall be accomplished in compliance with the specified criteria without bucking, opening of welds, cracking of glass, leakage or other harmful effects.
- The materials used must be capable of withstanding the effects of in situ installation and allow sufficient tolerance to prevent damage to the finished surface.
- Materials, finishes, shapes, sizes, thickness, and joint locations shall conform strictly to those required by the drawings and specifications.
- All work shall be of the highest quality, in accordance with best trade practices, and performed by skilled workmen.
- All components exposed in the finished work shall be free from warping & oil-cleaning effects.
Manufacturer’s Standards:
Materials, components and system incorporated in the work shall be in compliance with the standards and procedures of the appropriate manufacturers and the standards and codes referred to in this specification.

Storage and Handling:
- Store all materials indoors at moderate temperature (above the dew point).
- Support both sides of vertically stored cases.
- Wet glass must be towel dried prior to storage as prolonged moisture exposure can cause permanent surface staining.

INSPECTION

All shop and field materials and workmanship shall be subject to inspection by the in charge Architect at all the times. These inspections shall not relieve the contractor from the obligation to provide materials conforming to all requirements of the contract Document and matching approved samples.

TESTING

The contractor shall be required to perform necessary test at site. Following 3 tests shall be done at site using Spectrophotometer. Lux Level, Delta E and Kelvin, the results of these tests shall fall within the criteria defined by the Manufacturer. The values differ from one material finish to another. Manufacturer will provide the criteria once the product is shortlisted.

CLEANING

- Remove strippable film. Clean exposed surfaces in accordance with manufacturer’s instructions.
- Protect exposed surfaces from damage by subsequent construction.
- The glass surface of the Light panels should be maintained using standard commercial, non-streaking cleaners and polishes formulated for use on glass.
- When cleaning the panels, avoid excessive amounts of liquid solution on the glass, as this can damage the lamps and electrical wiring in the panels.
- Aluminum frames can be cleaned as needed using a soft brush or cloth with a minimal amount of warm water and a mild detergent. Do not use harsh abrasives, acids or chlorine-based cleaners or cleaning tools containing carbon steel, such as steel wool or wire brushes.
- Do not let liquid sit on or near the panels for an extended period of time. Avoid puddling near the base of the panels.

- Etching Film

Frosted crystal film with plotter cutting: film should provide the look of sandblasted or etched glass. The polymeric, calendered, self adhesive film shall be installed with crystal clear, acrylic
adhesives. The permanent, pressure-sensitive films should be translucent in nature with matte surface finish.

- Glass Inlay

Providing, supplying and fixing of liquid metal brass inlay on white lacquered toughened glass.

Minimum thickness of 6mm.

Tensile strength 120-200MPa, with heated treated temperature of approx. 650 degree Celsius and rapidly cooled to induce compressive stresses of 770kg/m2 to 1462kg/m2 on the surfaces and edge compression 680kg/m2 with carved approx. 0.2mm depth and inlayed by pouring a layer of liquefied semi-precious brass metal coating having zero flamed propagation and ignobility as per architectural design with Nano technology glass sealer and J 1plain clip fitting features

6. VENEER

FEATURES:

- Triple heat treated so as to get finest sanitized veneer with controlled resin/oil
- Double pressed only on Hardwood Plywood in BWR & MR Grades
- Thickness of 0.55mm to ensure no de-lamination or sanding off during polishing
- No warping, cracking or de-lamination
- A pioneer product from premier European and American veneer mills. Rated as the best grade(A++) veneers
- An extra back face of hardwood keruing veneer for solid and wrap proof construction.
- Freedom from borers, white ants, fungi etc.
- Corrugation free smooth surface and strong bonding for longer life
- Conforming to IS : 1328 (1996)

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<tr>
<th>Prescribed Test</th>
<th>Values for Conformity</th>
<th>Observed Value</th>
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<td>8 - 10</td>
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<tr>
<td>Squareness Test(%)</td>
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<td>&lt; 0.2</td>
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<tr>
<td>Edge Straightness Test(%)</td>
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<td>&lt; 0.2</td>
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<td>5300</td>
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<td>Modulus of Elasticity (Perpendicular to Face Grain) (N/mm$^2$)</td>
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<td>3875</td>
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<tr>
<td>Adhesion of Piles</td>
<td>Pass Standard</td>
<td>Conforms</td>
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### 7. ALUMINUM COMPOSITE PANELS CLADDING

The aluminum cladding shall be fabricated with a minimum of 4 mm thick aluminum composite panel of approved make comprising of a thermoplastic resin core. The panels shall be **PVDF coated to minimum 35 micron thickness** in approved metallic colour. The resin content of the PVDF shall be 75% to 80%. The back of the panel shall be chromatised 3-4 mm thick or otherwise protected to AAI/PMC's approval. The insulation in-fill of the composite panel shall be non-toxic on burning. The panels shall be acceptable to the Chief Fire Office.

Fasteners: The type, size, Alloy, quantity and spacing of all fasteners and or anchorage devices shall be as required for the specified performance standards.

a) Bolts, anchors and other fastening devices shall be of approved types as required for the strength of the connections, positive results during the pullout tests, shall be self-locking, unless otherwise noted shall be suitable for the conditions encountered, and shall be torque tightened, where required to achieve the maximum torque tension relationship in the fasteners. Washers, nut and all accessory items shall be of the same material as fasteners.

b) Fastening devices between Aluminum and aluminum shall be chrome nickel plated MS unless otherwise approved.

c) Fastening devices between Aluminum and dissimilar materials shall be chrome nickel plated MS unless otherwise approved.
d) Exposed fasteners are subject to AAI/PMC’s approval and shall be stainless steel.
e) Self-locking fasteners shall be stainless steel with nylon inserts of patches.

Cladding shall be non-toxic composite aluminum panels (as specified) of adequate strength with approved aluminum details. The panels shall be 4 mm thick composite units finished with PVDF coating overall 28-30 micron thick of approved metallic colour. The resin content of the PVDF coating shall be 75% to 80%. The back of the panel shall be chromatised 3-4 micron thick, compatible with adhesives for stiffeners if any or given a polymer coating.

All cladding panels of one kind shall be obtained in one lot from the manufacturers.

Each panel shall be guaranteed for a flatness of 1 mm from the true face after installation under no-wind conditions. Deviations from the true alignment of adjoining panels shall not be cumulative. Full load deflections shall be kept to the minimum possible. Each panel shall be capable of withstanding 300 Kg Sq.m wind pressure without any permanent deformation.

The cladding system shall be adequately ventilated. The air-gap between the cladding panels and the concrete block-wall shall be at least 50 mm to allow proper ventilation of the rain screen system. The cavity shall be closed by a perforated bird vermin-proof closer at bottom and by a flashing at top.

The fabrication processes including cutting, grooving, benching, folding, joining, root-in as well as approved aluminum support framework, fixed to wall with aluminum galvanized steel brackets.

The composite Aluminum panels shall satisfy the following fire codes requirements:

- BS476 part 6 class 0
- ASTM E-84 Flame Spread index 0
- Smoke developed index<15
- UBC 20-9 & NFP for 30 minute intermediate scale Multi-storey Apparatus Test to prove no flame spread beyond the area directly exposed to fire source.

**FABRICATION**

All assemblies shall be fabricated and assembled in accordance with the drawings and the requirements of these specifications, Deviations of any nature, without approval of AAI/PMC shall not be permitted.
ACP

The Aluminum composite panel should consist of 3 mm thickness of core in which Low Density Polyethylene (LDPE) 70% & High Density Polyethylene (HDPE) 30% sandwiched between two Aluminum skins AL 3105 H16 / 3003 H24 of 0.5mm thickness. Aluminum alloy sheet making a total panel thickness of 4mm. The weight of ACP should be 5.5 kg/m². The top surface shall be finished with PVDF KAYNAR 500 based coating and service coating on the reverse side shall be with a polymer paint. Coating shall conform to AAMA standards. The Aluminum meets as per standard ASTM, EN, BS.

<table>
<thead>
<tr>
<th>No.</th>
<th>ACP</th>
<th>STANDARDS TO BE FOLLOWED</th>
<th>UNIT</th>
<th>VALUES</th>
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<tr>
<td>1</td>
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<td>mm</td>
<td>4 mm (± 0.2mm)</td>
</tr>
<tr>
<td>2</td>
<td>Al. Skin Thickness</td>
<td>EN 515</td>
<td>mm</td>
<td>0.5 (± 0.03)</td>
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<tr>
<td>3</td>
<td>Weight</td>
<td>EN 1999 1-1</td>
<td>Kg/m²</td>
<td>5.5 Kg (± 5%)</td>
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MECHANICAL PROPERTIES

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<th>Property</th>
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<th>VALUES</th>
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<td>EN 515</td>
<td>H24</td>
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<td>Tensile Strength</td>
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<tr>
<td>5</td>
<td>Elongation</td>
<td>EN 485-2</td>
<td>%</td>
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CORE MATERIALS

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<th>No.</th>
<th>Property</th>
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SURFACE FINISH PROPERTIES

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<td>3</td>
<td>Humidity Resistance</td>
<td>ASTM D 2247</td>
<td>-</td>
<td>no change after 3000 hrs</td>
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<tr>
<td>4</td>
<td>Salt Spray Resistance</td>
<td>ASTM B 117</td>
<td>-</td>
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ACCOUSTIC PROPERTIES

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THERMAL PROPERTIES

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PROTECTIVE FILM

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• ACP- FIRE GRADE B1

The Aluminum composite panel should consist of 3mm thickness of mineral core in which Aluminum trihydroxide (ATH), Magnesium dithydroxide (MDH) 67%, Low Density Polyethylene (LDPE) 27% and Additive, Ash, Binder & Glue etc 6% sandwiched between two Aluminum skins AL 3105 H16 / 3003 H24 of 0.5mm thickness. Aluminum alloy sheet making a total panel thickness of 4mm. The weight of ACP should be 7.5 kg/m². The top surface shall be finished with PVDF KAYNAR 500 based coating and service coating on the reverse side shall be with a polymer paint. Coating shall conform to AAMA standards. The Aluminum composite Panel should be fire rated standard BS 476 part 6 & part 7 Class 0 & EN 13501-1 & DIN 4102 – B1.

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<td>1</td>
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<td>4 mm (± .2mm)</td>
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<tr>
<td>2</td>
<td>Al. Skin Thickness</td>
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<td>mm</td>
<td>0.5 (± .03 )</td>
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**MECHANICAL PROPERTIES**

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<td>Elongation</td>
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**CORE MATERIALS**

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**SURFACE FINISH PROPERTIES**

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### Finish Thickness

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### FIRE PROPERTIES

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### ACCOUSTIC PROPERTIES

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### THERMAL PROPERTIES

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### PROTECTIVE FILM

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<td>days 80 days</td>
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### MOSS WALL PANELS

#### STANDARDS:

The contractor must comply with all relevant Indian and European Standards Code of practice and technical literature relating to best practice pertaining to Semi Natural Plants and Maintenance Free Moss Wall. Nothing in this clause shall relieve the contractor of his obligations to provide a higher standard where required and directed.

1. UNI EN 13501 – 1:2009B-S 2 &USA Certification ASTM E 84:2003, CLASSE A RESISTANCE TO FIRE
3. TEC 1990706284 VERY HOSTILE ENVIROMENT FOR REPRODUCTION OF INCESTS
4. A Standard Specification For Semi Natural Plants And Maintenance Free Moss Wall

It is the Contractor’s responsibility to ensure that the codes adopted in these works are acceptance to local building authority is to be placed indoor with a relative humidity of 40%.
Any conflict discovered between the above-mentioned humidity level in the building regulations must be reported to AAI/PMC, for an instruction to be issued, but as a general rule, the more stringent shall apply.

QUALITY ASSURANCE:

Single approved source responsibility.

The stabilization process is not harmful to the environment because the used components are not toxic.

It is stabilized 100% Natural; totally ecological which preserves its naturalness without additional maintenance for both Semi Natural Plants and Maintenance Free Moss Wall.

SCOPE OF WORK:

Maintenance Free Moss Wall: The contractor shall be responsible for supply, fabrication, installation, test and guarantee of all items including taking all measures that may be required to complete the work as per Architectural concept drawings and specifications details.

The specialist contractor shall submit an outline of recent comparable works by the firm it’s technical partner to illustrate the competence, experience and suitability of the firm.

The Brief scope of work is:

a) Supply of all items of structural fixing of Moss Wall Panels for both plane and curved surface as concept of Architectural drawings.
b) Fabrication and installation of structural system if required.
c) All anchors, fixing, attachments, reinforcements, steel reinforcing for mullions and transoms required for a complete installation, except those specifically indicated as being provided by other trades.
e) Finishes, protection coatings and other support members.
f) Sealing with approved sealants within and around the perimeter.
g) Provisions to receive electrical outlets and outlets for conduits and other electrical work.
h) Co-ordination with the work of main contractor and other trades.
i) Only for Indoor Use Only

MATERIAL AND FINISHES:

Maintenance Free Moss Wall:

• The Moss wall is a product obtained with Natural Material which respects the environment.
• The process is preformed at the time of their life cycle where they look the best.
In the first phase the sap evaporates to leave for the new full liquid.
In the second phase the moss is washed and dried.
Then it is ready to pass the final quality control.

Semi Natural Plants:
The trunks are sourced from environmentally friendly areas and are subject to anti age.
Anti parasitic treatment which allows the trees to maintain their natural astonishing look for years.
The best and the finest man-made leaves in the market contribute to the make of these plants.

**WORKMANSHIP:**
The stabilization process is not harmful to the environment because the used components are not toxic. There are 2 types of wall mounting systems:

- Flexi Panel and Stainless Steel Galvanized Plate of 400mmX600mm. However, any shape size can be done using a Flexi Panel as per AAI/PMCs’ specifications.

Jointing: One panel can be placed next to each panel and the moss would overlap the other panel hence the corner of each panel would not be visible.

Accurately fit and firmly secure all exposed metal joints with metal to metal hair line contacts.

All panels can be screwed on the wall.

**INSPECTION:**
All shop and field materials and workmanship shall be subject to inspection by the In charge Architect at all the times. These inspections shall not relieve the contractor from the obligation to provide materials conforming to all requirements of the contract Document and matching approved samples.

**TESTING:**
The necessary test has already been approved by the laboratory.

1. **UNI EN 13501 – 1:2009B-s 2 & USA Certification ASTM E 84:2003, CLASSE A RESISTANCE TO FIRE**
3. **TEC 1990706284 VERY HOSTILE ENVIROMENT FOR REPRODUCTION OF INCESTS**
9. HIGH PRESSURE LAMINATE

Solid grade compact HPL wall cladding, (fixed by 'riveting / adhesive' joinery) is a decorative compact HPL laminate in 6mm thickness as per EN 438-6 Type EDS (Exterior Durable Standard) and EGS (Exterior General Standard).

It is manufactured using specially treated acrylic resins under high pressure and temperature hardened into sheets.

SCOPE:

Designing the cladding system with Decorative High Pressure Compact Laminates (HPL) as per design intent, preparation of shop drawings for approval, supply, fabricate, erect as per approved shop drawings at all floor levels and at all floor heights and the cladding shall be provided matching the lane of the adjoining wall finishes as shown in the approved drawings, wherever required.

Design the framing system with the gap as per drawing between wall/column/steel structures/any supporting system & cladding. Frame to support Decorative High Pressure Compact Laminates (HPL) and Decorative capping to any shape & profile and shall be supported between the Aluminum angle brackets of chromotised finish.

Brackets shall be fixed on to the Masonry wall with Solid block (Compressive strength not less than 3.5 N/mm²) / RCC / steel structures/any other supporting structures like brackets, Angles and the brackets shall be fixed with Polyamide expansion SS anchors of suitable dia and length with the strength as per design requirements. In order to decide the actual strength of expansion bolts to be achieved as per design, a pull out test on bolts shall be conducted at site on the block wall/RCC member at minimum 3 locations on each. The Engineer-in-Charge will decide the type of anchors to be used based on the results of Pull out test carried out as mentioned above. All fasteners and expansion bolts shall be of approved make. Groove width in the system both in horizontal and vertical shall not be more than 12 mm and the groove width shall be maintained uniform for both structural glazing and cladding system. Groove shall be sealed with non-structural and non-staining silicone sealant.

MATERIALS:

Frames:
Providing and fixing Aluminum extruded members (Box Tube) designed to withstand design wind pressure and movement as specified as continuous member for cladding the Decorative High Pressure Compact Laminates (HPL). Aluminum members shall be fixed into masonry wall/RCC.
member /steel structures with Brackets / Clamps and it shall be of chromotised finish Aluminum.

All fasteningstraps, nuts & bolts, rivets, washers/other fastening materials shall be of non-magnetic Stainless steel and Aluminum brackets shall be considered for HPL cladding with standard dimension and after the site survey if any undulation is observed in term that doesn’t allow to fix the Aluminum bracket only in these areas the additional support with locally fabricated Hot dip galvanized bracket can be considered. Aluminum shim shall be used for level adjustment of bracket but more than 20 mm is not acceptable. If more than 20 mm, bracket shall be designed according to site condition.

Aluminum brackets / clamps shall be fixed with chemical injection technique threaded anchorrods of approved make to the base structure, in the case of masonry wall / RCC members and SS anchor bolts in the case of steel structure. Extruded member shall be designed to accommodate HPL sheets as per the approved shop drawings and extruded Aluminum member shall be of 6063 T6 or 63400 (H9) grade conforming to BS1467 or IS8147, finished with transparent electrolytic colour anodic coating AC15 grade conforming to IS1868.
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**Sealing:** Providing and applying the sealant for Jointing / Sealing and it shall be done with Non-structural (weather) sealant / Non staining sealant of DC 991 HP of Dow corning make or approved equivalent with Polyurethane baker rods of Supreme make or approved equivalent. Sealing shall be carried out with Non-structural (weather) sealant / Non staining sealant with Polyurethane baker rods, wherever the system is interfacing with glazing or any other finish.
Cleaning: HPL panels may not be affected by dust, dirty handprints or algae growth. Do not use cleaning agents with abrasive or polishing components. Only use clean sponges, soft nylon brushes or cloths and avoid brushes with hard rigid bristles as recommended by the manufacturer.

Testing: One test for every 1000 Sqm or part thereof of cladding.

10. ARTWORK ON CANVAS

Hand Painted Canvas Painting (Original Artwork by local artists), complete in all respect as per direction and selection of AAI/PMC.

11. CARVED WOODEN FRAME

Carved teak wood frame finished with polish as per above specifications with track mounted luminaries with maximum optical flexibility as specifications, as per instruction of AAI/PMC.

12. FABRIC PANELLING

Local Manipuri fabric paneling as per drawings and details under instructions of AAI/PMC.

13. METALWORKS

DEFINITIONS/ TERMINOLOGY:

Bead: A single run of weld metal deposited on surface.

Butt Weld: A weld in which the weld metal lies substantially within the extension of the planes arc the surfaces on the parts joined.

Crater: A depression left in weld metal where the arc was broken or the flame was removed.

End Crater: A crater at the end of a weld or at the end of a joint.

Fillet Weld: A weld of approximately triangular cross-section joining two surfaces approximately at the right angles to each other in a lap joint, tee joint or corner joint. It is of two types:

(1) Continuous
(2) Intermittent.

Fusion Welding: Any welding process in which the weld is made between metals in a
state of fusion without hammering or pressure.

Non-fusion Welding: A term applied to the deposition, by the Oxy-Acetylene process of filler metal on parent metal without fusion of the latter.

Oxy-Acetylene Pressure Welding: Pressure welding in which any Oxy-Acetylene flame is used to make the surface to be united plastic. No filler metal is used.

Run: The metal deposited during one passage of the electrode or blow pipe in the making of a joint.

Throat thickness: See Fig. 10.1, CPWD Specifications.

Weld: A union between two pieces of metal at faces rendered plastic or liquid by heat or pressure, or both, Filler metal may be used to affect the union.

MATERIALS:

Micro-Alloying Elements: Elements such as niobium, boron, vanadium and titanium added singly or in combination to obtain higher strength to weight ratio and better toughness, formability and weldability as compared to unalloyed steel of similar strength level.

Weldability: A metallic substance is considered to be weldable by a given process and for the given purpose, when metallic continuity to a stated degree can be obtained by welding using a suitable procedure, so that the joints comply with the requirements specified in regard to both their local properties and their influence on the construction of which they form a part.

Controlled Rolling: A hot rolling process in which the temperature of the steel and its reduction ratio are controlled, particularly during the final rolling passes, in order to achieve fine grain micro structure and optimum mechanical properties.

Normalizing Rolling: A hot rolling process in which the final rolling passes are carried out at a suitable higher temperature, followed by cooling in natural air to a temperature below the transformation temperature, in order to produce a structure, analogous to that obtained by a separate normalizing treatment of hot rolled product.

Steel:
Supply of Material: General requirements relating to supply of structural steel shall conform to IS 8910.
Grades: There shall be nine grades of steel as given in Tables 10.1 and 10.2, CPWD Specifications. While placing the order the steel should be designated by ‘Designation’ (See Table 10.1 and 10.2).

Manufacture: The processes used in the steel making and further hot rolling into steel plates, strips, sections, flats, bars, etc., are left to the discretion of the manufacturer/supplier. If required, secondary refining may follow steel making, as also normalizing rolling/controlled rolling during manufacturing of sections or as per the agreement between the purchaser and the manufacturer/supplier.

Freedom from Defects: All finished materials shall be well and cleanly rolled to the dimensions, sections and masses specified. The finished material shall be reasonably free from surface flaws; laminations; rough/ jagged and imperfect edges and all other harmful defects.

Minor surface defects may be removed by the manufacturer/supplier by grinding provided the thickness is not reduced locally by more than 4 percent below the minimum specified thickness. Reduction in thickness by grinding greater than 4 percent but not exceeding 7 percent may be made subject to mutual agreement between the purchaser and manufacturer/supplier.

Subject to agreement with the purchaser, surface defects which cannot be dealt with as in may be repaired by chipping or grinding followed by welding and inspection by a mutually agreed procedure such that:

After complete removal of the defects and before welding, the thickness of the item is not to be reduced by more than 20 percent at any place.

Welding is carried out by procedure APPROVED by competent authority with approved electrodes and the welding is ground smooth to the correct nominal thickness; and subsequent to the finish grinding, the item may be required to be normalized or otherwise heat-treated at the purchaser’s discretion.

Welding as mentioned in 10.1.1.4.3, CPWD Specifications is not permissible for grade designation E 250 material.

Chemical Composition: Ladle Analysis the ladle analysis of the steel, when carried out by the method specified in the relevant part of IS 228 or any other established instrumental/chemical method, shall be as given in Table 10.1, CPWD Specifications. In case of dispute, the procedure given in IS 228 and its relevant parts shall be the referee method and
where test methods are not specified shall be as agreed to between the purchaser and the manufacturer/supplier.

Rivets: Rivets shall be made from rivet bars of mild steel as per IS 1148.

Bolts: These are of two types namely turned and fitted bolts and black bolts. Turned & fitted bolts are turned to exact diameter in automatic lathe. For these bolts, whether reamed or drilled bolts, the same unit stresses are allowed as for rivets. In case of black bolts which are not finished to exact sizes, a lower working stress other than for turned bolts is adopted. They shall conform to IS 1367 – Technical supply conditions for threaded steel fasteners.

Electrodes: The electrodes required for metal arc welding shall be covered electrodes and shall conform to IS 814.

STEEL WORK IN BUILT UP SECTION (WELDED)

The steel work in built up sections (welded) such as in trusses, form work etc. is specified in this clause.

Laying out: It shall be as specified in 10.3.1, CPWD Specifications.

Fabrication: Straightening, shaping to form, cutting and assembling, shall be as per 10.3.2, CPWD Specifications, as far as applicable, except that the words “riveted or bolted” shall be read as “welded” and holes shall only be used for the bolts used for temporary fastening as shown in drawings.

Welding: Welding shall generally be done by electric arc process as per IS 816 and IS 823. The electric arc method is usually adopted and is economical. Where electricity for public is not available generators shall be arranged by the contractor at his own cost unless otherwise specified. Gas welding shall only by resorted to using oxyacetylene flame with specific approval of AAI/PMC. Gas welding shall not be permitted for structural steel work. Gas welding required heating of the members to be welded along with the welding rod and is likely to create temperature stresses in the welded members. Precautions shall therefore be taken to avoid distortion of the members due to these temperature stresses.

The work shall be done as shown in the shop drawings which should clearly indicate various details of the joint to be welded, type of welds, shop and site welds as well as the
types of electrodes to be used. Symbol for welding on plans and shops drawings shall be according to IS 813.

As far as possible every efforts shall be made to limit the welding that must be done after the structure is erected so as to avoid the improper welding that is likely to be done due to heights and difficult positions on scaffolding etc. apart from the aspect of economy. The maximum dia of electrodes for welding work shall be as per IS 814. Joint surfaces which are to be welded together shall be free from loose mill scale, rust, paint, grease or other foreign matter, which adversely affect the quality of weld and workmanship.

Precautions: All operation connected with welding and cutting equipment shall conform to the safety requirements given in IS 818 for safety requirements and Health provision in Electric and gas welding and cutting operations.

Operation, Workmanship and process of Welding is described in Appendix B,

Inspection and testing of welds shall be as per IS 822.

Assembly: Before welding is commenced, the members to be welded shall first be brought together and firmly clamped or tack welded to be held in position. This temporary connection has to be strong enough to hold the parts accurately in place without any disturbance. Tack welds located in places where final welds will be made later shall conform to the final weld in quality and shall be cleaned off slag before final weld is made.

Erection: The specification shall be as described in 10.3.3, CPWD Specifications, except that while erecting a welded structure adequate means shall be employed for temporary fastening the members together and bracing the frame work until the joints are welded. Such means shall consists of applying of erection bolts, tack welding or other positive devices imparting sufficient strength and stiffness to resist all temporary loads and lateral forces including wind. Owing to the small number of bolts ordinarily employed for joints which are to be welded, the temporary support of heavy girders carrying columns shall be specially attended. Different members which shall be fillet welded, shall be brought into as close contact as possible. The gap due to faulty workmanship or incorrect fit if any shall not exceed. 1.5 mm if gap exceeds 1.5 mm or more occurs locally the size of fillet weld shall be increased at such position by an amount equal to the width of the gap.

Painting: Before the member of the steel structures are placed in position or taken out of the workshop these shall be painted as specified in para 10.2.2, CPWD Specifications.

Measurements: The mode of measurements shall be the same as specified in 10.2.4, CPWD Specifications except that weight of welding material shall not be added in the
weight of members for payment and nothing extra shall be paid for making and filling holes for temporary fastening of members during erection before welding.

**TUBULAR / HOLLOW SECTION TRUSSES:**

Structural Steel Tube: These shall be of:

1. Hot finished welded (HFW) type, or
2. Hot finished seamless (HFS) type, or
3. Electric resistance or induction butt welded (ERW), having carbon content less than 0.03 percent, yield stress of 21.5 kg/mm² (YST 210) type.

Conforming to the requirement of IS 1161. The steel tubes when analyzed in accordance with the method specified in IS 228 shall show not more than 0.06 percent sulphur, and not more than 0.06 percent phosphorous.

Tubes shall be designated by their nominal bore. These shall be light, medium or heavy as specified depending upon the wall thickness. The standard size and weights of tubes are listed in Appendix C, CPWD Specifications. Hollow sections shall be as per IS 4923.

Tubes shall be clean finished and reasonably free from scale. They shall be free from cracks, surface flaws, laminations and other defects. The ends shall be cut clean and square with axis of tube, unless otherwise specified.

Minimum Thickness of Metals: Wall thickness of tubes used for construction exposed to weather shall be not less than 4 mm and for construction not exposed to weather it shall be not less than 3.2 mm where structures are not readily accessible for maintenance, the minimum thickness shall be 5 mm.

Fabrication: The component parts of the structure shall be assembled in such a manner that they are neither twisted nor otherwise damaged and be so prepared that the specified cambers, if any, are, maintained. The tubular steel work shall be painted with one coat of approved steel primer after fabrication. All fabrication and welding is to be done in an approved workshop. The joint details shall be generally as per S.P-38 of B.I.S publication.

Straightening: All material before being assembled shall be straightened, if necessary, unless required to be of curvilinear form and shall be free from twist.

Bolting: Washers shall be specially shaped where necessary, or other means, used to give the nuts and the heads of bolts a satisfactory bearing.
In all cases, where the full area of the bolts is to be developed, the threaded portion of
the bolt shall not be within the thickness of the parts bolted together and washers of
appropriate thickness shall be provided to allow the nuts to be completely tightened.

Welding: Where welding is adopted, it shall be as per IS 816.

Caps and Bases for Columns: The ends of all the tubes, for columns transmitting loads
through the ends, should be true and square to the axis of the tubes and should be
provided with a cap or base accurately fitted to the end of the tube and screwed, welded
or shrunk on. The cap or base plate should be true and square to the axis of the column.

Sealing of Tubes: When the end of a tube is not automatically sealed by virtue of its
connection be welding to another member the end shall be properly and completely
sealed. Before sealing, the inside of the tubes should be dry and free from loose scale.

Flattened Ends: In tubular construction the ends of tubes may be flattened or otherwise
formed to provide for welded. Riveted or bolted connections provide that the methods
adopted for such flattening do not injure the material. The change of sections shall be
gradual.

**Hoisting and Erection:** Tubular trusses shall be hoisted and erected in position carefully,
without damage to themselves, other structure, equipment and injury to workman.

The method of hoisting and erection proposed to be adopted shall be got approved from
AAI/PMC. The contractor shall however be fully responsible, for the work being carried
out in a safe and proper manner without unduly stressing the various members. Proper
equipment such as derricks, lifting tackles, winches, ropes etc. shall be used.

Application of one coat of approved steel primer, i.e. red oxide zinc chrome primer
conforming to IS 2074 is to be carried out.

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**Brass Work**

i. **Router Cut Metal Jaali**- MS structure as per IS 2062 grade A.

Finish- Created, coated with sealer to make rust proof, 12mm High quality Marine Ply
according to BS standard(1088),Gluing EN 314 Class 3 Voluminal mass ,STD EN 323 Kg/m3 ,
Value 500 +/-10%. CNC carved and attached with MS structure, 2mm brass sheet to be laser
cut cleanly glued with top of marine ply with brass, coat with high quality sealer to stop
oxidization, design as per AAI/PMC.
ii. **Wooden Teetotum** - Thick MS pipe according to IS:1161/1989, Nominal bore 15mm, Outside diameter 21.3mm, medium class measuring a total of 11485x7800mm and as per the drawings given by AAI/PMC. Frames to be backed with 2 mm MS sheet, IS2062 grade A at places specified in the drawing and incorporating 50x12 mm thick MS bar. 120 pieces of wooden concave shaped ‘TEETOTUM’ to be hand crafted as per the design. Frames to be backed with 2 mm MS sheet, IS2062 grade A at places specified in the drawing and incorporating 50x12 mm thick MS bar.

Finish - Complete MS structure to be covered by pouring a layer of liquified semi-precious brass metal coating having zero flame propagation and ignibality as per the approved design/drawings to achieve the desired effect as per the design approved by AAI/PMC. Metal to be sealed with clear sealer matte finish coating to ensure no oxidation of the metal. All ‘TEETOTUMS’ to also be covered with a layer of liquified semi-precious brass / copper / rose gold metal coating having zero flame propagation and ignibality as per the approved design/drawings to achieve the desired effect as per the design approved by AAI/PMC. Brass to be antiqued slightly to make the contours of the birds stand out. Metal to be sealed with clear sealer matte finish coating to ensure no oxidation of the metal. Finish to be smooth and no tool marks to be visible.

iii. **Handcrafted Wooden Birds** - Thick MS pipe according to IS:1161/1989, Nominal bore 15mm, Outside diameter 21.3mm, medium class, 2.6mm thickness, measuring a total of 11485x7800mm and as per the drawings given by AAI/PMC. Frames to be backed with 2 mm MS sheet IS2062 grade A at places specified in the drawing and incorporating 50x12 mm thick MS bar.

Finish - Complete MS structure to be covered by pouring a layer of liquified semi-precious brass metal coating having zero flame propagation and ignibality as per the approved design/drawings to achieve the desired effect as per the design approved by AAI/PMC. Metal to be sealed with clear sealer matte finish coating to ensure no oxidation of the metal liquefied semi-precious brass metal coating having zero flame propagation and ignibality as per the approved design/drawings to achieve the desired effect as per the design approved by AAI/PMC. Brass to be antiqued slightly to make the contours of the birds stand out. Metal to be sealed with clear sealer matte finish coating to ensure no oxidation of the metal. All birds to also be covered with a layer of liquified semi-precious brass metal coating having zero flame propagation and ignibality as per the approved design/drawings to achieve the desired effect as per the design approved by AAI/PMC. Brass to be antiqued slightly to make the contours of the birds stand out. Metal to be sealed with clear sealer matte finish coating to ensure no oxidation of the metal. Finish to be smooth and no tool marks to be visible.

The drawings to be referred for this item are as follows:
14. **ENGINEERED STONE WORKS (Solid Acrylic Surface)**

**MATERIAL:** ACRYLIC POLYMER COMPOSITE COLUMN PANEL

Nonporous, homogeneous material maintaining the same composition throughout the part with a composition of acrylic polymer, aluminum tri hydrate filler and pigments.

Thickness: 12mm

Finish: Provide countertop with uniform finish characteristics: [Matte] [Semi-Gloss] [Gloss]

Thermoforming in countertop in shapes as indicated in Drawings.

Joint type: [Overlap] [Open] [Seamed]

Fire rating:

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Standard</th>
<th>Material Thickness</th>
<th>Class / Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flammability</td>
<td>NFPA 101 Life Safety Code</td>
<td>6mm &amp; 12mm</td>
<td>Class A</td>
</tr>
<tr>
<td>Flame Spread Index</td>
<td>ANSI/UL Standard 723 (ASTM E84, NFPA 255)</td>
<td>6mm &amp; 12mm</td>
<td>FSI &lt; 25</td>
</tr>
<tr>
<td>Smoke Developed Index</td>
<td>ANSI/UL Standard 723 (ASTM E84, NFPA 255)</td>
<td>6mm &amp; 12mm</td>
<td>SDI &lt; 25</td>
</tr>
</tbody>
</table>

Delivery, Storage, Handling:

- Store components indoors prior to installation.
- Handle materials to prevent damage to finished surfaces.
- Provide protective coverings to prevent physical damage or staining following installation for duration of project.

The material (Solid Surface) should conform to following Performance Characteristics as follows:
Fabrication:

The substructure supplier has to check the substrate for proper support to counter top, according to official construction recommendations.

Fabrications to be performed by a Manufacturer Certified fabricator/installer.

Fabricate components in shop to greatest extent practical to sizes and shapes indicated, in accordance with approved shop drawings and Manufacturer’s requirements.
Joints shall be inconspicuous in appearance and without voids. Attach 50mm wide reinforcing strip of solid surface material under each joint, in case it is not supported on substrate.

Provide holes and cutouts for plumbing and bath accessories as indicated on the drawings. The inside corner for cutouts should be minimum 6mm.

Fix the under mount sink as per manufacturer guidelines.

Rout and finish component edges to a smooth, uniform finish. Rout all cutouts, then sand all edges smooth to minimum 1.5mm radius.

Finish: All surfaces shall have uniform finish.

Cove backsplashes: Fabricate 12mm radius cove at intersection of counters and backsplashes. Fabricate in shop or field. Leave expansion gap between wall & backsplash as per need.

**Installation:**

Install components plumb and level, in accordance with approved shop drawings and product installation details.

Manufacturer recommended joint adhesive need to be used. The fabrication & installation of counter top should be done by authorized fabricator of DuPont. Keep components and hands clean when making joints.

The thermal expansion of the panels must be taken into consideration. In order to avoid tension and possible cracking, the expansion gap in the countertop must be as large as the expected expansion (rule of thumb: 1.5 mm/meter of countertop panel in all directions).

Keep components and hands clean during installation. Remove adhesives, sealants and other stains.

Fabricator/Installer to provide Care and Maintenance instructions, review maintenance procedures with the Owner's head of maintenance upon completion of project.

**Protection:** Protect completed installation from damage resulting from other trades with heavy Kraft paper, polythene or cardboard until date of final inspection.

**Cleanup:**

Remove all excess adhesives, sealants and other contaminates from countertop installation and all adjacent surfaces. Leave completed installation clean and ready for final inspection.
For high traffic areas such as airports, use of FR- Fire Grade certified acrylic solid surface material, approved under IS 12777 is suggested.

- **Check-in Counters**

  Check-in counter table of 1200mm (L) X 1000mm(W) X 800mm(H). The table should have another top below of 1000mm(L) X 500mm(W) with 18mm thick engineered stone finish. Top panel should be of two layers bottom layer to be with ply board upper layer with 18mm thick polished engineered stone on the top, with membrane finish. The edging shall be of matching with the top colour tone. In the understructure the legs shall be 18mm thick ply board and 18mm thick polished engineered stone. Connected to top & side panels with mini fix fitting & wooden dowels. The understructure shall have power management through cable trays. The front panel shall have indirect diffused light effect with 5-8W/Mtr LED strip. The table shall have storages in 18mm thick laminate of size 600x480x680mm. The work shall be carried out as per the directions received from AAI/PMC. The specifications of the component materials mentioned above are to be referred from the respective subheads from this document.

- **Immigration Counters**

  Immigration cubicle of 2200mm (L) X 2050mm(W) X 800mm(H). The cubicle should have table top of 850mm(L) X 2050mm(W) x 737mm(H) with 18mm thick mm engineered stone finish. In the understructure the legs shall be 18mm thick ply board and 18mm thick polished engineered stone connected to the top panel by minifix & wooden dowels. The table shall have another elevated top of width 150-250mm on all four sides in 38mm thick MDF with veneer finish. The two front panels shall be 18 mm thick engineered stone with curved edges and indirect diffused light effect with 5-8W/Mtr LED strip. Connected to top & side panels with mini fix fitting & wooden dowels. The table shall have two storages in 18mm thick laminate of size 600x480x680mm. The work shall be carried out as per the directions received from AAI/PMC. The specifications of the component materials mentioned above are to be referred from the respective subheads from this document.

- **Countertops**

  12mm acrylic solid surfaces of approved make with natural veins / stone finish, cladded over 19mm commercial board/ metal framework surface of retail countertops or display cabinetry. The cladded sheet should be manufactured as per ISO 19712, confirming to RoHS EU standards, fire resistant, certified under IS12777 as per Indian safety norms. The specifications of the component materials mentioned above are to be referred from the respective subheads from this document.
15. CHECK IN COUNTERS, INFORMATION/BOARDING GATE COUNTERS, CUSTOM COUNTER, IMMIGRATION / EMIGRATION COUNTER, INSPECTION TABLE, STAMPING TABLE AND OTHER ACCESSORIES:

GENERAL: Designing, Providing and placing counters etc. as per the design requirements.

MATERIAL:

a) Solid Acrylic Surfaces: 12 mm thick Solid acrylic of approved make should have the following parameters:

<table>
<thead>
<tr>
<th>Sl No.</th>
<th>Parameter</th>
<th>Unit</th>
<th>Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Specific gravity</td>
<td></td>
<td>1.65-1.75</td>
</tr>
<tr>
<td>2</td>
<td>Rockwell hardness(HRM) /surface hardness(mohsindex)</td>
<td>HRM/MohsIndex</td>
<td>Min 88(HRM)/2 3(mohsindex)</td>
</tr>
<tr>
<td>3</td>
<td>Tensile strength</td>
<td>Mpa</td>
<td>&gt;40</td>
</tr>
<tr>
<td>4</td>
<td>Flexural strength</td>
<td>Mpa</td>
<td>57-74</td>
</tr>
<tr>
<td>5</td>
<td>Color stability/Appearance</td>
<td></td>
<td>Nochange</td>
</tr>
<tr>
<td>6</td>
<td>Heat water resistance</td>
<td></td>
<td>Noeffect</td>
</tr>
<tr>
<td>7</td>
<td>Flexure modulus</td>
<td>Mpa</td>
<td>Min 6085</td>
</tr>
<tr>
<td>8</td>
<td>Flammability</td>
<td></td>
<td>Class A/ Class 1</td>
</tr>
<tr>
<td>9</td>
<td>Fungi and bacterial growth</td>
<td></td>
<td>Nogrowth</td>
</tr>
</tbody>
</table>

b) 19 mm thick (BWP) block board: All frame work to be made with 19 mm thick block board of approved make and should be of boiling water proof (BWP grade) conforming of IS 1659 as per approved drawing. It should conform to the following parameters:

<table>
<thead>
<tr>
<th>Sl No</th>
<th>Parameters</th>
<th>Requirement</th>
</tr>
</thead>
</table>
| 1     | Dimensional | a) Length +6mm  
b) Width +3mm  
c) Thickness +/-5% |
| 2     | Moisture | 5-15% |
c) **1 mm thick decorative laminate**: The laminate shall be of approved make, in suede or gloss finish, the color and pattern to be approved before execution.

d) **18 gauge Stainless steel cladding**: The grade of steel sheet to be used for bottom portion of table is of 304. Inclusive of pasting and fixing with SS screws or approved method as decided by Engineer In charge.

Any other minor accessories like Teflon beading (if required for exposed surface of frame work) bottom supports, wire managers etc also included in the scope of work.

**TEST & FREQUENCIES**: All the material shall be tested as per specification with following frequency:

a) **Solid Acrylic Surface, 19mm thick BWP block board & laminate (as applicable)** – one test per 100 Sqm of material. In case quantity is less than 100 Sqm, no outside laboratory test is required.

b) **Manufacturers test certificate** shall be supplied alongwith each batch of material irrespective of quantity.

**16. VANITY COUNTERS**

**MATERIAL**:

12 mm thick Solid acrylic of make should have following parameters:

<table>
<thead>
<tr>
<th>Sl. No</th>
<th>Parameters</th>
<th>Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>Modules of N/mm²</td>
<td>Average 5000</td>
</tr>
<tr>
<td>7</td>
<td>Modules of</td>
<td>Average 50</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Min. individual 4200N/mm²</th>
<th>Min. individual 42</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>4.200 mm²</td>
<td>42 N/mm²</td>
</tr>
<tr>
<td>7</td>
<td>4.200 mm²</td>
<td>42 N/mm²</td>
</tr>
</tbody>
</table>

<p>| 1453 |</p>
<table>
<thead>
<tr>
<th>Sl. no</th>
<th>Parameter</th>
<th>Unit</th>
<th>Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Specific gravity</td>
<td></td>
<td>1.65-1.75</td>
</tr>
<tr>
<td>2</td>
<td>Rockwell hardness (HRM)/surface Hardness</td>
<td>HRM/MohsIndex</td>
<td>Min 88 (HRM) /2-3 (Mohs index)</td>
</tr>
<tr>
<td>3</td>
<td>Tensile strength</td>
<td>Mpa</td>
<td>&gt;40</td>
</tr>
<tr>
<td>4</td>
<td>flexural strength</td>
<td>Mpa</td>
<td>57-74</td>
</tr>
<tr>
<td>5</td>
<td>Color stability/Appearance</td>
<td></td>
<td>No change</td>
</tr>
<tr>
<td>6</td>
<td>Heat water resistance</td>
<td></td>
<td>No effect</td>
</tr>
<tr>
<td>7</td>
<td>Flexure modulus</td>
<td>Mpa</td>
<td>Min 6085</td>
</tr>
<tr>
<td>8</td>
<td>Flammability</td>
<td></td>
<td>Class A/Class 1</td>
</tr>
<tr>
<td>9</td>
<td>Fungi and bacterial growth</td>
<td></td>
<td>No growth</td>
</tr>
</tbody>
</table>

19 mm thick (BWP) block board: All frame work to be made with 19 mm thick block board of make should be of boiling water proof (BWP grade) conforming of IS 1659 as per approved drawing shall conform following parameters:

<table>
<thead>
<tr>
<th>Sl. No</th>
<th>Parameters</th>
<th>Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Dimensional</td>
<td>a) Length</td>
</tr>
<tr>
<td></td>
<td></td>
<td>+6mm</td>
</tr>
<tr>
<td></td>
<td></td>
<td>+3mm</td>
</tr>
<tr>
<td></td>
<td></td>
<td>+/-5%</td>
</tr>
<tr>
<td>2</td>
<td>Moisture content</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Dimensional Changes caused by humidity</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>No de-lamination in the extreme ranges of humidity</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Dimensional changes to be not more than</td>
</tr>
<tr>
<td>3</td>
<td>Resistance to water</td>
<td>After 72 hrs boiling Min. pass</td>
</tr>
<tr>
<td>4</td>
<td>Adhesion of plies</td>
<td>Min. pass standard</td>
</tr>
<tr>
<td>5</td>
<td>Mycological Test</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>No appreciable signs of separation at edges</td>
</tr>
<tr>
<td>6</td>
<td>Modules of Elasticity</td>
<td>Average 5000</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Min. individual 4200N/mm2</td>
</tr>
<tr>
<td>7</td>
<td>Modules of Rupture</td>
<td>Average 50</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Min. individual 42</td>
</tr>
</tbody>
</table>

Final pattern of solid acrylic surface finish shall be approved by Engineer-In-Charge.

**FABRICATION /EXECUTION:** The vanity counters to be prepared with solid acrylic surface as per approved drawing and design to be fixed over 19mm thick BWP block board with underneath RCC slab of minimum 75mm thick or any other surface including all moulded wash basins, finishing of joints, silicon sealants etc to give joint less smooth surface complete as per
satisfaction of Engineer In Charge. Any additional requirement for fixing is to be arranged by contractor without extra payment. Necessary moulding of solid acrylic surface etc also included in the scope.

**TEST & FREQUENCIES:** All the material shall be tested as per specification with following frequency:

Solid Acrylic Surface, 19mm thick BWP block board & laminate (as applicable) – one test per 100 Sqm of material. In case quantity is less than 100 Sqm, no outside laboratory test is required.

Manufacturers test certificate shall be supplied along with each batch of material irrespective of quantity.

The drawings to be referred for this item is DP 974 DRG ID 01 070.

17. **TOILET CUBICLES**

**MATERIAL:** The Toilet cubical shall be of size and shape as shown on drawings for a unit of WCs, erected at locations enclosed by corner masonry walls. Divider, Door, End / Mid panels shall be of 12 mm thick Decorative Thermosetting Synthetic Resin Bonded Compact Laminated Sheets conforming to IS: 2046 and extruded aluminum grade 6063-7-5. Hardware and fittings shall be of grade 304/316 stainless steel conforming to relevant IS codes.

All the material supplied and installed shall be as per the description and specifications in the item. The following information shall be submitted by the contractor for obtaining approval of AAI/PMC before start of work

<table>
<thead>
<tr>
<th>Product data</th>
<th>Manufacturer’s data sheets on each product to be used, including preparation instructions and recommendations. Storage and handling requirements and recommendations. Details of construction and fabrication. Installation methods.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shop Drawings</td>
<td>Detailed plans and elevations, details of framing members, anchoring methods, clearances, hardware, and accessories clearly shown.</td>
</tr>
<tr>
<td>Name of fabricator / installer</td>
<td>Approved by the manufacturer, specializing in performing work of this section with minimum two years experience.</td>
</tr>
</tbody>
</table>
DELIVERY, STORAGE, AND HANDLING: Toilet cubical material and hardware shall be delivered and stored in manufacturer's unopened packaging until ready for fabrication and installation. It shall be protected from damage.

FABRICATION: The substrates shall be prepared including but not limited to blocking and supports in walls and ceilings at points of attachment using methods recommended by the manufacturer for achieving the best result. Area shall be inspected to receive toilet cubical for correct dimensions, plumbness of walls, and soundness of surfaces that would affect installation of mounting brackets.

Spacing of plumbing fixtures shall also be verified to assure compatibility with installation of compartment. Installations shall not be preceded until substrates have been properly prepared with blocking and supports in walls and ceilings at points of attachment and deviations from manufacturer’s recommended tolerances are corrected. All the fabrication work shall be carried out as per approved shop drawings.

INSTALLATION: All installation shall be carried out by the fabricator/installer approved by AAI/PMC. Installation shall be in accordance with manufacturer’s written instructions approved by the AAI/PMC

Blocking and supports in walls and ceilings shall be verified that they have been installed properly at points of attachment. Location should not interfere with door swings or use of fixtures. Installation of cubical units should be rigid, straight, true to plumb, and level. Evidences of drilling, cutting, and fitting to room finish shall be concealed by capping. U-channels and noise deafening tapes shall be provided as per drawing. All the units shall be tested for proper operation. The following fittings shall be provided in each toilet cubical.

2. Coat hook cum Door stopper – 1No.
3. Door knob cum vacant / engaged position showing device – 1No.
4. Lock set – 1No.

ADJUSTING, CLEANING AND PROTECTION: Adjustment of hardware for proper operation after installation may be permitted provided it does not damage the unit either structurally or aesthetically. Hinge cam may be set on in-swinging doors to hold doors open when unlatched and on out-swinging doors to hold unlatched doors in closed position.

Touch-up, repair or replacement of damaged products shall be done with prior approval of AAI/PMC, whose decision shall be final and binding.
Exposed surfaces of compartments, hardware, and fittings shall be cleaned thoroughly.

**TESTING:** Required numbers of tests shall be performed on Decorative Thermosetting Synthetic Resin Bonded Compact Laminated Sheets as per provision of IS: 2046. Hardware and fittings shall be of grade 304/316 stainless steel and extruded aluminum grade 6063-7-5 shall also be tested based on relevant IS codes as decided by AAI/PMC. Testing charges shall be paid by the department.

18. **URINAL PARTITIONS**

**MATERIAL:** Wall Hung Screen / urinal partitions using 8mm thick toughened and satin frosted glass panels, hung from the wall using two SS 304 grade pivoted clamps. The urinal partition shall have minimum standard dimension of 1200 mm Height x 450 to 500 mm Width. The edges of the glass panels shall be grinded & polished smooth with architectural profile.

<table>
<thead>
<tr>
<th>Product data</th>
<th>Manufacturer's data sheets on each product to be used, including preparation instructions and recommendations. Storage and handling requirements and recommendations. Details of construction and fabrication. Installation methods.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shop Drawings</td>
<td>Detailed plans and elevations, details of framing members, anchoring methods, clearances, hardware, and accessories clearly shown.</td>
</tr>
<tr>
<td>Glass partition</td>
<td>Glass shall be toughened in accordance with BSEN12150, BSEN 12600 All edges of the glass shall be polished The corners of the glass shall have 5mm radius unless otherwise specified Frosted toughened glass can be drilled, shaped, notched as required.</td>
</tr>
</tbody>
</table>

**DELIVERY, STORAGE, AND HANDLING:**

Urinal partition material shall be delivered and stored in manufacturer's unopened packaging until ready for fabrication and installation. It shall be protected from damage.

**FABRICATION:**

The substrates shall be prepared including but not limited to blocking and supports in walls and ceilings at points of attachment using methods recommended by the manufacturer for achieving the best result.
INSTALLATION: All installation shall be carried out by the fabricator/installer approved by the Engineer-in-charge. Installation shall be in accordance with manufacturer’s written instructions approved by the Engineer-in-charge.

ADJUSTING, CLEANING AND PROTECTION:

Adjustment of hardware for proper operation after installation may be permitted provided it does not damage the unit either structurally or aesthetically. Exposed surfaces of compartments, hardware, and fittings shall be cleaned thoroughly.

19. MIRROR

The mirror shall be of superior glass with edges rounded off or beveled, as specified. It shall be free from flaws, specks or bubbles. The size of the mirror shall be as specified and its thickness shall not be less than 5.5 mm. It shall be uniformly silver plated at the back and shall be free from silvering defects. Silvering shall have a protective uniform covering of red lead paint. Where beveled edge mirrors of 5.5 mm thickness are not available, fancy looking mirrors with PVC beading/border or Aluminum beading or stainless steel beading/border based on manufacturer’s specifications be provided nothing extra shall be paid on this account. Backing of mirrors shall be provided with environmentally friendly material other than asbestos cement sheet.

20. STAINLESS STEEL SKIRTING

SCOPE: This specification covers design, preparation of fabrication drawings, providing all materials, fabricating, transporting, erection in position to proper lines and levels, fixing, Stainless Steel (SS) sheet cladding/skirting for various locations such as wall, columns, façade or any other locations as instructed by the Engineer-in-Charge including necessary accessories, fixtures, fittings, temporary works and supports, and ancillaries. The SS work may have to be fabricated out of ss sheets, ss hollow sections, SS pipes, etc. and may involve any or combination of two or more of these in sizes, quantity and quality as specified in the drawings or as directed by the Engineer-in-Charge.

The Contractor shall design, prepare drawings, furnish all the materials, skilled staff and labour, transportation, equipment, tools, tackles, temporary work, hoisting, erection and all other things that may be required for carrying out the work described above as per drawings, specifications and the instructions of the Engineer-in-Charge.

DESCRIPTION: Stainless steel skirting board profile, available with or without adhesive that appears, after laying, modern and elegant.
**MATERIAL:** It should be polished and satinf effect stainless steel AISI 304/1.4301- V2A with a high of 100 mm. The profile can be with adhesive and without adhesive. It could cover a 10 mm perimetral joint and junctions and end caps, should be easy to lay skirting board profile.

**General-** Unless noted otherwise, grade 1.44xx (formerly 316) shall be used.

**Reference Standards-**

**Aluminum:** Provide alloy and temper recommended by aluminum producer or finisher for type of use and finish indicated, and with not less than the strength and durability properties of the alloy and temper designated below for each aluminum form required.

a. Extruded Bar and Shapes: ASTM B221 (B221M).
b. Extruded Pipe and Tube: ASTM B429 (B429M).
c. Drawn Seamless Tube: ASTM B483 (B483M).
d. Plate and Sheet: ASTM B209 (B209M).
e. Die and Hand Forgings: ASTM B247 (B247M).
g. Alloy for Colored Anodized Finish: Controlled alloys and temper as recommended by aluminum manufacturer to provide required color and color matching.

**Stainless Steel:** Stainless Steel of ASTM A240 (A240M); Provide the most suitable austenitic alloy, form and finish required to produce the Work.

a. Plate and Sheet: ASTM A480 (A480M, Stretcher level sheets).
c. Round, Square and Rectangular Welded Tubing: ASTM A554, Grades MT 304, MT 304L, MT 316, or MT 316L as standard with manufacturer.
d. Pipe: ASTM A312 (A312M), Grade TP 304.
e. Castings: ASTM A743 (A743M), Grade CF8 or CF20.

**Stainless Steel Sheets:** Stainless steel sheets shall be grade 1.44xx (formerly 316) as per the requirements and shall comply with the relevant AISI standards. They shall be non-magnetic type with minimum wall thickness of 2.00 mm and of required finish.

The stainless steel sheets shall be of approved make and quality and of required size, gauge and thickness as per design requirements. The framework for cladding should be designed by the Contractor in such a way that there are no surface deviations.

**Stainless steel tubes and plates:** Stainless steel tubes & plates shall comply to the relevant AISI standards. They shall be non magnetic type with minimum wall thickness of 2.00 mm and of required finish.
**Fasteners:** The type, size, alloy, quantity and spacing of all fasteners and/or anchorage devices shall be as required for the specified performance standards.

a. Bolts, anchors and other fastening devices shall be of approved types as required for the strength of the connections, shall be self-locking, unless otherwise noted, shall be suitable for the conditions encountered, and shall be torque tightened, where required, to achieve the maximum torque tension relationship in the fasteners. Washers, nuts and all accessory items shall be of the same material as fasteners.

b. Fastening devices between Aluminum and Aluminum shall be Grade 304 / 316 of AISI non-magnetic stainless steel unless otherwise approved.

c. Fastening devices between Aluminum and dissimilar materials shall be Grade 304 / 316 of AISI non-magnetic stainless steel unless otherwise approved.

d. Exposed fasteners are subject to AAI/PMC's approval and shall be M.S. epoxy coated.

Self-locking fasteners shall be stainless steel of grade 304 / 316 with nylon inserts or Patches.

**Stainless Steel Plate, Sheet & Strips:** Non-magnetic stainless steel in plate, sheet and strip shall conform to requirements specified in this specification and more stringent requirement listed below. Unless noted otherwise, grade 1.44xx (formerly 316) shall be used for visible components and components at areas not behind a vapour barrier, in all other circumstances grade 1.43xx (formerly 304) shall be used.

**Aluminum Extrusions:** All aluminum extrusions shall conform to the system principal’s specification for tolerances which shall, in any case, be better than DIN standards. Any section not conforming to the tolerances shall be rejected.

In general aluminum alloy for extrusions shall be 6063 T5 or T6 as per B.S.1474. However, the grade and tempering specifications shall be as recommended by the supplier for each application and shall be approved by the system principal.

All aluminum sections shall be either anodized in approved colour to a minimum thickness of 35 microns or coated with PVDF as specified except for sections concealed from view behind cladding which may be mill-finished.

All surfaces abutting the parent sections and designed to receive sealants shall have adequate sealant contact and adhesion. They shall be finished to match parent sections.

**Finishes to Stainless Steel:** Stainless steel shall be supplied with finishes to cast, sheet and rolled components as specified on the drawings or as directed by the Engineer-in-Charge.
All visible surfaces in stainless steel shall be as specified by the Engineer-in-Charge. The direction of the texturing shall be the same in any continuous run of panels. The stainless steel finish selected shall not discolour during its design life when subjected to normal atmospheric conditions.

Samples are to be submitted for approval by the Engineer-in-Charge prior to manufacture. With the exception of hidden welds, welds shall be fully finished to match adjacent surfaces.

**STORAGE:**

Stainless steel sheet surfaces are protected adequately during storage, transporting and processing.

**FABRICATION:**

**General:**

Sawing - with vertical panel saw, circular, compass or fret saw.

Drilling holes for joining - with drill bits for aluminum sheet and plastic panels (for larger holes use a drill bit with locating point).

Routing - with conventional routing equipment, to avoid pressure marks, please use plastic or wood vice jaws when chucking the work pieces.

Shearing - with a guillotine (check correct insertion of top cover sheet), blanking tools to be padded.

Bending- with folding table min. inside bending radius $r = 15 \times t$ ($t =$ panel thickness) spring-back effect higher than with solid sheet

Screwing- with conventional stainless wooden, sheet metal and metal screws. For outdoor use, please take panel expansion into account!

Folding (routing technique)- manually after routing a V-groove on reverse side using a panel saw with milling attachment or a hand-milling cutter (see data sheet "Routing and Folding Technique").

Smoothing edges- using a file with a rasp-like cut to file roughly cut contours Lengthwise.

Punching - with a steel band tool on punching base for panels of 2 and 3 mm in thickness (check correct insertion of upper cover sheet) - with conventional sheet punching machines (for panels of any thickness).
Pressing - with a brake press min. inside radius \( r = 15 \times t \) (t = panel thickness) spring-back effect higher than with solid sheet.

Riveting -- with the usual equipment, using rivets or blind rivets. For outside use, please take panel expansion into account!

Gluing-
   a) with the usual metal adhesives for aluminum (no liability for front-end plastic edges)
   b) using conventional double-faced tapes

Fabrication- The fabrication and installation of the cladding systems shall be carried out as per manufacturer’s instructions with invisible / concealed fastenings, aluminum sub-structure, silicon sealants properly tooled etc.

All cladding sheets of one kind shall be obtained in one lot from the manufacturers. Each sheet shall be guaranteed for a minimum flatness of \( \leq 1 \) mm from the true face after installation under no-wind conditions. Deviations from the true alignment of adjoining sheets shall not be cumulative.

Full load deflections shall be kept to the minimum possible. Each sheet shall be capable of withstanding wind pressure without any permanent deformation.

The cladding system shall be adequately ventilated. The air-gap between the cladding sheets and the concrete / block wall shall be at least 50 mm to allow proper ventilation of the rain screen system. The cavity shall be closed by a perforated bird / vermin-proof closer at bottom and by a flashing at top.

The fabrication processes including cutting, grooving, benching, folding, joining, rout-in as well as installation shall be performed as per manufacturer’s instructions. The sheets shall be backed by approved aluminum supporting framework, fixed to walls with aluminum brackets.

**INSTALLATION:**

**General:** All assemblies shall be fabricated and assembled in accordance with the drawings and the requirements of these specifications. Deviations of any nature, without approval of the Engineer shall not be permitted.

6mm thick flexi ply shall be fixed to the wall/column with SS screw and raw plug as a backing surface for skirting. For cladding 6mm thick flexi ply shall be fixed on aluminum frame work as per design requirement as a backing surface.
**Tolerances:** Furnish a schedule of fabrication tolerances for all major wall cladding components. In addition to the fabrication tolerances, provide for and schedule thermal movement including assembly and installation tolerances for all major and/or applicable wall cladding components and/or assemblies.

**Workmanship:** All work shall be performed by skilled workmen, specially trained and experienced in the applicable trades and in full conformity with the applicable provisions of the listed References and Standards and/or otherwise noted on the drawings or as specified herein.

All work shall be carefully fabricated and assembled with proper and approved provisions for thermal expansion and contraction, fabrication and installation tolerances and design criteria.

All forming and welding operations shall be done prior to finishing. Unless otherwise noted. Approved electrodes compatible to the parent material shall be used for welding. Where two different types of metal elements like stainless & mild steel are to be welded together, the welding process and choice of electrodes shall conform to the code requirements of mutual compatibility.

All work shall be true to detail with sharp, clean profiles, straight and free from defects, dents, marks, waves or flaws of any nature impairing strength or appearances; fitted with proper joints and intersections and with specified finishes.

All work shall be erected true to plumb, level, square to line, securely anchored, in proper alignment and relationship to work of other trades and free from waves, sags or other defects.

**Joints in Metal Work:** All exposed work shall be carefully matched to produce continuity of line, design and finish. Joints in exposed work, unless otherwise shown or required for thermal movement, shall be accurately fitted, rigidly secured with hairline contacts and sealed watertight.

Where two or more sections or metals are used in building up members, the surface in contact shall be brought to a smooth, true and even surface and secured together so that the joints shall be absolutely tight without the use of any point materials. Extrusions shall be finished to eliminate any edge projection or misalignment at joints.

Furnish physical samples of all joinery elements as for comparative appraisal and approval of the production materials. Physical samples of all typical wall intersection assemblies shall be colour coded on surfaces and/or areas to receive sealants.
**Shop Assembly:** As far as practicable, all fitting and assembly of the work shall be done in the shop. Work that cannot be permanently shop assembled shall be temporarily assembled in the shop and marked with the approval of Engineer before disassembly to ensure proper assembly later in the building.

**Sleeves:** Unless otherwise noted, all aluminum sleeves shall be extruded sections designed to accurately interlock with adjacent sections and incorporate serrated surfaces for the Amount of total deviation and/or misalignment in any direction for vertical members: 3 mm maximum in a height of 4 m (non-cumulative) and maximum 7 mm in full-height of cladding/curtain walling.

**Anchorage:**

a) Anchorage of the stainless steel sheet cladding system to the structure shall be by approved methods and in strict accordance with approved shop drawings. After the SS cladding system are properly positioned, all connections so designated on approved shop drawings shall be rigidly fixed by welding or other positive means.

b) All anchorage assemblies and their related components shall be thoroughly scheduled and described on the shop drawings so that anyone can evaluate an installation and ensure its compliance with the contract documents. Designate trades responsible for furnishing and/or installing materials if other than the Sub-Contractor. Descriptive items shall include the access removal movement and tolerances of related building and the SS cladding system direction and magnitude of thermal expansion, materials, sizes, quantities and any special instruction as may be required. All primary SS cladding, anchorage assemblies inclusive of frame/structural mullion shall receive a 100% inspection.

**Use of sealing materials:**

a) Sealing materials shall be used in strict accordance with the Manufacturer’s printed instructions and shall be applied only by workmen specially trained or experienced in their use. Before applying sealant, all mortar, dirt, dust, moisture and other foreign matter shall be completely removed from surfaces it will contact. Adjoining surfaces shall be masked when required to maintain a clean and neat appearance. Sealing compounds shall be tooled to fill the joint and provide a smooth finished surface.

b) The manufacturer(s) of the applicable materials shall, when required render technical assistance prior to the application of any sealant and witness the first applications as well as periodic site inspections thereafter. The contractor shall witness and document all inspections performed by the sealant manufacturer and provide close supervision of all workmen used to apply the sealant.

**Tensioning of Bolts:** All bolts shall be correctly tensioned. The tension shall be specified on shop drawings. At least 10% of bolts shall be mechanically checked for corrected tension.

**PROTECTION AND CLEANING:**
a) SS sections shall be protected during transit, fabrication and installation such that the sections are not bent, distorted or damaged.

b) The Contractor shall adequately protect all aluminum sections, glazing, cladding sheets, components and accessories from damage during shipment, storage, erection and after completion of the work by use of protective film/foil of approved non-staining quality.

c) At such time as may be directed by the Engineer, the Contractor shall remove all protective coverings and/or coatings and clean surfaces free of all soil and discoloration. Only those cleaning agents that are acceptable to the applicable aluminum, glass and coating manufacturers shall be used and where doubt exists, spot tests shall be made to satisfy the Engineer.

MAINTENANCE: It does not require any special maintenance; it is suggested to clean it with normal household cleaning products.

LAYING INSTRUCTION:

1. Choose in the approved finish.
2. Cut to the desired length.
3. Remove carefully any remain of oil, fat and dirty from the surface where the profile will be laid.
4. When the surface is perfectly dry, apply silicone (in case of self-adhesive profile, remove the protective film).
5. Press the profile evenly until it is completely adherent to the wall.
6. Use the special pieces to obtain a workmanlike application.
### 21. MODULAR STAINLESS STEEL RAILING (ALL TYPES)

**SCOPE:** This section refers to the design, supplying, fabrication and installing in position composite hand railing for staircase, open area, balcony / terrace, corridor, cafeteria etc. at different floors, levels and locations.

**CODES AND STANDARDS:** The provisions of the latest revisions of the following IS Codes shall form a part of these specifications to the extent they are relevant.

<table>
<thead>
<tr>
<th>Specification</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>IS:800</td>
<td>Code Of Practice For Use Of Structural Steel In General Building Construction.</td>
</tr>
<tr>
<td>IS:875</td>
<td>Code of Practice for Design Loads of Buildings and Structures</td>
</tr>
<tr>
<td>IS:813</td>
<td>Scheme of symbols for welding.</td>
</tr>
<tr>
<td>IS:814</td>
<td>Covered electrodes for manual metal arc welding of Carbon and carbon-manganese steel.</td>
</tr>
<tr>
<td>IS:816</td>
<td>Code of practice for use of metal arc welding of general mild steel construction.</td>
</tr>
<tr>
<td>IS:817</td>
<td>Code of practice for training and testing of metal arc welders.</td>
</tr>
<tr>
<td>IS:818</td>
<td>Code of Practice for safety and health requirements in electric and gas welding and cutting operations</td>
</tr>
<tr>
<td>IS:822</td>
<td>Code of procedure for inspection of welds</td>
</tr>
<tr>
<td>IS:823</td>
<td>Code of procedure for manual metal arc welding of mild steel</td>
</tr>
<tr>
<td>IS:1161</td>
<td>Steel tubes for structural purposes</td>
</tr>
<tr>
<td>IS:1181</td>
<td>Qualifying tests for metal arc welders</td>
</tr>
<tr>
<td>IS:1182</td>
<td>Recommended practice for radiographic examination of fusion welded butt joints in steel plates</td>
</tr>
<tr>
<td>IS:3696</td>
<td>Safety codes for scaffolds and ladders</td>
</tr>
<tr>
<td>IS:4923</td>
<td>Hollow steel sections for structural use</td>
</tr>
<tr>
<td>IS:7205</td>
<td>Safety code for erection of structural steel work</td>
</tr>
<tr>
<td>ASTM A276-06</td>
<td>Standard Specifications for Stainless Steel Bar and shapes</td>
</tr>
<tr>
<td>ASTM A479 / A 479 M -</td>
<td></td>
</tr>
<tr>
<td>Specification</td>
<td>Description</td>
</tr>
<tr>
<td>--------------------------------------------</td>
<td>-----------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Material confirms to ASTM A-276-06, ASTMA479/A479M-06a</td>
<td></td>
</tr>
<tr>
<td>Chemical Analysis Test Method ASTM E 1086-94 , ASTM B117</td>
<td></td>
</tr>
<tr>
<td>Dimensional tolerance as per ASTM A484/AA484M-06b</td>
<td></td>
</tr>
<tr>
<td>Specification used : AISI.(American Iron and Steel Institute)</td>
<td></td>
</tr>
<tr>
<td>All the materials testing are done through the NABL Certified Laboratory only.</td>
<td></td>
</tr>
</tbody>
</table>

**MATERIALS:**

**Stainless Steel railing / hand railing:** Pipes used in all Railing shall be Stainless Steel as per SS 304 Grade with minimum tube thickness of 1.5 mm having tolerance level as per ASTM A554. All components in railing including baluster, pipes, caps etc. shall be in brush finish or as approved by Engineer-In-Charge.

**Balusters:**

a) The balusters to have a standard height of approximate 1050 mm or as specified in the drawings.

b) All components used in the baluster to be manufactured using SS 304 grade material turned and finished on CNC and other automatic Machines.

c) The base plate of the Baluster to be solid Stainless Steel of size 115 mm dia and 8 mm in thickness or as specified in the drawings.

d) All connectors to be fixed to the Baluster using Allen Bolts. The baluster to have Zero welding except on the bottom plate.

e) Balusters to be fixed using Stainless Steel M8 Fasteners with SS 304 grade Stainless Steel Caps

f) The Baluster neck to be modular and can be tilted as per the handrail. The neck plate shall be minimum 2 mm thick in Stainless Steel 304 garde.

g) Handrails shall be connected to the neck plate using Stainless Steel CSK M5x10 mm Screw only
h) Balusters shall be installed with a centre to centre distance of 1 mt. or as indicated in the drawing.

Finish: The finish of all stainless steel shall be as approved by the Engineer-in-Charge.

Glass: The glass used in the railing work shall be either one of the following as specified below:

a) Laminated toughened glass panels comprising of multiple panels of 6mm thick clear toughened glasses + 1.52 PVB film +6mm thick clear toughened glasses and fixed to the vertical balusters with glass clamping discs.
b) Glass railing shall be of equal panels in each flight or as shown in the drawing and all visible edges of the glass shall be machine polished.

Aluminum Frame:

Aluminum channel - T-6065 grade of specified size shall be used for holding the glass from the bottom with wedges, gaskets and fixed to the structure with anchor fasteners at 300 mm c/c including cutting the floor, grouting the joints using non-shrink grout.

Samples /Mock-up- Before taking up fabrication and erection on mass scale, the sample of railing materials being used etc. including mock-up of the system shall be got approved by the Engineer-in-charge.

Manufacturing Tolerances:

a) A high degree of accuracy should be employed in the fabrication of the Hand rails, skirt rails and their support structure.
b) Deviations in section length, width and diagonal dimension tolerances should not exceed±2mm.
c) The twist and warping should not cause any point of the element to be more than 1mm out of plane.

FABRICATION, ASSEMBLY AND INSTALLATION:

General:

a) Use no materials, equipment or practices that may adversely affect functioning, appearance and durability of completed items specified herein and related construction. Items shall comply with specified criteria without buckling, opening of joints, undue stress on fasteners, sealants and gaskets opening of welds, cracking of glass, leakage, noises, or other harmful effects.
b) Conform strictly to materials, finishes, and shapes, sizes, thicknesses, and joint locations required by drawings and specifications.
c) Match all materials to produce continuity of line, texture, and color.
d) To fullest extent practicable, fabrication and assembly shall be executed in shop. Work not shop assembled shall be shop-fitted.
f) All components exposed in finished work shall be acceptably free from warping, oil canning effects, and telegraphing of welds, studs, and other fasteners.
h) Pipes used in the work shall be seamless type.

No site welding of SS pipes will be allowed and longitudinal joints shall be made by arrangement of internal SS sleeves, in vertical pipes no joints are permitted.

Glass:
a) Glazing shall be performed without springing or forcing of glass.
b) Install glass under the conditions recommended by respective product manufacturers.

Protection, Cleaning and Acceptance:
a) Protect the Work of this Section from any materials, equipment or practices that may impair function appearance or durability of the work.
b) Remove and replace or repair with approval of Engineer-in-Charge any portion of work including glass damaged prior to date of acceptance.
c) Acceptance of completed work requires installation be sound, free from defects in materials and workmanship and clean. Clean is defined as free of any substance that cannot be removed by a normal cleaning with detergent and water.

METHODOLOGY & WORKMANSHIP:

General:
a) Fit exposed connections together to form tight, hairline joints. Perform cutting, drilling, and fitting required to install handrails, skirt rails.
b) Set handrails and railings accurately in location, alignment and elevation; measured from established lines and levels and free from rack.
c) Adjust handrails and railings before anchoring to ensure matching alignment at abutting joints.
d) Space posts at interval indicated, but not less than that required by structural loads.
e) Fastening to In situ Construction. Use anchorage devices and fasteners where necessary for securing handrails and railings and for property transferring loads to in situ construction.
f) The hand railing shall follow the inclination of stair in case of stair-case and shall be perfectly in line, level and plumb for all other railings.
g) Any damage caused to treads/risers while fixing of balusters, posts, railings etc., the damaged tread and riser shall be removed and replaced by new ones at no extra cost to the Employer.
Anchoring Railing Ends: Anchor railing ends into concrete and masonry with round flanges connected to railing ends and anchored into wall construction with post installed anchors and bolts. Anchor railing ends to metal surfaces with flanges bolted to metal surfaces. Connect flanges to railing ends using non welded connections.

Attaching Handrails to Walls:

a) Attach handrails to wall with wall brackets. Provide brackets with at least 50 mm clearance from inside face of handrail and finished wall surface.
b) Locate brackets as indicated or, if not indicated, at spacing required to support structural loads.
c) Secure wall brackets to building construction as follows:
   i. For concrete and solid masonry anchorage, use drilled in expansion anchors
   ii. For steel framed gypsum board assemblies, use hanger or lag bolts set into wood backing between studs.

Installation Tolerances:

a) The hand railing, skirt railing shall be erected in proper alignment in relation to established lines and grids shown on the Shop Drawings.
b) The width of any joint should not deviate from the nominal width by more than ±1mm. Any variation should be equally distributed with no sudden changes.
c) Set posts plumb within a tolerance of 2 mm in 1 m.

TEMPORARY STORAGE & HANDLING:

a) The material shall deliver and store packed materials in original packing with seals unbroken and labels intact till the same are intended to be used.
b) The Contractor shall take necessary precautions during storage to prevent damage or contamination to the materials by water, foreign matter or other causes.
c) Store materials in a dry, well ventilated, weather tight place, and protect from damage.

CLEANING & PROTECTION:

Cleaning:

a) Remove temporary coverings and protection of adjacent work areas.
b) Clean installed products in accordance with manufacturer’s instructions before acceptance by the Engineer. Do not use chlorine-based or abrasive cleaners.
c) Remove from project site and legally dispose of all construction debris associated with this work.
   i. Protection
   ii. Protect installed product from damage during subsequent construction activities.
MODULAR TROLLEY FENDER SYSTEM

General: Floor mounted SS 304 Grade satn finished Fender railing for made by using SS Top rail Ø 38x1.5 mm Thk. mounted on SS Laser Cut Bracket made of SS Flat 54x12mm thk. The total height of the installed rail including Fender rail will be 250 mm from FFL. Further the Bracket will be mounted on Ø 95 x 6 mm thick SS 304 grade base plate fixed on the floor with 3 nos. of M10 x 100 mm CSK fasteners. The average spacing of brackets will be 1500 mm. The railing will includes all accessories for Fender Rail, No joint will be joined at site without using elbows. All material needs to be in SS 304 grade with satin finish only.

MATERIAL:

All stainless steel pipes and plates shall confirming to ASTM 316 in 18/8 composition 18 will be chromium and Nickel and carbon content will be 0.03 maximum and the relevant clauses associated with this grade of steel to be followed as per criteria / properties mentioned below:
<table>
<thead>
<tr>
<th>Element</th>
<th>316 Grade</th>
<th>Implications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carbon</td>
<td>.08</td>
<td>Increase in percentage decreases the corrosion resistance.</td>
</tr>
<tr>
<td>Silicon</td>
<td>1</td>
<td>-</td>
</tr>
<tr>
<td>Manganese</td>
<td>2</td>
<td>Affects the magnetic Characteristic and hardness of Iron</td>
</tr>
<tr>
<td>Phosphorus</td>
<td>.045</td>
<td>-</td>
</tr>
<tr>
<td>Sulphur</td>
<td>.03</td>
<td>-</td>
</tr>
<tr>
<td>Chromium</td>
<td>16to18</td>
<td>Addition of 12% forms stainless steel from ordinary steel. Removes the corrosive effect of carbon. Forms a passive film which prevents oxidation &amp; consequent corrosion.</td>
</tr>
<tr>
<td>Molybdenum (MOLY)</td>
<td>2 to3</td>
<td>Molybdenum increases the corrosion resistance. It has a superior tensile strength at high temperature as compared to 304 Grade Steel. This element can resist major chemical reaction and thus being a very costly element.</td>
</tr>
<tr>
<td>Nickel</td>
<td>10.0 to14.0</td>
<td>Nickel provides corrosion resistance, increases strength in both high &amp; low temperature, increases toughness in low temperature and lowers the effects of work hardening. Thus higher percentage makes</td>
</tr>
</tbody>
</table>

**Corrosion Resistance**-

**Nickel**: Improves corrosion resistance, formability and weld ability, higher percentage makes Steel more corrosion resistance & superior in quality. Thus as given in table with 10 to 14 % of Nickel AISI 316 is highly non corrosive.

**Surface Finish**: Surface finish of all the stainless steel materials will be in 240 grit satin finish/ matt finish

**Accessories**: Fixing will be done by stainless steel expansion bolts of approved size and make as per direction of Engineer-in Charge and welding to be done by using organ welding rods and surface being duly finished and cleaned by K2 passivation, which is nitric acid plus floric acid solution treatment by which chances of corrosion will be eliminated and any burn out marks on the metal will also be eliminated.

**Coating Mass**: All Stainless steel material will have to be coated by solution of Inox to avoid finger imprints and avoidance of settlement of environment/atmosphere dust. The coating thickness will be 2 to 4 microns.
22. DRY WALL PARTITIONS

a) 122mm Acoustic Dry Wall Partitions:
- Overall Thickness – 122mm
- Acoustic Performance – 56
- Fire Resistance - 60min.
- Max. Reachable Height - 4700mm
- Duty Rating: Severe (Tested as per BS 5234 Part 2)

Components:
- Size of Stud- 41x70x44x0.5mm
- Material- IS513 Y/S-300Mpa

- Size of Floor channel-32x72x32x0.5mm

- Size of Drop ceiling channel- 50x94x50x0.5mm
- Material-IS 513 Y/S-300Mpa
- 70μ Self Adhesive LDPE moisture barrier film
- Jointing compound conforming to ASTM C475
- Size of nogging channel- 40x72x40x0.5 mm
• Material- IS 513 Y/S-300 Mpa

**SPECIFICATION:**

1. 122mm thick dry wall partition which includes inner layer of tapered edge 12.5mm thick acoustic gypsum board panel (conforming to EN 520:2004, Type D) of size 1200x1830mm outer layer of tapered edge 12.5mm thick panel (conforming to EN 520:2004, A1:2009, Type A,D,R,I) of size 1220x2440mm is screw fixed to stud framework of the partition system.
2. 70x0.5mm framework stud {Material- IS 513, Y/S-300Mpa} is placed at 610mm c/c in 72x0.5mm floor and ceiling channel {Material- IS 513, Y/S-300Mpa}.
3. Floor & Deep Ceiling channel is anchored to the floor & True ceiling using plugs or anchor fasteners of Ø8x45mm {Material-IS 513 CR1 grade, Zinc coating, Pull Out Load-6.8kN for M30 concrete grade} at 600mm c/c in zigzag manner.
4. Nogging channel {Material-IS 513,Y/S-300Mpa} of 70x0.5mm width has to be provided at the horizontal joints of the two boards.
5. Floor channel to be wrapped with 70μ Self Adhesive LDPE moisture barrier film to further improve corrosion resistance performance.
6. Gypsum boards to be screw fixed with drywall screws of 25mm and heavy-duty screws 35mm at minimum spacing of 300mm at centre and 150mm at periphery.
7. 50mm Glass wool slab of density 20kg/m³ shall be placed in metal framework. Glass wool holding clip should be used to hold Glass wool slab in its position.
8. Finally square and tapered edges of the boards are to be jointed and finished so as to have a flush look which includes filling and finishing with Jointing compound air dried (conforming to ASTM C475) and fibre tape.
9. The junction of the partition with masonry & all penetration through the partition has to be treated with fire and Acoustic sealant.
10. All other detailing and specifications to be followed as per approved drawing of PMC/AAI/engineer in-charge.
11. For heights between 4200mm and 8000mm, deep ceiling channel should be used at head (subject to deflection criteria).
12. Control joints have to be provided at every 10 Mtr. c/c. along the length of wall.

b) **132mm 2hr Fire Rated Wall Partitions:**

- Overall Thickness – 132mm
- Acoustic Performance – 56 Rw dB
- Fire Resistance - 120min.
- Max. Reachable Height - 4900mm
- Duty Rating: Severe (Tested as per BS 5234 Part 2)

Components:
- Size of Stud- 34x70x36x0.5mm
- Material: IS513 Y/S-300Mpa
- Size of Floor channel: 32x72x32x0.5mm
- Material: IS513 Y/S-300Mpa
- 70μ Self Adhesive LDPE moisture barrier film
- Jointing compound conforming to ASTM C475
- Size of nogging channel: 40x70x40x0.5mm
- Material: IS 513 Y/S-300 Mpa

**SPECIFICATION:**

1. 132mm thick stud partition which includes double layer of tapered edge 15mm thick 2hr fire-rated gypsum board (conforming to IS 2095 Part 1: 2011/ EN520:2004, TYPE-F/ ASTM C1396, TYPE X) of size 1219x2438mm is screw fixed to C-stud.
2. 70x0.5mm C-stud (Material-IS 513, Y/S-300Mpa) placed at 610mm c/c in 72x0.5mm (Material-IS 513, Y/S-300Mpa) floor and ceiling channel.
3. Floor & Ceiling channel is anchored to the floor & True ceiling using plugs or anchor fasteners of Ø8x45mm (Material-IS 513 CR1 grade, Zinc coating, Pull Out Load-6.8kN for M30 concrete grade) at 600mm c/c in zig zag manner.
4. Floor channel to be wrapped with 70μ Self Adhesive LDPE moisture barrier film to further improve corrosion resistance performance.
5. 15mm thick fire stopping board strip of 72 mm width is placed between ceiling channel and RCC ceiling slab to improve fire performance of the system.
6. A noggin channel (Material-IS 513, Y/S-300 Mpa, Finish) of 70x0.5mm width has to be provided at the horizontal joints of the two boards.
7. First layer of gypsum boards to be screw fixed at minimum spacing of 600mm at centre and 600mm at periphery. Second layer to be screw fixed with screws of 50mm at minimum spacing of 300mm at centre and 300mm at periphery.
8. 50mm Glass wool slab of density 20kg/m³ shall be placed in metal framework. Glass wool holding clip should be used to hold Glass wool slab in its position.
9. Finally square and tapered edges of the boards are to be jointed and finished so as to have a flush look which includes filling and finishing with Jointing compound, (Conforms to ASTM C475) and fibre tape.
10. The junction of the partition with masonry & all penetration through the partition has to be treated with fire and acoustic sealant.
11. All other detailing and specifications to be followed as per approved drawings of manufacturer and approved by AAI/PMC or engineer in-charge.
12. For heights between 4200mm and 8000mm, deep ceiling channel should be used at head (subject to deflection criteria).
13. Control joints have to be provided at every 10 Mtr. c/c. along the length of wall.
### 23. TACTILE FLOORING

<table>
<thead>
<tr>
<th>S.No</th>
<th>Test Description</th>
<th>Test Standard</th>
<th>Mandatory Requirement</th>
<th>Test Method</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Dimensional Properties</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Deviation in Length &amp; Width</td>
<td>IS 4457:2007</td>
<td>±0.75%</td>
<td>IS 4457:2007 Annex B /</td>
</tr>
<tr>
<td></td>
<td></td>
<td>ISO 13006/E</td>
<td>±0.6%</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>N 14411 Gr. Bla</td>
<td>±0.1%</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Deviation in Thickness</td>
<td>±5%</td>
<td>±5%</td>
<td>IS 15622:2006 /</td>
</tr>
<tr>
<td>3</td>
<td>Straightness of Sides</td>
<td>±0.5%</td>
<td>±0.5%</td>
<td>ISO 10545-2</td>
</tr>
<tr>
<td>4</td>
<td>Rectangularity</td>
<td>±0.6</td>
<td>±0.6%</td>
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<tr>
<td>5</td>
<td>Surface Flatness</td>
<td>±0.5%</td>
<td>±0.5%</td>
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<tr>
<td>6</td>
<td>Surface Quality</td>
<td></td>
<td>Min 95%</td>
<td>Minimum 95% of the tiles shall be free from visible defects</td>
</tr>
<tr>
<td></td>
<td>Physical Properties</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>7</td>
<td>Water Absorption</td>
<td>&lt;0.5%</td>
<td>&lt;0.5%</td>
<td>IS 4457:2007 Annex C /</td>
</tr>
<tr>
<td></td>
<td></td>
<td>IS 15622:2006</td>
<td>&lt;0.5%</td>
<td>IS 15622:2006 / ISO 10545-3</td>
</tr>
<tr>
<td>8</td>
<td>Mohs Hardness</td>
<td>&gt;3</td>
<td>&gt;6</td>
<td>IS 13630 Part 13 / En101</td>
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<tr>
<td>9</td>
<td>Flexural Strength (Average MOR)</td>
<td>&gt;35N/mm2</td>
<td>&gt;35N/m²</td>
<td>IS 4457:2007 Annex D / IS 15622:2006 / ISO 10545-4</td>
</tr>
<tr>
<td>10</td>
<td>Breaking Strength</td>
<td>&gt;1300N</td>
<td>&gt;1300N</td>
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<tr>
<td></td>
<td>Abrasion Resistance/Deep Abrasion</td>
<td>&lt;175mm³</td>
<td>&lt;144mm³</td>
<td>IS 4457:2007 Annex E / IS 15622:2006</td>
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<tr>
<td>12</td>
<td>Skid Resistance</td>
<td>&gt;0.4</td>
<td>&gt;0.6</td>
<td>ASTM C1028-7</td>
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<tr>
<td>13</td>
<td>Density (gm/cc)</td>
<td>&gt;2</td>
<td>&gt;2.2</td>
<td>ASTM C373 - 16</td>
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<tr>
<td>14</td>
<td>Moisture Expansion</td>
<td>Nil</td>
<td>Nil</td>
<td>ISO 10545-10</td>
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</table>

**Chemical Properties**

- Moisture Expansion: Nil
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<tr>
<td>15</td>
<td>Resistance to Conc. Acid (wt. Loss)</td>
<td>&lt; 1.5%</td>
<td>≤1%</td>
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<tr>
<td>16</td>
<td>Stain Resistance</td>
<td>Resistant</td>
<td>Resistant</td>
<td>Min Class 3</td>
</tr>
<tr>
<td>17</td>
<td>Colour Resistance to UV Light</td>
<td>Resistant</td>
<td>Resistant</td>
<td>DIN 51094</td>
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<tr>
<td>18</td>
<td>Frost Resistance</td>
<td>Frost Proof</td>
<td>Frost Proof</td>
<td>ISO 10545-12</td>
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<tr>
<td>19</td>
<td>Thermal Properties</td>
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<td></td>
<td>ISO 10545-8</td>
</tr>
<tr>
<td>20</td>
<td>Thermal Expansion</td>
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<td>≤9 x 10-6K-1</td>
<td>ISO 10545-8</td>
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<tr>
<td>21</td>
<td>Thermal Shock Resistance</td>
<td>No damage</td>
<td>No damage</td>
<td>No damage</td>
</tr>
</tbody>
</table>

**Size** | **300 x 300 – 15mm**
---|---
Design | Liner & Button
**Mandatory requirements**
- Designed as per Foot Braille
- Slip Resistant Properties
- Vitrified Body
- Highly Stain & Chemical Resistance

Must be in conformance with ADA(Americans with Disabilities Act, USA) & DETR (Dept. of Environment, Transport & the Regions, UK) & RNIB (The Royal National Institute for the Blind, UK)
24. RAISED ACCESS FLOORING

Fiber Reinforced Calcium Sulfate Core:

General: The raised access floor shall be installed by using ‘Fully steel encapsulated panels’, composed of a high density calcium Sulfate core ( +/- 1200 kg / M3), locked into a steel box, manufactured out of ‘Hot Dip galvanised steel’ with a steel thickness of 0.5 mm.

All panels, with the exception of cut perimeter panels or panels provided with cut-outs, shall be completely interchangeable.

The raised access floor surface shall support the following concentrated loads, with a maximum deflection of 2.5 mm.

- 8.74 kN at panel centre
- 7.08 kN diagonal from corner
- 5.8 kN at centre of panel edge.
- Tested according to EN 12825.
The raised access floor shall have a fire reaction classification of ‘Class A1’.

The raised floor surface shall be supported by a ‘galvanised steel substructure’, consisting of adjustable pedestals and clip-on, galvanised steel, roll formed U-shape stringers, all supporting elements (pedestals and stringers) shall be provided with a black PVC washer for sound deadening purposes.

**Floor Panels:** Floor panel size shall be 600 x 600 mm, except for edge panels. Finished panels shall be manufactured within a manufacturing tolerance of 0.3 mm of the nominal size and shall be square within a tolerance of 0.38 mm measured diagonally corner to corner. The top and bottom surface of the panels shall be flat to within a 0.5 mm tolerance measured corner to corner. The total finished panel thickness shall be 31.5 mm.

The floor panels shall consist of a ‘Fibre reinforced Calcium Sulfate core’, with a core density of +/− 1200 kg / M3 and a thickness of 30 mm, locked into a steel box, consisting of a die pressed ‘Hot Dip galvanised steel tray’ bottom and a die pressed ‘Hot Dip galvanised steel lid’ top.

The steel box will be closed at panel edge level, and not at panel bottom, to allow for a completely level panel support on substructure.

Panel closure of bottom tray and top lid, will be through roll forming into triple rolled reinforced side edges, for additional strength and durability.

The panel edge closure of the panel lid will have a roll formed downturned edge, overlapping the steel tray bottom by a minimum of 10 mm and will be turned inward at a 45 degree angle to prevent de-lamination of the panel lid during the first installation and especially when panels are to be removed and reinstalled.

The panel closure provided on the edge of the panel, assures that panel top and panel back will have a perfectly flat steel surface, to assure a perfectly flat and continuous level, preventing lipping of the panels, both on the underneath supporting pedestals, as at the level of joining at the top between 2 adjacent panels.

The floor panels shall support the following concentrated loads, with a maximum deflection of 2.5 mm.

- 8.74 kN at panel centre
- 7.08 kN diagonal from corner
- 5.8 kN at centre of panel edge.
- Tested according to EN 12825.
The raised access floor shall have a fire reaction classification of ‘Class 0’.

**Stringers:** The U-shape, Clip-on stringers, shall have dimensions of 25 mm width by 30 mm height and shall be roll formed out of ‘Hot Dip galvanised steel’, thickness 1 mm.

The bottom edges of the U-shape shall be rolled inward to allow for an easy installation by hand without causing cuts.

The installed stringers shall interlock by means of a simple clip-on system with the pedestal heads, to prevent lateral movement.

The Stringers can be easily removed without the use of any specific tools.

All stringers supplied should be provided with a black PVC washer.

**Pedestals:** The adjustable pedestals shall be manufactured out of steel and shall have a factory-applied corrosion resistance galvanisation finish.

The pedestal bottom plate, of diam 90 mm or 90*90 square, shall be manufactured out of steel, thickness 2.5 mm, and shall be screw fixed to 16 mm diam threaded rods of various lengths to allow for the correct height adjustment of the pedestal heads.

The circular pedestal head plates, diam 90 mm or 90*90 square, shall be manufactured out of steel, thickness 2.5 mm and shall be mechanically fixed to a steel tube, with a diam of 21 mm, and a wall thickness of 2.5 mm.

The bottom part of the steel tube shall be threaded inside, to allow for screw fixing of the bottom part to the top part.

The height adjustment shall be levelled by means of a 16 mm nut, to positively lock the pedestal adjustments in place, without allowing for any lateral movement of the pedestal top.

The pedestal heads shall be provided with special black PVC washers, for sound deadening purposes.

**Factory finished "High Density Calcium Sulfate core panels with ' Hot Dip Galvanised steeltray backing", ‘Tongue & Groove Edge:**

Concrete sealer shall be compatible with pedestal adhesive, see Division 3.

Electrical contractor shall provide necessary material and labor to electrically connect the access floor to the building, see Division 16.

**Environmental Conditions for Storage and Installation:** Area to receive the access floor shall be enclosed and maintained at ambient temperature between 15° to 25° C, and at humidity level
between 40% to 65% relative, and shall remain within these environmental limits throughout installation and occupancy. All laminated floor panels shall be stored and maintained within these limits upon delivery to storage sites. All bare floor panels shall be stored in this environment at least 24 hours before installation begins.

**References:** European Standards EN 12825 “Characteristics and Requirements relevant to 'Raised access floors, designed to be installed inside buildings'”.

**Performance Certification:** Product tests shall be witnessed and certified by independent engineering and testing laboratory based in Italy with a minimum of five years experience testing access floor components. Continuous quality management system according to ISO 9000 including external quality controls at the manufacturing level will be assured.

**Performance Requirements:**

**Pedestals: Axial Load:** Pedestal assembly shall sustain a 45 kN axial load without permanent deformation.

**Corrosion Protection:** Pedestal assemblies shall be manufactured from 'Hot dip galvanised steel' for optimal corrosion protection.

**Floor Panels: Concentrated Load:** Panel shall be capable of supporting a concentrated load of 3600 N placed on a 625 mm² (using a square indentor) anywhere on the panel with a maximum top surface deflection of 2,5 mm. (According to EN standards) Panel shall not exceed a permanent set of 0,25 mm, after the load is removed.

**Ultimate Load:** Panel shall be capable of withstanding an 'Ultimate load' of 5700 N applied onto a 625 mm² area (using square indentor) anywhere on the panel without failure. (According to EN Standards)

**Fire Reaction:** Panels shall be certified “Class A1” according to UN ISO 1182. Tests shall be performed in accordance with UNI ISO 1182, and 'Class A1' certifications from an Italian laboratory has to be provided.

**Design Requirements:** Access floor system, where indicated on the design documents, shall consist of modular and removable "Calcium Sulfate core panels" supported by adjustable height pedestal assemblies forming a modular grid pattern.

Panel shall be easily removed by one person with a lifting device and shall be interchangeable except where cut for special conditions.
Quantities, finished floor heights (FFH) and location of accessories shall be as specified on the contract drawings.

**Submittals for Review**: Detailed 'Technical data sheets ', for each proposed product type, which provide the necessary information to describe the product and its performance.

Test reports, certified by an independent Italian testing laboratory with a minimum of five years experience testing access floor components as specified above (e. g. concentrated load, Ultimate load, fire-resistance, biological safety).

Certifications with regard to ‘Post consumer recycled content’ to be supplied by the raw material manufacturing company.’

**Submittals for Information**: Manufacturer’s installation instructions and guidelines.

Manufacturer’s Owner Manual outlining recommended care and maintenance procedures.

**PRODUCTS**:

Access floor system shall consist of the Calcium Sulfate core raised floor system and panel supported by a stringerless understructure system.

Alternative products shall meet or exceed the feature requirements as indicated herein and must receive prior written approval by the AAI/PMC.

**Support Components: Pedestals**:

Pedestal assemblies shall be manufactured from 'Hot Dip galvanised steel', and shall provide an adjustment range for finished floor heights as indicated in the drawings.

Pedestal assemblies shall provide a means of levelling and locking the assembly at a selected height, which requires deliberate action to change height setting and prevents vibration displacement.

Hot Dip Galvanized steel pedestal heads and bottom plates, shall be fixed to a threaded rod or to the pedestal tube that includes a specially designed adjusting nut.

Galvanized pedestal base assembly shall consist of a formed steel plate, thickness 2,5 mm with a diameter of 90 mm or 90*90 square of bearing area, fixed to a 21 x 2,5 mm steel tube or M16 threaded rod.

Pedestals head plates shall be designed to receive 'Screw down - tubular stringers.'
**Stringers:** Stringers are recommended for floor heights of more than 500 mm. Lower floor systems can be designed as a stringer less floor system to provide easy access to the floor void. Substructure system, installed with the use of horizontal stringers offers improved performance with regard to resistance to concentrated load and ultimate load resistance.

Stringers shall support each edge of panel.

Steel stringer shall be galvanized.

Stringers shall be individually and rigidly screw-fixed to the pedestal head.

Stringer grid shall be 600 x 600 mm ensuring maximum lateral stability in all directions.

**Panel Components: Floor Panels:**

**Calcium Sulfate core panels, with steeltray backing:** Panels shall be manufactured from 'Calcium Sulfate core panels', with a panel thickness of 3 mm. Panels shall be covered with a 0.5 mm thick 'Hot Dip galvanised steeltray' on the bottom side for protecting the panel against humidity and improved load bearing performances. The 'Hot Dip galvanised steeltray backing' shall have a vertical upstand of minimum 12 mm on all 4 sides for improved loadbearing performances. Paneledges shall be finished with a 0.5 mm ABS edge. The ABS edge shall be nodulated to avoid friction noise.

Panel size: 600 x 600 mm

The top surface shall be factory finished with 'Anti Static HPL' or 'Anti Static PVC', color to be selected by AAI/PMC.

**Accessories:**

Power, Voice & Data Servicenters shall be provided in locations as detailed on the drawings.

Provide manufacturer’s standard steps, ramps, fascia plate, perimeter support, and grommets where indicated on the drawings.

When applicable provide manufacturer’s standard underfloor air systems components (including, grilles, diffusers and perforated floor panels) where indicated on the drawings.

**Finishes:** Finish the surface of floor panels with floor covering material as indicated on the drawings. All storage and installation areas furnished with laminated floor panels must be maintained at ambient temperature between 15° to 25° C and at humidity level between 40% to 65% relative and shall remain within these ranges through installation and occupancy.

**Fabrication Tolerances:**
Floor panel thickness at corners: +/- 0,3 mm

Floor panel straightness of the surface: +/- 0,3 mm

Floor panel width or length of required size: +/- 0,2 mm

Floor panel squareness tolerance: +/- 0,4 mm

Specifications in accordance to DIN EN 12825 certified by relevant quality assurance documents e. g. internal quality control documents according to ISO certification ISO 9001ff.

**EXECUTION:**

**Preparation:**

Examine structural subfloor for unevenness, irregularities and dampness that would affect the quality and execution of the work. Do not proceed with installation until structural floor surfaces are level, clean, and dry as completed by others.

Concrete sealers, if used, shall be identified and proven to be compatible with pedestal adhesive. Verify that adhesive achieves bond to slab before commencing work.

Verify dimensions on contract drawings, including level of interfaces including abutting floor, ledges and doorsills.

The EPC Contractor shall provide clear access, dry subfloor area free of construction debris and other trades throughout installation of access floor system. Area to receive access floor shall be enclosed and be maintained at a temperature range of 15° to 25° C and a humidity range of 45 % to 65 % relative. All laminated floor panels shall be stored and maintained in this environment upon delivery to storage sites. Bare access floor panels must be stored in this environment at least 24 hours before installation begins.

**Installation:** Pedestal locations shall be established from approved shop drawings so that mechanical and electrical work can be installed without interfering with pedestal installation.

Installation of access floor shall be coordinated with other trades to maintain the integrity of the installed system. All traffic on access floor shall be controlled by access floor installer. No traffic but that of access floor installers shall be permitted on any floor area for 24 hours to allow the pedestal adhesive to set. Access floor panels shall not be removed by other trades before acceptance.

Floor system and accessories shall be installed under the supervision of the manufacturer’s authorized representative and according to manufacturer’s recommendations.
No dust or debris producing operations by other trades shall be allowed in areas where access floor is being installed to ensure proper bonding of pedestals to subfloor.

Access floor installer shall keep the subfloor broom clean as installation progresses.

Partially complete floors shall be braced against shifting to maintain the integrity of the installed system where required.

Additional pedestals as needed shall support panels where floor is disrupted by columns, walls, and cut-outs.

Under structure shall be aligned such that all uncut panels are interchangeable and fit snugly but do not bind when placed in alternate positions.

Finished floor shall be level, not varying more than 2,0 mm in 0,1m or 4,0 mm in 1,00 m or 12,0 mm in 10 m in accordance to DIN 18202.

25. VITRIFIED TILES

ACID OR ALKALI RESISTANT TILES:

**Manufacture and Finish:** The tiles shall be of vitreous ware and free from deleterious substances. The iron oxide content allowable in the raw material shall not exceed two percent. The tiles shall be vitrified at the temperature of 11000C and above and shall be kept unglazed. The finished, tile, when fractured shall appear fine grained in texture, dense and homogenous. The tiles shall be sound, true to slope, flat and free from flows and manufacturing defects affecting their utility. The tiles shall be conforming to IS 4457. The tiles to be tested for water absorption, compressive strength, acid resistance as per IS 4457. Sampling procedure for acceptance tests and criteria for conformity to be as per IS 4457. The tiles shall be of required colour.

**Dimensions and Tolerances:** Ceramic unglazed vitreous acid-resistant tiles shall be made in three sizes namely 98.5 X 98.5 mm, 148.5 X 148.5 mm and 198.5 X 198.5 mm. They shall be available in the following thickness: 35, 30, 25, 20 and 15 mm. The depth of the grooves on the underside of the tile shall not exceed 3 mm. Tolerance on length, breadth and thickness of tiles shall be + 2 percent.

**Shape:** The tiles shall be square shaped. Half tiles rectangular in shape shall also be available. Half tiles for use with full tiles shall have dimensions which shall be such as to make two half tiles, when joined together, match with the dimension of full tile. The shape of tiles other than square shall be as agreed to between the purchaser and the manufacturer. Tiles shall be checked for squareness and warp as per IS 4457.
Performance Requirements: The tiles when tested in accordance with method given in IS 4457, shall conform to requirement specified in the code (IS 4457).

Loss in Abrasion: The maximum percentage of loss in abrasion of the ceramic unglazed vitreous acid resistant tiles determined in accordance with the procedure laid down in IS 1237, shall be as mentioned in IS 4457.

Marking: Tiles shall be legibly marked on the back with the name of the manufacturer or his trade mark. Manufacturer’s batch number and year of manufacture. Each tile may also be marked with the ISI certification mark.

Preparation of Surface and Laying: RCC column / wall on which the tiles are to be laid shall be cleaned, wetted and mopped. The backing mortar for the tiles shall be with cement mortar 1:3 (1 cement: 3 coarse sand). The average thickness of backing mortar shall be 12mm thick plaster of cement mortar 1:3 shall be applied and allowed to harden. The plaster shall be roughened with wire brushes or by scratching diagonal at closed intervals. Over this backing mortar, dado / skirting shall be fixed using average 6 mm thick high polymer modified quick set adhesive of Type II, as per IS: 15477. Tiles shall be soaked in water washed clean and shall be fixed with the tile adhesive. The tiles shall be tamped and corrected to proper plane & lines. The tiles shall be set in a required pattern and jointed. The joints shall be 3mm thick. Top of skirting or dado shall be truly horizontal and joints truly vertical except where otherwise indicated. Odd size/ cut size of tile shall be adjusted at bottom to take care of slope of the flooring. Skirting and dado shall rest on the top of the flooring. Where full size tiles cannot be fixed these shall be cut (sawn) to the required size & their edges rubbed smooth. Preparation of surface and laying to be according to para 11.15.4, except the cement used to be acid and or alkali resistant cement and cement mortar to be used to be acid and or Alkali resistant mortar. Thickness of bedding of mortar for flooring to be 10 mm or specified on the item and for dado/skirting to be 12 mm or specified on item.

Pointing and Finishing: As per para 11.15.5, except that cement used for pointing to be acid and or alkali resistant cement.

PRESSED CERAMIC TILES

The tiles shall be of approved make and shall generally conform to IS 15622. They shall be flat, and true to shape and free from blisters crazing, chips, welts, crawling or other imperfections detracting from their appearance. The tiles shall be tested as per IS 13630.

Classification and Characteristics of pressed ceramic tiles shall be as per IS 13712.

The tiles shall be square or rectangular of nominal size. Table 1,3,5, and 7 of IS 15622 give the modular preferred sizes and table 2,4,6 and 8 give the most common non modular sizes. Thickness shall be specified by the manufacturer. It includes the profiles on the visible face and on the rear side.
Manufacturer/supplier and party shall choose the work size of tiles in order to allow a nominal joint width upto 2mm for unrectified floor tiles and upto 1mm for rectified floor tiles. The joint in case of spacer lug tile shall be as per spacer. The tiles shall conform to table10 of IS 15622 with water absorption 3 to 6% (Group BII). The top surface of the tiles shall be glazed. Glaze shall be either glossy or matt as specified. The underside of the tiles shall not have glaze on more than 5% of the area in order that the tile may adhere properly to the base. The edges of the tiles shall be preferably free from glaze. However, any glaze if unavoidable, shall be permissible on only upto 50 per cent of the surface area of the edges.

**Coloured Tiles:** Only the glaze shall be coloured as specified. The sizes and specifications shall be the same as for the white glazed tiles.

**Decorative Tiles:** The type and size of the decorative tiles shall be as follows:

i. Decorated white back ground tiles: The size of these tiles shall be as per IS 15622.

ii. Decorated and having coloured back-ground: The sizes of the tiles shall be as per IS 15622.

**Preparation of Surface and Laying:** Base concrete or the RCC slab on which the tiles are to be laid shall be cleaned, wetted and mopped. The bedding for the tile shall be with cement mortar 1:4 (1 cement : 4 coarse sand) or as specified. The average thickness of the bedding shall be 20 mm or as specified while the thickness under any portion of the tiles shall not be less than 10 mm.

Mortar shall be spread, tamped and corrected to proper levels and allowed to harden sufficiently to offer a fairly rigid cushion for the tiles to be set and to enable the mason to place wooden plank across and squat on it.

Over this mortar bedding neat grey cement slurry of honey like consistency shall be spread at the rate of 3.3 kg of cement per square metre over an area upto one square metre. Tiles shall be soaked in water washed clean and shall be fixed in this grout one after another, each tile gently being tapped with a wooden mallet till it is properly bedded and in level with the adjoining tiles. The joints shall be kept as thin as possible and in straight lines or to suit the required pattern.

The surface of the flooring during laying shall be frequently checked with a straight edge about 2 m long, so as to obtain a true surface with the required slope. In bath, toilet W.C. kitchen and balcony/verandah flooring, suitable tile drop or as shown in drawing will be given in addition to required slope to avoid spread of water. Further tile drop will also be provided near floor trap.

Where full size tiles cannot be fixed these shall be cut (sawn) to the required size, and their edge rubbed smooth to ensure straight and true joints.

Tiles which are fixed in the floor adjoining the wall shall enter not less than 10 mm under the plaster, skirting or dado.
After tiles have been laid surplus cement slurry shall be cleaned off.

**Material:**
The tiles shall be chamfered, double charged, unglazed, ceramics in matt finished tiles of nominal size of premium quality. The tiles shall be of approved make and conforming to the standards. The size and thickness of tiles shall be as per the architectural requirements. They shall be flat, and true to shape and free from blisters, crazing, welts, crawling or other imperfection detracting from their appearance. The tiles shall be tested as per standard acceptance criteria mentioned.

The tiles shall be square of nominal size as per architectural drawings and approved by the engineer-in-Charge. The thickness shall be minimum 9.8mm as specified.

The underside of the tiles shall not have any finish in order that the tiles may adhere properly to the base. The edges of the tiles shall be preferably free from polish. However, any finish, if unavoidable shall be permissible on only up to 50 percent of the surface area of the edges.

**Pointing and Finishing:** The joints shall be cleaned off the grey cement slurry with wire/coir brush or trowel to a depth of 2 mm to 3 mm and all dust and loose mortar removed. Joints shall then be flush pointed with white cement added with pigment if required to match the colour of tiles. Where spacer lug tiles are provided, the half the depth of joint shall be filled with polysulphide or as specified on top with under filling with cement grout without the lugs remaining exposed. The floor shall be kept wet for 7 days. After curing, the surface shall be washed and finished clean. The finished floor shall not sound hollow when tapped with a wooden mallet.

**RESSED CERAMIC TILE**

The tiles shall conform to Table 12 of IS 15622 (Tiles with water absorption $E \leq 0.08$ per cent Group B1a) and the joint thickness in flooring shall not be more than 1mm.

**Rate:** The rate for flooring shall include the cost of all materials and labour involved in all the operations described above. Nothing extra shall be paid for the use of cut (sawn) tiles in the work.

**Fixing of tile flooring with cement based high polymer modified quick set adhesive (water based):**

When tile flooring is to be laid over the existing flooring without dismantling old flooring it can be laid with adhesive. The old flooring shall be thoroughly cleaned and checked for undulations, if any shall be rectified with cement mortar 1:3 (1 cement: 3 coarse sand). Old cement concrete surface shall be hacked and cleaned off to have proper bond with the old surface.
High polymer modified quick set tile adhesive (conforming to IS 15477) shall be thoroughly mixed with water and a paste of zero slump shall be prepared so that it can be used with in 1.5 to 2 hours. It shall be spread over an area not more than one sqm at one time. Average thickness of adhesive shall be 3 mm. The adhesive so spreaded shall be combed using suitable trowel. Tiles shall be pressed firmly in to the position with slight twisting action checking it simultaneously to ensure good contact gently being tapped with wooden mallet till it is properly backed with adjoining tiles. The tiles shall be fixed within 20 minutes of application of adhesive. The surplus adhesive from the joints, surface of the tiles shall be immediately cleaned.

The surface of the flooring shall be frequently checked during laying with straight edge of above 2m long so as to attain a true surface with required slope.

Where spacer lugs tiles are provided these shall be filled with grout with lugs remaining exposed.

Where full size tile cannot be fixed these shall be cut (sawn) to the required size and edges rubbed smooth to ensure straight and true joints. Tiles which are fixed in floor adjoining to wall shall enter not less than 10 mm under plaster, skirting or dado.

**Preparation of Surfaces:** The joints shall be raked out to a depth of at least 15 mm in masonry walls.

In case of concrete walls, the surface shall be hacked and roughened with wire brushes. The surface shall be cleaned thoroughly, washed with water and kept wet before skirting is commenced.

**Laying:** 12 mm thick plaster of cement mortar 1:3 (1 cement : 3 coarse sand) mix of as specified shall be applied and allowed to harden. The plaster shall be roughened with wire brushes or by scratching diagonal at closed intervals.

The tiles should be soaked in water, washed clean, and a coat of cement slurry applied liberally at the back of tiles and set in the bedding mortar. The tiles shall be tamped and corrected to proper plane and lines. The tiles shall be set in the required pattern and jointed. The joints shall be as fine as possible. Top of skirting or dado shall be truly horizontal and joints truly vertical except where otherwise indicated. Odd size/cut size of tile shall be adjusted at bottom to take care of slope of the flooring.

Skirting and dado shall rest on the top of the flooring. Where full size tiles cannot be fixed these shall be cut (sawn) to the required size and their edges rubbed smooth. Skirting /dado shall not project from the finished “surface of wall” by more than the tile thickness, undulations if any shall be adjusted in wall.
Curing and Finishing: The joints shall be cleaned off the grey cement grout with wire/coir brush or trowel to a depth of 2 mm to 3 mm and all dust and loose mortar removed. Joints shall then be flush pointed with white cement added with pigments if required to match the colour of tiles. The work shall then be kept wet for 7 days.

After curing, the surface shall be washed and finished clean. The finished work shall not sound hollow when tapped with a wooden mallet.

Reference Standards:

<table>
<thead>
<tr>
<th>Code /Parameters</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>I.S. 383 -1970</td>
<td>Specification for coarse and fine aggregates</td>
</tr>
<tr>
<td>I.S. 2250 :1981</td>
<td>Tests for mortar</td>
</tr>
<tr>
<td>I.S. 2386 -1963</td>
<td>Method of test of aggregates in concrete</td>
</tr>
<tr>
<td>I.S. 8042 -1989</td>
<td>Specification for white port land cement</td>
</tr>
<tr>
<td>I.S. 8112 -1989</td>
<td>Ordinary portland cement 43 grade</td>
</tr>
<tr>
<td>I.S. 456 &amp; I.S.3025</td>
<td>Water</td>
</tr>
<tr>
<td>IS : 15622</td>
<td>Pressed Ceramic Tiles – Specification (Vitrified tiles shall confirm to Table-12 of IS :15622)</td>
</tr>
<tr>
<td>Antiskid VitrifiedTiles</td>
<td>Shall conform to EN-176 Group B1a and ISO 13006 stds.</td>
</tr>
<tr>
<td>Deviation in length</td>
<td>Method of testing shall be as per EN98</td>
</tr>
<tr>
<td>Deviation in thickness</td>
<td>Method of testing shall be as per EN98</td>
</tr>
<tr>
<td>Straightness of sides</td>
<td>Method of testing shall be as per EN98</td>
</tr>
<tr>
<td>Rectangularity</td>
<td>Method of testing shall be as per EN98</td>
</tr>
<tr>
<td>Surface flatness</td>
<td>Method of testing shall be as per EN98</td>
</tr>
<tr>
<td>Water absorption</td>
<td>Shall not be greater than 0.05 % (Method of testing shall be as per EN99)</td>
</tr>
<tr>
<td>Moh's hardness</td>
<td>Shall not be less than 6 (Method of testing shall be as per EN101)</td>
</tr>
<tr>
<td>Flexural strength</td>
<td>Shall not be less than 27N/sqmm. (Method of testing shall be as per EN100)</td>
</tr>
<tr>
<td>Abrasion resistance</td>
<td>(Method of testing shall be as per EN102)</td>
</tr>
<tr>
<td>Skid resistance (coefficient)</td>
<td>0.6 (Method of testing shall be as per ASTM C-1028)</td>
</tr>
<tr>
<td>Breaking strength</td>
<td>Shall not be less than 2500 N (Method of testing shall be as per ASTM C-678)</td>
</tr>
<tr>
<td>Density</td>
<td>Shall not be less than 2 gm/cm$^3$ (Method of testing shall be as per DIN -51082)</td>
</tr>
<tr>
<td>Frost resistance</td>
<td>Shall be frost proof (Method of testing shall be as per EN -202)</td>
</tr>
<tr>
<td>Property</td>
<td>Requirements</td>
</tr>
<tr>
<td>--------------------------</td>
<td>---------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Chemical resistance</td>
<td>Shall be resistant to chemicals (Method of testing shall be as per EN -106)</td>
</tr>
<tr>
<td>Thermal shock resistance</td>
<td>Shall be resistant to thermal shocks (Method of testing shall be as per EN -104)</td>
</tr>
<tr>
<td>Colour resistance</td>
<td>No damage (Method of testing shall be as per DIN -51094)</td>
</tr>
<tr>
<td>Thermal expansion</td>
<td>Shall not be more than $9 \times 10^{-6}$ (Method of testing shall be as per EN -103)</td>
</tr>
<tr>
<td>Stain resistance</td>
<td>Shall be stain resistant (Method of testing shall be as per ISO 10545-14)</td>
</tr>
<tr>
<td>Glossiness</td>
<td>Desired reflection effect as required by AAI/PMC (Method of testing shall be with the use of glossometer)</td>
</tr>
</tbody>
</table>
Part D : FURNITURE WORKS

The furniture layout is indicative and the EPC bidder shall submit the final furniture layout for approval from AAI/PMC. All furniture works to be approved from AAI/PMC prior finalization.

• Reception Table

Reception table of 3225mm (L) X 700mm(W) X 800(H)

Customized Size- Top panel should be of two layers bottom layer to be with ply board upper layer with 18mm thick polished engineered stone on the top, with membrane finish, the edging shall be of matching with the top color tone. The table should have another elevated top of 3000mm(L) X 250mm(W) with Glass top. In the understructure the side panel legs shall be MFC covered with 45 mm MDF Profile with veneer finish at vertical edges, connected to the top panel by minifix & wooden dowels. Adjustable stud. The modesty shall be 18 mm thick MFC with curved shape. Connected to top & side panels with minifix fitting & wooden dowels. With completely concealed wire management with vertical wire uptake from floor via middle leg having removable cover one side and wire separator for data and wire separation, segregates to horizontal cable tray below flipper including provision of all Electrical Switch, Socket, Flap out Cover, accessories completes satisfying to Electrical/LV/AV. The work shall be carried out as per the directions received from AAI/PMC. The table shall have pedestal storages in 18mm thick laminate of size 600x480x680mm. The pedestals shall have central locking mechanism. The drawers and filing box shall be mounted on telescopic ball bearing slides. The pencil tray shall be made of 2mm molded HIPS and shall be fitted inside the first drawer. It should freely slide in horizontal direction. The pencil tray shall have necessary compartments (Minimum 3 compartments) for keeping stationary items. The pedestals shall have central locking mechanism with D-Shape SS handles. The units are assembled by knock down fittings such as Minifix & dowels.

• Cabin Tables
  o Type 1:2800 mm L x 750mm W x 750mm Ht \with Side return L 1000xD 450xH 730mm& back storage L 1500xD 450mmxH 730mm.

Worktop shall be made up of 25-30mm thick E1 grade pre-laminated particle board of approved shade. The bottom shall have backing laminate. The Working & Non-working edges shall be provided with hot pressed 2mm thick edging using special hot melt glue at high temperature. All the worktops shall have M6 metallic inserts pre fitted at precise locations.
with CNC machines for fitting the brackets and supports. The table top shall have round seamless extension design.

All the exposed edges are with 2mm ABS edge Imported banding & sealed edges are with 0.8mm thick Imported edge banding. The top, side and hinged shutters are sealed with 2mm thick ABS edge banding.

Understructure - Steel Straight legs of section 50x30mm with leveling composes of leg, base, glide, accent plate and end bracket. Steel Straight legs with leveling apply powder coated finish. Leg composes of vertical tubes and cross tube beam. Vertical tube made of roll forming with average thickness 2mm, and cross beam made of steel tube with thickness 3mm. Base made of plastic injection with Nylon, 30% fiber glass, and in middle of base applies with M8 metal inserter. Glide made of plastic injection with Nylon 30% fiber glass. Accent plate made of 1.6mm SPCC steel with Powder coated finish. End bracket made of 5mm SPCC steel with epoxy finished. Base, glide, accent plate and end bracket deliver together with Steel straight-leg.

Mobile metal pedestrian cabinet made out of metal powder coated supports A4 and F4 file storage comes with pencil tray, equipped with weight-rated castors and full extension ball bearing slides for all drawers, anti tilt system security, fifth castor to support lower drawer weight, increased frame’s structural stability, and available option of key lock or combination lock. The 3-drawer unit shall be of size 500x400x600ht.

Gable Ends & Modesty: Gable ends shall be provided for supporting Worktop wherever required, on either end, as part of the partition, capable of supporting the table top & shall be made of E1 grade 18mm thick pre-laminated particle board with straight edge. Gable end height – 600-737mm.00-737mm. Modesty Panel Height 400-500mm.

Side Storage: Made of E1 grade 18mm pre-laminated board Hinged / Sliding Shutter / Door Free standing storage units of size as specified resting on floor having top, sides, back in pre-laminated board. The cabinet / credenza shall be provided with CAM Locks. The handles shall be PVC molded and shall be flush fitted. The cabinets / credenza shall be provided with 4 Nos. M10 levelers for height adjustment up to 20mm. The shutters shall have self-closing hinges. Electrical: Access flap, w450 with metal powder coated box and plate on side storage for electrical provision.

Product should be Bifma certified & Greenguard Certified.

○ Type 2:- 2100 mmL x 750mm W x750mm Ht with Side storage 900-1000mm x450mm x730mm
Worktop shall be made up of 25-30mm thick E1 grade pre-laminated particle board of approved shade. The bottom shall have backing laminate. The Working & Non-working edges shall be provided with hot pressed 2mm thick edging using special hot melt glue at high temperature. All the worktops shall have M6 metallic inserts pre fitted at precise locations with CNC machines for fitting the brackets and supports. The table top shall have round seamless extension design.

All the exposed edges are with 2mm edge Imported banding & sealed edges are with 0.8mm thick Imported edge banding. The top, side and hinged shutters are sealed with 2mm thick edge banding.

Understructure - Steel A legs of section 50x30mm with leveling composes of leg, base, glide, accent plate and end bracket. Steel A legs with leveling applies powder coated finish. Leg composes of vertical tubes and cross tube beam. Vertical tube made of roll forming with average thickness 2mm, and cross beam made of steel tube with thickness 3mm. Base made of plastic injection with Nylon, 30% fiber glass, and in middle of base applies with M8 metal inserter. Glide made of plastic injection with Nylon 30% fiber glass. Accent plate made of 1.6mm SPCC steel with Powder coated finish. End bracket made of 5mm SPCC steel with epoxy finished. Base, glide, accent plate and end bracket deliver together with Steel A-leg.

Mobile metal pedestal cabinet made out of metal powder coated, supports A4 and F4 file storage, comes with pencil tray, equipped with weight-rated castors and full extension ball bearing slides for all drawers, anti tilt system security, fifth castor to support lower drawer weight, increased frame’s structural stability, available option of key lock or combination lock. The 3-drawer unit shall be of size 500x400x600ht.

Gable Ends&modesty: Gable ends shall be provided for supporting Worktop wherever required, on either end, as part of the partition, capable of supporting the table top & shall be made of E1 grade 18mm thick pre-laminated particle board with straight edge. Gable end height – 600-737mm.00-737mm. Modesty Panel Height 400-500mm.

Side Storage : Made of E1 grade18mm pre-laminated board Hinged / Sliding Shutter / Door Free standing storage units of size as specified resting on floor having top,sides,back in prelam. The cabinet / credenza shall be provided with CAM Locks. The handles shall be PVC Moulded and shall be flush fitted. The cabinets / credenzashall be provided with 4 Nos. M10 levelers for height adjustment upto 20mm. The shuttersshall have self-closing hinges. Electrical: Access flap, w450 with metal powder coated box and plate on side storage for electrical provision.

Product should be Bifma certified &Greengaurd Certified.
○ Type 3: 1800 mmL x 600mm W x750mm Ht with Side storage 1000x450 x730mm

Worktop shall be made up of 25-30mm thick E1 grade pre-laminated particle board of approved shade. The bottom shall have backing laminate. The Working & Non-working edges shall be provided with hot pressed 2mm thick ABS edging using special hot melt glue at high temperature. All the worktops shall have M6 metallic inserts pre fitted at precise locations with CNC machines for fitting the brackets and supports. The table top shall have round seamless extension design.

All the exposed edges are with 2mm edge Imported banding & sealed edges are with 0.8mm thick ABS Imported edge banding. The top, side and hinged shutters are sealed with 2mm thick ABS edge banding.

Understructure - Steel Straight legs of section 25-30 x 80-85mm duly powder coated with leveling composes of leg, base, glide and end bracket. Leg composes of vertical tubes and cross tube beam. Vertical tube made of roll forming with average thickness 1.5-2mm, and cross beam made of steel tube with thickness 2-3mm. Glide made of plastic injection with Nylon 30% fiber glass.

Mobile metal pedestal cabinet made out of metal powder coated, supports A4 and F4 file storage, comes with pencil tray, equipped with weight-rated castors and full extension ball bearing slides for all drawers, anti tilt system security, fifth castor to support lower drawer weight, increased frame’s structural stability, available option of key lock or combination lock. The 3-drawer unit shall be of size 500x400x600ht.

Gable Ends&modesty : Gable ends shall be provided for supporting Worktop wherever required, on either end, as part of the partition, capable of supporting the table top & shall be made of 1.2mm sheet perforated CRCA powder coated. Gable end height – 600-737mm. Modesty Panel Height 400-500mm.

SideStorage : Made ofCRCA powder coated Hinged / Sliding Shutter / Door Free standing storage units of size as specified resting on floor having top,sides,back in metal powder coated finish. The cabinet / credenza shall be provided with CAM Locks. The handles shall be PVC Molded and shall be flush fitted. The cabinets / credenza shall be provided with 4 Nos. M10 levelers for height adjustment upto 20mm. The shutters shall have self-closing hinges. Electrical: Access flap, w450 with metal powder coated box and plate on side storage for electrical provision.

Product should be Bifma certified & Greenguard Certified.

○ Type 4: 2000 mmL x 900mm W x750mm Ht with Side storage 900x450 x730mm
Worktop shall be made up of 25-30mm thick E1 grade pre-laminated particle board of approved shade. The bottom shall have backing laminate. The Working & Non-working edges shall be provided with hot pressed 2mm thick ABS edging using special hot melt glue at high temperature. All the worktops shall have M6 metallic inserts pre fitted at precise locations with CNC machines for fitting the brackets and supports. The table top shall have round seamless extension design.

All the exposed edges are with 2mm edge Imported banding & sealed edges are with 0.8mm thick ABS Imported edge banding. The top, side and hinged shutters are sealed with 2mm thick ABS edge banding.

Understructure - Steel Straight legs of section 25-30 x 80-85mm duly powder coated with leveling composes of leg, base, glide and end bracket. Leg composes of vertical tubes and cross tube beam. Vertical tube made of roll forming with average thickness 1.5-2mm, and cross beam made of steel tube with thickness 2-3mm. Glide made of plastic injection with Nylon 30% fiber glass.

Mobile metal pedestal cabinet made out of metal powder coated supports A4 and F4 file storage comes with pencil tray, equipped with weight-rated castors and full extension ball bearing slides for all drawers, anti tilt system security, fifth castor to support lower drawer weight, increased frame’s structural stability, and available option of key lock or combination lock. The 3-drawer unit shall be of size 500x400x600ht.

Gable Ends & modesty: Gable ends shall be provided for supporting Worktop wherever required, on either end, as part of the partition, capable of supporting the table top & shall be made of 1.2mm thick sheet perforated CRCA powder coated.

Side Storage: Made of CRCA powder coated Hinged / Sliding Shutter / Door Free standing storage units of size as specified resting on floor having top, sides, back in metal powder coated finish. The cabinet / credenza shall be provided with CAM Locks. The handles shall be PVC Moulded and shall be flush fitted. The cabinets / credenza shall be provided with 4 Nos. M10 levelers for height adjustment upto 20mm. The shutters shall have self-closing hinges.

Electrical: Access flap, w450 with metal powder coated box and plate on side storage for electrical provision.

Product should be Bifma certified & Greenguard Certified.

○ Type 5: 2100 mmL x 600mm W x 750mm Ht with Side storage 1200x450 x 730mm

Worktop shall be made up of 25-30mm thick E1 grade pre-laminated particle board of approved shade. The bottom shall have backing laminate. The Working & Non-working edges
shall be provided with hot pressed 2mm thick ABS edging using special hot melt glue at high temperature. All the worktops shall have M6 metallic inserts pre fitted at precise locations with CNC machines for fitting the brackets and supports. The table top shall have round seamless extension design.

All the exposed edges are with 2mm edge Imported banding & sealed edges are with 0.8mm thick ABS Imported edge banding. The top, side and hinged shutters are sealed with 2mm thick ABS edge banding.

Understructure - Steel Straight legs of section 30x60 mm duly powder coated with leveling composes of leg, base, glide and end bracket. Leg composes of vertical tubes and cross tube beam. Vertical tube made of roll forming with average thickness 1.5-2mm, and cross beam made of steel tube with thickness 2-3mm. Glide made of plastic injection with Nylon 30% fiber glass.

Mobile metal pedestal cabinet made out of metal powder coated, supports A4 and F4 file storage, comes with pencil tray, equipped with weight-rated castors and full extension ball bearing slides for all drawers, anti tilt system security, fifth castor to support lower drawer weight, increased frame’s structural stability, available option of key lock or combination lock. The 3-drawer unit shall be of size 500x400x600ht.

Gable Ends&modesty: Gable ends shall be provided for supporting Worktop wherever required, on either end, as part of the partition, capable of supporting the table top & shall be made of 1.2mm thick sheet perforated CRCA powder coated.

SideStorage : Made of CRCA powder coated Hinged / Sliding Shutter / Door Free standing storage units of size as specified resting on floor having top,sides,back in metal powder coated finish. The cabinet / credenza shall be provided with CAM Locks. The handles shall be PVC Molded and shall be flush fitted. The cabinets / credenza shall be provided with 4 Nos. M10 levelers for height adjustment upto 20mm. The shutters shall have self-closing hinges.

Electrical: Access flap, w450 with metal powder coated box and plate on side storage for electrical provision.

Product should be Bifma certified & Greenguard Certified.

- Type 6:1500 mmL x 750mm W x750mm Ht with Side storage 900x450 x730mm & back storage of L3500xW450xH750mm

Worktop shall be made up of 25-30mm thick E1 grade pre-laminated particle board of approved shade. The bottom shall have backing laminate. The Working & Non-working edges shall be provided with hot pressed 2mm thick ABS edging using special hot melt glue at high
temperature. All the worktops shall have M6 metallic inserts pre fitted at precise locations with CNC machines for fitting the brackets and supports. The table top shall have round seamless extension design.

All the exposed edges are with 2mm edge imported banding & sealed edges are with 0.8mm thick ABS imported edge banding. The top, side and hinged shutters are sealed with 2mm thick edge banding.

Understructure - Steel straight legs of section 30x60 mm duly powder coated with leveling composes of leg, base, glide and end bracket. Leg composes of vertical tubes and cross tube beam. Vertical tube made of roll forming with average thickness 1.5-2mm, and cross beam made of steel tube with thickness 2-3mm. Glide made of plastic injection with Nylon 30% fiber glass.

Mobile metal pedestal cabinet made out of metal powder coated, supports A4 and F4 file storage, comes with pencil tray, equipped with weight-rated castors and full extension ball bearing slides for all drawers, anti tilt system security, fifth castor to support lower drawer weight, increased frame’s structural stability, available option of key lock or combination lock. The 3-drawer unit shall be of size 500x400x600ht.

Gable Ends & modesty: Gable ends shall be provided for supporting Worktop wherever required, on either end, as part of the partition, capable of supporting the table top & shall be made of 1.2mm thick sheet perforated CRCA powder coated.

Side Storage: Made of CRCA powder coated Hinged / Sliding Shutter / Door Free standing storage units of size as specified resting on floor having top, sides, back in metal powder coated finish. The cabinet / credenza shall be provided with CAM Locks. The handles shall be PVC molded and shall be flush fitted. The cabinets / credenza shall be provided with 4 Nos. M10 levelers for height adjustment upto 20mm. The shutters shall have self-closing hinges.

Electrical: Access flap , w450 with metal powder coated box and plate on side storage for electrical provision.

Product should be Bifma certified & Greenguard Certified.

* Workstations with Long storage

Table 1050 (L)X600 (D) x 737-750mm (H).

The size of the main working top would be: 1050 (L)X600 (D). The workstations should be desk based workstations. The side storage of each workstation should be 1050mmL x 450mm D x 702 mm Ht and has a seat on top at one end. The seat consists of seat cushion made of PU
foam upholstered with fabric. Fabric privacy Screen is provided between workstations for privacy having height of 300mm.

The divider screen of 1050mm shall be divided in soft pinup fabric and marker board. Height of the divider screen shall be 450mm.

The worktop should be made of 25 mm thick pre laminated particle board with its edges finished with 2mm thick ABS edge band. The Legs are made of MS Steel in 60mm x 30mm Section with thickness of 1.2mm. The cross members are made from 1.2mm thick sheet M.S. tubes. They are powder coated. All the edges are provided with machine pressed 2 mm thick edge band. Wire management system is with Cable Trays running under the worktop to carry Data and Electrical wires and Switches and Sockets are to be fixed by customer on slots provided in Cable Trays. Cable Raisers are installed at junction points only where cables are entering the system from Floor into the cable Tray. All metal parts are duly powder coated. Keyboard pull out tray made of 0.8 mm thick CRCA steel duly powder coated, of minimum thickness 40micron, with metallic roller slides (Telescopic channels) on both sides and shall be fixed to the bottom of worktop surface with the help of screws.

SideStorage : Made of CRCA powder coated Hinged / Sliding Shutter / Door Free standing storage units of size as specified resting on floor having top, sides, back in metal powder coated finish. The cabinet / credenza shall be provided with CAM Locks. The handles shall be PVC Moulded and shall be flush fitted. The cabinets / credenza shall be provided with 4 Nos. M10 levelers for height adjustment upto 20mm. The shutters shall have self-closing hinges.

Electrical: Access flap, w450 with metal powder coated box and plate on side storage for electrical provision.

Product should be Bifma certified & Greenguard Certified.

**Workstations**

**Table 1200 (L)X600 (D) x 737-750mm (H).**

The size of the main working top would be: 1200 (L)X600 (D). The workstations should be desk-based workstations. The Side Storage of each workstation should be 1200mm L x 450mm D x 702 mm Ht and has a Seat on top at one end. The seat consists of seat cushion made of PU foam upholstered with fabric. Fabric privacy Screen is provided between workstations for Privacy having height of 300mm.

The divider screen of 1200mm shall be divided in soft pinup fabric and marker board. Height of the divider screen shall be 450mm.
The worktop should be made of 25 mm thick pre laminated particle board with its edges finished with 2mm thick ABS edge band. The Legs are made of MS Steel in 60mm x 30mm Section with thickness of 1.2mm. The cross members are made from 1.2mm thick sheet M.S. tubes. They are powder coated. All the edges are provided with machine pressed 2mm thick ABSedge band. Wire management system is with Cable Trays running under the worktop to carry Data and Electrical wires and Switches and Sockets are to be fixed by customer on slots provided in Cable Trays. Cable Raisers are installed at junction points only where cables are entering the system from Floor into the cable Tray. All metal parts are duly powder coated. Keyboard pull out tray made of 0.8 mm thick CRCA steel duly powder coated, of minimum thickness 40micron, with metallic roller slides(Telscopic channels) on both sides and shall be fixed to the bottom of worktop surface with the help of screws.

Mobile metal pedestal cabinet made out of metal powder coated, supports A4 and F4 file storage, comes with pencil tray, equipped with weight-rated castors and full extension ball bearing slides for all drawers, anti tilt system security, fifth castor to support lower drawer weight, increased frame’s structural stability, available option of key lock or combination lock. The 3-drawer unit shall be of size 500x400x600ht.

Product should be Bifma certified &Greenguard Certified.

- Café Tables

Café Table 1000 (L)X1000 (D) x 737-750mm (H).

The Worktop shall be made of 25mm Prelamparticle Board of Grade E1 , Type-II as per IS:12823 and backing laminate of 0.6mm All the exposed edges are finished with 2mm thick ABS lipping machine pressed. Legs are made of powdered coated steel 60mmx 30mm Section.Cross Member are in CRCA steel and the Beam is made of MSof 1.2mm thickness in powder coated finish of 40-50 microns thickness .The above furniture should be as per specification and sample approved by client.

- Meeting Table

DIMENSIONS:5200 mm x 1800 mm and height 737 mm.

The Worktop shall be made of 25mm Pre-laminated particle Board of Grade E1 , Type-II as per IS:12823 and backing laminate of 0.6mm All the exposed edges are finished with 2mm thick lipping machine pressed. Legs are made of powdered coated steel 25-30mmx 80-85mm Section.Cross Member are in CRCA steel and the Beam is made of MSof 1.2mm thickness in
powder coated finish of 40-50 microns thickness. The above furniture should be as per specification and sample approved by client.

- **Board Room Table**

**DIMENSIONS:** Size 7200x2400x750mm.

Factory made Table in MDF panels total thickness: 30 to 40 mm, density 740kg/m³, Beveled edge: side measures 16 to 20 mm. Standard finish: MDF. Legs MDF panels total thickness: 30 mm, density 740kg/m³. Airfoil Edge or Inverted Airfoil Edge measures 16 mm standard veneer finish. Components are 3rd party certified compliant with GREENGUARD and ANSI/BIFMA Standards for Low-Emitting Products. Work surfaces, including Desks The Product should be complete as per the approved sample. Conference Table in Well Shape with Modules each Of Size-1200mm x 600mm + Curved end Modules-600mm made of 30-40mm thick MDF board supported by MDF understructure comprise of Gable ends & Modesty Panel of height 300-400mm. Electrical : Metal cable beam with duct & wire manager cap for electrical provisions.

- **Centre Table**

**Centre Table L1200 x D 600mm & height 400-450mm**

The Worktop shall be made of 25mm Pre-laminated particle Board of Grade E1, Type-II as per IS:12823 and backing laminate of 0.6mm All the exposed edges are finished with 2mm thick lipping machine pressed. Under structure shall be Straight/loop legs are made out of metal powder coated. The above furniture should be as per specification and sample approved by client.

- **Side Table**

**Side Table Dia 600mm & height 350-450mm**

The Worktop shall be made of 25mm Prelamparticle Board of Grade E1, Type-II as per IS:12823 and backing laminate of 0.6mm All the exposed edges are finished with 2mm thick ABS lipping machine pressed. Under structure shall be Straight/loop legs are made out of metal powder coated. The above furniture should be as per specification and sample approved by client.

- **Cabin centre Table**

**Centre Table L1200 x D 600mm & height 400-450mm**
The Worktop shall be made of 25mm Pre-laminated particle Board of Grade E1 as per IS:12823 and backing laminate of 0.6mm. All the exposed edges are finished with 2mm thick lippingmachine pressed. Legs are tapered and made out of solid wood. The above furniture should be as per specification and sample approved by client.

- **Coffee Table**

**Coffee Table L700 x D 700mm & height 400-450mm**

The Worktop shall be made of 25mm Pre-laminated particle Board of Grade E1, Type-II as per IS:12823 and backing laminate of 0.6mm. The laminate top shall be extended 200-300mm vertically below the table top. All the exposed edges are finished with 2mm thick lippingmachine pressed. Legs are made out of flat four starmetal powder coated base. The above furniture should be as per specification and sample approved by client.

- **Meeting round Table**

**Meeting Table Dia 1200 & height 700-750mm**

The Worktop shall be made of 25mm Pre-laminated particle Board of Grade E1, Type-II as per IS:12823 and backing laminate of 0.6mm. All the exposed edges are finished with 2mm thick lippingmachine pressed. Legs are made of powdered coated steel with pedestal round base with wire management and access flap on table top. The above furniture should be as per specification and sample approved by client.

- **Waiting Area multiple seating**

**Size Height 805mm, Depth 520mm, Length 1550mm suitable for 3 seats.**

The elliptical beam in high strength electro-welded steel (mm100 x 50). Diecast fasteningelements provided to fix to the beam with recycled polypropylene seating shells reinforced with fiberglass thickness 7mm& end arms covered in polyethylene, available in several colours. The high strength steel beam and the steel plate underneath the seat are powder coated in aluminum 68 as well as the tubular steel frame which anchors the seat’s shell, tube thickness 1.5mm. The complete under structure is powder coated 80-100 micron. A floor anchoring system to be provided to prevent accidental tipping of the composition. Each beam be supported by two sets of leg supports arranged in a diagonal pattern.

Height 805mm, Depth 520mm, Length 1550mm suitable for 3 seats.

Product shall be BIFMA certified
• **Waiting Area multiple seating**

**Size Height 805mm, Depth 520mm, Length 1000-1100mm suitable for 2 seats.**

The elliptical beam in high strength electro-welded steel (mm100 x 50). Diecast fastening elements provided to fix to the beam with recycled polypropylene seating shells reinforced with fiberglass thickness 7mm & end arms covered in polyethylene, available in several colours. The high strength steel beam and the steel plate underneath the seat are powder coated in aluminum 68 as well as the tubular steel frame which anchors the seat’s shell, tube thickness 1.5mm. The complete under structure is powder coated 80-100 micron. A floor anchoring system to be provided to prevent accidental tipping of the composition. Each beam be supported by two sets of leg supports arranged in a diagonal pattern.

Height 805mm, Depth 520mm, Length 1000-1100mm suitable for 2 seats.

Product shall be BIFMA certified

• **Recline seating**

**Size Height 980mm, Depth 660mm, Length 1480mm**

Lounge Chair with magnet operated continuously adjustable headrest and cushion. Inner frame of quality solid-wood and plywood. Upholstery of non deformable polyurethane foam, wrapped in polyester padding Fire retardant inner padding meets “California Bulletin 117A” Standards. Special foam meeting the 5852 British Standards. Die-cast Aluminum legs (h. cm 18 )in chromed or powder coated finishing. Product to be fabric upholstered.

Foam Density 50 Kg/cu/mtr. The complete under structure is powder coated 80-100 micron.

Height 980mm, Depth 660mm, Length 1480mm

Fabric should be 100% wool, with abrasion 45000 rubs according to martindale method EN ISO 12947.

Fabric Lightfastness (ISO) 5-7

Fabric Pilling (EN ISO) 3

Fabric Fastness to rubbing (ISO) dry 4-5, wet 4.

Fabric Flame resistance standards
Product shall be BIFMA certified

**Curved waiting area seating**

Size Height 980mm, Depth 660mm, Length 1480mm

Modular upholstered seating system.

The design is characterized by basic elements that are either curved or rectilinear in plan and allow for the creation of countless compositions, with tight curves or as closed circles. Internal structure is made entirely of metal/plywood with a polyurethane foam of different densities to ensure comfort and durability. The seat is made up of PU foam in density 50 Kg/cu meter, upholstered with fabric or leatherette. The back is upholstered leatherette/fabric.

Total outer Circumference 8500-8900mm, depth 730-850 mm, Total Height 780-850m

**Sofas**

- **Type 1**

  The seat is made up of PU foam in density 30+/-2KG/cu meter, upholstered with fabric or leatherette. The back is made up of PU foam in density 30+/-2KG/cu meter upholstered leatherette/fabric. Frame is made up of Steel or hot pressed plywood moisture resistant and termite proof and pinewood of cross sections devoid of major knots and surface defects. Leg assembly is made out of metal powder coated.

<p>| | |</p>
<table>
<thead>
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<tbody>
<tr>
<td>1 seater</td>
<td>810mmW X 690mmD X H 700mm +/- 5%</td>
</tr>
<tr>
<td>3 Seater Sofa</td>
<td>1800-2100mmW X 690mmDXH 700mm +/- 5%</td>
</tr>
</tbody>
</table>

- **Type 2: Size 810mmW X 690mmD X H 700mm +/- 5%**

  The seat is made up of PU foam in density 30+/-2KG/cu meter, upholstered with fabric or leatherette. The back is made up of PU foam in density 30+/-2KG/cu meter upholstered leatherette/fabric. Frame is made up of Steel or hot presses plywood moisture resistant and termite proof and pinewood of cross sections devoid of major knots and surface defects. Leg assembly is made out of metal powder coated.
1 seater - 810mmW X 690mmD X H700mm +/-5%

- **Type 3: Size 3000mmW X700mmDXH720mm +/-5%**
  
  The seat is made up of PU foam in density 30+/-2KG/cu meter, upholstered with fabric or leatherette. The back is made up of PU foam in density 30+/-2KG/cu meter upholstered leatherette/fabric. Frame is made up of Steel or hot presses plywood moisture resistant and termite proof and pinewood of cross sections devoid of major knots and surface defects. Leg assembly is made out of metal powder coated.

- **Type 4: Size As mentioned below +/-5%**
  
  The seat is made up of PU foam in density 30+/-2KG/cu meter, upholstered with fabric or leatherette. The back is made up of PU foam in density 30+/-2KG/cu meter upholstered leatherette/fabric. Frame is made up of Steel or hot presses plywood moisture resistant and termite proof and pinewood of cross sections devoid of major knots and surface defects. Leg assembly is made out of metal powder coated.

<table>
<thead>
<tr>
<th>Seater Type</th>
<th>Width (mm)</th>
<th>Depth (mm)</th>
<th>Height (mm)</th>
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<tbody>
<tr>
<td>1 Seater</td>
<td>900</td>
<td>700</td>
<td>720</td>
</tr>
<tr>
<td>3 Seater Sofa</td>
<td>2100</td>
<td>700</td>
<td>720</td>
</tr>
<tr>
<td>4 Seater Sofa</td>
<td>2400</td>
<td>700</td>
<td>720</td>
</tr>
<tr>
<td>5 Seater Sofa</td>
<td>2100*1500L</td>
<td>700</td>
<td>720</td>
</tr>
</tbody>
</table>

- **Cabin Chairs**
  - **Type 1**
    
    Medium Back Mesh Chair with back adjustable lumbar support for achieving comfortable seating posture.
    
    The chairs shall have Height adjustable PP arms.
    
    Nylon base with 50mm castors.
    
    Mechanism: Synchro Tilt mechanism with Pneumatic seat height adjustment of 127mm. Backlock in upright position.
    
    Seat Height adjustable with Minimum 415mm from Ground and Maximum 542mm.
    
    Overall size of the chair should be 695 mm W x 695 mm D x (985 mm - 1112mm) H
    
    The Chair should carry Warranty: 5 Years. And should be BIFMA certified.
o Type 2

Task chairs: High back Mesh finish with headrest. Seat Finish - PU foam Fabric upholstered. Fabric should be 100% polyester with weight 510g/m2. Fabric flammability levels EN 1021 1&2, CAL 117E. Abrasion resistance 75000 martindale. Light fastness 5-7 (ISO 105-B02).

Mesh back to be 100% polyester, with weight 400g/m2. Fabric CAL 117E. Abrasion resistance 40000 martindale. Light fastness 4 (AATCC-16).

Seat Height should be Adjustable up to 127mm. Seat Depth adjustable 50mm.

Lumbar Support should be Height Adjustable with Synchronized Tilt mechanism. The chair should be able to Tilt Lock at Upright Position with Back Tilt Tension adjustable.

Armrests type to be 4D with height adjustable, depth adjustable, to and fro movement and rotate the arms pads. Arm pads type - polyurethane.

Base to be in Type - 5-Star in nylon base.

Castor Dimensions 50-60mm.

Seat Height adjustable with Minimum 415mm from Ground and Maximum 542mm.

Overall size of the chair should be 695 mm W x 695 mm D x (985 mm - 1112mm) H. Headrest height extra.

Chair should carry warranty of 5 years, and should be BIFMA certified & Greenguard certified.

o Type 3

Task chairs: High Mesh Back finish with headrest. Seat Finish - PU foam Fabric upholstered. Fabric should be 100% polyester with weight 510g/m2. Fabric flammability levels EN 1021 1&2, CAL 117E. Abrasion resistance 75000 martindale. Light fastness 5-7 (ISO 105-B02).

Mesh back to be 100% polyester, Abrasion resistance 40000 martindale.

Seat Height should be Adjustable up to 127mm. Seat depth adjustable 50mm.

Lumbar Support should be Height Adjustable translucent lumbar of 60mm with Synchronized Tilt mechanism. The chair should be able to Tilt Lock at Upright Position with weight activated tilt tension mechanism. The chair should have back stop at 3 positions.

Armrests type to be 4D with height adjustable, depth adjustable, to and fro movement and rotate the arms pads. Arm pads type - polyurethane.
Base to be in Type - 5-Star in nylon base.

Castor Dimensions-50-60mm

Overall size of the chair should be 686 mm W x 686 mm D x (940 mm- 1060mm) H. Headrest height extra.

Chair should be BIFMA certified & Greenguard certified.

- **Type 4**

  Task chairs Medium Mesh Back finish. Seat Finish -PU foam Fabric upholstered. Fabric should be 100% polyester with weight 510g/m2. Fabric flammability levels EN 1021 1&2, CAL 117E. Abrasion resistance 75000 martindale. Light fastness 5-7 (ISO 105-B02).

  Mesh back to be 100% polyester, Abrasion resistance 40000 martindale.

  Seat Height should be Adjustable upto 127mm. Seat depth adjustable 50mm.

  Lumbar Support should be Height Adjustable translucent lumbar of 60mm with Synchronized Tilt mechanism. The chair should be able to Tilt Lock at Upright Position with weight activated tilt tension mechanism. The chair should have back stop at 3 positions.

  Armrests type to be 1D with height adjustable the arms pads. Arm pads type - polyurethane

Base to be in Type - 5-Star in nylon base.

Castor Dimensions-50-60mm

Overall size of the chair should be 686 mm W x 686 mm D x (940 mm- 1060mm) H.

Chair should be BIFMA certified & Greenguard certified.
o **Type 5**

Café chairs with back in High-strength polymer back with injection molded technology. Seat in High-strength polymer seat. The chair should have Weight assisted recline mechanism. Frame in metal powder coated base. Glides in plastic or felt. The chair should Stacks 5 high on the floor and 8 high on a cart.

*SH: 18.2”(461mm) H: 33.9”(861mm) D: 22”(559mm) W: 22.3”(566mm) *SW: 19.2”(487mm)
*SD: 17.5”(443mm)

Chair should be BIFMA certified & Greenguared certified.

- **Lockers**

Single case lockers with choice of four, six, or nine compartments separated by divider panels, with individually locking doors.

39.5”(1003mm) and 51.5”(1308mm) high units include four 18”(457mm) wide or six 12”(305mm) wide compartments. Each compartment should include one shelf that adjusts in 2”(51mm) increments.

The body Door front shall be made out of CRCA powder coated metal. The lockers to be provided with door pulls and locking system.

- **Lecture room Table**

The Worktop shall be made of 25mm Pre-laminated particle Board of Grade E1 , Type-II as per IS:12823 and backing laminate of 0.6mm All the exposed edges are finished with 2mm thick lipping machine pressed. Legs are made of powdered coated steel 25-30mmx 80-85mm Section. Cross Member are in CRCA steel and the Beam is made of MSof 1.2mm thickness in powder coated finish of 40-50 microns thickness. The above furniture should be as per specification and sample approved by AAI/PMC.
Part E – JOINERY WORKS

DOUBLE LEAF TOP & BOTTOM RAIL SWING DOOR WITH FLOOR SPRING

**GENERAL:** It includes design, providing, fabricating, packaging, delivering at site and installing in position, Double leaf Manual Swing Door with top and bottom rail and floor spring inclusive of 13.52mm thick Non-Performance Structural Interlayer Laminated Glass as per dimension and detailing as per approved shop drawings and as detailed below:

**ACCESSORIES:**

**Top Door Rail:** Top Door Rail with 100mm Height and cover plate without lock in SS Length - 1200 mm Finish

**Bottom Door Rail:** Bottom Door Rail with 100mm Height & lock, cover plate in SS Length - 1200 mm Finish

**Top Pivot:** Top pivot shall be made of satin finished Stainless Steel Grade SS 304 safe and durable with fixed pivot to Suit Top rail. The stainless steel Plate Thickness shall be minimum 3mm.

**Corner lock Patch:** The Corner lock Patch shall be satin finished stainless steel of Grade SS 304, bottom lock without cylinder with satin SS cover.

**Floor Spring Features:**
- Closing force adjustable size 1-4 according to EN1154
- For right and left hand closing doors
- For internal double action doors
- For leaf weights upto -150 kgs.
- For leaf width upto 1100mm
- Mechanical back check
- Hold open – optional at 85deg, 90 deg, 105 deg & 120 deg
- Closing speed 1 – 130-15deg
- Closing speed 2 – 15-0 deg
- Finish: Satin Stainless Steel
- Standards :EN 1154
Pull Handle:

'H' type pull handle size : Ø 25mm x 600mm C/C, overall 700mm length, accessories for glass/wood/metal of 50mm thick door

Material: Stainless Steel 304 grade  Finish: Satin

Half moon Door Stopper

Ø 42mm x 25mm Shielded Door Stop, Finish: Satin

GLASS: The glass for Double leaf Manual Swing Door with top and bottom rail shall be of 13.52mm Laminated glass : 6mm thick clear Fully Tempered (Heat Soak) glass + 1.52mm thick Clear Structural Interlayer + 6mm thick clear Fully Tempered (Heat Soak) glass. The laminated glass shall be assembled in the factory/workshop of the glass processor.

INSTALLATION: The system shall be installed as per the guidelines of manufactures and as approved by the Engineer-in-Charge

FINAL CLEANING: Protective coating and warning markings shall remain undisturbed until final acceptance. Immediately prior to final inspection, temporary protective covering or coating shall be removed and surfaces shall be washed with a suitable thinner and left in a finished condition having approved uniform appearance and free from all marks and blemishes. Both faces of the glass shall be washed and polished.

DOUBLE LEAF FRAMED AUTOMATIC SLIDING DOORS

GENERAL:

Design, Supply, Installation, Testing and Commissioning of Automatic Sliding Door System with clear opening 2000mm x 2400mm supplied with Intelligent Self learning Micro-Controller Unit, DC Motor with Integrated Electro-mechanical Lock and gear assembly, Step-down transformers and power switch unit, Roller carrier assembly with Safety Anti-rise wheels, Automatic sliding track unit in Aluminum, Stainless Steel Running Track for Rollers, cover
profile for track unit in Anodized aluminum finish, Concealed Glass clamping profile with hole preparation ensures positive glass holding, Digital device manager with several built in secured programmable functions which includes user setup modes such as AUTO/EXIT/LOCK/OPEN/MANUAL. Automatic operator activation by standard motion sensor and Safety of pedestrians ensured with Integrated Motion + Safety sensor. Automatic Operator tested as per International standards. Sliding Glass door shall be 13.52 mm thick ( 6mm thick Clear Fully Tempered (Heat Soak)glass + 1.52mm Structural Interlayer Lamination + 6mm thick Clear Fully Tempered (Heat Soak) Glass with 40 mm wide stainless steel u beading of grade SS 304 with hole preparation to ensure safe and secure positive holding of glass.

**SYSTEM REQUIREMENTS:**

Automatic sliding door operator with 13.52 mm thick Heat Soaked Laminated glass with Aluminum framed shutter panels, with automatic Operator, Microprocessor control panel. Self- learning, reversing when obstruction is encountered. Microprocessor-controlled control unit with adjustable parameters for opening and closing speed, hold-open time and opening and closing force. Class of protection IP 20. The system be suitable for power supply of 230V, 50Hz, AC power supply operation for various opening sizes all complete of the type and extent described in the drawings, specifications and schedule of work. The Glass panels shall comprises of 6mm thick clear Fully Tempered (Heat Soak Test) glass + 1.52mm thick Clear Structural Interlayer + 6mm thick clear Fully Tempered (Heat Soak Test) glass. The laminated glass shall be assembled in the factory/workshop of the glass processor.

A set of two sliding doors shall form the part of the vestibule (Airlock lobby) as specified.

Automatic Sliding aluminum Framed Door conforming to Indian or International Standards shall be supplied and fixed. Following minimum standard features shall be provided with each of the sliding doors:

A pair of bi-parting doors between sides screens all toughened glass.
The doors should be provided with electro-magnetic locks. Automatic control should be done by two infrared detectors, with a range of operating, control options and safety devices.

The panels will consist of 13.52 mm thick Heat Soaked Laminated Clear glass. Fr Grade Corian cladded Walls / RCC structure / steel columns will be used for achieving clear opening height. The system will be also equipped with Floor guide system, one pair of light- barriers and release devise for sliding panels and side screens.

**Quality Assurance:** Manufacturer must be able to demonstrate compliance with ISO 9000: 2000 certification and also fulfils future European standards and regulations, TUV type tested compliance with EU low-voltage directives.

Minimum requirements for product:

a) Automatic sliding door mechanism shall be from approved make.

b) Motor: Permanent magnet D.C. motor with a sealed integral gear box.

c) Drive : Variable speed Geared Transmission through timer belt system.

d) Microprocessor : 16 bit – Intelligent door


f) Safety stop / Reverse

g) Automatic compensation of friction

h) Adjustment of all basic parameters via integrated display push button/ display programme switch.

i) Anodized Aluminum Header frame.

j) Anodized Aluminum hinged operator cover.

k) 2 trolleys/ roller sets per sliding leaf.

l) Insulated and modular Track Rail, track profile separate from Main profile.

m) UVV (Accident Prevention) and VDE (Electrical engineering) compliance.

n) Sleek header frame.

o) 5 position programme selective switch & error notification panel (Digital).

**Mechanical Features:**
a) Maximum clear width : 2000 mm
b) Minimum clear width : 2800 mm
c) Maximum recommended clear height : 2400 mm
d) Maximum sliding leaf weight : 2 x 100 kg.
e) Locking arrangement : Electro-magnetic

Performance:

a) Opening speed (Incremental setting) : 10 - 70 Cm/s
b) Closing speed (Incremental setting) : 10 – 50 Cm/s
c) Maximum Opening and Closing force : 150 N.
d) Hold open time : 0–180 Seconds
e) Independent Adjustment of Speed and Force : Yes.
f) Battery back-up : 30 minutes (min.).

Electrical Features:

a) Standard power supply : 230V, 50Hz, AC
b) Type of motors : DC motor
c) Direct Drive Transmission : Geared Transmission
d) Power consumption during operation : Not to exceed 230W
e) Ambient temperature during operation : 0 to 50 deg. Celsius.

Safety:

a) Safety Stop / Reverse : Yes – Adjustable
b) Infrared barriers : 1 SET
c) Glass : 13.52mm clear Heat soaked laminated glass

BMS Compatibility: Provision shall be made for monitoring of parameters of Automatic Sliding doors through Building Management system (BMS). The Automatic Sliding doors should be capable of interconnected with BMS and shall have open code architecture. Every item of
machinery, likely to produce vibration or sound must be isolated from structure so as to eliminate any possibility of vibration and sound travelling to the structure and other parts of the building. The cost of isolation material required for this purpose shall be deemed to be covered in the scope of work and quoted rate.

DOOR HARDWARE

STANDARDS:

The Door Hardware specification, performance, quality and finishes shall be in accordance with the following standards as indicated on the design drawings or in the particular specification.

- British (BS) Standards
- BS EN Standards
- German (DIN) Standards
- European (CEN) Standards
- ISO Standards

Door Hardware supplied shall be manufactured in factories accredited with BS EN ISO 9000 to ensure quality control.

All Door Hardware manufacturers and principal source suppliers shall be affiliated to and comply with the requirements of the guild of architectural ironmongers in London, U.K. and/or their respective European counterpart bodies.

Door Hardware of a specialised nature not covered by any of the above standards shall, as far as possible, be constructed from components manufactured to these standards, in terms of performance, quality and finish.

MATERIALS:

General:

a) Door Hardware shall be supplied with all necessary components and ancillary fittings and including all matching fixing screws, bolts, of correct size and capacity to suit the particular installation function and loading. Non-corrosive materials shall be utilized throughout.
b) All Door Hardware shall be supplied with the manufacturer’s fitting instructions, which must be strictly adhered to in all cases.

c) The woodwork Contractor, in liaison with the Door Hardware supplier, is responsible for ensuring the correct operation of the Door Hardware after installation.

**Function:** All items of Door Hardware shall be suitable for the purpose shown on the design drawings and detailed in the specification and shall comply with BS 476 and BS 5588.

**Finish:**

a) All materials used in the components of an item of Door Hardware shall be of best quality material and shall be resistant to corrosion, in accordance with BS EN 1670.

b) Lacquer coating to polished brass finish etc. is not required.

c) When PVD (diamond/ultra) finish is specified the PVD process shall be carried out to all items specified by a single source, to maintain consistent colour throughout for the particular project. PVD finish shall be warranted for a minimum of 15 years against corrosion and tarnishing.

d) All stainless steel Door Hardware products shall be manufactured from 316 grade satin stainless steel to BS EN Standard except where detailed in the following paragraph.

e) Internal Door Hardware for kitchens, pantries and services shall be manufactured from 316 grade satin stainless steel to BS EN standard. This shall also include adjacent Washrooms/Toilets for use by kitchen/catering staff, whilst at work.

f) All Aluminum Door Hardware shall conform to BS EN 12373 latest revisions.

g) The Door Hardware manufacturer/supplier shall comply with the requirements of this specification in respect of Operating and Maintenance Manuals.

**Samples of all Door Hardware:**

a) After award of the Door Hardware Contract a sample of each item of Door Hardware with all its accessories shall be provided to the woodwork Contractors to evaluate its fixing.

b) These samples inclusive of all accessories etc. need not be of the specified finish, but shall be typical in all other respects to the specified item to be used in the Works.
HINGES:

General:

a) Hinges shall comply with BS EN 1935.

b) Hinges and their screws shall be suitable for the application and shall be of similar material and finish.

c) PVD finish can be proposed in lieu of polished brass finish.

d) Doors fitted with overhead Closers, shall be fitted with hinges manufactured in satin stainless steel double ball bearings.

Door hinges:

Hinges shall be one of the following types as indicated on the design drawings: Stainless steel with double ball bearings.

For service areas hinges shall be one of the following types, as indicated on the design drawings: 316 grade satin stainless steel with double ball bearings.

External window and internal screen hinges:

Hinges shall be one of the following types as indicated on the design drawings:

- Stainless steel with double ball bearings.
- The largest size required will be 95 x 19 x 26mm deep, unless otherwise indicated on the design drawings.

For service areas hinges shall be one of the following as indicated on the design drawings: 316 grade satin stainless steel with double ball bearings.

FLOOR SPRINGS:

General:

a) All external main entrance doors and all internal thoroughfare doors shall have floor springs with hold open, adjustable closing speed, back check, delayed action and latch action facilities, unless otherwise indicated on the design drawings.
b) The floor spring and all its components, shall be manufactured to BS EN 1154, BS 6459 and BS 5750 and be of suitable capacity for its intended purpose, and shall function without undue opening effort.

c) Floor springs shall not be used on bathroom or toilet doors unless indicated on the design drawings. Where required the spring strength shall be weak and the hold open facility deactivated or removed.

**Application:**

a) Centre pivoted floor springs shall not be used for external door application, unless detailed on the design drawings.

b) External doors shall be set in a traditional 90° rebated frame, with minimum 20mm rebate depth, using 5mm offset components, unless otherwise indicated on the design drawings.

c) All other internal main thoroughfare and main rooms entrance doors shall be provided with 5mm offset components, unless indicated otherwise on the drawings.

**Function:**

a) All floor springs shall be supplied with variable closing speed, back check, hold open, delayed action and latch action facilities unless otherwise indicated on the design drawings.

b) The floor box cover plate shall be without raised bevelled edges.

c) Door stops shall always be use in conjunction with floor springs.

**Finish:** When door furniture is in satin stainless steel finish the exposed components of the floor spring shall be manufactured in 316 grade as appropriate.

**OVERHEAD DOOR CLOSERS:**

**General:** Overhead door closers and all of their components shall be to BS EN 1154, BS 6459 & BS 5750 and be suitable for their intended purpose, and shall function without undue effort in use.

**Application:** The minimum required thickness of door leaf when using a concealed overhead door closer is 55mm.

**Function:**
a) Overhead door closers shall be supplied with adjustable closing force, adjustable back check, latch action, limit function and hold open facilities, unless otherwise indicated on the design Drawings.

b) Door closers shall be used in conjunction with door stops.

**Finish:** When door furniture is in satin stainless steel finish the exposed components of the closer shall be manufactured in 316 grade as appropriate.

**DOOR STOPS:**

**General:** Door stops are required for all doors, regardless of method of door hanging, pivoting or closer method.

**Type:**

a) The floor door stop shall include both floor pin and screw fitting to the floor.

b) Door stops shall be floor mounted of semi-dome type with shielded base of 50 x 45mm and projection of 25mm to the rubber door buffer insert, unless otherwise indicated on the design drawings.

c) Where floor door stops are not practical wall mounted door stops, having a suitable projection from the wall, shall be provided.

**Application:**

a) Fixing to the floor or wall shall allow the maximum opening angle of the door leaf without making contact with any wall finish. The door stop rubber buffer insert shall be aligned to make full face contact with the door leaf bottom rail in the case of floor mounted door stops.

b) Floor door stops must be positioned on the finished floor to avoid any possible encroachment of thoroughfare access, to the door opening when in the open position or within the room when door leaf is in closed position.

**Finish:** The door stop finish shall match the door furniture and/or other DOOR HARDWARE finishes previously described.

**LEVER ACTION FLUSH BOLTS:**
General:

a) Lever action flush bolts to BS EN 12051 shall be used on the dead leaf, at top and bottom of the inside rebated edge, on all double leaf doors and windows.
b) The bolt shall have a minimum 15mm throw to provide sufficient penetration and security into the frame head keep plate and floor socket.
c) Lever action flush bolts width size shall be 19mm except for thick door or gate leaves where larger width shall be used as indicated on the design drawings.
d) For window/screens with small section timber stiles, narrower lever action bolt widths or sunken slide bolts shall be used as indicated on the design drawings.

Function: The criteria for lever action flush bolts size; for double leaf doors or windows shall be as follows:

a) Bottom bolt size: 152 x 19mm shall be fitted in the internal side of the meeting stile rebate check of the dead leaf.
b) Top bolt size: width equal to bottom bolt, length to suit leaf height and accessibility. The length of top bolt shall normally be pre-determined by the lever action being accessible within the range of 1800mm to 1950mm above finished floor level.
c) For double leaf windows that are not accessible from finished floor level the top bolts shall be of the same minimum length as bottom bolts.

Finish: The bolt finish shall match the door furniture and/or other Door Hardware finishes previously described.

FLOOR BOLT SOCKETS:

General:

a) Easy-clean bolt sockets shall be provided for bottom bolts of double leaf doors, and/or double leaf windows/screens with non-timber cill.
b) The bolt socket shall be to the corresponding size of the lever action bottom shoot bolt diameter.

Type: Floor bolt sockets shall be suitable for setting into the floor finish.
**Function:** Windows and doors with timber cill do not require a floor socket; the keep plate supplied with the lever action flush bolt shall be used.

**Finish:** Floor bolt sockets finish shall be match the other Door Hardware and/or furniture on the door, shall only be carried out if instructed.

**LOCK CASES:**

**General:**

a) All lock cases shall comply with BS 5872 and/or DIN 18251.

b) Mortise lock cases shall be centralised in the leaf thickness, unless shown otherwise indicated on the design drawings.

**Type:**

a) All lock cases that are key operated shall be of Euro-Profile (PZ) type to suit cylinder locks, unless otherwise indicated on the design drawings, or as specified.

b) Key operated mortise cylinder lock cases for use with lever handle or knob furniture when particularly specified, shall be at 72mm centres and suitably sprung for lever handle/knob return action.

c) External main entrance double leaf doors and internal main Thoroughfare corridor double leaf doors that are on floor springs together with internal double swing action doors on centre pivot shall be provided with a „Euro-Profile“ mortise deadlock case.

d) All hinged doors without closer mechanism shall have mortise cylinder lock case with latch action, with the exception being toilet and bathroom doors, which shall be provided with latch only lock case and „croft“ door bolt.

**Forends and strike plates:**

a) The latch action protection area of all strike plates used with latch action lock cases shall project beyond the jamb no more than 2mm.

b) This shall also apply to mortice latch only lock cases.

**Rebate sets:**
a) Lock cases for double leaf doors or windows shall be supplied with a proprietary rebate set of either 15mm or 20mm or 25mm. The rebate set shall be supplied by the lock case manufacturer to ensure matching material and finish.

b) For centre pivoted internal double swing action double leaf doors with curved meeting edges a deadlock case shall be used.

c) For extra large external doors the lock case manufacturer shall supply a larger rebate set.

**Backsets:**

a) Lock cases shall have backsets available in 5mm increments.

b) The backset of the lock case shall be fitted to ensure the door furniture is centred on both faces of the door leaf lock stile flat face when the door is in the closed position.

c) Double leaf doors backset shall be measured as half the flat face on the rebated side of the lock stile, (outside the room being entered), plus the full rebate depth of the lock stile, i.e. 15, 20 or 25mm.

d) Main entrance double leaf doors with plant-on door stop mullions to the meeting stiles shall be measured at half the flat face on the rebated side of the lock stile, (outside the room being entered), plus the full rebate depth of the lock stile as stated above, but including the necessary lock stile overlay of the plant-on doorstop mullion as shown on the design drawings.

e) For doors with carved stiles, the carving module or pattern shall determine the backset, with similar allowance for double leaf doors as described above.

**Finish:** Exposed components of lock cases, (i.e. forends, strike plates and rebate sets) shall be finished to match other Door Hardware and/or furniture on the door.

**CYLINDER LOCKS:**

**General:**

a) All cylinder locks shall be of „Euro-Profile“ (PZ) type unless otherwise indicated on the design drawings or as specified.

b) Cylinder locks shall comply with BS EN 1303 and/or DIN 18254.

c) The cylinder lock specification shall include the following features
• 6 pin Tumblers.
• Anti-picking devices.
• Hardened anti-drilling devices.
• Master-keyed and sub-mastered applicable to the project.
• All cylinder locks shall be supplied with a lifetime warranty.

**Individual cylinder differ keys and GMK / SMK system keys:**

a) Cylinder locks shall be supplied with THREE (3 No.) differ keys per cylinder lock. All cylinder key systems shall be of a manufacturer/type so that the keys cannot be duplicated locally.
b) Grand Master Keyed (GMK) and Smart Master Keyed (SMK) key quantity shall also be THREE (3 No.) unless otherwise stated.
c) A GMK, and as necessary SMK, system key schedule of key accessibility to individual differs/doors shall be provided by the Engineer-in-Charge for all cylinder lock systems.
d) Immediately upon completion of the project contract a final „As Built“ system key schedule shall be provided to the Engineer-in-Charge. This final key schedule shall be issued before actual project handover to Engineer-in-Charge by the joinery or Contractor.

**Cylinder lock length:**

a) All double cylinder locks shall be of equal length on both sides of centre point; that is of equal incremental extension. Single cylinder locks shall be centred on the leaf thickness.
b) The Cylinder lock projection beyond the face of the door furniture shall be not more than 3mm maximum for security reasons along with practical aesthetics. They shall not be underflush.

**Finish:** The finish shall match that of the adjacent furniture. However due to constraints in manufacturing materials, certain finishes shall be subject to submission for approval by the Engineer-in-Charge.

**Cylinder knobs and privacy cylinders:** Where keyless knobs are required, these shall be of „figure of eight“ (8) pattern as per EVVA- Werk system, unless otherwise instructed by the Engineer-in-Charge.

**‘CROFT’ DOOR BOLT:**
**General:** Croft door bolts shall be used on all toilets and bathrooms doors when indicated on the design drawings or in the specifications.

**Type and application:**

a) The barrel length shall be 95mm long x 25mm wide, unless otherwise indicated on the design drawings or in the specification.

b) The bolt shall be of the straight shoot type, unless indicated otherwise on the design drawings.

c) The keep plate shall be of solid brass surface mounted enclosed type with a matching beaded edge detail as the barrel. Edge mounted keep/strike plate shall not be used unless incorporated on the original design drawings or in the specification.

**Finish:** The Croft door bolt shall be manufactured from stainless steel as described in Clause 7.03.02 Para IV.

**LEVER ACTION DOOR FURNITURE:**

**General:**

a) Unless indicated otherwise on the design drawings, internal doors shall be provided with lever action furniture. Door furniture shall comply with BS EN 1906.

b) Dead leaves of internal double leaf doors shall have „Dead-fixed“ latch only lever furniture without key-hole as indicated on the drawings.

c) Double leaf doors in service areas shall only have furniture to the dead leaf when indicated on the drawings.

d) All internal doors lever furniture shall be on back-plate, unless otherwise indicated on the design drawings or in the specification.

e) All lever handle furniture, shall be with pivot centre point at 970mm AFFL on the lock stile/s, unless otherwise indicated on the design drawings.

**Back-plates on 72mm centres for cylinder lock:** Unless indicated otherwise on the design drawings, all back-plates for lockable door furniture shall be on the European Standard of 72mm centres for mortice euro-profile (PZ) cylinder lock cases.
**Follower spindles:**

a) All proprietary follower spindles, for lock cases with latch action, shall be supplied to suit the door leaf thickness, and be fully inserted within the lever handle/s.

b) Unless otherwise indicated on the design drawings all follower spindles shall be of the standard 8mm square.

The follower spindles shall be supplied by the door furniture manufacturer and will be of a non-corrosive metal.

**Securing lever latch action handles to back-plate**

The method of securing lever latch action handle to the back-plate shall incorporate grub screw fixing from the underside of the lever onto the follower spindle and a blue steel non-corrosive spring clip retaining the lever handle on the rear side of the back-plate/rose.

**Finishes:**

a) Finish shall be as specified for internal, external and use.

b) Stainless steel furniture shall be in satin finish of 316 grade for the areas as noted previously.

c) Where aluminum furniture is required, it shall be in satin anodized finish to BS 1615.

**CENTRE DEAD KNOB DOOR FURNITURE:**

**General:**

a) Knob mortice lock furniture shall comply with BS EN 1906 and shall not be used with latch action lock cases for doors, unless indicated on the design drawings. In which case knob diameter shall not exceed 57mm and the lock case must be suitably sprung for use with knob furniture.

b) When indicated, dead-fixed knob furniture of the same maximum diameter with back-plate or rose and escutcheon may be used on lock stiles with an Euro-Profile mortice dead lock case.

**Dead-fixed centre door knobs:**
a) Generally decorative dead-fixed centre door knobs shall only be used on the outside face of double leaf entrance doors, which are provided with floor spring and deadlock lock case. In such cases pull handles or dead-fixed lever furniture shall be used on the inside face.
b) Decorative dead-fixed centre door knobs may be used on both sides of entrance gates, with back-to-back fixing method.
c) Knob and rose diameters or back-plate size, and design, shall be as shown on the design drawings or indicated in the Programme.
d) Location of decorative dead-fixed centre door knobs shall be as indicated on the design drawings, to suit adjacent carving designs.
e) Decorative dead-fixed centre door knobs shall be provided with a Euro-Profile mortise deadlock case to the lock stile with matching design escutcheon/s to the stile face/s at location shown on the design drawings.

Fixing:

a) Where centre door knobs are to both faces of the leaf and are concentric, back-to-back fixing shall be used. In all other instances, where door face design permits, concealed bolt through method should be used.
b) Where the door face design does not allow for the bolt through method, or lever action furniture is to be used on the internal face lock stile, a secure and robust secret fixing method of the centre door knob shall be used to approval of the Engineer-in-Charge.

Finish: Dead-fixed centre door knobs shall be as per the design drawings or as specified.

PULL HANDLES AND PUSH PLATES:

General:

a) Pull handles and push plates shall be used for double leaf doors in main thoroughfare corridors or entrances, when indicated on the design drawings only.
b) Pull handles and push plates shall also be used for single leaf doors in other locations as indicated on the design drawings or as specified.
c) When pull handles and push plates are used they shall be provided with a Euro- Profile mortice deadlock lock case to the lock stile only, with Euro- Profile piercing below the handle or with matching design escutcheon/s to the stile face/s at the location shown on the design drawings, or as specified.

**Fixing:**

a) Where pull handles are to both faces of the door and are concentric, back-to-back fixing shall be used. When push plates are provided to the outside face of the door the pull handles shall be of the bolt through fixing type and bolts shall be covered by the push plates on the outside face of the door.

b) Where door face design permits, the concealed bolt through method shall be used. When door face design does not allow for bolt through method, or lever or knob furniture is to be used on the outside face lock stile, a secure and robust secret fixing method of the pull handle shall be used to approval of the Engineer-in-Charge.

c) Pull handles shall be positioned between 1200 and 1350mm on centre of their height above AFFL, unless particularly shown otherwise on the design drawings.

d) Push plates shall be positioned on the outside face of the lock stile concentric with the pull handle.

**Finish:** Pull handles and push plates shall finished to match the furniture on adjacent doors in the room.

**CYLINDER ROSES / ESCUTCHEONS:**

**General:** Cylinder roses/escutcheons shall be of matching design, shape and finish with the dead-fixed centre door knob, pull handles, or other door furniture.

**Type:** Unless otherwise indicated on the design drawings, all cylinder roses/escutcheons shall be of ‘Euro-Profile’ piercing to conform to the design requirements. The overall diameter and other dimensions and design shall comply with the design concept of the door stile.

**Finish:** The design and finish shall match that of the adjacent door furniture.

**WINDOW / SCREEN KNOBS:**
General:

a) Knobs for windows/screens shall be either round or oval shape and of the size indicated on the design drawings.

b) Where window/screen knobs are to be made from timber to match the window/screen finish they shall not from part of the Door Hardware supply scope, but will be included in the joinery scope of work.

c) Window lever furniture may be specified for external windows for use with adjustable backset budget locks, or window casement fasteners for use with casement stays.

d) Windows shall not have any furniture externally, unless otherwise indicated on the design drawings.

Type:

a) The knobs shall be on a rose to suit the available flat width of the window stile unless otherwise indicated on the design drawings.

b) Window/screen knobs, and any other window furniture, shall match the design of the door furniture in the room, unless otherwise on the design drawings.

c) For window screens the maximum diameter of a knob shall be 38mm.

d) Full height, walk-through type, glazed French windows shall be lockable from inside only and may have lever or mortise knob action furniture.

Finish: The finish shall match that of the adjacent door furniture.

ADJUSTABLE ROLLER CATCHES:

General:

a) Spring activated ball or double ball catches shall not be used for windows.

b) Roller catches for windows/screens etc. shall be of adjustable type with barrel depth of 43mm x 19mm diameter, or where indicated on the design drawings adjustable magnetic catches may be used.
**Function and installation:** Adjustable roller catches for windows/screens shall be recessed into frame head or cill or both, with the keep plate fixed into the leaf, as indicated on the design drawings. Keep plates shall not project beyond the leaf/frame edge face by more than 2mm.

**Finish:** Roller catches finish shall match other Door Hardware and/or furniture on the window/screen.

**WINDOW LOCKS & BOLTS:**

**General:**

a) External Windows, and where indicated internal window screens, shall be provided with a lock accessible from inside only. The locks shall comply with BS EN 12051.

b) External windows and internal screens shall not be provided with mortise lock case, except full height, walk through type glazed French windows. In such instances the lock shall only be accessible from inside.

**Type:**

a) All external windows shall have either or both the following lock type, dependent on the teakwood timber stile member section size as indicated on the design drawings.

- Budget locks with 10 to 22mm adjustable backset where lever or knob action furniture is required on the inside.
- Chubb type security bolt of suitable backset with star key, and budget lock as above, but with tee key where lever or knob action furniture is not required.

b) Internal window screens shall be held in closed position by adjustable roller catches and chubb type security bolt of suitable backset, and/or adjustable backset budget locks to top and bottom of the screen leaf.

**Finish:** The finish shall match the hinges, with the escutcheon or ferrule if specified to match the leaf furniture.

**NEOPRENE DOOR AND WINDOW/SCREEN SEALS:**

**General:**

a) Neoprene seals, which comply with BS 7386 shall be used as specified in the design drawings.
b) The seals shall be fitted to the frame and not to the leaf except in special circumstances. Double leaf doors shall also have seals at the meeting stiles.

c) Heavy duty sound proofing seals will be required to all opening edges and meeting stiles for plant room frames/doors, whether they form part of the in work or otherwise.

**Neoprene compression seal:**

a) All frames with hinged or offset pivoting leaves shall be provided with Sealmaster ARH neoprene compression seal (or approved equivalent) to jambs, head, (and cill for windows), unless particularly specified otherwise.
b) Plant room doors shall be fitted with seal master CA neoprene compression seal, to the jambs, head and cill of the frame, along with the meeting stiles of the door leaves.

**Neoprene wiper seal:**

a) External frames with hinged or offset pivoting leaves shall also be provided with Sealmaster ARK wiper seals (or approved equivalent) to jambs and head, (and cill for windows), unless specified otherwise. This also includes external or internal plant room doors, unless specified with N30 or N60 intumescent seals.
b) For external frames of extra tall and/or wide or extra thick leaves alternative seal types, similar to Sealmaster ARL, ARM, PEFA/PEFS or a combination of these shall be used.
c) External fire rated door and window sets may not require ARK wiper seal, dependent on thickness, as similar blade is already incorporated in the Sealmaster Intumescent fire and smoke seal.

**Double action internal door seals:**

a) Internal doors with curved edges to the pivot stiles on a centre pivoted action, shall be fitted with Sealmaster PEFA/PEFS neoprene seals (or approved equivalent), centralised on the frame jambs, scalloped rebate, frame head, and for double leaf doors at the meeting stiles.
b) Where indicated on the design drawings a PEFS seal will not be required at the frame head/top of door. The PEFA seal shall only be used at the frame head, depending on the design detailing.
c) All Doors with PEFA/PEFS neoprene seals; operating in a scalloped lockset frame jamb in the case of single leaf, or curved edge meeting stiles in the case of double leaf; shall be provided with a closing mechanism.

d) The closing mechanism shall be floor spring, or concealed overhead cam action closer for door leaves of 55mm minimum thickness. For service areas surface mounted closers shall be used.

e) These doors shall have deadlock bolt action only, or where called for on the design drawings an additional adjustable roller bolt action.

**Intumescent fire and smoke seals:**

a) Fire rated doors frames shall be fitted with Sealmaster intumescent fire and smoke seals (or approved equivalent) to BS 476 and certifire approval No. CF142. The seal shall incorporate an angled self-extinguishing elastomeric replaceable wiper blade, which matches the fire rating of the door.

b) Where double leaf door and window sets meeting stiles are not rebated or the section detail cannot accommodate N30 or N60 seals, then Sealmaster IMN/IMP for FD30S rating, or N60S/IMP for FD60S rating shall be fitted.

c) For FD60S rated door and window sets the N60 Intumescent Seal elastomeric wiper blade shall be flame retardant and Sealmaster intumescent plugs shall be fitted to hinges, locks, and other Door Hardware, which breaks the continuity of the seal.

d) Glazing to FD30S fire rated door or window set panes shall be provided with either a bedding of sealmaster FireGlaze compound or Sealmaster G30 glazing strips as appropriate. For FD60S rating they shall be provided with both Sealmaster GL60 FireGlaze liner and Fire Glaze compound.

e) To achieve FD60S integrity Sealmaster gap filling compounds, such as intumescent compound or masterseal will be required at all door/windowframesets joints between the building structure, and around all Door Hardware cutouts.

f) Sealmaster N30 and N60 fire and smoke seals may take the place of Sealmaster ARK wiper seals on external doors or windows where prevalent, depending of leaf thickness.

g) Under no circumstances whatsoever shall fire only seals be used.
Seals aluminum channel finish: All types of Sealmaster seals shall incorporate Aluminum carrier channel for general thoroughfare areas.

AUTOMATIC DOOR BOTTOM SEAL:

General:

a) All external doors to all main buildings shall have automatic door bottom seal. These seals shall also be fitted to external doors of other buildings where indicated on the design drawings.
b) Automatic door bottom seal shall also be fitted to plant rooms with noise emitting equipment such as an AHU, whether internal or external to the main buildings.
c) Where an automatic door bottom seal is required for internal doors it will noted on the design drawings or as specified
d) Automatic door bottom seals shall not be used on service or staff Buildings, unless specified.

Type: Automatic door bottom seals shall be mortise type from either Zero International, Athmer, Ventura or Hafele ranges to suit the door construction and pivoting method.

Application:

a) All mortise type Automatic door bottom seals shall be concealed fixing and grooved into the door bottom rail. The black or grey neoprene element of the seal must extend to full width of the door leaf, and in the case of double leaf doors must meet together at the meeting stiles.
b) Where it is not possible to accommodate the mortise type, surface mounted Automatic door bottom seals be considered.

Finish: The mortise fixed concealed Automatic door bottom seal shall be in the manufacturer’s standard mill finish for the aluminum carrier.

RECEIVING AND DELIVERY

General:
a) It is the responsibility of the Door Hardware Contractor to check all items before delivery.
b) Checking shall include ensuring related items are kept together and that the items function correctly.
c) The Engineer-in-Charge shall be notified when missing or faulty components are likely to delay the works.

Packaged sets:

a) The Door Hardware Contractor shall supply the Door Hardware packaged in sets, identified by door/window No. and type or furniture unit and type along with the relevant Door Hardware schedule page/s for the particular door/window or Furniture Unit per package.
b) The packaged sets of Door Hardware shall be delivered, to the respective door Contractors factory stores, unless otherwise instructed by the Engineer-in-Charge.

Itemized delivery note:

a) Each delivery shall be recorded on the Door Hardware supplier’s standard format delivery note, listed by set number and door no. or furniture unit type.
b) Deliveries of a single item in full project quantity shall not be made, unless at the request of the Engineer-in-Charge.

Operation and Maintenance Manual:

a) The Door Hardware Contractor shall supply O&M Manuals in accordance with this specification.
b) These O&M Manuals shall be delivered to the Engineer-in-Charge, together with covering letter copied to all relevant parties.
1.0 Introduction

This document outlines the material specifications and performance / technical requirements for execution and installation of signage at the Airport. The material specifications are given for the key materials used in manufacture of the signage and performance criteria serves as a guideline for the detailing and implementation of the various details of the signage. This document shall be the key reference to be read in conjunction with the sign drawings, sign schedules, general arrangement drawings and sign design guidelines and other documents mentioned in the bidding documents.

2.0 Brief outline of work

General:

Provide Way-finding Signage products in accordance with the Contract Documents. The Way-finding Signage work is specified both by performance and manufacturer. The drawings show the design intent for setting out parameters and finished profiles, which are indicative only. The Contractor will have full responsibility for the work in this specification, including but not limited to the following:

a) Be responsible for the engineering, procurement and installation of the Way-finding Signage work based upon the Drawings and the requirements of the Specification.

b) Be responsible for the final selection of materials, sizes, thickness, types, locations of fixings and sealants, all in accordance with specified standards detailed herein and submission of samples for review by the Engineer-in-Charge prior to manufacture.

c) Compliance with the requirements of the National Indian Building Codes 2016, standards,
codes and other applicable local regulations. Submit all information necessary to the relevant statutory authorities to obtain approval in timely manner so as to comply with the construction programme.

### 2.1 Standards & Codes

The following Indian Standard Specifications and Codes as amended up to date will be applicable to the Complete Signage System:

<table>
<thead>
<tr>
<th>Standard</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>IS 16451:2018</td>
<td>Graphical Symbols- Safety Colours and Safety Signs-Registered Safety Signs</td>
</tr>
<tr>
<td>IS 16454</td>
<td>Safety Identification- Escape and Evacuation Plan Signs</td>
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<tr>
<td>IS 16881: Part 1</td>
<td>Public Information Guidance Systems Part 1 Design Principles and Element Requirements for Location Plans, Maps and Diagrams</td>
</tr>
<tr>
<td>IS 16898: Part 2</td>
<td>Basic Principles for Graphical Symbols for Use on Equipment Part 2 Form and Use of Arrows</td>
</tr>
<tr>
<td>IS 16888</td>
<td>Safety Colours and Safety Signs Classification, Performance and Durability of Safety Signs</td>
</tr>
<tr>
<td>ISO 3864</td>
<td>Graphical Symbols - Safety colours and safety signs - Part 1: Design principles for safety signs and safety markings, 2011</td>
</tr>
<tr>
<td>IS 9583 (1981)</td>
<td>Installation and battery backup for Emergency signage</td>
</tr>
<tr>
<td>IS 733</td>
<td>Aluminium alloy and grade 63400</td>
</tr>
<tr>
<td>NFPA 170, 2012 Fire Safety and Emergency Symbols</td>
<td></td>
</tr>
<tr>
<td>OSHA/ANSI Standards for Sign Regulations, 2013</td>
<td></td>
</tr>
<tr>
<td>Guidelines on readability ratio for all signs and FIDS (IATA &amp; IRC)</td>
<td></td>
</tr>
</tbody>
</table>
3.0 Scope of Work:

The EPC Contractor will be responsible for design, supply, installation, testing and commissioning of the signage at the Airport within the specified time based on designs specifications & outlined guidelines as described hereunder.

It is to be noted that the various sign types are specified and agreed for their design, visual appearance, dimensions, orientations, form, colour, suggestive fixing and placements at the airport. However, the actual detailing and design of the structure, at times material specification, population, location planning, content finalization, detailing for fixing, joineries, integration with the built architectural elements, connection and coordination with electrical and data cabling, installation, stability, accuracy and correctness of design implementation as per the performance criteria is the responsibility of the EPC Contractor.

The design drawing for each sign type indicating overall dimensions, materials specifications, suggestive fixing, artworks, suggestive content, location of fixing, suggestive quantities, through the sign drawings and general arrangement drawings that are attached herewith for reference only. This document gives the technical specification for the specified materials and notes on best practice, workmanship that shall be guideline for the EPC Contractor to accomplish the job. It is EPC Contractor’s responsibility to detail for fabrication by creating shop drawings/working drawings, final artworks and contents thereof, which shall be presented to the Engineer-in-Charge for approval. The integration and coordination of the signage for their fixing with architectural element like walls, floor, ceiling and structural member shall be detailed and worked out by EPC Contractor based on performance and design criteria given in the document.
Electrical connection to the signage as required shall be extended from nearest light fixture / plug point with protective cover as required as per site conditions / approved by Engineer-in-Charge.

All Structure foundation, fixing screws etc. shall be designed and provided as per site conditions and to withstand maximum wind velocity at the proposed location.

4.0 List of materials

Following materials are mentioned in the document, which cover the majority of the work for sign fabrication but is not limited and newer options/advanced materials can be explored on the basis of meeting the performance criteria of signage. Components and accessories like hardware shall be procured of the best quality confirming to the Indian standards for matching life expectancy to the materials they are used in combination with.

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Material</th>
<th>Format</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Acrylic</td>
<td>Sheets</td>
</tr>
<tr>
<td>2</td>
<td>Vinyl films</td>
<td>Films and laminates</td>
</tr>
<tr>
<td>3</td>
<td>Aluminium</td>
<td>Extrusions, Profiles, sheets</td>
</tr>
<tr>
<td>4</td>
<td>Stainless steel</td>
<td>Sheets, Rolled sections</td>
</tr>
<tr>
<td>5</td>
<td>Mild Steel</td>
<td>Sheets, Rolled sections</td>
</tr>
<tr>
<td>6</td>
<td>Illumination and electrical</td>
<td>Lamps and electronics (LED)</td>
</tr>
<tr>
<td>7</td>
<td>Powder coating</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Polyurethane painting</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>Photo-luminescent signs</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>Retro-Reflective Vinyl</td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>Anodizing</td>
<td></td>
</tr>
</tbody>
</table>
5.0 Signage Detailing

5.1 Sign construction

Fabrication quality must be of a high standard from the perspective of load bearing strength, foundation strength, wind-velocity in the region, etc. and all illuminated signs will need to meet general electrical safety standards as determined by Indian Standards. It is envisaged that all illuminated signs will also need to offer a minimum of IP54 rating to prevent water and dust ingress. There should be no dangerously sharp corners or raw edges and all burrs must be removed. All graphics must be sealed to resist the abrasive action of weather or washing. All graphics and construction materials must be able to withstand the effects of temperature variations within the range of -5ºC and 65ºC.

Sign faces must be fairly easy to remove and replace if necessary with hidden/flush screw heads on the top of the frame. The hanging rods/poles must allow an adjustment in height and also allow some lateral adjustment.

All signs must be able to be cleaned back to a visual standard equal to that when first installed.

In addition to design, the sign structure for dead loads and imposed or live loads - structure must be able to withstand accidental damage or knocks without becoming dangerous. Graphic surfaces or panels must be easy to replace in case of damage or change in text. Replacement of complete signs must be straightforward and should be achieved without the use of any specialized equipment. Ideally, graphic panels should be removable without any adjustment to any fixing bracket, rod or support to the extent possible.

5.2 Typical sign details:

(a) Illuminated signs

The illuminated sign units have been designed so that only the text, icons and motif patterns illuminate.

The Illumination levels in the signs shall give uniform spread and brightness to stand out in the ambient lighting conditions during day and night of Terminal interior. Burning out due to placement of LED modules close to the sign face and dark spots shall be avoided by carefully fixing the LED inside the sign frame. A light diffuser film shall be used on the inside of white acrylic for even light distribution and achieving the desired results. The colour temperature for all LED lighting should be 5700K ± 300K or as per approved colour temperature by Engineer-in-Charge.
Internal illumination in all signages shall be carried out using Power LED modules with electronic controllers / drivers. Adequate ventilation to dissipate the heat from inside the sign shall be provided, in non-visible areas and locations & detail to ensure meeting the IP rating requirements.

EPC contractor is expected to provide details of power supply to be provided for LEDs / Drivers for all illuminated signs (Mode / medium / route of wires / cables from nearest supply source, etc.).

(b) Non-illuminated signs

Some location signs are non-illuminated. They shall be manufactured to look identical to the illuminated signs. They do not need to be as deep as the illuminated sign units but fixing requirements and details will remain the same.

Information, prohibition and some safety signs faces can be manufactured as shallow trays. Sign fixing brackets and hinges must be made of Stainless Steel. Allowance must be made for height & lateral adjustment and levelling.

(c) Emergency escape signs

Emergency escape signs shall be placed in compliance with guidelines given in the National Building Code 2016 and must be executed using all fire resistant materials namely MS CRCA powder coated sheet sign frames and boxes, Acrylic for the sign face with vinyl graphics applied from the inside to protect them against heating in case exposed to fire. The sign shall have internal illumination using a rechargeable battery with a 1-3 hours backup as per IS 9583 (1981). In general materials in Emergency signs shall comply with flame spread Index of '0'.

All fire life safety plans shall be Powder Coated / Anodized Aluminium Sheets mounted on wall.

(d) Vinyl signs / graphics

At some places application of vinyl graphics is required to provide counter numbers, gate numbers, signing text, door signs and statutory signing labels. Full artwork, layout guidelines and detailed schedule information is available in enclosed documents for reference only.
5.3 Warranty

All signage systems shall be guaranteed for the installed system including graphics and sign panels for a period of 2 years as Defect Liability Period and subsequently for a period of 5 years under an All Inclusive Comprehensive Maintenance Contract (AICMC).

5.4 Technical Data & Drawing Submission

a) Reference drawings and locations of sign shown etc. attached with this tender documents are for reference to the EPC contractor.

b) The EPC Contractor is to prepare all the necessary fabrication GFC drawings, structural details, location plans, population of signage, artworks and content as per functional requirement and these shall be submitted to the Engineer-in-Charge in 3 sets and be approved by him before fabrication is commenced. All such drawings shall show the dimensions of all parts, method of construction, assembly and installation.

c) Each material to be used in the fabrication of signs shall be approved through approval of technical submittal in 3 copies.

d) Further four sets of all approved shop drawings shall be supplied by the EPC Contractor Engineer-in-Charge for reference & record for execution of work.

e) For all floor mounted and totem signage, the EPC contractor will provide drawings approved by a certified structural consultant from the perspective of load bearing strength, foundation strength, wind-velocity in the region, etc.

Approval of drawings and technical submittal by the Engineer-in-Charge shall not relieve the EPC Contractor of full responsibility for any discrepancies, errors or omissions therein of contract specifications.

Upon completion of work, the EPC Contractor shall submit 4 sets of as-built drawings, Technical manual, etc. for signages package in line with SCC clauses.

5.5 Quality check and inspection

The EPC Contractor shall inform the Engineer-in-Charge of the progress in fabrication and as to when individual pieces are ready for inspection for their physical and performance checks at OEM works.
All gauge templates, sample materials, sizing templates, colour swatches, necessary to satisfy the Engineer-in-Charge shall be supplied by the EPC Contractor. The EPC contractor will submit routine test certificates of all the materials to the Engineer-in-Charge and the Engineer-in-Charge will conduct visual and functional checks of all signage at site.

6.0 Colours

All the Signage shall use the following colour specifications.

<table>
<thead>
<tr>
<th>S. no.</th>
<th>Application</th>
<th>Colour</th>
<th>Colour reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Sign Framing</td>
<td></td>
<td>RAL 9006</td>
</tr>
<tr>
<td>2</td>
<td>Background (Exterior-Road)</td>
<td>Blue</td>
<td>RETRO-REFLECTIVE</td>
</tr>
<tr>
<td>3</td>
<td>Primary Message (Exterior-Road)</td>
<td>White</td>
<td>040 acrylic for illuminated and retro-reflective for non-illuminated</td>
</tr>
<tr>
<td>4</td>
<td>Background (Exterior-Curb Side)</td>
<td>Yellow</td>
<td>PANTONE YELLOW C</td>
</tr>
<tr>
<td>5</td>
<td>Primary Message (Exterior-Curb Side)</td>
<td>Black</td>
<td>PANTONE BLACK 6C</td>
</tr>
<tr>
<td>6</td>
<td>Background (Interior)</td>
<td>Black</td>
<td>RAL 9011/ PANTONE BLACK 6C</td>
</tr>
<tr>
<td>7</td>
<td>Primary Message (Interior)</td>
<td>Yellow</td>
<td>PANTONE YELLOW C</td>
</tr>
<tr>
<td>8</td>
<td>Secondary Message (Interior)</td>
<td>Cyan</td>
<td>PANTONE 311C</td>
</tr>
<tr>
<td>9</td>
<td>Fire Signs</td>
<td>Green</td>
<td>PANTONE 3405C</td>
</tr>
<tr>
<td>10</td>
<td></td>
<td>Red</td>
<td>PANTONE 032C</td>
</tr>
<tr>
<td>11</td>
<td>Statutory Signs (Background)</td>
<td>Blue</td>
<td>PANTONE BLUE 541C</td>
</tr>
</tbody>
</table>
The above specified colours will be used through various materials like Vinyl Films, Powder Coating, Painting and Printing.

In case a special colour needs to be developed, it will be the EPC Contractor’s responsibility to coordinate with the manufacturer and present the various swatches to the Engineer-in-Charge for approval. All materials specific to the colour are important for the visual appearance of signs and execution of these shall confirm to the technical specifications and notes for quality of workmanship given in this document.

Materials
Before taking up the fabrication of any signages, EPC contractor shall submit the sample of materials complying contract specifications or better to Engineer-in-charge, upon his approval only procurements and executions thereof to be taken by the EPC contractor.

Acrylic

White Cast acrylic sheets with 40% light transmission shall be used as face of all illuminated signs except for the emergency exit signage. Clear, transparent acrylic sheets shall be used as face of all illuminated emergency exit signs. The acrylic should have excellent weather-ability and UV stability. Acrylics made from virgin polymers shall be used for the sign faces.

For sign faces up to 1000mm height or 2200mm width, 5mm thick acrylic sheet shall be used with a +/- 10% tolerance for the thickness. For sign faces greater than the above-mentioned height or width, 6mm thick acrylic sheet to be provided. The sign face should not bulge or cave in normal conditions.
7.1 Workmanship for Acrylic

The surfaces of Acrylic come covered with a masking film on both surfaces for protection during transport, storage and fabrication. The masking film should be left in place during fabrication work and all marking-out drawn on the film. EPC contractor should not remove the marking film until necessary to prevent dust collection and accidental surface scoring or scratching. However, care should be taken not to have the surface scratched during handling.

Before pasting the vinyl graphics, it is advised to wash the sheet surfaces to be decorated, with clean, fresh water using a soft cloth. This has the advantage of removing all traces of static charge from the sheet after removal of the film, which might otherwise attract dust. For all general purpose cleaning operations, acrylic should be washed simply with clean cold water to which a little detergent has been added. The use of any solvents such as methylated spirits, turpentine, white spirit or proprietary window cleaning products is neither necessary nor recommended.

Flatness of the sheets is very important for the signs to appear neat. The cutting shall be done using powered saw to a tolerance of +/- 1mm. The edges shall be cleaned of any bur and chamfered to make the acrylic comfortably sit inside the frame.

7.2 Vinyl Films

7.3.1 Block out vinyl films

Cast films should provide complete light blocking characteristics with less than 0.001% light transmission.

The cast vinyl film will have thickness between 0.1mm to 0.13mm, with clear acrylic based permanent pressure sensitive adhesive.

The film shall provide strong adhesion to a wide variety of substrates with perfect dimensional stability and perform well as second surface media.

The films should be non-colour fading, non-peeling and non-cracking.

The films should be able to withstand temperatures in the range -5° to +65°C
7.3.2 Opaque vinyl films

Cast opaque films of thickness between 0.063mm to 0.09mm, with clear acrylic based permanent pressure sensitive adhesive.

The film shall provide strong adhesion to a wide variety of substrates with perfect dimensional stability and perform well as second surface media.

The films should be non-colour fading, non-peeling and non-cracking.

The films should be able to withstand temperatures in the range -5° to +65°C

7.3.3 Translucent Vinyl film

Translucent Graphic Film to allow light transmission

Cast vinyl film of thickness 0.05 mm with clear pressure sensitive adhesive

A cast vinyl film with a clear, permanent, pressure-sensitive adhesive and a translucent synthetic liner that does not split if wet

The films should be non-colour fading, non-peeling and non-cracking.

The films should be able to withstand temperatures in the range -5° to +65°C

7.3.4 Protective over-laminate for digital prints

The over-laminate film shall be a semi-matt cast film, resistant to chemicals and abrasion while cleaning.

7.3.5 Other films: Printable vinyl/ Opaque vinyl/ Printable floor application/ Floor laminate

All vinyl has to have exact match with the colour specified for each sign. Sample shall be approved by Engineer-in-charge before execution.

7.3 Workmanship for Vinyl pasting (Plotter cut Vinyl sheet graphics/text)

Vinyl shall be pasted on Acrylic sheets or on glass/metal panel after removing the masking film/cleaning the surface.
Proper preparation of application surface is essential to obtain high quality and long lasting markings.

7.4.1 Application:

Clean the substrate as per recommendation of vinyl manufacturer.

Remove entire liner from adhesive side of film.

Align the film and press one edge to surface with finger.

With a squeegee, apply remaining film using overlapping strokes. Hold the film away from surface to avoid pre adhesion.

The CNC cut vinyl sheet should be applied to the substrates with the use of approved application tape to insure correct placement and accuracy. Vinyl application should be done in a dust free environment.

7.4.2 Remove pre-mask:

Remove application film from the face of the film by pulling tape back upon itself at a 180-degree angle. Application film should be removed after 24 hours of application.

Re-apply squeegee to all edges to prevent edge lifting. This must be done after application of film removal. Use firm even pressure.

7.4.3 Remove entrapped air:

All film pasting on the surface including the over-laminate should be free from air bubbles. Inspect the film in flat areas for bubbles. To eliminate the bubbles, puncture the film at one end of the bubble with a pin and press the entrapped air with the thumb or squeegee.

Self-matching and complementing films should be used for all situations involving layers of films laminated in a single sign.

The graphics for the Block-out vinyl sheet should be plotted in accordance with specified artwork accurately on a CNC cutter. The edges of the CNC cut vinyl sheet should be clean and smooth. Vinyl sheet should be plotted in a dust free environment.
The final applied graphics shall be free from any kinds of wrinkles, air bubbles and placement/orientation problems.

7.4 Printing

The graphics and text of the signage system shall be printed with inkjet / Eco solvent printers, with a hard over-lamination film to resist scuffing, scratching. Printing shall be done via cyan, magenta, yellow, black printing system.

Same colours of the signage shall be uniform as specified and shall not vary from sign to sign.

7.5 Aluminium Sections:

Aluminium plates and sections / extrusions shall conform to Aluminium alloy of grade 63400 of IS-733.

The completed sign sample in all respects shall be approved basis a presented sample as sign prototype. For illuminated signs, aluminium section has to be of minimum dimension not less than 25 mm in depth and not more than 2.5 mm of fascia trim. For non-illuminated signs, aluminium section has to be of minimum dimension not less than 10mm depth and not more than 2.5mm of fascia trim. Section shall be strong enough to take load of the signage and shall not distort on application of dead or live load.

Section shall be easily open-able for maintenance / cleaning / changing laminate.

All sections shall be perfectly straight, free from surface damages, bends and twists. Bent profiles shall not be forcefully straightened.

7.6 Stainless steel

Stainless steel of grade 304 shall be used for sheets for panelling and cladding while 304L shall be used in heavy gauge components for example pipe, plate and fixing to improve weld-ability.

Tools used only for fabrication of stainless steel and components shall be stored separately to avoid accidental switching with tools previously used on carbon steel fabrication work. For stainless steel pipe, plasma cutting and grinding back to bright sound metal is required
if the pipe ends cannot be machined. Flame cutting is not allowed. All weld end preparations and adjacent single continuous straight lengths of pipe should be used instead of joints.

Use of hot or cold hammering as a means for repair is prohibited. The pipe used, shall be consistent from an internal & external dimensions perspective.

All adjacent edges should be at true right angle or mentioned otherwise.

Surfaces of piping components / fabricated units / signs shall be kept free of foreign materials such as grease, paint, oil and the like.

Steel wire slings shall not be used for handling and transportation of stainless steel pipes. Canvas or nylon slings shall be used.

All parts assembled for bolting shall be in close contact over the whole surface and all bearing stiffeners shall bear tightly on top and bottom without being drawn or caulked. The component parts shall be so assembled that they are neither twisted nor otherwise damaged, as specified cambers if any shall be provided. Drilling done during assembling shall not distort the metal or enlarge holes. The butting surfaces at all joints shall be so cut and milled so as to butt in close contact throughout the finished joints.

The edges and ends of all cut / sheared flange plates, web plates of plate girders, and all cover plates shall be planed / grinded to make it free from any burr.

Final finish has to be done in the workshop itself after fabrication is complete. Sign has to be bubble wrapped / packed safe to transport to the site without any distortion/damage.

7.7 CRCA M.S. Sheets

The CRCA M.S sheets to be used in the work shall conform to IS 513.

7.8 Sheet Metal fabrication

The Metal handling and Fabrication work for CRCA Mild Steel sheets shall be executed by a specialized agency.
CRCA mild Steel Sheets Fabrication shall be executed with CNC bending, CNC Laser and punching machines with precise work control and quality generation. Besides the specified machines, the Metal handling and Fabrication must have in-house CO₂ welding and skilled CAD/CAM facilities, engineers and skilled and trained personnel and adequate storage facilities.

Sheet metal blanking shall preferably be done using laser cutting to save on material, reduce wastage, have fewer burrs on cut blanks, speed of execution and achieve accuracy.

All surfaces exposed to view shall be clean and free from dirt, stains, grease, scratches, distortion, waves, dents, buckles, tool marks, burrs and other defects which mark the appearance of finished work. Cutting edges shall be smooth and free from all defects.

All surfaces exposed to view shall be straight and true to lines or curves. Arises and angles shall be as sharp as practicable. Mitre joints shall be formed in true alignment with profiles accurately intersecting and all joints carefully eased to a radius of approximately 1 mm unless otherwise shown. Metal corners shall be bent to the smallest radius possible without causing grain separation or otherwise impairing the work.

All exposed connections shall be formed with hairline joints flush and smooth. All face panels must be flat, true and free from weld stud witness or other surface imperfections / blemishes. Edges shall be machined and finished free from cutter marks (not guillotined). All fabrication should have dressed welds, bend radii, finish, permitted texture levels, squareness of construction, no twist or warp or sagging of shape.

7.9 Structural Steel Fabrication

7.10.1 Workmanship and Fabrication for metal work:

For all the works, workmanship shall be of first class quality, throughout, and true to line, level and dimension as shown in the drawings or instructed by the Engineer-in-Charge.
All parts assembled for bolting shall be in close contact over the whole surface and all bearing stiffeners shall bear tightly on top and bottom without being drawn or caulked. The component parts shall be so assembled that they are neither twisted nor otherwise damaged, as specified cambers if any shall be provided. Drilling done during assembling shall not distort the metal or enlarge holes. The butting surfaces at all joints shall be so cut and milled so as to butt in close contact throughout the finished joints. Hand flame cutting will not be permitted.

The edges and ends of all cut/sheared flange plates, web plates of plate girders, and all cover plates, and the ends of all angles, tees, channels and other sections forming the flanges of plate girders, shall be planed/ground.

Punching of holes will not be permitted. All drilling shall be free from burrs. No holes shall be made by gas cutting process.

All welding work should be shop welding as far as possible. The pieces shall be manipulated to ensure down hand welding for all shop joints as far as possible. All parts to be welded shall be arranged so as to fit properly on assembly. After assembly and before the general welding is to commence the parts are to be tack welded with small fillet or butt-welds as the case may be. The welding procedure shall be so arranged that the distortion and shrinkage stresses be reduced to a minimum.

All joints required in structure to facilitate transport or erection shall be shown on the drawings or as specified by the Engineer-in-Charge. Should the EPC Contractor need to provide joints in locations other than those specified by the Engineer-in-Charge he should submit his proposals and obtain the prior sanction of the Engineer-in-Charge for such joints.

Each piece of steel work shall be marked distinctly before delivery, indicating the position and direction in which it is to be fixed. The complete marking plan is to be submitted to the Engineer-in-Charge before erection commences.
In the case of welded fabrication any distortion remaining in the member after welding operations are completed shall be rectified by and/or at the expense of the EPC Contractor to the approval of the Engineer-in-Charge.

Templates and jigs used throughout the work shall be all steel. In cases where actual materials have been used as templates for drilling similar pieces, the Engineer-in-Charge shall decide whether they are fit to be used as parts of the finished structure.

Apart from the requirements of welding specified under the above sub clauses, sections above, the EPC Contractor shall ensure the following requirements in the welded joints.

- Strength-quality with parent metal.
- Absence of defects
- Corrosion resistance of the weld shall not be less than that of parent material in an aggressive environment.

No gasket or other flexible material shall be placed between the holes. The holes in parts to be joined shall be sufficiently well aligned to permit bolts to be freely placed in position. Driving of bolts is not permitted. The nuts shall be placed so that the identification marks are clearly visible after tightening. Nuts and bolts shall always be tightened in a staggered pattern and, where there are more than four bolts in any one joint, they shall be tightened from the centre of the joint outwards.

7.10.2 Protection of Steel Works:

Painting shall be applied under the temperature requirement specified by the manufacturer.

The steel work, prior to delivery, shall be cleaned form scale, rust, dirt and grease etc., by means of chipping, scraping and wire brushing using skilled operators as described in the painting systems below. The cleaning shall proceed each day over the extent of surfaces,
which can be painted on that day. The paint shall be applied by brushing or spraying as per approval of the Engineer-in-Charge.

Site weld locations shall be left free from paint within 50mm of the weld position, and contact surfaces in connection using High Strength Friction Grip Bolts shall not be painted. Immediately after completion of erection all damaged paint shall be scraped off and made good.

The Steelwork specialist shall also clean down and apply one coat of primer to all site bolts, site bolted connections and site weld locations and the paint work generally shall be left in sound condition for any subsequent painting.

All paints and primers shall be of best quality and to be stored and applied strictly in accordance with the manufacturer’s instructions.

In addition, the following specification shall apply to the shop painting of contact and inaccessible surfaces:

- Surfaces to be painted shall be thoroughly cleaned from scale, rust, dirt, grease etc. by means of sand/grit/shot blasting or other equivalent means.

- Surfaces, which are to be brought permanently into close contact or made inaccessible either in the shops or upon erection shall, after cleaning, be given two coats of Red Lead Primer Paint. The surfaces shall be brought into contact while the paint is still wet.

- All enclosed surfaces of box members shall be completely sealed by oiling or by coating with approved bitumen paint and all such members and tubes shall have their ends closed by suitable plates welded in position.
Surfaces in contact during shop assembly shall not be painted. Surfaces which cannot be painted, but require protection, shall be given a rust inhibitive grease.

The EPC Contractor shall take all precautions to prevent dust and dirt coming in contact with freshly painted surfaces or with surface being painted. The second coat of paint shall only be applied when the first coat has dried.

Exposed machined surfaces shall be adequately protected.

A uniform film thickness of paint is to be ensured throughout the work.

Surfaces, which have not been shop coated, but require surface treatment shall be given necessary surface preparation and coats at site as specified in the painting system.

### 7.11 Erection & Site Work:

The EPC Contractor shall be responsible for checking the alignment and level of foundation and correctness of foundation bolt centres, well in advance of starting erection work, and shall be responsible for any consequences for non-compliance thereof.

Following the completion of the straightening, the surface of the member shall carefully be inspected for damage and got approved by the Engineer-in-Charge before further use.

All equipment used by the EPC Contractor shall be sufficient for the purpose and for the erection of the steel work, in the time specified in the EPC contract. Any lifting or erecting machinery shall be to the approval of the Engineer-in-Charge and shall be removed from the site if he considers such appliances dangerous or unsuitable for their functions. Adequate arrangement shall be made to resist wind loads and lateral forces arising at the time of erection.
The EPC Contractor is entirely responsible for the stability of the structure during erection and shall arrange that sufficient tack bolts, braces or guy ropes are used to ensure that work will remain rigid until final bolting, riveting or welding is completed. The EPC Contractor shall supply and fix, without extra charge, any temporary bracing which may be necessary.

At stanchion splices and at other positions where concrete cover to the steel is liable to be restricted, bolts will be placed with their heads on the outside of the members.

All field assembly bolting and welding shall be executed in accordance with the requirements for shop fabrication excepting such as manifestly apply to shop conditions only. Where steel has been delivered painted the paint shall be removed before field welding for a distance of at least 50mm on either side of the joints. The number of washers on permanent bolts shall not be more than two for the nut and one for the bolt head.

### 7.12 Lamps and fixtures:

Power LEDs shall be used in all the illuminated signs.

All lamps shall be supported using clips to ensure no damage and facility to easily replace them when required.

IP Category – IP 54 or higher for indoor and IP65 or higher for outdoor with colour temperature of 5700 +/- 300K.

Type of Drivers – Non-potted for indoor and potted for outdoor, complying serviceability class B.

#### 7.12.1 Recommended contrast between Light output and background.

<table>
<thead>
<tr>
<th>Types of Areas</th>
<th>Range of Service Luminance in Lux for Signs in given area.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Curbside area</td>
<td>400-1000</td>
</tr>
<tr>
<td>Interior Area</td>
<td>240-1000</td>
</tr>
</tbody>
</table>
### 7.13 Wiring for Signage:

**Illuminated signs**

The EPC Contractor shall also ensure that all the connections inside the sign are made through Bakelite connectors and thimbles & screws are used for end terminations of wires. Thimbles wherever installed shall be properly covered with insulated sleeves and no temporary taping is done at any point. All the connectors shall be ISI marked.

All connectors and joints shall be mounted or fixed to the internal structures of signs with insulating materials.

The inter-connecting wiring between light fixtures & within the sign shall not be less than 1.5 Sq.mm and shall be FRLH, PVC insulated 1.1 KV grade, with multi-stranded copper conductor.

An earth terminal shall be provided on each of the lit sign which shall be connected with the earthing conductor laid along with incoming circuit / point wiring.

All wiring within the sign enclosure shall be covered with flexible PVC conduit, which shall be properly fixed with, clamps, saddles etc. in such a way that no shadow is cast on the illuminated surfaces. In no case any loose wiring shall be left inside the sign enclosure.

Wiring for all type of sign needs to be concealed and out of public reach and sight. No conduit shall have joint in the floor where it is exposing to humidity or water seepage.

All cabling /wiring /conduit works etc. shall be in conformity to CPWD specifications & as per IEE Rules with up to date amendments.

### 7.14 Powder Coating

#### 7.14.1 Powder coating on Aluminium Plates/sections
Wherever specified the aluminium plates shall be coated in approved colour and shade with polyester powder to a minimum thickness of 65 microns. **The polyester powder coating work shall be executed by specialized agency.**

Test Certificates from approved laboratory for the powder-coated material shall be submitted by the EPC Contractor.

The polyester coated surface shall be of uniform texture, colour and gloss and shall be free from cracks, warps and other imperfections.

### 7.14.2 Powder coating on Mild Steel

Wherever specified, the M.S plates & sections and CRCA mild Steel plates & sections shall be powder coated in approved colour and shade with polyester powder coat to a minimum thickness of 65 microns, and the EPC contractor shall submit the thickness test certificate for the same.

### 7.14.3 Anodizing on Aluminium sections/extrusions

The aluminium sections/extrusions shall be anodized in black finish. The anodizing coating thickness should be 16.5 microns or more, and the EPC contractor shall submit the thickness test certificate for the same.

### 7.15 Polyurethane Painting

PU paints matched to shades as per colour specifications shall have a good make to ensure the quality and life of the product. PU paint applications shall be done in following steps or as instructed by the each manufacturer.

- **Surface cleaning:** Remove grease, oil and other contaminants by using a de-greasing solvent using mechanical tools. Ensure that all the dust particles are removed by suction or air blast and surface is fully dry and cleaned.

- **Application of primer:** Stir the components thoroughly and then mix base and catalyst in proportions by volume as instructed in the product specifications to uniform consistency. Avoid agitation of mixing. Add 10% thinner immediately before application. However additional thinner may be added if required to achieve a good workability. For Airless spray, use any standard equipment. This requires an over coating interval of minimum one overnight and a dust free environment.
• **Application of the final finish:** Stir the base thoroughly and then mix base and catalyst by volume as instructed in the product specifications to uniform consistency. Allow the mixture to mature for 30 minutes and stir again before use and application. Apply using a conventional spray. Add 10% thinner depending on conditions. Use any standard equipment. Two coats could be applied for a good result.

7.16 **Photo luminescent signs**

All Photo luminescent signs shall be procured from specialized agency providing signs with following specifications but not limited to:

• Water proof Non corrosive
• Withstand temperatures from -5°C up to 65°C.
• Non-reactive to Dilute Alkalis and Acids.
• Glow time in excess of 2 mcd/m² after 60 minutes
• UV-stable and weather-resistant for outdoor applications.
• Ability to absorb energy from almost any light source (sunlight, fluorescent, incandescent) and then to emit light when ambient darkness occurs.
• The light produced is yellow-green in colour and is highly visible, lasting up to 10 hours.

7.17 **Retro-reflective signs**

High Intensity grade sheeting: A very-high-intensity retro-reflective sheeting that has the highest retro reflectivity characteristics at short road distances should be used. It should be weather resistant and exhibit colour-fastness. The sheeting should be of encapsulated lens type consisting of spherical glass lens, elements adhered to a synthetic resin and encapsulated by a flexible, transparent waterproof plastic with a smooth surface.

Sheet of good quality manufacturers should be used.

7.17.1 **Acceptable Minimum Co-Efficient of Retro-Reflection for High Intensity Grade Sheeting (Candelas per Lux per Square Meter)**

<table>
<thead>
<tr>
<th>Observation angle in degrees</th>
<th>Entrance angle in degrees</th>
<th>White</th>
<th>Yellow</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>0.2</td>
<td>-4</td>
<td>250</td>
<td>170</td>
</tr>
<tr>
<td>0.2</td>
<td>+30</td>
<td>150</td>
<td>100</td>
</tr>
<tr>
<td>0.5</td>
<td>-4</td>
<td>95</td>
<td>62</td>
</tr>
<tr>
<td>0.5</td>
<td>+30</td>
<td>65</td>
<td>45</td>
</tr>
</tbody>
</table>

The EPC contractor will submit a certificate from the manufacturer that shows compliance to the above table. When totally wet, the sheeting shall not show less than 90 per cent of the value of retro-reluctance indicated in the table above.

**Adhesives:** The sheeting should have two types of adhesives:

- Pressure sensitive adhesive of the aggressive tack type requiring no heat, solvent or other preparation for adhesive to a smooth clean surface.
- Tack free Adhesive activated by heat, applied in a heat-vacuum applicator as specified by the sheeting manufacturer.

The adhesive should form a durable bond to smooth, corrosion and weather resistant surface of the base plate.

**Fabrication:** The surface to be reflectorized shall be effectively prepared to receive the retro-reflective sheeting. The aluminium sheet shall be de-greased either by acid or hot alkaline etching and all scale/dust removed to obtain a smooth plan surface. If surface is not smooth, approved surface primer may be used.

Complete sheets of the material shall be used on the sign except where it is unavoidable. At splices, sheeting with pressure-sensitive adhesive shall be overlapped not less than 5mm and sheeting with heat-activated adhesive may be spliced with an overlap not less than 5mm or butted with a gap not exceeding 0.75mm. Where screen printing with transparent colour is proposed, only butt joining shall be used. The material should cover the sign surface evenly and shall be free from twists, cracks and folds.
## List of Makes (Additional)

<table>
<thead>
<tr>
<th>Material Description</th>
<th>Manufacturer / Supplier</th>
<th>Colour / Finish</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cast exterior grade opaque vinyl</td>
<td>3M / Avery / Metamark or equivalent</td>
<td>To match with RAL specified code</td>
</tr>
<tr>
<td>Retro-reflective vinyl</td>
<td>3M / Avery Grade IV</td>
<td>White &amp; Blue</td>
</tr>
<tr>
<td>Acrylic sheet for backlit operation</td>
<td>Astari / plexiglas or equivalent</td>
<td></td>
</tr>
<tr>
<td>Digital printing media</td>
<td>3M / Avery / Metamark or equivalent</td>
<td></td>
</tr>
<tr>
<td>Over-lamination for digital printed media</td>
<td>3M / Avery / Metamark or equivalent</td>
<td></td>
</tr>
<tr>
<td>Photo-luminescent film</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Translucent vinyl</td>
<td>3M / Avery / Metamark or equivalent</td>
<td>Yellow, Cyan and other RAL specified codes</td>
</tr>
<tr>
<td>Aluminium fabricated sheet</td>
<td>Jindal / Hindalco / Tata</td>
<td></td>
</tr>
<tr>
<td>Aluminium extrusion</td>
<td>Jindal / Hindalco / Tata</td>
<td></td>
</tr>
<tr>
<td>SS fabricated box section</td>
<td>Jindal / Tata / RINL</td>
<td>Brush finish 304 grade</td>
</tr>
<tr>
<td>SS fabricated sheet</td>
<td>Jindal / Tata / RINL</td>
<td>Brush finish 304 grade</td>
</tr>
<tr>
<td>MS fabricated box section</td>
<td></td>
<td>Hot dipped Galvanised</td>
</tr>
<tr>
<td>MS fabricated sheet</td>
<td></td>
<td>Hot dipped Galvanised</td>
</tr>
<tr>
<td>CRCA MS fabricated sheet</td>
<td>Hot dipped Galvanised</td>
<td></td>
</tr>
<tr>
<td>--------------------------</td>
<td>-----------------------</td>
<td></td>
</tr>
<tr>
<td>PU paint</td>
<td>DuPont / Asian Paints / Berger or equivalent</td>
<td></td>
</tr>
<tr>
<td>Powder coat</td>
<td>Asian Paints / Berger / Rapid Coat or equivalent</td>
<td></td>
</tr>
<tr>
<td>Power LEDs for back lighting</td>
<td>Osram / Philips / Luco LED / LT or equivalent</td>
<td></td>
</tr>
<tr>
<td>Drivers for LEDs</td>
<td>Osram / Meanwel / Union or equivalent</td>
<td></td>
</tr>
<tr>
<td>LED TVs</td>
<td>Samsung / Sony or equivalent</td>
<td></td>
</tr>
</tbody>
</table>
TS-10
LANDSCAPE & HORTICULTURE WORKS
NOTE:

(The Technical Specifications are intended only to provide a fair idea about the requirements and concepts of the Project. The designs, technical specifications etc. to be executed at site are required to be submitted by the EPC Agency to AAI/ PMC for prior approval)

Work shall be carried out to Indian Standards, CPWD Specifications and Code of Practices. In absence International Standards shall be followed. These shall be latest issue. Specifications given hereunder are not to be considered as conclusive and are for reference and guidance only. Any discrepancies noticed shall be directed to the notice of PMC/ AAI for direction and approval. However as a general rule more stringent specification shall take precedence.
GENERAL TECHNICAL SPECIFICATIONS:

The general technical specifications for Landscape & Horticulture shall be the “CPWD Specifications-2009 & CPWD Specifications for Horticulture & Landscaping - 2018 with up-to-date correction slips” published by Director General of Works, CPWD, Nirman Bhawan, New Delhi and the various Indian Standards mentioned in the body of these specifications with latest edition, all up-to-date correction slips, etc. or as directed by the Engineer-in-Charge. The CPWD Specifications can be downloaded from their website www.cpwd.gov.in and the same shall form part of the Contract Document.

MATERIALS - GENERAL:

• Fertilizer:

Shall be complete fertilizer consisting of nitrogen, phosphorous and potash (NPK17:17:17 (5kgs/M3). It shall be applied by weight in two applications. The first application shall be within one week before planting harrowed into the top 6 inches of soil. The second application shall be done, as the Horticulturist -in-charge / Landscape Architect will think is needed at a later stage.

If pH exceeds 7.5 ammonium sulphate or equivalent fertilizer should be added. Sufficient Limestone or equivalent fertilizer shall be added to bring it to a range of pH 6.5 to 7.5 in case pH is below 6.5.

• Root Barriers/HDPE Edges :

The root barriers will be of HDPE sheets in 50 to 100m rolls of 0.3m depth and 0.7mm thickness fixed between two types of lawn or lawn and planting as shown in the drawings. It should be 20mm above the finished grade of the lawn to prevent invasive runners from mixing with other lawn. Typical properties of the root barrier membrane are:

<table>
<thead>
<tr>
<th>PROPERTY</th>
<th>VALUE</th>
<th>STANDARD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Material</td>
<td>HDPE</td>
<td>-</td>
</tr>
<tr>
<td>Dimension(length)</td>
<td>100 m</td>
<td>-</td>
</tr>
<tr>
<td>Dimension(depth)</td>
<td>300, 600, 1000 &amp; 1500mm</td>
<td>-</td>
</tr>
<tr>
<td>Thickness</td>
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<td>- transversedirection</td>
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<td></td>
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<tr>
<td>Elongation at rupture</td>
<td></td>
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</table>

- **Drain Cell:**

Size 305X305X20mm, 100% recycled polypropylene, weight -250gms/sq.ft. The compressive load will be above 1200KN Opening - above 70% are easy to install, by interlocking them horizontally and vertically. Replacement if broken during execution and maintenance period included.

- **Geotextile Fabric:**

Laying & Fixing the Geo-Fabric 150 GSM,- 100% recycled polypropylene, of thickness 1.3mm, -Tensile strength at breaking more than 4.5KN/m. CBR plunger strength more than 0.6 KN, and Tearing strength more than 0.12KN, Breadth Tolerance to be 0.5%, and Elongation at breaking 25-100%, EOS O90 0.07-0.2mm, Vertical Permeability Kx (10-1 ~10-3) CM/S, including cutting & Fixing, etc. charges for complete finish work (measurement taken only of actual work done excluding wastage). Supply & transport of geotextile as per the specification given here.

- **Coir Mat on Slope:**

a) Supply & transport of coir mat as per the specification. Rate to include transport, base-preparation, installation, labour etc.
b) Begin at the top of the slope and anchor Coir Mat in a 12” deep initial anchor trench.
c) Backfill trench and tamp earth firmly.
d) Unroll matting down slope Overlap edges of adjacent parallel rolls 6” and anchor with stable at 12” centers.
e) When Coir Mat must be spliced, place end over end (shingle style) with 12” overlap and anchor using two staggered rows of staples at 6” centers.
f) Lay mat loosely and anchor sufficiently to maintain direct contact with the soil.
g) For slopes 2:1 and steeper use a minimum of 3 staples per square yard and for slopes flatter than 2:1 using a minimum of 2 staples per square yard.
h) Anchor, fill and compact end of the matting in 12” x 6” terminal anchor trench.

- **Light Weight Material Filling:**

  **Option-a—Brick bat:** Filling 4” thick Brick Bat of good quality, well burnt of size 2” to 4” by proper arrangement & filling gaps in between the perforated pipes for subsurface drainage (as per consultant) by river Sand of approved grain size, broken bricks & crush of bricks & for filter media, achieving a clean finished given level, etc everything complete all as directed by engineer in charge/ Landscape Architect

  **Option-b- Cinder:** Filling required area with well burnt wood pieces or cinder that are neutral in their effect on the soil or plants. The Cinder pieces should not have sharp edges. After laying achieving a clean finished given level etc as directed.

- **HDPE sheet:**

  Available in custom size and length. Colour - Natural laid over waterproofing layer. Non-corrosive, Non-Toxic. Low coefficient of friction, Corrosion resistant, Abrasion and impact resistant, Anti-Weather and Anti-Aging, Self-lubricating. Wear Resistant. Great liner material for industrial material handling applications, UV Resistant High Operating Temperature High Tensile Strength, High Viscosity, Flame Retardant Reprocessed. Supply & transport of as per the specification Job to include transport, base-preparation, installation, labour etc. This is laid under the mounds on the Podium for area of 6x6m under the mounds.

**IRRIGATION SYSTEM:**

- **Materials:**

  a) All garden hydrant system mains and sub mains and branches shall be uPVC pipes as per IS: 4985 of class 10 kg/cm2 rating with matching fittings.
  b) For drip irrigation system LLDP drip tubing of 10 kg/cm2 rating with all matching fittings and special e.g. coupling, tees, bends and reducer, etc. with solenoid valve assemblies shall be provided.
  c) All pumping system shall be vertical inline stainless steel pump placed in the STP plant room. All electrical works for the pumps including control cables shall be included.
d) Suitable filtration units, disc filters, pressure gauges, air release valves shall be provided as accessories for irrigation system.

e) Materials of valves used in the irrigation system shall be as already specified in water supply section of DBR.

f) Confirmation about adequacy of water head available at site for safe operating of the system shall be proposed by the agency.

g) Treated effluent from STP for flushing and horticulture purpose as per Guidelines of Ministry of Environment.

• System Procedure:

Detailed micro irrigation system based on plantation & soil conditions can be designed by using hydraulic formulae to calculate the frictional losses & by selecting appropriate Emission devices.

Further entire networking of lateral pipe will be joined to the mainline by control valve for sectional operation. Likewise, there will be various sections depending on size, shape of Plot & flow requirement.

Ring main line will be designed to cater entire requirement of plot & considering ground slope. There will be provision of Non Return & Air Release Valves at strategic location as required.

Pumping system with filtration can be designed after arriving to final figure of total head required in meters & maximum sectional discharge at pumping station. Filtration is proposed only after getting water quality analysis report; this system will make water potable for irrigation only.

Automation is suggested from one single station & cable networking is required to be done parallel to the mainline with field control devices.

• Materials:

Materials shall be of approved make and quality specified. They shall conform to the respective Bureau of Indian Standard Specifications and supported by Manufacturing Certificate.

Samples of all materials shall be as per the list of approved brand manufacturer, which shall be got approved before placing order and the approved samples shall be deposited with the Client.

• General Conditions:
The Contractor shall,

1. Submit method statement for installation of the system and shall get approval before commencing the work.

2. Ensure that the irrigation system installed operates to its optimum efficiency.

3. Ensure that there are no dry patches in the lawn area and water is effectively distributed to all the areas it is intended to be.

4. Ensure that the dry areas like roads, pavements, etc., are not wetted.

5. Ensure that the pump, valves, sprinklers, PVC pipes, etc., are installed and commissioned as per manufacturer’s guidelines.

6. Submit shop drawings of the area to be installed with proper placement of accessories as indicated in the tender drawing and shall get approval before commencement of work.

7. Bring to the notice of client any changes to be brought to the irrigation plan w.r.t pipe sizing/ routing, by way of shop drawings duly approved before proceeding with the installation.

8. Locate hose point positions wherever required as indicated in the tender drawing and get approval from the consultant/client before proceeding.

9. Ensure that the pump supplied shall give the required head range & discharge, and guarantee its operation to get the desired effect.

10. Recommend the pump room sizing and the electrical requirements required at site in coordination with the supplier and submit the necessary details to the client for approval. The pump room shall also accommodate filtration unit and should have sufficient space for movement to carry out repairs/maintenance.

11. Indicate the size and position of RCC NP2 class pipes to be placed at road/pathway/concrete structure crossings or wherever required as per site conditions.

- **Piping Materials:**

  **General:** All sizes are in metric unit; whereas equivalent imperial unit shall be used in case of imported material.
Polyvinyl chloride (PVC) pipes and fittings: PVC Pipes of diameter 110 mm to 90 mm shall be of 10 Kg/cm², 75 mm to 40 mm shall be of Class 3, 6 kg/cm² and for diameter below 40 mm shall be of Class 4, 10 kg/cm². PVC pipes and fittings shall be jointed with solvent cement. The pipes shall conform to IS 4985. PVC Fittings shall be of injection molded PVC conforming to IS 7834.

ASTM High Pressure Pipes and Fittings: ASTM (American Society for Testing & Materials) pipes of diameter 3” to 1.25” with SCH 40 pressure class and the fittings shall be jointed with solvent cement specialized for ASTM. These pipes are manufactured as per ASTM D 1785 standard.

Fittings: Fittings shall be injection molded and shall be 10 kg/cm² pressure rating and to conform to Indian Standard/ISO standard. Molded fittings will be preferred at all places however if bends is required to be used in some situation shall be fabricated from 10 kg/cm² Pipes.

• Valves:

Solenoid Valve: (Glass Filled Nylon): The electrical solenoid valves shall be of the globe type normally closed, electronically actuated, diaphragm operated.

The valve’s body and bonnet shall be molded of non-corrodible, glass-reinforced nylon, rated at an operating pressure of 220 PSI (15.5 Bar). The body of the valve shall have brass inserts, with through holes, which will accept the bonnet Stainless steel bolts.

The diaphragm shall be of molded construction, reinforced with nylon fabric. A heavy-duty removable seat shall be available to protect and support the diaphragm.

The valve shall be equipped with an internal filter as well with a self-cleaning metering rod, so only clean water can enter the solenoid chamber. A filter cleaning system, that continuously cleans the filter when the valve is operating, shall be available.

The valve shall be equipped with a flow control mechanism with handle, which regulates the flow from full on to completely off. It shall have an accurate set pressure regulator, to keep the downstream pressure constant after setting it. The regulator shall be of the top dial model with clearly shown pressure values in bars and PSI. It shall regulate the flow at a pressure range of 1.4 to 7.0 Bar.

The valve shall be available in 1, 1.5, 2 and 3 inch size and it shall have a BSP female thread inlet and outlet. It shall accommodate a flow rate from 0.023 (1” size) to 69.1 m³/hr (3” size).
The valve shall have a 24 volts 50 cycle solenoid with a 370 mA in-rush current and 190 mA holding current.

The solenoid shall be an encapsulated, one-piece unit with a captive plunger. The Valve shall be equipped with a manual internal bleed only giving the capability to release the upper chamber water to the downstream piping, allowing the valve to open. No external bleed shall be available.

**Pressure Regulating Device:** Pressure regulator shall regulate and maintain constant outlet pressure between Regulation from 1.4 to 7 bar; 140 to 700 kPa, Pressure rating: 10 bar; 1000 kPa, Required dynamic pressure differential: 1 bar; 100 kPa, should work with Works with AC and DC latching solenoids Should have adjustment knob with detents to permit fine-tune setting in 1/3 psi (0.02 bar) increments.

**Pressure Relief Valves:**

1. Quick Pressure Relief Valve, hydraulically operated, diaphragm actuated control valve to relieve excessive system pressure when the pressure rises above the pre-set value.
2. It should immediately, accurately, and with high repeatability responds to system pressure rise by fully opening.
3. It should be Line Pressure Driven and shall have long term drip tight sealing.
4. It should have long term setting stability with wide setting range.

**Air Valves:**

a) Air valve is required to be installed on main line at strategic location and on high points and also on the ends of pipe line main to allow entry and exit of air at the time filling and emptying of pipe line

b) Air Valves will be 32 mm made up of cast aluminum depending on the size of main line, double acting air/vacuum type. Every valves shall be isolated from the mainline by a gate valve.

c) Air valves will be installed so that they are a minimum 100 mm and a maximum 200 mm below grade.

d) Round valve box should be installed on each air valve for protection & identification.
**Quick Coupling Valves:**

a) Wherever required the Quick Coupling Valve will be 25 mm brass quick coupling turf valves.

b) Each QCV will be secured with proper stake/reinforcement to avoid movement of it.

c) 25 mm brass coupler keys and swivel hose elbows shall also be provided by the contractor to enable use of the QCV’s.

d) Each QCV will be isolated with gate valve and covered with Round Valve Box.

**Valve Boxes:**

a) Valve boxes shall be of specified make and would be of appropriate size to accommodate the valve for easier operation/maintenance. The top cover of the valve box shall be flushed with the finished ground level.

b) Valves boxes shall be high impact resistant plastic, colored green. All covers shall feature locking bolts. All plastic valve boxes shall be supported by a simple block work construction.

c) Access to solenoid valves, ball valves and air release valves shall be through a circular tapered valve box measuring 10” & 6”.

d) Access to the butterfly valves shall be through a rectangular valve box of 12 “.

**Sprinklers:**

**Spray pop-up sprinklers:**

- The sprinkler shall be equipped with an adjustable arc (0-360°) nozzle or fixed arc nozzle discharging a flow of between 0.04 and 1.1 m³/hr for the full circle and it shall be available in sizes to cover a radius of 1.2, 1.8, 2.4, 3.0, 3.6, 4.6, 5.2 meters at a pressure of 2.1 Bar. And it shall be available with strip patterns as side strip, end strip, center strip, left corner and right corner strip covering rectangles of 1.5mx4.6m, 2.7mx5.5m, 1.5mx9.1m, at a pressure of 2.1 Bar.

- The sprinkler shall be available with a 4, 6, or 12” (10, 15, or 30cm) pop-up stroke, depending on the body specified, to bring the nozzle into a clean environment. The
sprinkler shall have the option of either a factory-installed or field-installed drain check valve capable of checking up to 10 feet (3.0 m) in elevation change.

- The sprinkler shall have available an optional, snap-on cap, molded in purple alcryn rubber, or a replacement body cap, molded in purple to indicate the use of reclaimed water.

- The body of the sprinkler shall be constructed of corrosion and UV-resistant, heavy-duty A.B.S. The riser of the sprinkler shall be constructed of abrasion and UV-resistant A.B.S. and shall be adjustable for pattern alignment. The riser shall be compatible with female threaded nozzles and shall have a stainless steel spring for positive retraction when irrigation is complete.

- The sprinkler shall have a pressure-activated, multi-function, UV stable wiper seal that will clean debris from the pop-up stem while it retracts. This seal shall prevent the sprinkler from sticking in the up position and be capable of sealing the sprinkler riser stem to the sprinkler cap under normal operating pressures. The seal shall be removable from the cap for easy service and shall be replaceable.

- The sprinkler shall have a standard pressure-regulating device as an integral part of the pop-up riser. This regulator will prevent fogging or misting of the nozzle spray pattern by maintaining a constant nozzle outlet pressure of 2.1 Bar with inlet pressures of up to 7.0 Bar, regardless of the nozzle installed.

- The sprinkler shall have a factory-installed, removable flush cap with a pull-up tab that shall prevent debris from entering the sprinkler during installation and allow the system to be flushed before installing the nozzle. The flush cap shall have a directional flushing action that allows the water to escape only in one direction. The flush cap shall open as the stem extends and completely close when the stem is in the retracted position.

- The sprinkler shall have an exposed surface diameter after installation of 2.25” (6 cm). The sprinkler shall have a ½” BSP thread bottom inlet. In addition, the 6” (15 cm) and 12” (30 cm) sprinklers shall be equipped with a standard ½” BSP thread side inlet.
Multi-stream multi-trajectory rotating nozzles:

- The sprinkler shall be of the viscous fluid brake rotary type and be a multi-stream, multi-trajectory rotating stream sprinkler.
- In full or part circle mode the sprinkler shall be capable of covering 2.4 to 10.7 meter radius at 2.8 Bar pressure with an equivalent full circle discharge rate of 0.173 to 0.84 M3/hr. Side Strip sprinklers shall be capable of irrigating a rectangular area of 1.5 x 9.1 m at 2.8 Bar. Left strip and right strip sprinklers shall be capable of irrigating a rectangular area of 1.5 x 4.6 m at 2.8 Bar pressure.
- The sprinkler shall produce and maintain a matched precipitation rate no greater than 15 mm per hour throughout the arc adjustment range and radius adjustment range, (up to 25% of radius reduction), when spaced at 50% of wetted diameter.
- The part circle sprinkler shall have an infinitely adjustable arc from 45° to 105°, 90° to 210° or between 210° to 270° depending on the model selected. The full circle sprinkler shall irrigate a full 360°. The 45° to 105° model shall not require coverage from adjacent sprinklers closer than 3’ from the head.
- Full or part circle sprinklers shall be capable of up to 25% radius reduction using a stainless steel radius adjustment screw. The radius reduction screw shall have a slip clutch mechanism to prevent internal damage if turned past the minimum or maximum radius settings. The radius reduction screw shall reduce the pressure and flow upstream of the adjustable orifice thereby maintaining stream integrity.
- Part circle sprinklers shall have arc adjustment capabilities using a stainless steel ring. The adjustment ring shall be effective only while the sprinkler is popped up and shall be ineffective while the sprinkler is popped down. When turned past the minimum or maximum arc limits the adjustment mechanism shall have a ratcheting action to prevent internal damage.
• This same ratcheting action shall allow the orientation of the left edge of the variable arc when installed on a fixed riser or in a popup body. This is independent of and in addition to any ratchet that may exist in a popup body.

• The sprinkler itself shall pop-up at approximately 1.0 Bar of water pressure. Upon cessation of water pressure, the sprinkler itself shall retract. When installed in a pop-up body the sprinkler itself shall pop-up after the body stem is almost fully extended. Upon decreasing pressure the sprinkler itself shall pop-down before the pop-down of the body stem is complete.

• The sprinklers adjustable orifice shall be manufactured from polyurethane and acetyl plastic materials for durability.

• The sprinkler shall be fitted with a detachable filter.

**Gear driven rotor pop-up sprinklers (5 – 11 m radius):**

• The sprinkler shall be of the gear-driven closed case, rotary type, capable of covering a radius of between 15 and 37 feet (4.6 to 11.3 meters) and to give a flow of 0.15-1.22 M3/hr at a pressure range of 2.1 – 3.5 Bar.

• The sprinkler shall have radius reduction capabilities by means of a stainless steel nozzle retainer/radius adjustment screw. The sprinkler shall be available in an adjustable part circle configuration. The adjustable part-circle unit shall be minutely adjustable from 40-360°. The adjustable unit shall be adjustable in all phases of installation. All adjustments shall be done from the top of the riser.

• The gears of the sprinkler shall be water lubricated and they shall be enclosed in an inner case to prevent dirty water entry. The sprinkler shall be equipped with a self-adjusting stator to ensure constant rotation speed irrespective of the nozzle installed. It shall be provided with an optional drain check valve to prevent low head drainage.

• The sprinkler shall have an exposed diameter of 30mm after installation, and it shall have a ½ inch female threaded inlet. The sprinkler shall have a thick rubber cover firmly attached to the top of the sprinkler riser. The body and the riser of the sprinkler shall be constructed of non-corrodible, heavy duty A.B.S. It shall have a stainless steel spring for
positive retraction of the riser when irrigation is complete. It shall be serviceable after installation by unscrewing the body cap, removing the riser assembly and extracting the inlet filter.

- The sprinkler shall be supplied with a set of minimum eight nozzles.

**Swing Joint:**

- All the connection between pipes to sprinkler shall have swing joint risers or an approved equivalent with O ring sealing for the threaded joints.
- The length of all swing joint risers will be 300 mm or as per site requirement.
- Swing Joint should have four elbows for easy installation (Four Way Swing Joint)

**Drip Irrigation:**

**On line drippers**- The dripper shall be single outlet and it shall have a fixed flow of 24 Liters per Hour (6.34 Gallons per Hour) for a pressure range of 7-60 psi. The dripper shall have an independent pressure compensation mechanism with dual regulation having an EPDM diaphragm and a turbulent flow labyrinth path. It shall be continuously self-cleaning during operation and under pressure.

The dripper shall have a flow path of the following dimensions: depth 0.057”, width 0.053”, and length 0.59”.

It shall have no emission spike at low pressure start ups of 7 PSI. It shall also be provided with a built-in anti-siphon mechanism to prevent suction of external impurities.

The dripper shall have a color coded cap to identify flow.

The drippers shall have the Anti-Leak mechanism to prevent water draining out of the dripper at a pressure of 7 PSI. It shall have a barbed inlet having an inlet filter.

The dripper shall have a Coefficient of Manufacturing Uniformity (CV) 0.03 or less.

**Integrated /subsurface drip lines**- The dripper line shall consist of a ultra violet resistant low density Linear polyethylene tube with internal pressure compensating continuously self-cleaning integral flat drippers welded to the inside of wall of the tube at the specified spacing as an integral part of the tubing assembly.
The tube shall have a 17mm or 16 mm outside diameter.

The dripper shall be constructed of plastic with a hard plastic diaphragm retainer and a self-cleaning EPDM diaphragm extending the full length of the dripper. It shall have an inlet filter raised from the wall of the tubing. It shall have the ability to independently regulate discharge rates with a constant flow at an inlet pressure of 7-60 psi.

The drippers shall have a manufacturer’s coefficient of variability (CV) of 0.03 or less.

The dripper discharge shall be 0.4, 0.61, or 0.92 gph utilizing a combination turbulent flow/reduced pressure compensation cell mechanism and an EPDM diaphragm to maintain uniform discharge rates. It shall also be continuously self-cleaning during operation and under pressure and have a flow exponent X=0 and a Kd of 1.3.

The drippers shall have the following flow passages:
- 0.42 gph dripper - (Length = 0.760”, Width = 0.044”, Depth = 0.044”)
- 0.61 gph dripper - (Length = 0.610”, Width = 0.048”, Depth = 0.048”)
- 0.92 gph dripper - (Length = 0.610”, Width = 0.052” and Depth = 0.052”).

The dripper flow versus pressure shall be tested by an independent organization such as the Center of Irrigation Technology, and shall have available reports to be presented upon request.

The dripper flow shall not be affected by temperature up to 60 degrees Celsius and shall not have a spike at start up.

The filtration requirement of the dripper shall be a maximum of 80-120 mesh.

**Self-Cleaning Screen/Disc Filter:**

The screen filters shall have a heavy duty high rate durable filtration system with a maximum pressure rating of 10 bars. The filter cartridge shall be a stainless steel wedge wire screens of at least 100 Microns mesh size. In case a disc filter is used the disc element shall also provide for a 100 Micron size filtration. The filter shall be monitored continuously and the back wash arrangement shall be triggered when the pressure differential exceeds 5 psi. This back wash shall be regulated also by means of a flush control timer controller which shall induce a time based flush cycle. Element- PP (disc), Temp-60 degree C, Clamp-SS size 63mm inlet 63mm
outlet 63mm drainage, PH-4th 10, connection threaded, power 110V/220V, Flow rate 50 m3/hr, feed pressure 2.5-3.0 kg/cm² max. Pressure 10kg/cm².

The filter itself shall be powder coated or shall be epoxy lined and mounted on a stand with intake fittings of suitable variety or of durable engineering plastic. If more than one filter is used the same shall be mounted on a single common manifold with a common back wash arrangement. The Mesh or the internals shall have no moving parts that may require maintenance or induce wear and tear.

**Pressure Gauge:**

- The pressure gauge shall be constructed of die cast aluminum and stove enameled.
- It shall be weather proof with an IP 55 enclosure.
- It shall be a stainless steel Bourdon tube type pressure gauge with a scale range from 0 to 10 Kg/cm² and shall be constructed in accordance with IS:3524.
- Each pressure gauge shall have a siphon tube connection.
- The shut off arrangement shall be by Ball Cock.
- Gauge dial should be 4 inch

**Irrigation Control Wires:**

- The irrigation cables shall be used between the solenoid valves and the irrigation controllers.
- The cables shall be of the single conductor type UF and they shall be engineered for direct burial use.
- The wires shall be of the solid or stranded construction with soft bare copper conductor.
- They shall have extra heavy thickness of special polyvinyl chloride insulation highly resistant to the saline, acid or alkaline contaminants.
- The copper conductors of the wires shall meet the requirements of ASTM B-3, B-8.
- The thermoplastic insulation shall meet ASTM D-2219. All irrigation wires shall have surface printing on insulation.
Irrigation controller:

The automatic irrigation controllers shall be of an advanced commercial design, with a large, backlit, 8 line by 20 character display, and user-friendly dial-and-button type programming. The controller shall have a removable facepack for programming and diagnostics outside the controller enclosure. It shall have a non-volatile memory.

The controller shall be a two wire decoder controller with 99 station capacity. The controller shall be packaged in a powder-coated metal or Stainless Steel wallmount enclosure, with an optional powder-coated steel or Stainless Steel pedestal mount. The controller shall also be available in a pre-assembled plastic pedestal enclosure. All enclosures shall be suitable for outdoor installation.

Station decoders shall be available in 1 station, 2 stations, 4 stations, and 6 station decoder options, and a sensor decoder for sensor hook ups.

Master Valve / Pump start: two independent MV / Pump starts programmable per station

Power Input: 120/230 VAC transformer of at least 120 volt-amp capacity power Output: 4A @ 24V secondary. Each station output shall have capacity of up to .56 A @ 24VAC.

No. of valves operating simultaneously: 14 standard 24 VAC solenoids (12 valves plus 2 Pump/Master Valve outputs) No. of Stations operating simultaneously: 6 stations No. of Programs/Start Times: 6 automatic programs and 4 custom programs with 10 start times per Program

Watering Schedule options: Day of Week, Interval Day (1 to 31 days), or Odd or Even days, by program.

Station Run Time: Up to 6 hours, in one minute or one-second increments.

The controller shall also have the following features and capabilities:

• Cycle and soak programming by station
• Programmable delay between stations of up to 6 hours in one-second increments
• Programmable Rain Shutdown delay of up to 31 days
• Individual programs, or the entire controller, may be adjusted with Season Adjust from 0 to 300% in one percent increments
• Quick Check test program
• Shall permit stations to be grouped into Simultaneous Station Groups
• Shall permit connection of up to 4 switch closure sensors, with Programmable response to each sensor, by program.
• Shall permit connection of a true flow meter which connects via the master power module of the controller.
• Shall permit connection of a local weather sensor directly into an ET terminal connected to the main power and communication module in order to utilize the current weather conditions in calculating the actual run time required for each station.
• This has to be performed at the controller level in Standalone mode without a central computer software.
• Shall have the ability to determine high or low flow conditions when multiple stations are operating, and shall perform diagnostics to identify stations which contribute to the problem flow. Allowable limits and duration of incorrect flow shall be preset.
• All station output modules shall feature transparent plastic housings with colored indicator LEDs showing station status (OK, Running, and Faulted). Station output modules shall be furnished with built in, fully encased Metal Oxide Varistor (MOV) surge protection components. Shall be equipped with a Smart Port input to permit connection of wireless remote controls and other devices
• Shall be adaptable to compatible computerized central control systems through an optional communications module, with a selection of common communications media including hardwired cable, UHF radio, dial-up modem, cellular telephone and Ethernet – LAN.
• When configured for operation within a central system, the controller shall feature full two-way communications with the central computer.
a) Software: Irrigation Central Control Software:

- The software shall provide full two-way communications with the field controllers. The software shall completely emulate the functions of the controllers, and shall provide access to all controller functions, programming, reporting, and logging. The software shall permit organizing clusters of controllers into Sites for convenience and lowest cost communications, with up to 100 controllers per site sharing the point of connection to the central computer.

- The software shall be selectable for operations in different languages and shall perform with either American or Standard International units of measurement.

- The software shall not be required to communicate irrigation events constantly, and shall download those events to the controllers so that they may run full irrigation schedules offline from the central computer. The system shall not require site hardware other than the controller itself for full featured operation of all pre-programmed instructions.

- The software shall display the status of all controllers at any site including whether or not they have been changed in the field since the last central system download, whether the controller(s) are currently active (watering), status of any sensors or other alarms, and whether the controllers are in the off position.

- The software shall retrieve automatically or on demand by the operator the current and accumulated flow of each controller equipped with a flow sensor, and shall display total water usage in gallons or liters for day, week, month, and year, versus the last comparable elapsed period (i.e., month to date vs. last month, etc.).

- The software shall feature a separate station database for each controller including all settings for flow, cycle and soak, pump/master valve associations, and programmable Simultaneous Station Groups.

- The software shall provide detailed summaries of water usage by controller, site, and system, with export functions for common spreadsheet formats. The software shall calculate actual start and end times, in real time as edits are made, displaying the effects
of all start, run, stack/overlap, and other changes as made by the operator. The software shall also provide a color-coded visual indicator in Gant chart form of all program durations.

- The software shall display in real time the status of all communications as they are sent and received, and shall indicate whether they were fully or partially successful. Software shall include transmit and receive indicator lights for all communications functions.
- Control software shall include ability to start or stop controller programs or stations on demand at any time.
- The control software shall also be able to retrieve controller programs from the field for display on the central computer, and either allow program changes made in the field at the controllers to be saved to the central database, or allow replacement of field changes with programs from the central computer.
- The central software shall permit automatic download or synchronization of software programs with the field controllers, and shall allow even more frequent automatic communications intervals to check for alarms and status, to reduce cost and increase response time. The software is not required to be online for sensor and meter shutdowns and reactions in the event of emergencies but shall indicate emergencies when reported by the controllers.

b) Map Graphics:

- The software shall have customized map graphics for System, Site, and Controller levels of operations. Each level shall have a dedicated “site map” from which operators can directly issue commands and downloads.
- The software shall include editing tools to create and link boundaries and objects, to include individual station symbols, for all entities in the irrigation system.
- The boundaries and objects shall be created over a background image (JPG, GIF, TIF, BMP, or PNG formats) that is scaled to actual size in the host software.
- The map graphics editor shall also permit creation of other objects, terrain features, etc. deemed useful to the operator. The map graphics shall be selectable, and when the
background image is switched off shall still permit operations from the vector-based control objects linked to the system.

- The map graphics shall be included in the base price of the system and may be populated at any time after system start up.

c) Central Requirements:

- The central computer shall have a minimum 1 GB RAM for Windows XP and Vista, 2 GB RAM for Windows 7. Computer operating system shall be Windows XP, Windows Vista, Windows 7 & 8 (32 bit or 64 bit versions).
- Hardwired communications with Sites via GCBL cable shall require at least one available Com port, USB or serial, at the central computer.
- Dial-up communications for either land-line POTS connections, or cellular GSM connections, shall require a hardware-based modem at the computer location. The 56k v.92 standard modem shall reside on a card or in an external desktop enclosure, such as US Robotics 5686 or equal. “Soft” modems (having no dedicated hardware and circuitry) are strongly discouraged.
- Ethernet (LAN) communications require an Ethernet connection to the network at the central computer. GPRS mobile connections require an internet connection at the central computer.

d) Communications Hardware Specifications:

- The controllers shall be furnished with communications modules and accessories to provide full two-way communications with a central computer.
- The controllers shall be grouped in order to share a connection “upstream” to the central computer in the most cost-effective manner possible. Groups that share a connection are Sites, and each Site shall have a Master Controller which manages the connection to the computer. Other controllers that share this connection are Client controllers.
- Each controller shall have a Com module installed, of the correct type for the selected communications medium. Each Com module shall have a unique address (1-999) and no
duplicate addresses shall be assigned within a system. Each Com module may also be
designated as the Master, and there shall be one Master (and not more than one) per Site.

- The Master Controller (for communications purposes, the first controller on a Site) shall have one of the following Com modules installed.

e) LAN Connection:

- shall be installed in the controller when an Ethernet local area network is used for central communications. The Ethernet module shall be housed in the controller cabinet, and shall be installed within 100 m/300 ft. of the network receptacle. The Ethernet module shall be equipped with a standard 8P8C receptacle (“RJ-45” style) for use with CAT5, 5e, or 6 cables. The Ethernet module shall be directly addressable via web browser for network configuration, and shall require a fixed IP address.
- Each Master controller may provide connections for a number of Client controllers via hardwire cable or UHF radio. Any Com module version shall be capable of providing hardwire and radio connections to Client controllers, in addition to the upstream link to the central computer.
- It shall be possible to hardwire multiple controllers downstream from the Master controller, and place the RAD3 for wireless communications in any one of the downstream hardwired controllers to take advantage of optimal broadcast location. The designated radio-equipped controller shall be the only radio controller in the hardwired leg of communications, and shall talk individually to each radio Client controller on the Site.
- Controllers with radio antennas and hardwired connections to central computers shall be installed with Poly phaser model IS-B50HN-C1 or equal inline surge suppression connected to earth ground for lightning protection. Similar protection is recommended for any radio antenna-equipped controller mounted inside buildings.
- Any UHF radio-equipped controller shall be addressable with UHF Maintenance Radio commands, to permit remote access from a UHF portable radio. UHF Maintenance Radio
commands include ability to start and stop programs, stations, Simultaneous Station Groups, and Custom Manual programs. UHF Maintenance Radio commands and functions are separate and distinct from ICR remote controls.

- Plastic pedestal mounted controllers shall include APPBRKT mounting bracket to house Com modules and radio components. APPBRKT is not required for the standard wall mount metal cabinet.
- Two-wire decoder controllers shall communicate with exactly the same devices and follow the same rules. Decoder outputs shall have no effect on the communications capabilities or considerations. Decoder controllers may be mixed in any proportion with other controllers, within a Site or system.

f) **ET Specifications**:

1) The central control system shall incorporate automatic irrigation adjustment based on dedicated evapo-transpiration sensors connected to designated controllers. The central control system will maximize water-savings and minimize run-off by using site-specific ET data to calculate individual run times for irrigation zones at station level.

2) The central control system shall retrieve ET and rainfall data from the ET sensor(s) every day, and apply the ET factors to a system-wide, zone-level plant/soil/water database. The calculated run times shall be downloaded to all designated controllers. The designated controllers shall operate the new ETbased schedules within their existing feature sets.

3) The central software shall include a system-wide database to station level for each zone of irrigation under ET control. The database shall include, at a minimum, the following characteristics for each irrigated zone or station:

- Plant Type
- Plant Variety (including Crop Coefficient)
- Root Depth
• Maturity factor

• Soil type (including both infiltration rate and water holding capacity).

• Slope factor

• Sun exposure

• Sprinkler Type

• Precipitation Rate (adjustable for efficiency and spacing)

4) The software shall include common plant and sprinkler types. The software must also include the ability to create custom plant types, which may then be added to a list, allowing regional species to be characterized and then selected by zone. The control system shall base calculations on the industry-standard Modified Penman-Monteith equation for landscape plantings, and shall use generally accepted industry standards for replenishment of the soil reservoir. The System shall also allow percentage-of-ET adjustment to station level, to control plant stress and maximize water savings.

5) The central control software must include compensation for naturally-occurring rainfall, and apply an adjustable percentage of the rain to the soil reservoir. The control system shall adjust the automatic irrigation to only replenish the required balance, if any, after the rainfall has been applied.

5) ET Sources:

• The central control system shall use ET sensors specifically designed for the purpose of gathering and reporting local evapo-transpiration and rainfall data. The “ET sensor” refers to a sensor platform that includes separate inputs for solar radiation, air temperature, relative humidity, and rainfall. The ET sensor shall be weatherproof and designed for all-season outdoor installation in direct sunlight. The ET sensor shall not require recurring fees to sustain operations.

• The ET sensor platform shall also include provision for mounting and reading an optional wind sensor, which shall add actual wind speed to the ET calculation. If the optional wind sensor is not used, the sensor platform must include a programmable automatic average
prevailing wind factor to be included in the ET calculation, in lieu of actual wind measurement.

- The ET algorithm shall be performed within the sensor platform itself (not at the controller or central computer), and the ET, rain, and sensor data must be locally visible at the host controller(s) for diagnostics and local conditions. The ET Sensor shall be CE approved for safety and emissions. The ET Sensor shall be a low-voltage device and shall not require a separate high-voltage power source for operation.

- The ET sensor shall be connected with only two 18AWG/1mm wires and may be extended up to 100ft/33m from the host controller. Use of foil-shielded wire is permissible but not required. Wires shall not be exposed to direct sunlight, nor stapled to any surface, and may be run in plastic or metal conduit or within a mounting pole.

**h) Host Controllers and Communications:**

- The ET sensors shall report to the central computer via the communications connection of a local satellite irrigation (or “host”) controller, and shall not require separate communications media. The host controllers may upload ET and rainfall data on demand via hardwire cable, dial-up telephone connection, GSM cellular, and/or UHF radio.

- The host controller must include a Sensor Check feature to verify valid communications with the sensor. The host controller must also detect loss of communications with the ET sensor and display a local alarm if communications are lost, and shall report any such loss of communications to the central computer.

- In the event that connection with the ET sensor is lost, the system shall continue to operate with the last valid 24 hour ET data. It shall not be permissible for the controller to revert to a rigid, pre-set monthly adjustment factor.

- The central control software shall initiate ET checks on an automatic, userspecified schedule, and the host controllers shall not be required to initiate calls for ET updates.

**i) Microclimates and Sensor Locations:**
• Each controller in the central control system shall permit its own designated ET source. It is not necessary to provide an ET sensor for each controller in the system, but each controller must have its own designated ET source, which may be any ET-equipped controller in the system.

• It shall be possible for an entire system to adjust based on a single ET sensor, if it has been designated as the source for each controller.

• It shall be possible for all the controllers within a given microclimate in the central system to respond to a local sensor within the same microclimate. In this manner, each identified microclimate may have its own specific ET source, and the designated controllers shall be separately adjusted for local conditions.

• It shall possible for each controller to respond to its own individually connected ET sensor if more precise ET measurement is desired.

• There shall be no limit to the number of ET sources, nor to the association of any controller, regardless of location, with any of the specified ET sensors.

• Controllers do not necessarily require individual ET sensors and may be associated in the software with any controller that has an ET sensor installed.

• Each controller connected to an ET sensor shall permit up to 3 of the connected controller’s sensor inputs to be mapped to the ET sensor, permitting direct, off-line suspension of irrigation for rain, temperature, and wind inputs. The shutdown limits for rain, temperature and wind speed shall be user programmable to controller program level. Shutdown shall occur offline within 18 minutes of a violating event.

• Controllers that do not have an ET Sensor connected directly shall require their own dedicated sensors for rain and other climatological shutdowns.

• Specified controllers shall permit grouping of similar stations into Simultaneous Station Groups which operate within hydraulic capacity as a single entity, in order to minimize the water window. The SSG shall have its own ET characteristics which shall be used to calculate the run times and application amounts for all stations within the group, and shall have the same characteristics for water management as individual stations.
Pumping System:

- The capacity of proposed pumping system shall be enough to take care of proposed Irrigation system.

- The contractor shall supply the required / specified pump station of reputed make conforming to IS or international standards. The pump body has to be of SS/CI & the rotor is to be copper.

- The pumping system having designed flow 3 LPS at 55-65 m head complete set (1 working + 1 stand by+ 1 Jockey) with Inlet & Outlet Valve, Check Valves. Pressure Gauge Suction & Delivery of 65 mm X 65 mm. Material of construction: - Pump Casing: Cast Iron, Impeller: Cast Iron, Electrical: 50Hz, 415V, 3 Phase and withstand voltage drop to 320volts

- All necessary / required accessories & fittings required for the connection / installation / erection of the pumping system shall be included in the offer.

- Electrical cable of 2.5 sq2 mm copper conductor, 3 core must be added as the accessories to power the Pumping system, taking the main feeder just outside the pump room.

Miscellaneous:

- Irrigation Drip Line Stakes: Stakes for securing flexible pipes shall be galvanized steel wire, Gauge 8. Minimum overall length of hoop-shaped stake is 20cm

- Non-metallic Nipple: Nipples where used shall conform to SAS 14/15, Class 5 uPVC or BS 4346: Part I, uniformly grey in color.

- Keys: the Contractor shall provide Keys for all valves, controller cabinets, boxes, quick couplers, etc. The number of keys to be provided to the Engineer for each type of fitting shall be six (6).

- Hoses: Hoses, quick couplers and appropriate connectors shall be provided by the Contractor for quick coupling valves, drain down points, 'Y' strainer blow down points, etc.
• Quick couplers and hoses - One (1) quick coupler with swivel end unit and twenty five (25) meters of industrial weight double nylon cord reinforcement hose for each installed eight (8) quick coupling valves.

**Laying of pipe work:**

a) Pipes will be laid in the routes and sizes as indicated on the drawings and stated in the relevant sections of this specification. In the case where multiple pipes or electrical conduits are laid in the same trench, they must be located side by side, not crossing each other or stacked one upon the other.

b) All pipe laying and jointing will be performed in site in the trench on the prepared bedding; not assembled above ground and placed in the trench at a later stage.

c) At the end of each day’s work, all open ends of pipe work and conduit will be plugged and staked to prevent entry of vermin, dirt, water or moisture and movement of the pipe.

d) Where pipe is required to pass over or under drainage pipe, the Contractor is to ensure a minimum clearance of 100 mm between the irrigation pipe and the drainage pipe.

e) Main Line Trench Should be 600 mm + Mainline Size and Sub main should be 450 + Sub main size.

f) Refilling trench with good soil and free from any rock/ stones.

g) Mainline Pipe should be pressure tested for its integrity while it is being built, following procedure must be followed.

**Irrigation system Testing Procedures :**

Adjustment of the system:

The contractor will adjust the various components of the irrigation system to ensure the overall operation of the system is efficient. This includes the programming of the irrigation control system and adjustment of part circles sprinkler heads, pressure setting at the solenoid valves (PRS Dials)

a) Ensure that all the open ends of the pipe line is closed before embarking on the system testing.

b) Check all the operation of pumps for satisfactory working of it.
c) All isolation valves and thrust blocks must be in place and cured for the mandatory period of time before starting the system testing.

d) Flush the pipe line for any foreign materials which may have found entry during Course of the installation.

e) Install Air valves, quick coupling and lateral valve assemblies prior to start of the testing.

f) Allow the pump water slowly filling the entire mainline network, velocity of fill not exceeding 0.5 to 0.7 m/s to avoid chances of any water hammer event.

g) Apply full pressure 1.5 times the system working pressure and check for any leakages.

h) There shall not be permissible leaks at any point in the system.

i) After arresting any leakages found start the test again, if no further leakage is found start the sprinkler radius, valve pressure etc. taking one valve at a time operating manually.

j) All tests shall be carried out by the contractor and approved by Engineer In Charge

**Commissioning:**

a) The commissioning of irrigation controller system will be carried out by the manufacturer representative in conjunction with and approved by engineer In charge.

b) The commissioning will include, at the time of hand over, a demonstration of all sections and individual elements pertaining to the operation of the irrigation system.

**Hand Over :**

Before hand over, the Contractor shall ensure the following;

a) In addition to the static pressure test or commissioning, the completed system must be operated without fault for at least fifteen days prior to hand over.

b) Should any major leaks occur during this period; the static pressure test procedure will be repeated once the problem has been rectified?

c) If the system is repaired, then it must operate for at least fifteen days without fault prior to hand over being accepted.
d) In lieu of an official hand over, any works properly tested, commissioned (if applicable) and used by the RGIA for at least fifteen days without fault will be deemed as handed over.

**BAMBOO WOOD PRODUCTS**

Following tests are to be performed to find out the characteristics of Bamboo wood:

<table>
<thead>
<tr>
<th>TECHNICAL DETAILS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Performance</td>
</tr>
<tr>
<td>Characteristics</td>
</tr>
<tr>
<td>Density</td>
</tr>
<tr>
<td>Modulus of Rupture (MOR),</td>
</tr>
<tr>
<td>Modulus of Elasticity (MOE),</td>
</tr>
<tr>
<td>Hardness Test</td>
</tr>
<tr>
<td>Moisture Content</td>
</tr>
</tbody>
</table>

**Specialized Test**

<table>
<thead>
<tr>
<th>Performance</th>
<th>Test Method</th>
<th>Criteria</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thermal Conductivity</td>
<td>IS: 3346Y1980</td>
<td>≤ 0.50 W/ mYK</td>
<td>0.354 W/ mYK</td>
</tr>
<tr>
<td>Volatile organic compound</td>
<td>IS: 13745–1993</td>
<td>≤ 6.00 mg/ 100gm (oven dry method)</td>
<td>0.4309 mg/ 100gm</td>
</tr>
<tr>
<td>Termite Test</td>
<td>Laboratory Test</td>
<td>6month in Termite Mound</td>
<td>No Termite Attack</td>
</tr>
<tr>
<td>Borer Test</td>
<td>Laboratory Test</td>
<td>6month in Borer Box</td>
<td>No Borer Attack</td>
</tr>
<tr>
<td>Property</td>
<td>Standard</td>
<td>Requirement</td>
<td>Result</td>
</tr>
<tr>
<td>----------------------------------</td>
<td>----------------</td>
<td>--------------------------------------------------</td>
<td>--------</td>
</tr>
<tr>
<td>Flame penetration</td>
<td>IS:1734(PartY3)1983</td>
<td>≥ 30min</td>
<td>38min</td>
</tr>
<tr>
<td>Water Absorption</td>
<td>IS 2380Y 1981</td>
<td>≤ 4% (2hrs), ≤ 8% (24hrs)</td>
<td>1.17% (2hrs), 3.42% (24hrs)</td>
</tr>
<tr>
<td>Swelling due to general absorption</td>
<td>IS 2380Y 1981</td>
<td>≤ 8%</td>
<td>3.22%</td>
</tr>
<tr>
<td>Swelling due to surface absorption</td>
<td>IS 2380Y 1981</td>
<td>≤ 4% (2hrs), ≤ 8% (24hrs)</td>
<td>1.2% (2hrs), 3.2% (24hrs)</td>
</tr>
<tr>
<td>Flammability</td>
<td>IS: 1734 (PartY3)1983</td>
<td>≥ 5min (time taken for second ignition)</td>
<td>5min</td>
</tr>
<tr>
<td>Rate of burning</td>
<td>IS: 1734 (PartY3)1983</td>
<td>≥ 10min (time taken to lose weight from 70% to 30%)</td>
<td>11min</td>
</tr>
<tr>
<td>Screw Withdrawal Resistance</td>
<td>IS:2380Y 1981</td>
<td>≥ 250 Kg (Flat Face)</td>
<td>439Kg</td>
</tr>
<tr>
<td>Screw Withdrawal Resistance</td>
<td>IS:2380Y 1981</td>
<td>≥ 200 Kg (Edge)</td>
<td>349Kg</td>
</tr>
<tr>
<td>Sound Absorption Coefficient</td>
<td>IS:10420Y 1982</td>
<td>Bamboo Wood Wall Cladding</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Frequency Coefficient</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Hz</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>250</td>
<td>0.01</td>
</tr>
<tr>
<td></td>
<td></td>
<td>500</td>
<td>0.01</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1000</td>
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<td></td>
<td></td>
<td>2000</td>
<td>0.07</td>
</tr>
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<td></td>
<td></td>
<td>3000</td>
<td>0.12</td>
</tr>
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<td></td>
<td></td>
<td>4000</td>
<td>0.10</td>
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**FLOORING/WALL CLADDING FINISH (Specialized Test)**

<table>
<thead>
<tr>
<th>Cross Cut Test</th>
<th>DIN EN ISO 2409</th>
<th>≤ GT 2</th>
<th>GT 0</th>
<th>GT 0</th>
<th>GT 0</th>
<th>GT 0</th>
</tr>
</thead>
</table>

IMPHAL AIRPORT C-nil I-nil O-nil
<table>
<thead>
<tr>
<th>Performance Characteristics</th>
<th>Test Method</th>
<th>Criteria</th>
<th>Classification</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Natural</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Carbonized</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Satin</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Wall Cladding</td>
</tr>
</tbody>
</table>

**Flooring/ Wall Cladding Finish (General Test)**

<table>
<thead>
<tr>
<th></th>
<th>Test Method</th>
<th>Criteria</th>
<th>Natural</th>
<th>Carbonized</th>
<th>Satin</th>
<th>Wall Cladding</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gloss Value</td>
<td>DIN EN ISO 2813</td>
<td>± 5%</td>
<td>33 Y</td>
<td>34 Y</td>
<td>31 Y</td>
<td>34 Y</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>34%</td>
<td>35%</td>
<td>33%</td>
<td>34%</td>
</tr>
<tr>
<td>Scratch Resistance</td>
<td>Coin Test</td>
<td>No Scratch</td>
<td>No Scratch</td>
<td>No Scratch</td>
<td>No Scratch</td>
<td>No Scratch</td>
</tr>
<tr>
<td>Coin Test</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Heat Resistance</td>
<td>DIN 68861 Part 6</td>
<td>≥ 20 Newton</td>
<td>39 Newton</td>
<td>37 Newton</td>
<td>39 Newton</td>
<td>40 Newton</td>
</tr>
<tr>
<td>(Cigarette Test)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Scratch Resistance</td>
<td>Hamburger planner</td>
<td>≥ 20 Newton</td>
<td>39 Newton</td>
<td>37 Newton</td>
<td>39 Newton</td>
<td>40 Newton</td>
</tr>
<tr>
<td>Coin Test</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Abrasion Resistance</td>
<td>DIN EN 438Y2 (500g load per wheel S 33)</td>
<td>Initial Point &gt;100 cycles</td>
<td>Initial Point – 260 cycles</td>
<td>Initial Point – 240 cycles</td>
<td>Initial Point – 240 cycles</td>
<td>NA</td>
</tr>
<tr>
<td>Abrasion Resistance</td>
<td>ASTM D 4060 (500g load per wheel CS 17)</td>
<td>Initial Point &gt;15000 cycles</td>
<td>Initial Point &gt;15000 cycles</td>
<td>Initial Point &gt;15000 cycles</td>
<td>Initial Point &gt;15000 cycles</td>
<td>NA</td>
</tr>
</tbody>
</table>
### Scratch Resistance

<table>
<thead>
<tr>
<th>Pencil Hardness</th>
<th>ISO 15184</th>
<th>≥ 1 H</th>
<th>7H</th>
<th>7H</th>
<th>7H</th>
<th>7H</th>
</tr>
</thead>
</table>

### Scratch Resistance Surface

<table>
<thead>
<tr>
<th>Steel wool test, Type 2</th>
<th>No Scratch</th>
<th>No Scratch</th>
<th>No Scratch</th>
<th>No Scratch</th>
<th>No Scratch</th>
<th>No Scratch</th>
</tr>
</thead>
</table>

### Impact Resistance

<table>
<thead>
<tr>
<th>DIN 438 EN Part 2 – 12</th>
<th>≥ 2 Newton</th>
<th>3 Newton</th>
<th>3 Newton</th>
<th>3 Newton</th>
<th>3 Newton</th>
</tr>
</thead>
</table>

### Resistance to Indentation

|-------------------------|------------|----------|----------|----------|----------|

### Chemical Resistance

<table>
<thead>
<tr>
<th>DIN 68861 Part 1</th>
<th>5</th>
<th>5</th>
<th>5</th>
<th>5</th>
<th>5</th>
</tr>
</thead>
</table>

### Inflammability

<table>
<thead>
<tr>
<th>DIN 4102 Part 14</th>
<th>B1</th>
<th>B1</th>
<th>B1</th>
<th>B1</th>
<th>B1</th>
</tr>
</thead>
</table>

Following is the procedure followed in performing above mentioned test:

#### 11. Moisture content of the board:

Procedure: Each specimen was weighed to accuracy not less than ±0.2%. The specimens were dried in an oven at a temperature 103 ±20°C, until the mass is constant to ±0.2% between two successive weightings made at an interval of not less than one hour.

Calculation: The moisture content expressed as percentage of the oven dry mass is given by the formula:

\[ M1 - M0 \]
Moisture content % = \frac{M0}{M1} \times 100

Where, \( M1 \) = initial mass \( M0 \) = oven dry mass

12. **Density of the board:**

Procedure: The dimensions of each test specimen were measured to an accuracy of not less than ±0.3 \% & each specimen was weighed to an accuracy of ±0.2 \%.

Calculation:

\[
\text{Density (gm/cm}^3\) = \frac{\text{Mass of the test specimen in gm}}{\text{Length (cm) x Width (cm) x Thickness (cm)}}
\]

13. **Water Absorption:**

Procedure: Each test specimen must be edge insulated and weighed to an accuracy of not less than ±0.2 \% & the width thickness & length were measured to accuracy not less than ±0.3\%.

Then the specimens were submerged under 25 mm fresh clean water maintained at a temperature of 27 ±20C. The test specimens were separated by at least 15 mm from each other & from the bottom & the sides of the container. After a 2 hours submersion, the specimens were suspended to drain for 10 minutes, at the end of which time the excess surface water was removed & then specimens were immediately weighed. The specimens were then submerged for an additional period of 22 hours & the above weighing procedure was repeated.

Calculation: The amount of water absorbed by each test specimen after 2 hours & 24 hours was calculated from the increase in of the specimen during the submersion. It is expressed as follows:

\[
\text{Water absorption %} = \frac{M2 - M1}{M1} \times 100
\]

Where, \( M1 \) = Mass of the test specimen before experiment \( M2 \) = Mass of the test specimen after the experiment

14. **Swelling due to General Absorption:**

Procedure: The thickness at the edge of each test specimen must be insulated and measured to an accuracy of 0.01mm at three places along one long edge. The points at which the thickness was measured were clearly marked. Each test specimen was immersed in fresh
clean water having a temperature of 27 ±20°C. The short edge of the lower most, & the test specimen was separated by at least 15mm from each other & from bottom & sides of the container. They were covered by 25mm of water. At the end of 2 hours each test specimen was withdrawn from the water, wiped with a damp cloth & was allowed to stand under normal room conditions for 1 hour with its bottom edge on a non-absorbent surface. The thickness of each test specimen was measured at the same points as before and to the same degree of accuracy. The increase in thickness was measured.

Calculation: The average of three values obtained for the changes in thickness expressed as a percentage of the original average thickness was reported as the swelling value.

\[
\frac{T2 - T1}{X 100}
\]

Where, \( T1 = \) Average thickness before experiment \( T2 = \) Average thickness after the experiment

**15. Swelling due to Surface Absorption:**

Procedure: The thickness of each test specimen was measured to an accuracy of ±0.03mm at four places. The average of four readings was recorded. The edges of each test specimen was then sealed by quickly dipping them in turn to a depth of 5mm into a shallow bath of molten paraffin wax having a melting point about 550°C, the temperature of both bath was being about 900°C. The procedure was repeated until the pickup of wax for each specimen was of the order of 5gm for each 10mm thickness of the board. Each test specimen was then immersed in fresh clean water having a temperature of 21 ±20°C, the water being renewed for each test. The face being tested was immersed to a depth of approximately 3mm. care was taken not to wet the top surface of the test specimen. At the end of the 2 hrs each test specimen was withdrawn from water & the wet surface was wiped with a damp cloth, the test specimen was then laid, wet surface down, for one hour on a glass sheet. The thickness of each test specimen was re measured at the same points as before & to the same degree of accuracy & the increase in thickness was recorded.

**16. Janka Hardness Test:**

The Janka hardness test measures force requires to embedded in Bamboo wood measured in the Kilogram required to embed a 0.444-inch (11.28mm) steel ball to half its diameter in Bamboo wood. It is one of the best measures of the ability of a Bamboo wood to withstand denting and wear. It is also a good indicator of how hard or easy a species is to saw or nail.
Sample size: The specimen for Janka hardness test shall be 13cm in length and 13cm in width and for either 1.4cm thickness or 2cm thickness.

Test procedure: Loading attachment, attached to the heads of the testing machine, shall engage the blocks attached to the specimen. The specimen shall be fixing to the testing attachment and start loading 1mm/ minute until half ball penetration

Calculation: Load required to penetrate half ball = in Kgf or Newton

17. **Static Bending Test (Modulus of Rupture and Modulus of Elasticity)**

Sample size: The specimen for static bending test shall be 5 X 5 cm in cross-section and 75 cm in length or 2 X 2 cm in cross-section and 30 cm in length.

Test procedure: Loading fixtures, attached to the heads of the testing machine, shall engage the blocks attached to the specimen. The specimen shall be stressed by separation of the heads of the testing machine until failure occurs. The direction of loading shall be as nearly.

Rate of loading: The load shall be applied continuously throughout the test at a uniform rate of motion of the movable crosshead of the testing machine as calculated by the following formula:

\[
\frac{Z L^2}{6 t} = N
\]

Where, \(N\) = Rate of loading in cm / min.
\(Z\) = Unit rate of fiber strain of outer fiber length/minute = 0.005 \(L\) = Span in cm.
\(t\) = Thickness of the specimen in cm.

Calculation:
\[3P'L\]
\[MOR = \frac{3P'L}{2 bd^2} \times 9.8\]

\[PL3\]
\[MOE = \frac{PL3}{4 Dbd^3} \times 9.8\]

Where, \(MOR = \) Modulus of Rupture \(N/mm^2\) \(MOE = \) Modulus of elasticity
\(P'\) = Maximum load in kg
P = load in kg at the limit of proportionality which shall be taken as the point in load – deflection curve above which the graph deviate from straight line.

L = Span length mm

b = Width of the specimen in mm

d = Thickness of the specimen in mm D = deflection

18. **Test For Screw Withdrawal Resistance:**

Sample size: The length & width of the test specimen shall be 150mm & 75mm respectively. The thickness shall not be less than 30 mm. if the thickness of the board is less than 30mm, two or more specimen may be bonded with suitable adhesives.

Two wood screws no. 8 & 50 mm in length shall be threaded into the specimen at right angle to the face up to half of their length in a pre-bore of 2.5 mm. the hole should be preferably at mid width about 5 cm from the ends of the specimen.

Test procedure: The specimen holding fixture shall be attached to the lower platen of the testing machine. The specimen shall be inserted in the fixture, which is equipped with a slot to easy engagement of the head of the screw of nail, shall be attached to the upper platen of the testing machine.

Rate of loading: Load shall be applied to the specimen throughout the test by a uniform motion of the movable head of the testing machine at a rate of 1.5mm per minute.

19. **Accelerated Water Resistance Test:**

The exterior grade sample is put in boiling water for 2 hours. After that dry it in open atmosphere for 24 hours and then check the internal bonding strength of the sample by similar method as describe above.

For passing the IS standard the IB should not be less than 0.15 N.

20. **Termite Resistance Test:**

The sample was kept in termite mound for six months.

Result – sample checked thereafter for termite attack. There was no attack seen.

21. **Borer Resistance test:**

The sample was kept in borer box for six months.

Result – sample checked thereafter for borer attack. There was no attack seen.

**FINISH TESTS**

Following is the procedure followed in performing above mentioned Finish Test: -
12. **Gloss Value:**

According to ISO 2813, 60° geometry Radiation from a light source is reflected off the surface of the floor at a defined angle (normally 60° for coated parquet surfaces) and measured by a sensor. The more glossy the surface, the less light gets reflected from its surface, and the lower the specular gloss. The specular gloss readings are too imprecise for very matt surfaces meaning that surfaces with identical gloss value may look considerably different. In the gloss value test it is therefore necessary to carry out a visual inspection of the test surfaces against a master sample.

13. **Cross cut Test:**

Purpose: To test the adhesive properties of the coating to the substrate using a multiple blade cutter and tape.

Standard: DIN EN ISO 2409

The surface is rated according to the table, as follows:

<table>
<thead>
<tr>
<th>Grid Cut Classification</th>
<th>Description</th>
<th>Appearance of surface in area of grid-cut where flaking has occurred (Example for six parallel cut)</th>
</tr>
</thead>
<tbody>
<tr>
<td>GT 0</td>
<td>The edges of the cuts are completely smooth, none of the lattice squares is detached.</td>
<td>![GT 0 Sample]</td>
</tr>
<tr>
<td>GT 1</td>
<td>Small flakes of coating have detached at the intersections of the cuts. The area affected is not significantly greater than 5% of the cross cut area.</td>
<td>![GT 1 Sample]</td>
</tr>
<tr>
<td>GT 2</td>
<td>The coating has flaked along the edges and/or the intersections of the cuts. Area of the cross-cut considerably greater than 5% but not significantly greater than 15% of the total cross-cut area.</td>
<td>![GT 2 Sample]</td>
</tr>
<tr>
<td>GT 3</td>
<td>The coating has flaked along the edges of the cuts in wide strips partly/completely and/or partial/complete flaking on some of the squares. A cross-cut area considerably greater than 15% but not significantly greater than 30% is affected.</td>
<td>![GT 3 Sample]</td>
</tr>
<tr>
<td>GT 4</td>
<td>The coating has flaked along the edges of the cuts in wide strips and/or partial/complete flaking on some of the squares. A cross-cut area considerably greater than 30% but not significantly greater than 65% is affected.</td>
<td>![GT 4 Sample]</td>
</tr>
<tr>
<td>GT 5</td>
<td>Any flaking that cannot be classified under Category 4.</td>
<td>![GT 5 Sample]</td>
</tr>
</tbody>
</table>

14. **Abrasion Resistance:**

Purpose: The Taber abraser is commonly used to provide comparative data regarding the abrasive resistance of a coating.
Standard:
S33 sandpaper (EN 438-2): Test according to EN 438-2, S 33 strips of sandpaper are attached to the abrading wheels.

CS17 (ASTM D4060): Test according to ASTM D 4060, CS 17 wheels. Specially defined abrading wheels are used for this test.

Expression of Results: Evaluate visual Initial Point, at the first sign that the wheels have worn through the coating from the substrate. (S 33 sand paper is more rough compare to CS 17 wheels. So the result of S 33 is less compare with CS 17)

15. **Pencil Hardness:**

Purpose: To determine the surface hardness of coating with regard to stresses inflicted by scratching with sharp edges, or other rough surfaces.

Standard: ISO 15184

Expression of Results: The number of the first pencil that you use after you have made a scratch in the coating that doesn't leave a mark is considered the "pencil hardness" of the coating.

16. **Scratch Resistance Coin Test- Hamburger Planer:**

Purpose: To check the adhesion between lacquer film and substrate on one hand and to check the adhesion between different lacquer layers on the other hand.

Expression of Results: The test result is the applied force in Newton just before damage becomes visible on the test surface (white mark). It is essential that you move towards this point incrementally. Use the above method to test each specimen in at least three separate areas in order to relativise the vibrations from the base. We recommend you calculate an average from the test results. 20N and above is considered as a passed result.

17. **Scratch Resistance Coin Test- Coin Test:**

Purpose: To check on spot the adhesion between lacquer film and substrate on one hand and to check the adhesion between different lacquer layers on the other hand.

Expression of Results: Resistance to scratch by manual force on finished surface. It is recommend to use standard coin for this test. Apply standard uniform force for scratch resistance.

18. **Scratch Resistance Surface:**
Purpose: Resistance to fine scratches is tested by rubbing on the surface with steel wool, applying normal pressure.

19. **Impact test:**

Standard: DIN EN 438 Part 2 – 12

Purpose: To determine the minimum spring force to cause damage on the coating film and its substrate. In the impact test a metal ball applies a force to a varnished surface at a pre-defined spring tension/weight. The ball leaves behind a dent which is largely dependent on the hardness of wooden substrate. The test measures the weight at which the first continuous cracks appear in the varnish in the form of concentric rings along the edge of the dent. These cracks are marked with a felt-tip pen before being wiped off with solvent. The cracks in the varnish are made visible by the residue from the pen at the point of impact. The drop-weight test is thus a method of measuring the elasticity of a varnish film. Due to the qualities of different woods, it only makes sense to compare measurements for one and the same wooden substrate.

Expression of Results: The test result is the value in Newton at which no residue of pen colour remains after having it wiped off with solvent.

20. **Resistance to Indentation:**

Purpose: To determine the minimum load by applying successively decreasing loads to the diamond point and examine the indentation or cut on the surface.

Standard: DIN EN 438 Part 2 – 25

The test specimen is tested during one revolution of a defined diamond point at a pre-defined load (Newton). Several scratch tests are carried out side by side at different levels of pressure during which the pressure on the surface is changed on a scale from high to low. With each revolution, the pressure on the specimen is adjusted to a different part of the surface.

Expression of Result: The test result is the value in Newton at which an indentation on the surface is no longer visible.

21. **Heat resistance (Cigarette test):**

Purpose: To determine the surfaces behavior on exposure to glowing cigarette.

Standard: DIN 68861 Part 6

3 cigarettes from different brands are used for this test. The first 10mm of each cigarette is smoked before being placed on the coated surface. The cigarette is removed from the test surface once the cigarette has burned down a further 40mm.
If any changes to the surface arise, either in its colour or other visible changes, the surface will need to be cleaned as thoroughly as possible with a defined cleaning agent.

Rating of the test results from the cigarette test:

6A  No change
6B  Change in gloss visible to naked eye 6C  Gloss and/or colour change
6D  Colour change
6E  Destroyed

22.  **In flammability Test:**

Purpose: Determination of the burning behavior of floor covering systems using a radiant heat source.

Standard: DIN 4102 Part 14
This standard is for measuring the critical radiant flux of horizontally mounted floor-covering systems exposed to a graded radiant heat energy environment in a test enclosure, when ignited with a pilot flame.

Building Material Classes:


23.  **Chemical resistance:**

Standard DIN 68861:
In the following table you can find a list of the chemicals used to measure chemical resistance in accordance with DIN 68861:

<table>
<thead>
<tr>
<th>Chemicals/substances</th>
<th>Beginning temperature of substances (± 5) °C</th>
<th>Duration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Distilled water</td>
<td>20</td>
<td>(24 ± 1) h</td>
</tr>
<tr>
<td>Cleaning agent (def. mixture)</td>
<td>20</td>
<td>(24 ± 1) h</td>
</tr>
<tr>
<td>Acetone, min. 95 %</td>
<td>20</td>
<td>(120 ± 10) s</td>
</tr>
<tr>
<td>Ethanol, clean, not denaturated, 50 % in distilled water</td>
<td>20</td>
<td>(24 ± 1) h</td>
</tr>
<tr>
<td>Red wine, alcohol content 10 % to 12 % vol.</td>
<td>20</td>
<td>(24 ± 1) h</td>
</tr>
<tr>
<td>Red wine vinegar, acetic acid solution 3 % to 5 % vol.</td>
<td>20</td>
<td>(24 ± 1) h</td>
</tr>
<tr>
<td>Olive oil</td>
<td>20</td>
<td>(24 ± 1) h</td>
</tr>
<tr>
<td>Item</td>
<td>Value</td>
<td>Time</td>
</tr>
<tr>
<td>------------------------------------------</td>
<td>-------</td>
<td>------------</td>
</tr>
<tr>
<td>Milk, 3 % to 5 % fat</td>
<td>80</td>
<td>(24 ± 1) h</td>
</tr>
<tr>
<td>Coffee, 40 g dehydrofrozen instant coffee per l cooking water</td>
<td>80</td>
<td>(24 ± 1) h</td>
</tr>
<tr>
<td>Black tea, 10 g tea leafs brewed with 1 l cooking water. Brewing time 5 min</td>
<td>80</td>
<td>(24 ± 1) h</td>
</tr>
<tr>
<td>10%, ammonia solution</td>
<td>20</td>
<td>(8 ± 1) h</td>
</tr>
<tr>
<td>Blue/black ink</td>
<td>20</td>
<td>(24 ± 1) h</td>
</tr>
</tbody>
</table>

**CLASSIFICATION:**

5: No visible changes (no damages).

4: Slight changes in gloss and colour, only visible when light sources are reflecting on or next to the marks to the eyes of the observer, or single just visible marks.

3: Light marks, visible from different directions, for example the visibility of nearly complete form of filter paper.

2: Strong marks, but the structure of the surface is broadly unchanged.

1: Strong marks, the structure of surface has changed or the sealer is completely or partially worn off, or the filter paper inheres to the surface.
TS-11
AIRPORT SYSTEMS & IT SYSTEMS
SECTION-1 AIRPORT SYSTEM

GENERAL CONDITIONS

1. The offered equipment by the EPC Contractor shall be compact, fully solid state, highly reliable and shall use latest state of the art technology.

2. The design and selection of the offered equipment by the EPC Contractor shall be consistent with the requirements of long term trouble free operation with highest degree of reliability and maintainability.

3. All offered equipment by the EPC Contractor shall be manufactured to continuously operate safely without undue heating, vibration, wear, corrosion, electromagnetic interference or any similar problems.

4. The offered equipment by the EPC Contractor shall be designed for continuous operation (24-hours a day and 365-days a year). The design life of the equipment shall be a minimum of Seven YEARS.

5. This life shall be achievable through normal and regular maintenance.

6. All types of spares and spare modules of the offered equipment shall be readily available with the EPC Contractor during life-time of the equipment, for maintenance, repairs and up keep of the equipment during warranty & CAICMC period, if applicable.

7. Offered equipment by the EPC Contractor shall undertake and ensure implementation of its offered solution and shall keep its in view the safety and protection of personnel, during normal operation and maintenance or during malfunctioning of any equipment or its sub-component. This shall be ensured as an integrated feature of design, manufacture and installation of offered equipment by EPC Contractor.

8. Offered equipment by the EPC Contractor shall ensure adequate protection to be included for ensuring safety of personnel from any possible hazards, including EMI radiation, high voltages, etc.

9. The offered equipment by the EPC Contractor shall furnish the details of EMI and Safety Standards met by his equipment and built-in safety features.

10. The offered equipment shall be constructed on a modular basis, using plug-in type units and components to the extent possible. Parts subject to failure, wear, corrosion or other
deteriorations or requiring occasional inspection, adjustment or replacement shall be made accessible and capable of convenient inspection and removal.

11. Input and output termination cables in offered equipment shall be properly labelled to permit ready identification of the incoming/outgoing wiring.

12. All interconnecting cables in offered equipment shall also be appropriately labelled to facilitate convenient interconnection and minimize chances of incorrect connection.

13. All connecting cables required to inter-connect the equipment shall be supplied by the EPC Contractor as a part of the offered system. All cables shall be fully assembled, connector pre-terminated and factory tested at the time of supply as part of overall system check.

14. **Contractor shall be responsible for Integration of existing System of CCTV/FIDS/IP EPABX/PAVA/**.

15. **Licenses**

All Hardware system/component and Software supplied by EPC Contractor shall be licensed, as applicable, in favour of Airports Authority of India and valid for lifetime of the offered system.

16. **Mains Power Supply**

16.1 Complete offered equipment shall operate with an un-interrupted AC power 230 Volts (±10%) single phase 50 Hz ± 5%. Reliable over & under voltage and over current protection circuits shall be provided in the power supply units of offered solution. The power supply units in complete offered solution shall be self-protecting, and shall protect connected equipment against conducted interference, noise, voltage dips and surges & impulses.

16.2 Mains Power Supplies used in offered solution/equipment shall be rugged enough to withstand variation in mains voltage and frequency over a long period of time so that the failures in the equipment due to power supply are minimized.

17. **Installation Standards**

17.1 Installation shall be carried out by technically well qualified and certified personnel as per the requirements.

17.2 Contractors shall not outsource any part of the contract to any other EPC Contractor/third party contractor without prior permission of AAI.

17.3 Liability, if anything, arising out of such third party contracts to any other EPC Contractor by contractor shall be to the contractor’s account.

18. AAI shall not be liable on behalf of contractor to any other third party contractor/
Government of India/State/Regulatory Authorities.

19 Any liabilities arising out of such third party contracts by contractor or its men working at site shall be only to contractor’s account and shall be deducted out of its running bills.

20 Contractor shall submit Police Verification Certificates and obtain necessary Airport Entry Permits, for allowing its men to work at AAI restricted premises. Fees in this regard if any, shall be borne by the EPC Contractor.

21 Quality Assurance Standards


22 Reliability

To ensure high availability and high reliability, the offered equipment design by the EPC Contractor and its OEM partner shall employ the most suitable engineering techniques, materials and dependable components, field proven design and rigorous inspection during manufacturing to ensure a very high MTBO (Mean Time between Outage) and MTBF (Mean Time between Failure) of equipment.

23 Environmental Conditions

The offered equipment shall be capable of maintaining its guaranteed performance when operating continuously for 24 hours a day and 365 days a year without any deviation in quality or degradation of system performance and all the parameter detailed in these specifications shall be guaranteed over the following environmental conditions:

i) Indoor Equipment:

   Operating Temperature: 0 degree to + 40 degree Centigrade.

   Relative Humidity: 80% up to 35 deg centigrade.
ii) Outdoor Equipment:

Operating Temperature: -10 degree to + 50 degree Centigrade.
Relative Humidity: 90% up to 35 deg. centigrade

i) Storage Temperature: -10 to + 70 degree Centigrade

**STANDARDS & CODES:**

<table>
<thead>
<tr>
<th>Standards</th>
<th>Code</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>NFPA-72</td>
<td></td>
<td>National fire protection academy code for fire alarm &amp; public address system</td>
</tr>
<tr>
<td>NFPA-72</td>
<td></td>
<td>National fire protection academy code for fire alarm &amp; public address system</td>
</tr>
<tr>
<td>IS-2189</td>
<td></td>
<td>Selection, Installation &amp; Maintenance of Fire Detection and Alarm System.</td>
</tr>
<tr>
<td>NFPA 70</td>
<td></td>
<td>National Electric Code</td>
</tr>
<tr>
<td>UL</td>
<td></td>
<td>Underwriters Laboratories, Inc. (UL) Publication-2775</td>
</tr>
<tr>
<td>IS-694</td>
<td></td>
<td>Specification for PVC insulated cables for working voltages up to and including 1100V</td>
</tr>
<tr>
<td>IS-9968 (Pt-1)</td>
<td></td>
<td>Rubber Insulated Braided Wire</td>
</tr>
<tr>
<td>IS-1554 (Pt-1)</td>
<td></td>
<td>PVC Insulated Cables</td>
</tr>
</tbody>
</table>
To ensure the protection of people and property in the form of an intruder alarm system, hold-up alarm systems, CCTV systems, access control systems or social alarm systems.

In terms of electromagnetic compatibility it is necessary to address issues of the conformity assessment of products, selection of suitable components and in particular method of installation in a specific area of deployment.

<table>
<thead>
<tr>
<th>Standard</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>EN 50130-4:1995</td>
<td>Code of practice for testing of computer based Systems</td>
</tr>
<tr>
<td>BS 5887:1980</td>
<td>Specification for low frequency cables and wire for Telecommunication</td>
</tr>
<tr>
<td>BS 4808</td>
<td>Optical fibres and cables</td>
</tr>
<tr>
<td>BS 6558</td>
<td>Software for computers in the application of industrial safety related Functional safety of programmable electronic systems:</td>
</tr>
<tr>
<td>IEC65-WG9 65A</td>
<td>Generic aspects 65A (Secretariat)</td>
</tr>
<tr>
<td>IEC65-WG10</td>
<td></td>
</tr>
<tr>
<td>IEEE802.3</td>
<td>CSMA/CD Local Area Network Protocol</td>
</tr>
<tr>
<td>IEEE 802.4</td>
<td>Token Bus Local Area Network Protocol</td>
</tr>
<tr>
<td>IEEE 802.5</td>
<td>Token Ring Local Area Network Protocol</td>
</tr>
<tr>
<td>ISO 9000-3</td>
<td>Guidelines for the application of ISO 9001 to development, supply and maintenance of software.</td>
</tr>
<tr>
<td>ASTM B 3-90</td>
<td>Soft or Annealed Copper Wire.</td>
</tr>
<tr>
<td>ASTM 4565</td>
<td>Cold Bend Test.</td>
</tr>
<tr>
<td>Standard</td>
<td>Description</td>
</tr>
<tr>
<td>----------</td>
<td>-------------</td>
</tr>
<tr>
<td>ASTM 4565</td>
<td>Physical and Environmental Properties of Insulation and Jackets for Telecommunications Wire and Cable.</td>
</tr>
<tr>
<td>ANSI/ICEA S-90-661</td>
<td>Individually Unshielded Twisted Pair Indoor Cables.</td>
</tr>
<tr>
<td>Category 3, 5, 5e &amp; 6</td>
<td>For Use in General Purpose and LAN Communications.</td>
</tr>
<tr>
<td>ANSI/TIA/EIA568B.2</td>
<td>Commercial Building Telecommunications Cabling Standard, Part 2: Balanced Twisted Pair Cabling Components Addendum 1 Category 6</td>
</tr>
</tbody>
</table>
CCTV SYSTEMS

A. BRIEF OF CONCEPT DESIGN

1. SURVEILLANCE CLOSED CIRCUIT TELEVISION (CCTV SYSTEM)

CCTV systems are used in different areas of the airport to monitor a variety of activities and areas. These systems operate with minimal manual intervention and provide a record of events which can be viewed later as well depending on the storage of recordings.

1.1 DESIGN CRITERIA

The CCTV system should cover the complete terminal building area. The surveillance should be round the clock with cameras installed outside and inside the terminal building. The system should provide imaging performance in terms of detection, orientation, classification and identification of the image as per standards depending on the location at the airport. The system should be capable to provide video analytics and raise alerts whenever an exception happens. The system should have redundancy to ensure fault-tolerance and use latest standards and technology.

1.2 DESIGN CONCEPT

The system mix of Indoor/Outdoor, Vari-focal Dome and Box cameras, PTZ cameras has been planned to cover every important aspect of Airport buildings along with roadway approaches, curbside traffic, cargo, parking etc.

All the cameras will get monitored 24x7 from CISF Security Room at Ground Floor in terminal building with viewing access to Airport Manager & Airport Director Room. The entire monitoring for the ATC cum terminal building shall also be monitored in the AOCC within the ATC cum technical block.

All cameras will get power from HPOE network switches, hence no need to lay separate Power cables for PTZ cameras which require more than 30W of power.

Entire solution will be IP based using Fibre backbone connected to Centralized Server for Video Management.
1.3 CAMERA DEPLOYMENT AND COVERAGE

A. Cameras installed should ensure complete coverage of the Airport. Important areas to be covered:

- Terminal building (**All Levels including 0, 1 & 2**)
  - All Entry/Exit gates
  - Check Inn Counters
  - Baggage Handling area
  - Security Check Inn
  - External Car parking
  - Immigration
  - Public Utility area like Shops, Dinning area etc
- Apron
- Control tower
- Parking
- Lift (inside/outside)

The location of camera has to be marked by EPC Contractor and vetted from concern department of AAI.

B. INTERFACE WITH OTHER SYSTEMS

The system shall have interface with following systems:

1.3.1 Access Control System to provide automatic switching of cameras on alarm.

1.3.2 Fire Alarm System – CCTV system shall cue relevant cameras in the area of the alarm.

1.3.3 Building Management System – to cue nearby cameras upon escalator or elevator emergency stop push button activation or activation of the lift intercom or lift emergency stop push button.
C. SCOPE OF WORK

1. Scope of work is briefly but not exhaustively described in succeeding paragraphs. The EPC Contractor has to quote the price to meet general, qualitative and technical requirements of tender.

2. SITC of CCTV work will be done as per attached drawing indicated. However detailed marking drawing will be submitted by EPC Contractor to AAI for approval and execution of work.

3. The EPC Contractor shall provide and install the fault-tolerant IP network at Airport for installation of Surveillance CCTV (SCCTV) System with supply of all required hardware such as Cameras, VMS Software, Servers, Storage/NAS, Workstation, Network Switches, Monitors, UPS, Data & Power cabling etc. including their installation, integration with existing system (If required), testing & commissioning as per tender requirements.

4. It shall be the responsibility of the EPC Contractor to ensure the performance of all Cameras and other devices as per prevailing standard and configuration.

5. The upgrades for the supplied Application, Antivirus, Control and Management Software and firmware shall be supplied and installed by the EPC Contractor within the quoted cost and without any legal implication to AAI, during the warranty and defects liability period including AICMC.

6. The EPC Contractor shall have to survey the actual requirement of cables & conduits for the Complete Airport complex under consideration. The supply and laying of various types of cables and conduits shall be after the survey of the routes and ascertaining of the exact cable length(s) requirements for the Airport.

7. The laying of the outdoor cables shall be in accordance with the CPWD specifications.

8. The offered System shall be complete with all equipment and accessories including connectors, patch cords, other networking accessories, mounting, and fixing hardware, plugs, sockets, etc.

9. Cost of Adaptors, Connectors, Patch Cords, Mounting/Fixing hardware, Electrical Switches/Sockets inside the Racks and other accessories required for completion of work is
10. The EPC Contactor is to prepare all the GFC drawings (including mounting & installation detail) as per functional requirement and these shall be submitted to the Engineer-in-Charge in 3 sets and to be approved by him before installations commenced. All such drawings shall show the location of all equipments and details of installation. A further set (4 copies) of all approved shop drawings shall be submitted by the EPC Contractor for use of the Engineer-in-Charge for execution of work.

11. Inspection of the equipment at OEM site & submission of testing report to engineer-in-charge.

12. Testing of system components shall be done as per original equipment manufacturers specifications and guidelines.

13. The entire work has to be executed with total responsibility by EPC Contractor. All necessary technical completeness shall be ensured by the EPC Contractor at the time of quoting/completion of works.

14. EPC Contractor shall be responsible to conduct Site Acceptance Test (SAT), and to supply detailed documentation including as-built drawing in Hard/soft copy at all the Airports.

15. The EPC Contractor may undertake survey at the Airport at its own cost to understand the scope and intricacies involved in carrying out the work.
Fig 1: Surveillance CCTV System Schematic Diagram

Fig 2: Typical diagram of Two-Operator Console for SCCTV System Control Room
Details for submission of documents by the EPC contractor & it’s specialized agency/ agencies.

1. THE EPC CONTRACTOR SHALL PROPOSAL THAT MEETS THE “TECHNICAL SPECIFICATION” OF THIS TENDER DOCUMENT, INDICATING CLEARLY THE MAKE AND MODEL OF EQUIPMENT OF EACH ITEM, BEING OFFERED FOR THE APPROVAL OF ENGINEER-IN CHARGE BEFORE EXECUTION OF WORK.

A. TECHNICAL SPECIFICATION

<table>
<thead>
<tr>
<th>DETAILED TECHNICAL SPECIFICATIONS &amp; FEATURES</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>1. VIDEO SURVEILLANCE APPLICATION SOFTWARE: Supply of VMS Software for Camera Server (For Terminal Building, Utility Building, Isolation Bay etc), NVR/NAS (For ATC cum Technical block), Work-Station loaded in all the Servers to be provided with Camera licenses suitable for all ONVIF Cameras with full functionality, 3 concurrent client user licenses, Virtual Matrix capability, 100% Failover Recording, complete as per specifications with media (2 Nos. software CD/media at each site) and license as applicable.</td>
</tr>
<tr>
<td>1.1 Provision/Features covered in video surveillance software system:</td>
</tr>
<tr>
<td>i. The software should have inbuilt facility to store configuration of cameras.</td>
</tr>
<tr>
<td>ii. The software shall Support flexible 1/4/9/16/25 user defined Windows Split screen display mode or scroll mode on the PC/Workstation monitor or on preview monitor as per site requirement.</td>
</tr>
<tr>
<td>iii. The software shall be able to control all cameras features such as PTZ control, Iris control, auto/manual focus, and color balance of camera, Selection of presets, Video tour selection etc.</td>
</tr>
<tr>
<td>iv. The software is required to generate reports of stored device configuration. The control software is required to provide alarm and alarm log. The log shall be able to be archived, printed and displayed using a device filter, a device group filter and/or a time window.</td>
</tr>
<tr>
<td>v.</td>
</tr>
<tr>
<td>vi.</td>
</tr>
<tr>
<td>vii.</td>
</tr>
<tr>
<td>viii.</td>
</tr>
<tr>
<td>ix.</td>
</tr>
<tr>
<td>x.</td>
</tr>
<tr>
<td>xi.</td>
</tr>
<tr>
<td>xii.</td>
</tr>
<tr>
<td>xiii.</td>
</tr>
<tr>
<td>xiv.</td>
</tr>
<tr>
<td>xv.</td>
</tr>
<tr>
<td>xvi.</td>
</tr>
<tr>
<td>xvii.</td>
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<td></td>
</tr>
</tbody>
</table>

1.2 **User facilities covered in application software**

i. The user shall consist of Administrator Tool application, a Monitoring application, and an Archive Player application.

ii. The client shall perform the following applications simultaneously without interfering with any of the Archive Server operations (Recording, Alarms, etc.):

| a. | Live display of cameras |
| b. | Control of PTZ cameras |
| c. | Playback of archived video |
| d. | Retrieval of archived video |
| e. | Instant Replay of live video |
| f. | Configuration of system settings |

iii. The user applications shall provide an authentication mechanism, which verifies the validity of the user.

iv. The user shall be able to define bookmarks, the amount of time he wishes to go back from a predefined list or through a custom setup period.

v. The user shall be allowed to add bookmarks to recorded clips of video.
<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>vi.</strong></td>
<td>The user shall be able to choose and trigger an action from a list of available actions included but are not limited to:</td>
</tr>
<tr>
<td>i.</td>
<td>View camera in a video tile</td>
</tr>
<tr>
<td>ii.</td>
<td>View Map or procedure in video tile</td>
</tr>
<tr>
<td>v.</td>
<td>Starting/ stopping PTZ pattern</td>
</tr>
<tr>
<td>iv.</td>
<td>Go to PTZ preset</td>
</tr>
<tr>
<td>v.</td>
<td>Sending alert massages</td>
</tr>
<tr>
<td>vii.</td>
<td>The user shall be capable to display all camera sequences created in the system.</td>
</tr>
<tr>
<td>viii.</td>
<td>The user shall be allowed for unlimited cameras sequences, which can be run independently of each other on either of the monitor tiles.</td>
</tr>
<tr>
<td>ix.</td>
<td>The user shall be able to drag and drop a camera from a tree of available cameras into any video tile for live viewing.</td>
</tr>
<tr>
<td>x.</td>
<td>The user shall support digital zoom on a fixed/ PTZ camera’s live and recorded video streams.</td>
</tr>
<tr>
<td>xi.</td>
<td>The user shall be able to control pan-tilt-zoom, focus and dome relays.</td>
</tr>
<tr>
<td>xii.</td>
<td>The user shall be allowed to access the PTZ configuration menus with no need of additional hardware.</td>
</tr>
<tr>
<td>1.3</td>
<td><strong>Integration Interface with other system:</strong></td>
</tr>
<tr>
<td></td>
<td>The system shall provide an integration interface to third party systems using well defined API SDK/ Open Database Connectivity. The API SDK for third party (Other system manufacturers involved in this project) shall be provided along the system without any additional cost which shall enable them to develop the software interface with CCTV system. The software shall have the inbuilt facility to seamlessly integrate to industry standards fire alarm system &amp; Building Management System (BMS) system with/without any SDK.</td>
</tr>
</tbody>
</table>

2. **IP PTZ DAY/NIGHT COLOUR MEGA PIXEL ONVIF CAMERA**

2.1 **TECHNICAL SPECIFICATIONS:**

- Image Device: ~ 1/3” or better CCD/CMOS sensor
- Focal length (For Indoor Camera): ~ 4.7 mm to 94 mm or better
- Focal length (For Outdoor Camera): ~ 4.3 mm to 129 mm or better
<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Optical zoom (For Indoor Camera):</td>
<td>20 x or better</td>
</tr>
<tr>
<td>Optical zoom (For Outdoor Camera):</td>
<td>30 x or better</td>
</tr>
<tr>
<td>Number of Pixels:</td>
<td>1920 x 1080</td>
</tr>
<tr>
<td>Resolution: 1080p HD @25 FPS or better</td>
<td></td>
</tr>
<tr>
<td>Minimum Illumination : B/W: 0.1 Lux or better; Colour: 0.6 Lux or better</td>
<td></td>
</tr>
<tr>
<td>Pan Travel: 360° Continuous</td>
<td></td>
</tr>
<tr>
<td>Tilt Travel: 0 - 90°</td>
<td></td>
</tr>
<tr>
<td>Manual Tilt Speed: 0.5°/SEC to 90°/SEC</td>
<td></td>
</tr>
<tr>
<td>Manual Pan Speed: 0.5°/SEC to 90°/SEC</td>
<td></td>
</tr>
<tr>
<td>Preset Tilt Speed: 0.5°/SEC to 90°/SEC</td>
<td></td>
</tr>
<tr>
<td>Preset Pan Speed: 0.5°/SEC to 300°/SEC</td>
<td></td>
</tr>
<tr>
<td>CE certified &amp; UL listed</td>
<td></td>
</tr>
</tbody>
</table>

2.2 **TECHNICAL FEATURES:**

Termination Box, Integrated RJ 45 and power connector should be provided with each camera

ONVIF (Open Network Video Interface Forum) compliant

Video Stream: Dual H.264 or better video stream for independent viewing and recording

Auxiliary inputs & outputs: 1 alarm input, 1 relay output

Privacy masking zones : 4 or more

Preset positions Min.: 64

Iris Control : Auto

Focus: Auto

Tilt Travel: Auto flip

Wide Dynamic Range (WDR): 70 dB or better

Back Light compensation: Auto

White balance: Auto
<table>
<thead>
<tr>
<th>Specification</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electronic shutter</td>
<td>Auto</td>
</tr>
<tr>
<td>Remote access</td>
<td>Via browser for configuration, viewing and control</td>
</tr>
<tr>
<td>Ethernet</td>
<td>10/100 Base-T Auto sensing, Half /Full Duplex (RJ45)</td>
</tr>
<tr>
<td>S/N Ratio</td>
<td>&gt;= 50 dB</td>
</tr>
<tr>
<td>SD Card</td>
<td>32 GB</td>
</tr>
<tr>
<td>Power supply (Indoor type)</td>
<td>Shall have the ability to be powered by PoE+ 802.3 as well as DC/AC power adapter</td>
</tr>
<tr>
<td>Power supply (Outdoor)</td>
<td>Power Supply should be of the same OEM of Camera as per OEM’s design, however generally AC 230 V @ 50Hz input</td>
</tr>
<tr>
<td>Camera Housing &amp; Mount</td>
<td></td>
</tr>
<tr>
<td>Housing (Indoor)</td>
<td>IP 54, shall be of same make as of camera.</td>
</tr>
<tr>
<td>Housing (Outdoor)</td>
<td>IP 66 rated, Built in Heater and Blower and shall be of same make as of camera. IK10 certified for vandal proof rating.</td>
</tr>
<tr>
<td>Mount</td>
<td>Surface/Ceiling/pipe/corner/parapet/ pendant with wall mount bracket/In Ceiling as required.</td>
</tr>
<tr>
<td>The camera OEM housing and mount should be:</td>
<td></td>
</tr>
<tr>
<td>i. Of the same make as that of camera and suitable for the model number offered as specified by the manufacturer and should be an integrated unit.</td>
<td></td>
</tr>
<tr>
<td>ii. Should be compact and indoor/outdoor type as required.</td>
<td></td>
</tr>
<tr>
<td>iii. Should support the weight of camera and accessories such as housing, pan &amp; tilt head in any vertical or horizontal position etc.</td>
<td></td>
</tr>
<tr>
<td>3. IP DAY/NIGHT FIXED COLOUR MEGA PIXEL ONVIF CAMERA</td>
<td></td>
</tr>
<tr>
<td>3.1 TECHNICAL SPECIFICATIONS:</td>
<td></td>
</tr>
<tr>
<td>Image Device</td>
<td>~ 1/3” CMOS sensor</td>
</tr>
<tr>
<td>Lens</td>
<td>OEM Varifocal lens, Auto Iris, lens f ~ 3 mm to 9 mm (+/- 25% for Indoor Camera) &amp; f ~ 10 mm to 40 mm (+/- 10% for Outdoor Camera) or better</td>
</tr>
<tr>
<td>Number of Pixels</td>
<td>1920 X 1080</td>
</tr>
<tr>
<td>Resolution</td>
<td>1080p HD @25 FPS or better</td>
</tr>
<tr>
<td>Minimum Illumination</td>
<td>B/W: 0.1 Lux or better; Colour: 0.6 Lux or better</td>
</tr>
</tbody>
</table>
### Outdoor cameras: With IR sensor
- CE certified & UL listed

### 3.2 TECHNICAL FEATURES:
- Termination Box, Integrated RJ 45 and power connector should be provided with each camera
- **ONVIF** (Open *Network Video Interface Forum*) compliant
- Video Stream: Dual H.264 or Better video stream for independent viewing and recording
- Electronic Shutter: Auto
- Auxiliary inputs & outputs: 1 alarm input, 1 relay output
- Iris Control: Auto
- Back Light compensation: Auto
- White balance: Auto
- Wide Dynamic Range (WDR): 70 dB or better
- Remote access: Via browser for configuration, viewing and control
- Ethernet: 10/100 Base-T Auto sensing, Half/ Full Duplex (RJ45)
- S/N Ratio: $\geq 50$ dB
- **SD Card**: 32 GB
- Power supply (Indoor type): Shall have the ability to be powered by PoE 802.3 as well as normal DC/AC power
- Power supply (Outdoor): Power Supply should be of the same OEM of Camera as per OEM’s design, however generally AC 230 V @ 50Hz input

### Camera Housing & mount
- **Housing (Indoor)**: IP 54, and shall be of same make as of camera.  
- **Housing (Outdoor)**: IP 66 rated,  
  Built in Heater and Blower and shall be of same make as of camera.
- **Mount**: Surface/Ceiling/pipe/corner/parapet/pendant with wall mount bracket/In Ceiling as required.

The camera mount should be
i. Of the same make as that of camera and suitable for the model number offered as specified by the manufacturer and should be an integrated unit.

ii. Should be compact and indoor/outdoor type as required.

iii. Should support the weight of camera and accessories such as housing in any vertical or horizontal position etc.

4. **Network Attached Storage (NAS): SAS/SATA Disk (in RAID 6 Configuration), suitable power socket, DC power converters, connectors, cables etc.**

Network Attached Storage (NAS) shall be supplied for the complete storage for all cameras for 24x7 in real time mode for a period of 30 days and additional 25% vacant space in NAS.

### 4.1 TECHNICAL SPECIFICATIONS:

**NAS Storage System** with RAID 6 configuration shall be used to record video streams based on the configuration assigned by administrator. Workstations & Servers within the LAN should be able to access the recorded video streams. The Storage device shall support simultaneous play back and recording at full duplex operation.

It shall provide a high quality recording storage and play back of images. It shall support integration with LAN to provide Centralized Management and shall operate on Windows/Linux/Unix/OEM OS. Support of user management for security level control and authentication required. These Storage device shall have the following features and specifications:

- **Controller:** Dual Active-Active Controllers in failover mode with no single point of failure
- **Onboard Cache:** 16 GB per Controller (Mirrored)
- **Storage Disk:**
  - i. 10K/ 7.2K rpm SAS/NL-SAS/SATA disk for 30 days
- **Host Interface:** At least four Gigabit Ethernet (IP) ports and four FC ports
- **HDD type support:** SAS, SSD, NL-SAS/ SATA
- **Inbuilt RAID Support:** RAID-Double Disk failure support/ RAID-6
- **Network Transport Protocols:** TCP/IP
- **Server/ Storage should support Protocol (As per solution):** CIFS, NFS, ISCSI, FCP, HTTP/HTTPS, FTP, NTP, SNMP, SMTP, DHCP and DNS.
- **Power Supply:** Hot pluggable Redundant Power Supply

### 4.2 TECHNICAL FEATURES:
<table>
<thead>
<tr>
<th>Parameter</th>
<th>EPC Contractor will indicate required information against each parameter</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. Drive type</td>
<td></td>
</tr>
<tr>
<td>b. Drive speed</td>
<td></td>
</tr>
<tr>
<td>c. Drive size</td>
<td></td>
</tr>
<tr>
<td>d. RAID group used to configure</td>
<td></td>
</tr>
<tr>
<td>e. usable capacity (Data + parity + spares)</td>
<td></td>
</tr>
<tr>
<td>along with total disks supported by NAS</td>
<td></td>
</tr>
<tr>
<td>f. balance disk space to configure additional 50% usable capacity</td>
<td></td>
</tr>
</tbody>
</table>

**Storage System should be provided with:**

No other upgrades should be required for desired scalability except for disk Arrays enclosures and Disk drives as required.
Once data is stored in Storage, no client/operator should be able to delete or modify data.

FC Switches, if required, as part of the solution should be provided as per system design without any extra cost to AAI.

If any additional appliance required to provide the NAS capability then the solution should be in high availability mode and the cache of the same should be extra.

5. **Rack Mountable NVR/ Camera Server complete with all accessories including Supply of Licensed OS & Antivirus as per specifications and preferred makes.**

   All the Servers (NVR/CAMERA SERVER, VIDEO ANALYTICS SERVER) quantity mentioned in schedule at site shall be essentially supplied by the contractor as per following specifications.

5.1 **TECHNICAL SPECIFICATIONS:**

   **CPU:** 64-bit high performance, Minimum Two Processor of 8 Core each or higher Intel/AMD CPU operating at 2.1 GHz or more with a minimum of 11 MB L3 cache or higher

   **Memory:** 16 GB DDR RAM Upgradable to 64 GB

   **Chassis type:** Rack mountable

   **Hard Drives:** SAS 10K rpm or higher hot swappable Hard Disk in RAID 5 or 6 configuration having usable space of 500 GB or more.

   **Power supply:** Redundant Power Supply

5.2 **TECHNICAL FEATURES:**

   **Network Adapter(NIC):** Dual 10Gbps ports

   **Keyboard:** USB Keyboard

   **Mouse:** Optical Mouse with scroll

   **Operating System:** Licensed MS Windows Server or Linux (Latest version)

   Anti-Virus Software compatible with Windows/ Linux along with update subscription valid till warranty and AICMC period
6. **Workstation (Client PC Type A & B)**

<table>
<thead>
<tr>
<th>6.1 TECHNICAL SPECIFICATIONS:</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>CPU</strong>: Minimum 7th Generation Core i7 Intel/AMD Processor or higher operating at 3 GHz or more with 8 MB Cache or higher</td>
</tr>
<tr>
<td><strong>Memory</strong>: 16 GB DDR 3 or higher</td>
</tr>
<tr>
<td><strong>Hard Drives</strong>: 500 GB SATA/ SAS or more</td>
</tr>
<tr>
<td><strong>Video Card</strong>: 4 GB NVidia Ge Force DVI or better dual port Graphics card.</td>
</tr>
<tr>
<td><strong>RAID</strong>: supported</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>6.2 TECHNICAL FEATURES:</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Keyboard and Joy stick</strong>: Variable speed Joystick controller with LCD/LED display (for programming and to control the speed dome for PAN / TILT / Zoom) or keyboard. It shall also be able to select any camera on any monitor.</td>
</tr>
<tr>
<td>Keyboard and joystick shall be installed and integrated on Console for camera monitoring and PTZ control.</td>
</tr>
<tr>
<td><strong>Mouse</strong>: Optical Mouse with scroll and Mouse Pad</td>
</tr>
<tr>
<td><strong>Network Adapter(NIC)</strong>: Two numbers of 10Gbps ports</td>
</tr>
<tr>
<td><strong>Sound Card</strong>: In- Built</td>
</tr>
<tr>
<td><strong>DVD writer</strong>: DVD RW/ Blu-Ray combo internal/external</td>
</tr>
<tr>
<td><strong>USB 3.0</strong>: 2 nos. at front panel</td>
</tr>
<tr>
<td><strong>Operating System</strong>: Licensed MS Windows or Linux (Latest version)</td>
</tr>
<tr>
<td><strong>Anti-Virus Software</strong>: Anti-Virus Software compatible with Windows/ Linux along with update subscription valid till warranty and AICMC period</td>
</tr>
<tr>
<td><strong>Client VMS application</strong> software including Supply of Licensed OS &amp; Antivirus Software</td>
</tr>
</tbody>
</table>

7. **55" Displays (for Client PC Type A) complete with wall/ceiling/floor mounting arrangement**
7.1 TECHNICAL SPECIFICATIONS:

<table>
<thead>
<tr>
<th>Specification</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Screen Size</td>
<td>55” (diagonal) or higher</td>
</tr>
<tr>
<td>Monitor Type</td>
<td>Industrial/ Professional suitable for 24x7 operation</td>
</tr>
<tr>
<td>Back Light</td>
<td>LED</td>
</tr>
<tr>
<td>Aspect Ratio</td>
<td>16:9</td>
</tr>
<tr>
<td>Resolution</td>
<td>Full HD, 1920 X 1080 pixels or better</td>
</tr>
<tr>
<td>Brightness</td>
<td>450 cd/m² or better</td>
</tr>
<tr>
<td>Contrast Ratio (Native)</td>
<td>2400:1 without IPS/ 1100:1 along with IPS</td>
</tr>
</tbody>
</table>

7.2 TECHNICAL FEATURES:

<table>
<thead>
<tr>
<th>Feature</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Viewing angle</td>
<td>178°</td>
</tr>
<tr>
<td>Operating Voltage</td>
<td>Suitable for single phase AC supply 180-230 V, 50 Hz</td>
</tr>
<tr>
<td>Video Input Ports</td>
<td>Digital Ports: HDMI/ DVI-D; /USB Port</td>
</tr>
</tbody>
</table>

8. 3X2 55” Thin bezel LED Video-wall displays with Controller and complete with wall/ceiling/floor mount and mounting fixtures

3 x 2 (6 LED Panels) Thin bezel Industrial Video Wall Displays with **Video-wall Controller** for Common Control Client Workstation complete with wall/ceiling/floor mount & mounting fixtures as per specifications.

Video wall shall be Hardware/Software clustered displays with Client Workstation. 55” or more LED/LED backlit LCD Thin Bezel Monitor with mounting accessories for display of video images of all cameras in Common Control Room as per following specifications:

8.1 TECHNICAL SPECIFICATIONS:

<table>
<thead>
<tr>
<th>Specification</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Screen Size</td>
<td>55” or more 3x2 (6 Panels)</td>
</tr>
<tr>
<td>Aspect Ratio</td>
<td>16:9</td>
</tr>
<tr>
<td>Display Type</td>
<td>Industrial/ Professional suitable for 24x7 operation</td>
</tr>
<tr>
<td>Contrast Ratio (Native)</td>
<td>2400:1 without IPS; 1100:1 along-with IPS</td>
</tr>
<tr>
<td>Brightness</td>
<td>450 cd/m² or more</td>
</tr>
<tr>
<td>Resolution:</td>
<td>1920X1080 or higher pixels</td>
</tr>
<tr>
<td>-----------------------</td>
<td>-----------------------------</td>
</tr>
<tr>
<td><strong>8.2 TECHNICAL FEATURES:</strong></td>
<td></td>
</tr>
<tr>
<td>Viewing angle:</td>
<td>178°</td>
</tr>
<tr>
<td>Operating Voltage:</td>
<td>Suitable for single phase AC 180-230 V AC, 50 Hz</td>
</tr>
<tr>
<td>Video Input Ports:</td>
<td>Digital Ports: HDMI/ DVI-D; PC – VGA in: 1xD-Sub;</td>
</tr>
<tr>
<td>Thin Bezel design:</td>
<td>Screen-to-screen distance between two neighboring displays shall not be more than 4 mm (left – right sides combine, top &amp; bottom sides combine).</td>
</tr>
</tbody>
</table>

**9. OPERATOR CONSOLE FOR CONTROL ROOM**

9.1 **Console for use of two operator using 24x7 along with two chairs** shall be supplied with 02 nos. of rotating pushback chairs and to accommodate workstation, joystick, keyboard and mouse. The Console as per following features:

The console shall be built to withstand life span of 07 years on normal use, wear and tear.

a. The structure of the Console should have following component and design:
b. Structure shall be made of Extruded Vertical & Horizontal Aluminium profiles (powder coated finish) fastened together with heavy duty MS joineries. Having all SS Bolts and nickel plated hardware.
c. Work-surface shall be minimum 25 mm thick MDF with High Pressure laminate. Front edge Nosing shall be injection moulded on the profiled wooden core. Depth shall be 50 – 60mm.
d. Desk shall house CPU on Slide out metallic CPU trays.
e. Monitors shall be mounted on aluminium die-casted arms. Monitor arm shall be able to mount monitors complying VESA (Video Equipment Standards Association) standards 75 x 75, 100 x 100, 200 x 100 & 200x200 mm.
f. CPU cabinet front, back shutters shall be of 18 mm Laminated MDF Board with premium finish. Side leg shall be of 25mm of the same finish.
g. Rear shutters shall have provision of Airflow opening for cooling and heat dissipation effect.
h. Electricals: Each console shall be equipped with individual power distribution unit.
i. Approximate dimensions of the console shall be 1800 mm (W) X 1000 mm (D) X 750 mm (H).
j. The console must be UL listed and certificate should be enclosed.
k. **A typical diagram for Operator Console (2 operators) is attached at Fig 2 for reference.**
**Final drawings and design will be approved by Engineer-In-charge/CHQ before the time of execution.**

<table>
<thead>
<tr>
<th>9.2</th>
<th>Fabrication, supply and installation of Console for Control room shall be done by the EPC Contractor and shall have the following provisions:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>a. Provision to suitably install Workstations.</td>
</tr>
<tr>
<td></td>
<td>b. Keyboard, Mouse shall be installed on Console for camera monitoring and PTZ control.</td>
</tr>
<tr>
<td></td>
<td>c. Lockable compartment for keyboard shall be provided.</td>
</tr>
<tr>
<td></td>
<td>Space for proper termination of cables shall be provided.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>10.</th>
<th><strong>GI POLE FOR MOUNTING OF CAMERA</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>GI Pole (Class B) of 4&quot; dia, up to 5 Mtrs. height from ground level with accessories shall be supplied and installed for mounting of camera.</td>
</tr>
<tr>
<td></td>
<td>The pole shall be grouted with MS base plate of min. size 300 mm x 300 mm x 6 mm under the ground embedded in concrete complete as per site requirement. The pole shall have IP65 junction box where all the cables shall be terminated. The supply and installation of pole also covers civil and mechanical works including painting.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>11.</th>
<th><strong>EARTHING</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>The system shall be configured to be grounded electrically to a common ground point to prevent interference to the system from external and internal sources and to protect equipment and personnel.</td>
</tr>
<tr>
<td></td>
<td><strong>Earthing of the System:</strong> The contractor firm shall provide the Earthing to each system separately by making the earth-pit as follows:</td>
</tr>
<tr>
<td></td>
<td>Supply and installation of the copper plate - 600x600x3mm</td>
</tr>
<tr>
<td></td>
<td>GI (galvanized) pipe of 40 mm diameter is to be used</td>
</tr>
<tr>
<td></td>
<td>The earth-pit to be dug for a depth of 3.75 mts.</td>
</tr>
<tr>
<td></td>
<td>Copper plate is to be properly fastened with nuts and bolts to the copper wire of size 14SWG. This copper strip/copper wire is laid up to the main distribution board of the centre.</td>
</tr>
<tr>
<td></td>
<td>The copper strip without GI pipe or thick copper wire with GI pipe should be laid up to the Server Room.</td>
</tr>
<tr>
<td></td>
<td>19 mm GI pipe to be laid for watering purposes. This will have a funnel at the top of the earth pit chamber.</td>
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</tbody>
</table>
Minimum 70 Kg. of salt and approx. 100 Kg. of coal are to be filled in the pit, in layers, after the plate and the pipes are laid in the pit.

Measurement the earth resistance at the pit should be less than 2 Ohms.

**Standard Chemical Earthing may be provided instead of above-mentioned Conventional Earthing in case of the rocky soil at site and/or 2 ohms resistance is not achieved.**

Contractor shall ensure proper grounding/Earthing of all system equipment, cabinets and AC power supply outlet.

12. **TRAINING & DOCUMENTATION**

The EPC Contractor along with OEM partner firm shall provide following types of training as detailed below:

12.1 **OPERATION, MAINTENANCE AND SYSTEM ADMINISTRATION TRAINING**

On the Job operation, maintenance and system administration training of the persons nominated by AAI. The training shall be designed and structured covering following parameters:

- Basics of SCCTV System.
- a. System setting up and Configuration of offered system from Scratch.
  - Installation procedures for system hardware & software, configuration recovery, reloading of software drivers/modules of operating system and application software.
- b. Configuration, optimization and alignment of the system with the help of the documents and software supplied along with the equipment/system.
- c. Breakdown maintenance of the system.
- d. Fault isolation up to Module level using diagnostic tools and general purpose test equipment,
- e. Preventive maintenance of the system.
- f. Installation Procedures for system hardware & software, configuration recovery, reloading of software driver/modules of operating system and application software.

12.3 **DOCUMENTATION**

FOUR SETS HARD COPY ALONGWITH SOFT COPY IN PENDRIVE for Operations, Technical and Maintenance manual, etc. shall be submitted at Airport.
All manuals and documents shall be in English language and in such a way that a qualified engineer/technician is able to fully understand and do the preventive as well as breakdown maintenance with the help of these manuals.

The Technical and Maintenance manual will cover:
- General technical description and theory of operation
- Block diagram of complete system
- Servicing/ Maintenance instructions including preventive maintenance schedule
- Fault analysis and repair
- Installation procedures for software, configuration recovery, reloading of software modules of application software.
- Technical & operational manuals
- Maintenance manuals
- Maintenance and System Administrative procedures.

- The cost for the Maintenance/Service during DLP period of 24 months is covered under the scope of work and quoted rates shall be deemed to cover regular examination of the installations by the trained technician of the contractor including necessary adjustments, cleaning including replacement of parts etc. to keep the equipment in excellent operational state.

- The contractor shall also provide 24 hour emergency repair service to attend the SCCTV at any time of the day or night including Sundays and Holidays.

- All Inclusive Comprehensive Maintenance Contract (AICMC) to be undertaken by the EPC Contractor for the next five years after completion of the guarantee / warranty & defect liability period of TWO year. Refer separate schedule of cost & billing.

- The detailed terms and conditions of the all-inclusive Comprehensive Maintenance Contract for SCCTV are appended under SCC for Operation & All inclusive comprehensive Maintenance contract. The quoted amount for AICMC will be taken into consideration for evaluation of the bids.
FID SYSTEM

BRIEF OF CONCEPT DESIGN

FLIGHT INFORMATION DISPLAY SYSTEM (FIDS)

1.1 Overview

The Flight Information Display System (FIDS) shall be used to display information to the public & the staff using LED/LCD panels or LED Boards. System shall also be able to display output on handheld devices like PDA / Web browser etc.

The FIDS shall allow the administrator of the system to compose the templates of the displays and distribute them remotely. The information is displayed in multiple languages. The FIDS shall allow the administrator of the system to define access rights for each user or group of users.

The FIDS shall be able to be operated in standalone mode in the case the other systems of the airport are down, it shall also allow the user to manually insert all the information to display.
1.2 FIDS system is required:

1.2.1 To direct the passengers flow.
1.2.2 To provide flight information in real time on the airport
1.2.3 To provide mobile FIDS functionality in order to receive flight information on a mobilephone.
1.2.4 To show Baggage information such as First Bag Last Bag for multiple flights
1.2.5 To display free text information display (missing passenger’s information, messagebroadcasting, location and event driven information etc.)

1.3 Design Objectives:

1.3.1 Architecture is based on "client-server" configuration. User interface to be web-based.
1.3.2 System and application software are controlled and configured by working parameters stored in tables and easy to change without programming actions
1.3.3 System should provide flexible mechanism to allow users to select filters and sort database information.
1.3.4 The system should be easy to deploy throughout the whole airport.
1.3.5 System should be easy to maintain, system maintainer should be able to remotely connect, Configure, upgrade, troubleshoot and monitor the system and devices

It is to be noted that the system is intended to be used 24 hours a day. Remote monitoring and management of the devices shall be possible. The FIDS shall follow ICAO / IATA requirements. System shall be able to manage all kinds of information on the displays installed at the airport including Flight Information, Advertisement and branding, Dynamic and free text information.

1.4 Server/Content Management

System shall have advance Page Designing software with dynamic carouseling and graphic capabilities, page designer shall have state of the art designing capabilities to design dynamic
Flight information and advertisement layouts to show different types of objects and processed information through FIDS system. System should be able to remotely connect and screen capture the remote device to facilitate troubleshooting and testing.

In case of failure of a device from the group/bank of devices, system shall be able to auto adjust the sequence of flight information on the bank of devices to readjust the information loss due to faulty display in the set.

System shall possess advance advertisement scheduling and play list functionalities.

It shall be possible to display flight information, entertainment, Dynamic message, ad-hoc free text messages, meteorological information, etc. on the same screen. The FIDS product provided must be able to display at least all the operating Flights of the current day and the next operating flights if necessary. The FIDS Screen at the Boarding gate shall give information on the current flight status and the time.

FIDS device monitoring utility should have the facility to switch on/off the display, to configure and send the updates and the pages remotely.

Preferred Database is Oracle. Preferred Operating System for the Servers is LINUX.FIDS shall be easy to interface to an AODB or RMS that might be requested to a later stage. FIDS shall have functionalities to protect data from Human errors, from data corruption and from site failures.

Access to FIDS shall be possible with Open VPN for tele-maintenance purposes. FIDS shall be provided with an administrator tool to easily manage privileges for each user or group of users. FIDS shall be able to easily manage changes on timeout parameters without any programming.

Data entry for FIDS operator shall be simplified as much as possible by using menu with pre-defined values rather than free text entries. FIDS operators at Check-in desks or gates shall be able to modify status and information on the display by using a simple web interface and choosing between pre-defined layouts.
1.5 FIDS DISPLAY REQUIREMENTS

The system shall use displays in various configurations throughout the terminal as per the line of sight requirement. It is recommended that the size of displays be limited to a minimum types for ease of maintenance.

The system shall use portrait orientation displays at the gate areas, check-in counters, baggage reclaim and transfers areas. It is recommended that portrait orientation displays be used at departure hall, arrival hall and all outdoor areas.

Displays outside the terminal shall be of high brightness for make text legible and shall be weather rated (IP55 or better) or installed in weather rated enclosure.

All LED panels shall have at least 1920x1080 resolution.

**NTP Time Server**

NTP Time Server shall be used to synchronize IP devices over the Airport LAN.

1.6 Typical FIDS Architecture

FIDS Servers architecture shall be proven with high reliability, high performance and easily scalable. Three-tier architecture with minimum two redundant DB servers in hot stand-by shall be provided, according to the airport size other servers such as application servers or area servers shall be provided. The system shall use standard MPEG-2, H.264 or similar COTS available compression format for any video transmission.
B. COPE OF WORK

Scope of work is briefly but not exhaustively described in succeeding paragraphs. The EPC Contractor has to quote the price as described in the following scope of work to meet general, qualitative and technical requirements of tender as per this Section.

1. The EPC Contractor shall provide the following systems at specified Airports.

<table>
<thead>
<tr>
<th>S. No.</th>
<th>System</th>
<th>Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Flight Information Display System (FIDS)</td>
<td>SITC of Flight Information Display System for complete terminal building.</td>
</tr>
</tbody>
</table>

2. The scope of Flight Information Display System comprises of:
i. Supply of all required hardware such as Display with controller, Servers, Data Entry Terminal, Network equipment, Equipment Rack, KVM Switch, UPS, Data & Power cabling etc. and all required software such as Application, Antivirus, AFAS etc. including their upgrades, their installation, testing & commissioning with two years onsite warranty and five years Comprehensive Annual Maintenance Contract (AICMC) with Spares.

ii. The EPC contractor shall carry out the upgradation of system software as and when required. This shall be executed after taking prior approval from Engineer-in-charge.

iii. The EPC Contractor shall have to survey the actual requirement of all type of cables at the specified Airports. The supply and laying of various types of cables shall be made after the survey of the routes and ascertaining of the exact cable length (s) requirements at site.

iv. The laying of the outdoor cables shall be in accordance with the CPWD specifications.

v. The offered system shall be complete with all equipment and accessories including connectors, patch cords, other networking accessories, mounting, and fixing hardware, plugs, sockets, etc.

vi. Cost of Adaptors, Connectors, Patch Cords, Mounting/ Fixing hardware, Electrical Switches/ Sockets inside the racks and other accessories required for completion of work is deemed to be included in the quoted prices. This also includes cable channel/ Tray to be installed by the EPC Contractor within Equipment Room/ Control room as per requirement.

vii. Testing of system components shall be done as per original equipment manufacturers specifications and guidelines.

viii. The entire work has to be executed with total responsibility by EPC Contractor. All necessary technical completeness shall be ensured by the EPC Contractor at the time of quoting/ completion of works.

ix. EPC Contractor shall be responsible to conduct Site Acceptance Test (SAT), and to supply detailed documentation including as-built drawing in hard, soft copy at all the Airport.
x. The EPC Contractor may undertake survey at specified airport at its own cost to understand the scope and intricacies involved in carrying out the work as per scope of tender.

Details for submission of documents by the EPC contractor & its specialized agency/ agencies.

THE EPC CONTRACTOR SHALL PROPOSAL THAT MEETS THE “TECHNICAL SPECIFICATION” OF THIS TENDER DOCUMENT, INDICATING CLEARLY THE MAKE AND MODEL OF EQUIPMENT OF EACH ITEM, BEING OFFERED FOR THE APPROVAL OF ENGINEER-IN CHARGE BEFORE EXECUTION OF WORK.

1. TECHNICAL SPECIFICATION/PARAMETERS FOR FIDS EQUIPMENTS

<table>
<thead>
<tr>
<th>1.1</th>
<th>GENERAL FEATURES:</th>
</tr>
</thead>
<tbody>
<tr>
<td>i.</td>
<td>System shall be capable of supporting various display devices including but not limited to TFT, LCD, LED Display Board, Intelligent Monitor, etc.</td>
</tr>
<tr>
<td>ii.</td>
<td>Display clustering: System shall be capable of installing grid of multiple displays for spreading one page of information on multiple displays. The grid composition shall be user configurable.</td>
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<tr>
<td>iii.</td>
<td>Devices shall be capable of displaying the information in Portrait and Landscape mode. This shall be user configurable.</td>
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<tr>
<td>iv.</td>
<td>The display client software shall be able to handle various graphic formats including MPEG 2/4, MP4, JPEG, video clips, etc.</td>
</tr>
<tr>
<td>v.</td>
<td>The displays shall have LED’s to indicate operational status and network connectivity for easy maintenance.</td>
</tr>
<tr>
<td>vi.</td>
<td>All the displays shall have IR Remote, controlling basic display functions such as Brightness, Contrast, Colour Control, etc.</td>
</tr>
<tr>
<td>vii.</td>
<td>The display shall not have any controls within the reach of the public/or such controls shall be suitably covered to avoid possible tampering.</td>
</tr>
<tr>
<td>viii.</td>
<td>Display controller shall be capable of remote monitoring of the displayed content/information from the central server &amp; any work station in the network.</td>
</tr>
<tr>
<td>ix.</td>
<td>It shall be possible to reset, restart and reboot the intelligent controller &amp; display monitor remotely on the network.</td>
</tr>
<tr>
<td>x.</td>
<td>It shall be possible to put the display in standby mode (soft power off) from the remote (network: server/workstation) or shall have a remote control to switch the display on or off in a go.</td>
</tr>
<tr>
<td>xi.</td>
<td>Display monitor shall be provided with cabinet suitable for industrial/professional 24x7 use with arrangement for Wall and Ceiling Mount installation with provision for Swivel movement.</td>
</tr>
<tr>
<td>xii.</td>
<td>Display Monitor cabinet shall be designed for uniform heat dissipation/removal and shall have mechanism to remove heat from the cabinet. Heat removal mechanism</td>
</tr>
</tbody>
</table>
shall automatically start functioning when temperatures reach certain threshold levels.

xiii. Suitable wall/ceiling/pedestal mounting shall be provided for Display Monitors in single or clustered configuration.

2.

TECHNICAL FEATURES:

2.1 GENERAL FEATURES

a) Application software shall meet requirements specified in this tender document. Software shall be supplied with license for the complete site without having any consideration for the number of clients, display, etc.

b) FIDS application shall include appropriate tools and interfaces for control, configuration, administration and maintenance of FIDS server and FIDS Database.

c) FIDS software shall have Standard Graphic User Interface for all modules and shall be fully menu driven. All software tools, configuration windows shall be windows based and menu driven.

d) The FIDS software shall be an open application using industry standard interfaces/protocols.

e) The FIDS software shall be able to handle proprietary as well as standard interface protocols.

f) FIDS Application Software shall have HTML/. devices.

g) Necessary Software tools shall be provided by the EPC Contractor for System Administration, Maintenance, Monitoring and User/Client Operations, which shall monitor all connected devices and report status of the systems and all display devices.

h) Grouping of Display Devices in different areas of the terminal building shall be possible. The system administrator shall configure these groups. Assignment of relevant flight data to be displayed on different groups shall be possible.

i) The updated flight information shall be displayed on field display devices (Display Boards, Monitors, etc.) in real time.

j) The FIDS displays shall access the flight information database using standard web browsers (such as internet explorer, Firefox, safari, etc.).

k) In case of network outage, the client shall show the last updated information for a configurable period of time. Thereafter, display shall display a predefined page selected by user.

2.2 RDBMS AND FIDS DATABASE

a) The FIDS Application Software shall be designed to work with industry standard RDBMS System like MS SQL, Oracle, MySQL, etc. The FIDS Application Software and the RDBMS shall be installed on the FIDS Servers.

b) The RDBMS shall be supplied with necessary number of client access license.
c) The Flight Information Database shall be maintained on the Main/Hot standby servers.

d) FIDS shall comply to push and pull data with AODB on XML/HTML; SITA/ARINC PREFANS/FANS ACARS based network, ICAO AFTN network, CUTE system, BHS and NTP Server for time synchronization

e) FIDS RDBMS shall maintain lookup tables for Airlines/Airports as per standard IATA Codes.

f) Transaction Log Tables and Archived Transaction Log shall be maintained on RDBMS Server for all transactions. The Transaction Log Tables records shall be moved to Achieved Log Tables based on administrator configurable time parameters.

g) RDBMS shall implement record level locking, to enable updating of a flight record from only one Server or a Workstation at a time. Suitable WAIT message shall be displayed to other users trying to access the same record.

h) The database architecture shall be based on the following standards:

1. The flight schedule shall be stored in a seasonal flight table where every flight record contains the flight frequency, validity period, etc.

2. Each record shall be presented in ICAO and IATA standard Airport/Airline/Flight Number codes and formats.

3. Each record shall handle not less than eight exceptions on the schedule, e.g., for public holidays.

4. A flight record shall handle at least four VIAs.

5. A flight record shall handle at least six code share flight numbers.

6. The seasonal flight schedule shall be expanded into an actual flight table where every flight is one record. The time window for the expansion shall be configurable.

7. Actual flights which are operated shall be stored in an archive table for statistics and reports. The record shall be deleted from the actual flight table according to configurable time parameters.

8. The flight records in the actual and archive flight table shall have a departure and arrival log; a join to a rotation between the arrival and departure log shall be possible.

9. The flights origin, destination, VIAs, airline, codes shares, etc. shall be represented by the appropriate ICAO and IATA codes to be linked to lookup tables.

10. All flights shall be distinct by flight nature according to IATA flight nature. The flight nature shall be stored in a lookup table and linked by the nature code to the flight record.

11. The flight record shall be expandable to any field required by the airport. Information about the flight shall come from interfaces not limited to SITA, TEXT, AFTN, Flight Schedule, AODB and Docking System as made available at airport.

12. The design of FIDS Database and Application Software shall enable the user to
retrieve reports and statistics for historical and actual flights.

13. Administrative terminals, Client Terminals and Data entry terminals shall access the database using standard web browsers (such as internet explorer, Firefox, safari, etc.) for functions/ processes:

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<tbody>
<tr>
<td>I.</td>
<td>Updating the flight information database;</td>
</tr>
<tr>
<td>II.</td>
<td>Accessing the flight information database;</td>
</tr>
<tr>
<td>III.</td>
<td>Configuration and administration of the FID System, Database;</td>
</tr>
</tbody>
</table>

i) EPC Contractor shall supply all necessary protocols (ICDs - Interconnect Control Documents), details of database structures with detailed inter-dependencies, communication protocols of the system at site to enable integration of FIDS in future with various other third party automation technologies.

j) The FIDS RDBMS shall maintain a **MASTER FLIGHT TABLE (MFT)** based on defined periodicity.

k) **ACTUAL FLIGHT TABLE (AFT):** From the flight database, the system shall automatically generate Actual Flight Table containing flights in chronological order for a user defined time interval (time interval in multiple of Hours shall be configurable/predefined by user). The AFT shall be generated automatically by the system on continuous bases. Updating of the AFT shall also be on continuous basis. The left over flights of the previous intervals (configurable) and their status shall not be changed and shall be added on top of the new AFT automatically.

l) Each flight in the actual flight table shall have a traffic type flag not limited to the following:

   a. Operational
   b. Cancelled
   c. Diverted
   d. Re-routed
   e. Non-operational.
   f. Suspended
   g. Planning

m) The current flights in the AFT shall be displayed on the display devices automatically as per the configuration of the display (by the operator through Software) without any manual intervention of the operator.

n) It shall be possible to manually update any data field of the Flight Information Data for all the flights in the AFT for the current day by the operator, and then transmit for displaying on the configured display devices.

o) System shall permit insertion and deletion of the flights from the AFT. System shall allow editing the database and updating the same from client terminal with appropriate access authorizations.

p) **EDITING FLIGHT FOR A DAY:** FIDS shall be provided with Software Tool to query the
Database for a list of flights for any specific day of the week for editing. Operator shall have appropriate software interface for editing and modification of these flights.

q) Data entry on user forms/pages shall be validated for possible logical errors and accordingly pop-up shall be presented to user indicating warning along with the help options.

### 2.3 DISPLAY CONFIGURATION TOOL

i. It shall be possible to schedule such designed templates to the display devices based on programmed template and timed sequence.

ii. All the parameters in the display configuration tools shall be user configurable.

iii. Provision shall be available to configure number of displays into groups to display same set of information’s.

iv. The Display Configuration tool shall be primarily used to define the entire Video display network in terms of groups. The display shall be grouped on the bases of area (such as arrival, departure, etc.), flight types (domestic, international, etc.), flight operation (arriving, departing flight, etc.), language, gate type, baggage display, check in counter, etc. Once groups are made, each group will display the same set of messages in a synchronized manner.

v. For example, the Arrival Hall may be required to be split into two groups, namely those that display arrival messages in English and those that display arrival messages in Hindi. Once this is done using the Display Configuration Editor, these display monitors will automatically display arrival messages as per configured language option.

### 2.4 INDIAN LANGUAGE DICTIONARY

i. The Indian Language Dictionary shall be created and maintained for all flight information fields.

ii. The Dictionary shall be accessed during flight information display to provide automatic translation from English to Hindi and one local Indian language as per site requirement so that Flight Information entered in English by the operator is automatically translated into Hindi and any other Indian language script, by the use of this dictionary.

iii. The dictionary shall be editable and it shall have feature for addition and/or deletion of more words of Hindi and Local Indian Language.

### 2.5 BAGGAGE CLAIM SOFTWARE MODULE

FIDS software shall have Baggage Claim module, with the following features:

i. Assignment of Baggage Belt Number to a flight.

ii. On changing of flight status to “ARRIVED”, the assigned Baggage Claim information shall be displayed on the respective Baggage Claim Display Monitor and Directory Display Monitor.
### Boarding Gate Display Module

- **Assignment of Gate Number to a Boarding Flight**
- **Next Flight Number to be displayed for Boarding**
- **Boarding information shall be possible through CUTE System**
- **The Boarding Gate Display Module shall be operated from Client Workstation by authorized user.**

### Page/Template Design Tool

- **Page/Template Design Tool** shall be provided for designing Screen Layout for display devices by choosing position of data (Header, Footer, Flight records, Airline Logo, Time of the Day, Free-form messages, Ticker/Scroll messages with flight data, etc.), fonts, text attributes (Regular, Bold, Italics), colour (Foreground, Background), background image, scrolling (direction, speed), etc.
- **The page design tool shall be a standard OEM product using GUI (Graphical User Interface).**
- **The page design tool shall work from the FIDS server and client terminal connected to the FIDS network.**
- **The access to this module shall be protected by passwords, and controlled by access level assigned by system administrator.**
- **The design tool shall have easy to use Tool bars, Menus, Buttons, etc. and shall include Search for help on various functions/ capability of the system.**
- **The page design tool shall have ability to manage graphics, true type fonts, video clips, and multimedia advertising. It shall permit use of animation and graphics for displaying flight information and free-form information pages.**
- **It shall have provision to use different images of common graphic formats as backgrounds for screen templates.**
- **The page design tool shall support selection and display of multiple language fonts.**
- **Page design tool shall be provided with predefined screen layouts (template) with the system, and shall also have capability for designing new page templates. Any number of such custom made screens shall be stored and displayed on a**
specified date and time.

x. Page design tool shall allow user to define page format and design each page combining fixed and dynamic information.

xi. The software shall also permit creation of free-form pages wherein any special message or information of the general type can be entered for selective display on the intelligent display devices.

xii. The Page Design Tool shall be user programmable. Display configuration shall be done to the extent of user to create and edit display script for one or many displays, display clocks, blank screens.

xiii. Only System administrator shall be allowed to publish newly designed pages.

xiv. It shall permit preview of any designed page.

xv. The design tool shall allow the user to construct a display layout including graphics, true type fonts, video clips to a selection of flight data.

xvi. The tool shall have common features used in other design tools, like:

a) Horizontal, Vertical Grid alignment

b) Snap to grid function

c) Copy style function

d) Different layers, bring to front, send to back, etc.

e) Tickers

f) Page carousels.

h) Advanced table functions for summary displays

xvii. It shall be possible to place the Airline logo(s) (Image files in standard graphics format) on screen at User configurable/selectable specific positions using the page design tool.

xviii. The system shall display free text information in a scrolling line at selectable position in the display devices (TFT-LCD/LED, etc.). This feature shall be user selectable and user configurable.

xix. The module shall allow creating pages for displaying on TV using full screen and also in scalable window. The page shall be selectable in the aspect ratio of 4:3, 16:9, 21:9 and free form.

2.8 SECURITY

i. Multi-level password security shall be incorporated for addition, deletion, modification and update of the database for individual users. This shall be configurable by the user.

ii. Access to Server Operating System, Database and FIDS Application Software shall be restricted as per user authorization matrix, with access passwords.
### 2.9 DEVICE MONITORING AND CONTROL

**i.** This module shall enable user to view status of displays/device connected to it and shall have access to the devices.

**ii.** System shall monitor all the devices connected in the network and report status of system and display devices.

**iii.** The modules shall be accessible from main system and also from remote PC connected to the FIDS network.

**iv.** The access to this module shall be protected by passwords and controlled by access level assigned by system administrator.

**v.** Maintenance Utility shall be able to run from any PC/Client connected to the FIDS network.

**vi.** The module shall remotely monitor health of each device connected in the system through SNMP and view online status of the display devices.

**vii.** The module shall allow the user to remotely view the display content (i.e. currently displayed) of the LED/LCD display monitor.

**viii.** Maintenance shall also enable to remotely view the content transmitted to the LED Line Display Board/LED Display Board.

**ix.** Maintenance utility shall enable to remotely control display devices i.e. switch off, reboot, set device out of service, etc.

**x.** Licensed Remote Desktop Tool like Netviewer, Gotoassist, Logmein, Webex, Showmypc, shall be provided for remote access of Clients, Display Controllers, etc.

### 2.10 REAL TIME CLOCK FOR DISPLAY DEVICES
i. The page design tool shall fix the clock to be shown in digital form at any selectable position on the screen. The clock shall have some of the attributes as for text items such as colour and size.

ii. Clock’s display shall be selectable for display and no display, as per user requirement.

iii. The clock shall automatically get synchronized with the database server clock/NTP server. Software provision shall be made in the display controller to force automatic periodic synchronization, as well as manual synchronization as and when required by the user.

2.11 AUTOMATIC FLIGHT ANNOUNCEMENT SYSTEM (AFAS) MODULE

i. This software module shall scan the flight information database for valid announcements, construct announcements, convert announcement text into voice format/audio signals and send to the appropriate zone of the PA system for announcing. It shall translate the flight information in to voice format for automatic announcement on the existing PA system of the Airport.

ii. The system shall construct announcements, convert in to voice and send to the appropriate zone for announcing on the PA System.

iii. The system shall select zone of the PA system and send zone selection signals to the PA system for effecting the announcement in the selected zone.

iv. To construct voice for announcement, the system shall have the following technology:

A. Text-to-speech engine to automatically synthesize flight information into a voice for announcement. The text to speech engine shall have:

   a) The voice broadcast shall provision for male and female voice;

   b) Different accents.

   c) User shall have option to listen synthesized voice output

   d) The above feature shall be user selectable.

OR

B. Pre-recorded voice library for constructing announcements. Pre-recorded library shall include available list of 2048 airports, 2048 airlines, 4096 flight numbers and combination of existing flight route details up to 10240 in all three languages (Local, Hindi, and English) in male and female voices. The system shall allow updating of pre-recorded library and new voice file shall be added to the library.
This system shall translate flight information’s into an audio file to be scheduled for announcement over Existing PA systems at the airport.

The system shall be interfaced with the existing Public Address system. Audio output from this system shall be made available as input for the PA system.

The System shall be built around proven technology such as IVR technology.

The system shall build words and sentences from an in built Voice Library as per match with the database.

The system shall allow for creating new announcements and updating of Voice Library of pre-recorded announcements.

Multilingual announcement shall be possible i.e. Hindi, English and one of the Indian Language as per the requirement of the airport.

The system shall provide for the following predefined announcements but not limited to:

- Arrival, Arrival Delay, Arrival Cancellation
- Departure, Departure Delay, Departure Cancellation.
- Check In Call
- Boarding Call, Final Call
- Baggage in hall
- General announcements.

Operator shall have control over the following parameters but not limited to:

- Voice generation Technology i.e. Text to speech engine or pre-recorded voice library.
- Accent, male/female voice in text to speech engine
- Time of announcement,
- Time between announcements,
- Frequency,
- Repetition rate of announcement
- Male/female voice in case of synthesized
- There shall be a provision of fixed announcements to be repeated at regular intervals.
### i) The System shall be able to select zones for announcement

### j) The system shall permit to perform flight announcement manually by the operator/user.

### k) Complete announcement script in all three languages (Local, Hindi, and English) shall be provided well in advance to AAI for approval, before recording.

#### 2.12 INTEGRATION WITH OTHER SYSTEMS

The system shall be capable of integrating with the other systems such as:

- **a)** Airport Operational Database (AODB)
- **b)** Departure Control System (DCS)
- **c)** Baggage Handling System (BHS)
- **d)** CUTE System

Integration with other technology/system involved in Airport operation shall be brought out by the supplier as per tender conditions.

#### 2.13 PUBLIC SUMMARY DISPLAYS

**a)** **CODE SHARE HANDLING**

- **i)** The carrier (master) shall be displayed in first line. The carrier is displayed in one row and all code shared are displayed in rotation (alternatively) in a second row in alphabetic order.

**b)** **FREE TEXT, PAGING**

- **i)** All public displays shall have a free text line for important information.

- **ii)** The free text line shall be displayed on demand (selectable by user) in the last row of the public display.

**c)** **DISPLAY CLUSTERING**

- **i)** If a display in a cluster of displays fails, the system shall detect the failure and migrate the data to the next display device. i.e. if the 2nd display in a cluster of 3 fails the more relevant information of the second display shall move to the 3rd display until the 2nd display is back to operation.

- **ii)** A carousel e.g. between different languages and flight information pages shall be synchronized

- **iii)** The cluster shall always display the same type of information.

The flight which was previously displayed in the last row shall be displayed in the first row of the following display in a cluster of displays

#### A. ARRIVAL SUMMARY
The display shall contain the following:

- Airline logo
- Scheduled time of arrival
- Estimated time of arrival
- Flight number
- Origin, via
- Remark *

### B. DEPARTURE SUMMARY WITH GATE INFORMATION

The display shall display the following information:

- Airline logo
- Scheduled time of departure
- Estimated time of departure
- Flight number
- Destination, via
- Gate number

### C. REMARKS FIELD SHALL DISPLAY FROM THE FOLLOWING

#### i) ARRIVAL FLIGHTS

- On-time
- Expected hh:mm
- Delayed hh:mm
- Landed hh:mm
- Arrived hh:mm
- Diverted

#### ii) DEPARTURE FLIGHTS
a) On-time;
b) Delayed hh:mm;
c) Departed hh:mm;
d) Cancelled;
e) Next Info hh:mm;
f) Gate Open;
g) Boarding;
h) Final Call;
i) Gate Closed;

D. LOCATION RELATED DISPLAYS (CHECK-IN COUNTER, BOARDING GATE, BELT)

a) The display shall show flight information only if the resource is active.
b) The operator shall be able to open the display on demand, if allocation time is exceeded due to delays. The operator shall be able to close the display at any time.
c) If a control device is used at location it shall be password protected. According to the allocation plan, only the current flight shall be displayed.
d) CHECK IN COUNTER DISPLAYS

i) The check-in counter display shall switch between common check-in, and dedicated check-in.

ii) In case the desk is allocated to more than one flight the display shall show information of all those flights allocated to the check in.

iii) The common check-in counter layout shall show airline or Ground Handler Logo, Class, and four free configurable Remarks.

iv) According to the allocation, the layout shall display the IATA Colour code.

v) The counter display shall show flight number and logo of the airline, as well as code share information, destination, Via, Passenger Class.

vi) Free text remark shall be made available as per the operator request.

e) BAGGAGE CLAIM AREA
i) The display will show up to 5 flights only if the flight is on blocks and allocated to the resource.

ii) Airline Logo, Airline, Code shares, Origin, Scheduled time of arrival, and First & Last Bag Time are to be displayed.

iii) The layout shall change automatically according to the number of flights to be displayed to achieve the maximum character size and legibility from distance.

iv) The flight shall disappear from the display after a configurable period of time or after the manual input “last bag” + ‘x’ minutes. The parameter ‘x’ shall be user configurable.

vi) **BAGGAGE SUMMARY WITH BELT INFORMATION:**

The display shall contain the following:

a) Belt number:

b) Airline logo

c) Origin, via

d) Flight Number

### 2.14 CLIENT SYSTEM

FIDS Application Software and its component for access control and configuration of FIDS database as per the requirements specified in the tender.

The client application shall have standard web browser based/HTML interface to the FIDS server.

Touch Screen Client Application shall have design to utilize the touchscreen interface for easy data entry by on-screen keypads.

Any additional software plug in/ module, if required for access, control, configuration and administration of the FIDS, shall be supplied for use at an airport site irrespective of number of client/terminals at that site.

### 3.0

The EPC Contractor along with OEM partner firm shall provide following types of training as detailed below:
The cost for the Maintenance/Service during DLP period of 24 months is covered under the scope of work and quoted rates shall be deemed to cover regular examination of the installations by the trained technician of the contractor including necessary adjustments, cleaning including replacement of parts etc. to keep the equipment in excellent operational state.

The contractor shall also provide 24 hour emergency repair service to attend the FIDS at any time of the day or night including Sundays and Holidays.

All Inclusive Comprehensive Maintenance Contract (AICMC) to be undertaken by the EPC Contractor for the next five years after completion of the guarantee / warranty & defect liability period of TWO year. Refer separate schedule of cost & billing.

The detailed terms and conditions of the all-inclusive Comprehensive Maintenance Contract for FIDS are appended under SCC for Operation & All inclusive comprehensive Maintenance contract. The quoted amount for AICMC will be taken into consideration for evaluation of the bids.

3.3 DOCUMENTATION

FOUR SETS HARD COPY ALONG WITH SOFT COPY IN PENDRIVE for Operations, Technical and Maintenance manual, etc. shall be supplied at Airport.

All manuals and documents shall be in English language and in such a way that a qualified engineer/technician is able to fully understand and do the preventive as well as breakdown maintenance with the help of these manuals.

The Technical and Maintenance manual will cover:
- General technical description and theory of operation
- Block diagram of complete system
- Servicing/Maintenance instructions including preventive maintenance schedule
- Fault analysis and repair
- Installation procedures for software, configuration recovery, reloading of software modules of application software.
Technical & operational manuals

Maintenance manuals

Maintenance and System Administrative procedures.

### 4. FIDS SERVER

To work as Main & Standby (Set of 2 Servers)

#### 4.1 TECHNICAL SPECIFICATIONS:

1. **CPU:** 64-bit high performance, 6/8 Core Intel/AMD CPU operating at 2 GHz or more with 12 MB Cache or more

2. **Memory:** 8 GB of DDR RAM or more/better expandable up to 32 GB

3. **Chassis:** Rack Mount type

4. **SAS 10K/SATA 7200 rpm hot-swappable Hard Disk in RAID 5 or better configuration having usable space of 320 GB or more.

5. **Hot Swappable redundant power supply.**

#### 4.2 TECHNICAL FEATURES:

1. **NIC** - Dual Integrated 10/100/1000 Mbps ports.

2. **DVD- RW Drive**

3. **USB Optical Mouse with scroll, Keyboard shared through KVM switch, USB 2.0 or higher Ports and other Ports as required**

4. **Other PCB/Modules/hardware as per system requirements.**

5. **OS:** UNIX/LINUX/Microsoft Windows Server licensed (Latest version).

6. **Licensed Antivirus with update subscription valid till warranty and AICMC period.**

### 5. AF AS & IVRS SERVER

#### 5.1 TECHNICAL SPECIFICATIONS:

1. **CPU:** Intel i7/AMD or better CPU operating at 2 GHz or more with 8MB Cache or more

2. **RAM:** 4GB or more

3. **7200 rpm Hard Disk having usable space of 500 GB or more**
iv. To be mounted in rack.

5.2 TECHNICAL FEATURES:

i. NIC – 2 Nos. of 10/100/1000 Mbps ports

ii. At least 2 x PCI express I/O slots, suitable slot for 3rd party cards as required.

iii. USB 2.0 or higher port: At least 4 USB ports (2 in the front).

iv. DVD RW Drive

v. OS: UNIX/LINUX/Microsoft Windows Licensed Operating System

vi. Licensed Antivirus client version valid for Warranty &AICMC Period.

vii. In addition to the above, the Server for AFAS shall be equipped with:

| PA Interface: | Professional Two Channel On-board Sound Card with Digital I/O for AFAS Application with Zone Selection facility for at least 8 Zones. |
| IVRS Interface: | Four port telephone card and one port GSM modem |

6. CLIENT TERMINAL

Client Terminals shall be used to access FIDS Application Software User Interface for viewing and updating the Flight Information Database.

6.1 TECHNICAL SPECIFICATIONS:

i. CPU: Intel i7/AMD or better CPU operating at 2.4 GHz or more with 8MB Cache or more

ii. RAM: 8GB or more

iii. Motherboard Chipset: OEM Motherboard

iv. SAS/SATA 7200 rpm Hard Disk having usable space of 500 GB or more

6.2 TECHNICAL FEATURES:

i. NIC – Gigabit Ethernet port

ii. At least 2 x PCI express I/O slots

iii. USB 2.0 or higher port: At least 4 USB ports (2 in the front).

iv. DVD RW Drive
| v.     | USB optical Mouse with scroll and Keyboard                      |
| vi.    | 21” LCD/LED or better monitor.                                   |
| vii.   | OS: UNIX/LINUX/Windows Licensed, latest version                  |
| viii.  | Licensed Antivirus valid for client version for Warranty & AICMC Period. |
| ix.    | **Standard Computer table made of combination of steel/MS material along with top shelf of standard material & size from reputed manufacturer such as Godrej/ Durion etc. as approved by Engineer in charge shall be supplied by the contractor with each Workstation/Client Terminal at equipment room** |

7. **DISPLAY DEVICES**

7.1 **GENERAL FEATURES:**

i. Devices shall be capable of displaying the information in Portrait and Landscape mode. This shall be user configurable.

ii. All the displays shall have IR Remote, controlling basic display functions such as Brightness, Contrast, Colour Control, etc.

iii. It shall be possible to put the display in standby mode (soft power off) from the remote (network: server/workstation) or shall have a remote control to switch the display on or off in a go.

iv. Display monitor shall be provided with cabinet suitable for industrial/professional 24x7 use with arrangement for Wall and Ceiling Mount installation with provision for Swivel movement.

v. Suitable wall/ceiling/pedestal mounting of Stainless Steel (SS) shall be provided for Display Monitors in single or clustered configuration, the design of SS mounting to be approved by Engineer in charge.

7.2 **FIDS LED DISPLAY BOARD**

**True Colour LED Display Board For Outdoor Installation**

7.2.1 **TECHNICAL SPECIFICATIONS:**
### Display Area:

For 3X2 m Board shall be 2.88×1.92m and

For 1.5 m X 1m Board shall be 1.44×0.96m.

Pixel:

### Pixel Pitch:

**For 3x2 m² Board:** 10mm and

**For 1.5X1 m² Board:** 5mm

For arrival & Departure both at-least one 3×2 LED board is mandatory.

### Pixel density:

For 10mm pixel pitch it shall be 10000 dot/m²

and

For 5mm pixel pitch it shall be 40000 dot/m².

### Pixel Configuration:

For 3X2 m² Board shall be 1R,1G,1B and

For 1.5X1 m² Board: SMD LED with 3 IN 1 (RGB)

### LED make:

Avago, Cree, Nischia, Osram

[RoHS compliant and Lead (Pb) Free]

### Brightness:

≥ 4000 cd/m²

### Contrast Ratio:

3000:1

### TECHNICAL FEATURES:

#### Optimal viewing distance:

10 – 50 MTRS.

#### Optimal Viewing Angle:

100° (H), 40° (V)

#### Grey Scale/Colours:

256/16 Million Colours
<table>
<thead>
<tr>
<th>iv.</th>
<th>Processing:</th>
<th>16 bit/color</th>
</tr>
</thead>
<tbody>
<tr>
<td>v.</td>
<td>Interface:</td>
<td>TCP/IP LAN RJ45</td>
</tr>
<tr>
<td>vi.</td>
<td>Weather Protection:</td>
<td>IP65 (Front)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>IP54 (Rear)</td>
</tr>
<tr>
<td>vii.</td>
<td>Ambient Light Sensor</td>
<td></td>
</tr>
<tr>
<td>viii.</td>
<td>Max. Power Consumption:</td>
<td>( \leq 1000\text{W/m}^2 )</td>
</tr>
<tr>
<td>ix.</td>
<td><strong>Construction material:</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Stainless Steel Cabinet SS grade 304</td>
<td></td>
</tr>
</tbody>
</table>

### 7.3 FIDS LED DISPLAY MONITORS

i. **Technical Features:**

ii. Each Display monitor shall consist of:

iii. Professional Grade LED Monitor

iv. Suitable for 24x7 operation

v. Inbuilt Pluggable Intelligent Controller within OEM cabinet of Monitor.

No external/attached controller will be accepted.

#### 7.3.1 FIDS LED DISPLAY MONITORS: 40/42/55"

i. **TECHNICAL SPECIFICATIONS:**

ii. Back Light: LED

iii. Aspect Ratio: 16:9

iv. Resolution: Full HD or better.

v. Brightness:

   - **For 55":** 700 cd/m\(^2\) or better
   - **For 40/42/43":** 450 cd/m\(^2\) or better
vi. Contrast (Native) Ratio: 2400:1 without IPS; 1100:1 along with IPS

vii. Viewing angle: (Horizontal/vertical): 176° or more

7.3.2 TECHNICAL FEATURES:

i. Ambient Light Sensor

ii. Video Input Ports:

iii. Digital Ports: HDMI or DVI-D; USB

iv. Front Glass with Anti-Glare and Hard coating

v. Display Monitor for outdoor side installation no external cabinet to be installed over composite monitor. It shall be OEM Cabinet and inherent part of Monitor & protect from dust, sunlight, etc.

vi. Displays shall be CE, FCC certified, UL Listed.

The approx. Qty of 55” display monitor is 34 & 42” display monitor is 49.

7.4 INTELLIGENT CONTROLLER (for 40/42/55” Displays)

7.4.1 TECHNICAL SPECIFICATIONS:

i. Processor: Intel/AMD 1.5 GHz or better, FSB 400 MHz

ii. RAM: 2 GB or more

iii. Flash Hard Disk: 32 GB or more

iv. Keyboard and mouse connectivity

v. LAN/Network: Integrated 10/100/1000 Base T NIC with RJ 45 connector

vi. Wi-Fi connectivity supporting 802.11 a/b g/n

7.4.2 TECHNICAL FEATURES:

i. USB 3.0/2.0 Port: 2 Nos.

ii. Graphic Card shall be having specifications to meet the requirement of supporting Display/Monitor.

iii. Software: Windows or Linux base Embedded Operating system and associated software as required.

OPERATIONAL MAINTENANCE DURING WARRANTY PERIOD AND COMPREHENSIVE ANNUAL MAINTENANCE CONTRACT: Details in Annexure – 1
The cost for the Maintenance/Service during DLP period of 24 months is covered under the scope of work and quoted rates shall be deemed to cover regular examination of the installations by the trained technician of the contractor including necessary adjustments, cleaning including replacement of parts etc. to keep the equipment in excellent operational state.

The contractor shall also provide 24 hour emergency repair service to attend the FIDS at any time of the day or night including Sundays and Holidays.

All Inclusive Comprehensive Maintenance Contract (AICMC) to be undertaken by the EPC Contractor.

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### 8 NETWORK TIME PROTOCOL (NTP) SERVER

#### 8.1 TECHNICAL SPECIFICATIONS:

1. GPS/GLONASS satellite supported L1/L2/L5 Frequency band, Rack Mount Type, NTP SERVER to maintain and display IP based NTP time across the network containing L2/L3 switches shall be supplied by the EPC Contractor. NTP server shall act as a master clock with accuracy better than 50 ms in the network to which other clients shall interconnect over the network using NTP client software on Windows or Linux OS and synchronize periodically. It shall provide diagnostic and status ports/ indications for automatic/ manual intervention.

2. The GPS NTP Server shall be equipped with two independent network interfaces (10/100/1000 Mbps Ports).

#### TECHNICAL FEATURES:

3. NTP Server shall support all the required networking protocols.

4. SNMP v3 support for status and configuration and SNMP Trap messages.

5. The GPS NTP Server shall be supplied and configured by EPC Contractor, with a GPS Antenna/Converter Unit and standard RG58 coaxial cable, as per site requirement.
Contractor for the next five years after completion of the guarantee / warranty & defect liability period of TWO year. Refer separate schedule of cost & billing.

- The detailed terms and conditions of the all-inclusive Comprehensive Maintenance Contract for FIDS are appended under SCC for Operation & All inclusive comprehensive Maintenance contract. The quoted amount for AICMC will be taken into consideration for evaluation of the bids.

**TECHNICAL SPECIFICATIONS OF IP EPABX SYSTEMS**

**A. BRIEF OF CONCEPT DESIGN**

1. **IP EPABX SYSTEM:**
   Fully redundant IP EPABX with hot standby configuration shall be considered.

1.1 **System Architecture**
   The telephony system should be designed with IP at the core Server & Gateway type communications system, allowing fully distributed IP solutions across data networks. The system will be call servers based and it should support traditional TDM or mixed IP-TDM or full 100% IP configurations, telephony, gateway, end points.

   All telephony applications, End points should be from same OEM & PRI card should not be installed in any PC / Server.

   Scalable solution to meet any futuristic requirements providing Voice connectivity via Fiber cable.

   Different type of IP phones are being considered based on functional requirement and usage.

**B. SCOPE OF WORK**

**IP EPABX System**

1. Supply of IP EPABX
2. Supply of Feature Phone with AAI Logo Printing
3. Supply of MDF Exchange Side with Line Protection Device
4. Termination of cable pairs on Interlinking, Field & Exchange side MDF.
5. SITC of Operator Console, Voice Mail, Call Billing Software with PC
6. Providing dedicated Earthing to the system as per Specifications.
7. Connection of IP phones to the LAN Network
8. Training
9. Documentation (Cabling route, MDF/SDF diagram)
10. Warrantee Support (two years)
11. Post Warranty AICMC Support (five years)
C. TECHNICAL SPECIFICATIONS: IP EPABX

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>A.</strong></td>
<td>Supply of IP Server based EPABX, non-blocking and open standard, with Redundancy, Hot Standby and Duplicate Servers (19&quot; Rack mountable) in load sharing architecture with 300 IP users in a standard 19&quot;/ 24U Rack as per technical specifications and equipped with the following:</td>
</tr>
<tr>
<td></td>
<td>a) 100 Nos. IP User Licences</td>
</tr>
<tr>
<td></td>
<td>b) 100 Nos. Analogue Extensions/ Ports</td>
</tr>
<tr>
<td></td>
<td>c) 2 Port E1 ISDN PRI (30 Channel)</td>
</tr>
<tr>
<td></td>
<td>d) 8 Nos. CO Trunk Lines</td>
</tr>
</tbody>
</table>

**Qualitative requirements of IP EPABX**

1. System Architecture: The proposed system should support following mandatory features as a basic technical requirement.

1.1. The Switching system of the EPABX should be designed with IP at the core allowing fully distributed IP solutions across data networks. It should support 100% IP or 100% TDM or a hybrid of IP/TDM technologies.

1.2. The system should support IP Communication Devices (wired and wireless) e.g. IP Phones (Hard and Soft phones), Mobile IP Phones, multimedia PCs, SIP phones, Video phones (Hard & soft), or H.323 terminal devices, etc.

1.3. The system should also support Legacy TDM communication devices (Digital and analog 2-Wire telephone instruments with or without Caller-Id (Both FSK and DTMF), Fax, modems, ISDN phones, etc.

1.4. The system should support Hybrid trunks, Analog CO, E&M circuits, Digital Trunks (PRI, BRI, CAS, E1 R2MFC and DPNSS), IP Trunks (H.323 & SIP).

1.5. The system should be Server and Media Gateway based, scalable, distributable and modular in architecture. The operating system shall be UNIX/LINUX based. The architecture should be capable of seamless migration to its maximum capacity by simply adding peripheral boards with media gateways on the set of control server/servers without compromising on any functions/features of this system or any degradation of service.

1.6. The Media Gateways should be module, 19" Rack mountable and should have two 10/100 mbps LAN interface with half/full duplex in auto negotiation.
| 1.7. | The system should support third party Open Standard phones like RFC3261 compliant SIP VoIP phone, SIP Video phone (Hard & Soft), and 2 wire Analog phones, etc. |
| 1.8. | The IP Phone (H.323) and SIP Phone should be directly registered with Call Server, not any other IP card in the media gateway. If IP and SIP phones registered with an external server, then the server should be in geographical redundant (placed at two different location in LAN network) mode. |
| 1.9. | The proposed system should support direct SIP integration with Microsoft Lync 2013 including following. EPC Contractor should provide proper document towards certification with Microsoft Lync 2013 integration. |
| 1.9.1. | TCP or TLS/SRTP (encryption) |
| 1.9.2. | Including Load Balancing |
| 1.9.3. | Including Media Bypass |
| 1.10. | The system should manage CAC (Call Admission Control) mechanisms to optimize the usage of the bandwidth in the WAN for multi-site configurations. |
| 1.11. | The Call Servers in the system should able to handle traffic minimum 200K Busy-Hour Call Attempts (BHCA) or 20K Busy-Hour Call Capacity (BHCC) per server (BHCA is 10 time of BHCC) & support up to 250 users (minimum 100 TDM and balance SIP) and 100 Trunks per single server. It should be possible to add or cascade multiple servers to expand the system up to 1K users in a single logical system. |
| 1.12. | It shall be possible to distribute the telephony servers across the IP network to improve the overall resilience of the solution for business continuity and disaster recovery purposes. |
| 1.13. | In multi-server scenario, the Call processing shall be distributed amongst the servers, i.e. no central control. |
| 1.14. | The voice and signalling frames should be marked [tagged] in order to be recognized. The standards of marking supported will be: |
| Level 2: | IEEE 802.1p/Q extension side and Level 3: TOS / DiffServ (RFC 2474) |
| 1.15. | The system should support for voice encoding the following standards: |
| 1.15.1. | G.711 with a-law and μ-law |
| 1.15.2. | G722 (extension side) |
| 1.15.3. | G.729A & G.729AB with voice activity detection |
1.16. **Call Switching** typically, internal calls (i.e., limited to a single location) should be based on the G.711 uncompressed PCM standard, but WAN calls outside the location should use the G.729A compression algorithm.

1.17. The system clock (UTC clock) shall be synchronized with the outside world using the Network Time Protocol (NTP).

1.18. The system should be suitable to accommodate both Decadic Pulse (DP) and DTMF telephones. The system should support outgoing DTMF transmission even from IP Digital Phones.

1.19. VoIP Support System should support VOIP solutions as an integral part of the system. The VOIP should not be implemented through plug in interface boards in any slot of the system. It should be integrated in the media gateway, not involve any external gateways, routers, etc.

1.19.1. The system should be fully compliant to VOIP standards like H.323 and SIP (Session Initiation Protocol). EPC Contractor to give clear compliance for the requested standards.

1.19.2. The system should be able to operate with any H323 compliant device and it should be able to support internal gatekeeper for the same. If required it should be able to inter operate with H323 standard based external gatekeepers.

1.19.3. The SIP proxy, SIP registrar should be inbuilt in the system and should support any SIP compliant hard phones or soft phones.

1.19.4. System should support the QOS features for the VOIP implementation. It should be compliant with both QOS standards (Layer 2 – 802.1 p/q) extension side and Layer 3- Diffserv (RFC 2474) / TOS.

2. **System Security**

2.1. The system should support the following security measures for VoIP signalling as well as the media streams:

2.1.1. **TLS (Transport Layer Security)** to protect VoIP signalling messages.

2.1.2. **Secure Real-time Transport Protocol (SRTP)** to protect media streams.

2.2. The Server should not host services like Telnet and FTP by default.

2.2.1. The system should not support direct root access. SSH should be supported for the remote access of the call servers.

2.2.2. In multiple server scenarios the inter-server communication should be secured by IPsec protocol.
2.3. The call Server must be provided adequate protection from possible virus, worm and Trojan infestation points such as internal e-mail servers.

2.4. The password and access control must include at least:

2.4.1. System should support password aging.

2.4.2. Depending upon the administration task, different profile should be created with password protection to handle different administration and maintenance tasks.

2.4.3. Internal OS controls for remote point of access restriction and service availability.

2.4.4. The System must support Security log services such as information about successful and unsuccessful login attempts for a minimum of SIXTY days history.

2.5. The communication between the Servers and Media Gateways should support secure protocol like TSL and the inter media gateway communication should support SRTP. The Media Gateway should not host services such as FTP, Telnet or local dynamic routing to prevent exploitation in Distributed Denial of Service attacks.

2.6. IP Phones should be programmed to deny direct or external initiated connections via HTTP, telnet, FTP, TFTP or any other protocol as means to prevent distributed Denial of Service attack exploitation.

2.7. IP Phones must support 802.1x (EAP-MD5 or better) for authentication and access control to the network, this mechanism must allow the user to be connected to the call server once he has passed the authentication process; not before.

2.8. The system should have the capability to, based on standard mechanisms (such as 802.1Q), assign automatically the corresponding voice VLAN number to the IP station clients during IP station initialization, allowing for the separation of voice and data traffic at IP station.

3. **System Management**

3.1. The system must include a dedicated management server/platform that will be based on the latest technologies, such as XML or JAVA/JEE and Operating System should be Linux based. If the management platform is Windows based, EPC Contractor should provide necessary antivirus software to avoid any virus, worm and Trojan infection.

3.2. The management platform must provide a single or multiple GUI (Graphical User Interface) web based client.
3.3. The Management platform must provide web access allowing the administrator to manage the system to use any PC with an internet browser connected to the same network.

3.4. The management platform should support online help with user guide, task help and individual field help to ease of use.

3.5. Security

3.5.1. Administration users connecting directly to the Call Server (console) shall support authenticated via a Secure HTTP/SSL access to the call server.

3.5.2. All management traffic between a remote console/session and the call server must be encrypted. (SSH for direct command line sessions, HTTPS (SSL) for web sessions, SFTP for file transfers, etc.).

4. Directory Module

4.1. The Directory module should manage the telephone directory. This should be LDAP compatible to be synchronized with other directory applications, must also allow web access and provide information on all desktops allowing click to call features to the users.

4.2. It should support Web Interface to Directory. The exchange directory should be available on web. The LDAP server and web server application should be integral to the exchange. This feature should available for all type of user’s extensions.

4.3. It should provide to display equipped voice terminals with access to system directory on digital and IP phones directly or through XML interface. Also System should provide internal and external directory. Any internal user can use by browsing the URL link from his laptop/PC to see the directory and dial the required no. by selecting under LDAP directory. The LDAP communication should be secured by communicating in a SSL tunnel.

4.4. This web based directory client should support presence management by clicking pre-defined out of office message also manage the routing of the incoming calls accordingly. It should also possible to set the out of office message and call routing from all type of phones (Analog, Digital, IP) by dialling predefined codes without browsing the web based directory client.

4.5. It should also possible to see the presence of other internal users by searching the web based directory.
<table>
<thead>
<tr>
<th></th>
<th>System Capacity:</th>
</tr>
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<tbody>
<tr>
<td>5.</td>
<td>The server based EPABX should be in redundant configuration (Main and Standby) and can support 250 users at present and be upgraded to 500 users without changing the server or adding any additional server.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>System Survivability</th>
</tr>
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<tbody>
<tr>
<td>6.</td>
<td>The system should offer maximum availability, with the switchover of call control processing functions to an alternate or redundant processor (or soft-switch control point) in the event of significant fault of the primary server/servers.</td>
</tr>
<tr>
<td>6.1.</td>
<td>Main and Standby Server should be kept in separate location of the same LAN network i.e. there should not be any limitation on distance between these two servers.</td>
</tr>
<tr>
<td>6.2.</td>
<td>All critical resource elements (call server, hard disks, data bases, IP interfaces, DSP resources, Processor, RAM, Hard disk, All the IO ports - Serial and Ethernet TCP/IP port of the servers must be redundant configuration.</td>
</tr>
<tr>
<td>6.3.</td>
<td>All the Servers and the Media Gateways in the system should has dual Ethernet interface which can be connected to two different LAN network or two different LAN switch with the same IP address (if two different LAN network is not available) in order to achieve Network Redundancy.</td>
</tr>
<tr>
<td>6.4.</td>
<td>The system must support Remote Location Units connected over IP with distributed call control.</td>
</tr>
<tr>
<td>6.5.</td>
<td>Replacement of cards without switching off exchange (Hot-swappable) including the control cards and peripheral/interface cards.</td>
</tr>
<tr>
<td>6.6.</td>
<td>All the tone generation and tone detection should be local to the gateway.</td>
</tr>
<tr>
<td>6.7.</td>
<td>System should support following call server option:</td>
</tr>
<tr>
<td>6.8.</td>
<td>Card based call server which should be accommodated inside a media gateway.</td>
</tr>
<tr>
<td>6.8.1.</td>
<td>1U standard 19&quot; Rack Mount server from the same OEM of the EPBX.</td>
</tr>
<tr>
<td>6.8.2.</td>
<td>Industry Standard 19&quot; Rack Mount server from reputed manufactured like HP, IBM &amp; DELL.</td>
</tr>
<tr>
<td>6.8.3.</td>
<td>High End Industry Standard 19&quot; Rack Mount server from reputed manufactured like HP, IBM &amp; DELL with VMware to support virtualisation of multiple call servers and application like voicemail, UMS &amp; UC in a single physical Machine.</td>
</tr>
</tbody>
</table>
6.9. The system should be able to restart automatically without human intervention when the external ac power supply is resumed after complete power failure i.e. Even after the batteries are discharged.

7. **Media Gateway**

7.1. The Media Gateway should support more than 250 users in single Media Gateway and can be upgraded to 15000 users by multiple Media Gateways.

7.2. Each media gateway of the remote unit should have minimum 200 VoIP (Hardware and Software) resources in order to achieve 100% non-blocking connectivity with main system from the day one. The resources should be increased if the number of users increases.

8. **Physical**

8.1. Should have appropriate to meet technical and scalability requirement

8.2. The exchange cabinet should have cooling fans integrated with rack/exchange cabinet.

9. **System Features**

9.1. Numbering scheme: The EPABX should be suitable for up to 10-digit extension numbering scheme. This numbering scheme should be flexible. System should also allow mixed numbering scheme.

9.2. The system should provide distinctive ringing for internal calls, junction calls, auto call back, etc.

9.3. The system should support the attribution of an external number DDI or individual line or a bundle head to a trunk, a bundle, an attendant, a group of attendants, a subscriber, and a group of subscribers or virtual equipment. The unanswered DDI communication can overflow, to Attendant or attendant group, Local subscriber, Network subscriber, Voice mailbox, automated attendant, abbreviated number, External number.

9.4. The proposed system should support automatic route selection (ARS) and least cost routing (LCR) features to route the calls based on priorities related to user profile, tariff, and network availability, along the most cost-effective path. This service will be transparent for users and irrespective of the physical carrier connection.
| 9.5. | Voice guidance should be offered as standard features with minimum 32 simultaneous announcements with minimum 200 different voice prompts. |
| 9.6. | DTMF and Busy Tone Resources Minimum - 50 DTMF receivers to be offered. Busy tone detectors for every circuit to be offered. |
| 9.7. | Basic Telephone Features |
| 9.7.1. | Abbreviated dialling |
| 9.7.2. | Automatic call-back on busy trunk/bundle/network link |
| 9.7.3. | Automatic DISA, user authentication |
| 9.7.4. | Call forwarding unconditional on busy/no reply to extension, hunting group, Voice mail, operator, paging, etc. |
| 9.7.5. | Immediate forwarding |
| 9.7.6. | Call pick-up |
| 9.7.7. | Call parking |
| 9.7.8. | Call waiting indication / voice prompts. |
| 9.7.9. | Calling line identification restriction for internal calls |
| 9.7.10. | Camp on busy telephone/hunting group/voice mail |
| 9.7.11. | Controlled private call by Pin code and password |
| 9.7.12. | Do not disturb |
| 9.7.13. | Dynamic call baring |
| 9.7.14. | General night service |
| 9.7.15. | Hunting group (fix head, cyclic, longest idle time) |
| 9.7.16. | Parallel ringing minimum in 3 answering position simultaneously. |
| 9.7.17. | Internal/external music on hold |
| 9.7.18. | Internal/external inquiry call |
| 9.7.19. | Individual hold |
| 9.7.20. | Instrument locking to prevent the outgoing |
| 9.7.21. | Last internal/external number redial |
| 9.7.22. | Personal code modification |
| 9.7.23. | Store and redial external number |
| 9.7.24. | Transfer in conversation on free/busy telephone |
| 9.7.25. | Boss Secretary Feature: |
| 9.7.26. | One touch key for Boss and Secretary |
| 9.7.27. | Call Screening through Secretary |
| 9.7.28. | Boss & Secretary busy indication Reminder |
| 9.7.29. | Simultaneous 8-Party ad-hoc conference calls in any combination (internal & external) and 12 different conferences should support simultaneously. It can be built in feature of the call manager or can be an external solution. |
| 9.7.30. | Voice prompts on/off per telephone |
| 9.7.31. | Voice message deposit on forwarded telephone |
| 9.7.32. | Mobile extension: It should be possible to register external mobile numbers (GSM/CDMA) as an extension of the call manager to enable all PBX features like Enquiry, Brokering, Call Park, Transfer, Conference, access to Voice mail, Call forwarding & Call diversion, etc. |
| 9.7.33. | Further it should be possible to use this extension to ring parallel with the office phone as one number answering position. |

**10. System Network Support**

| 10.1. | The system should support international telephone standards such as QSIG, DPNSS, DSS1, SS7, H.323, SIP for trunking |
| 10.2. | Following QSIG should be supported |
| 10.2.1. | Heterogeneous, open numbering plan |
| 10.2.2. | Calling/Connected Line Identification Presentation and Restriction. |
| 10.2.3. | Calling/Connected Name Identification Presentation and Restriction. |
| 10.2.4. | Call Forwarding Unconditional, Busy, No Reply, Call Transfer |
| 10.2.5. | Call Completion to Busy Subscriber, on No Reply, call Offer. |
10.2.6. The system should have options to network over any of ATM, IP, ISDN, Frame Relay technologies.

10.3. The system must support the following external telephony interface signalling:

10.3.1. E1 CCS PRI (VN3-4-6-7 / ETSI) DASS2
10.3.2. E1 CAS (R2, Q421, MFC Ericsson, Q23, Decadic)
10.3.3. T1 CCS generic
10.3.4. T1 CAS
10.3.5. T0 ISDN BRI (VN3-4-6-7 / ETSI)
10.3.6. E&M
10.3.7. Analog Loop Start and Ground Start.

Technical Specifications

1. The contractor shall provide Server Based IP-EPABX System that shall be non-blocking and open standard (based on SIP), with Active-Active Redundant Servers, in load sharing architecture, able to switchover to other server without disconnecting the call in case of failure of one server, with 64 IP users expandable to 500 users in a standard 19"/24U Rack. The system should equipped with the following:

   i. 250 Nos. IP User Licenses
   ii 64 Nos. Analogue Extensions/Ports.
   iii 2 Port E1 ISDN PRI (30 Channel)
   iv 8 Nos. CO Trunk Lines
   v. 16 Nos. IP Soft phone with video

2. The offered system should have a valid TEC approval. TEC approval certificate copies for ISDN connectivity should be enclosed along with the offer.

3. The equipment quoted by EPC Contractor must be SIP compliant.

4. The system should be Server based IP PBX supporting IP and Analog Extensions.

5. System should be redundant in Active-Active mode.

6. The system should support standards-based multi-site networking, H.323 trunks or advanced networking, to interoperate with other PABX's, allowing feature transparency.
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<td>7.</td>
<td>System should be able to provide centralized voicemail with the option of distributed centralized voicemail in case of connectivity failure.</td>
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<td>8.</td>
<td>The system should support BRI/PRI/E1/Analog Trunks.</td>
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<td>9.</td>
<td>The system should have in-built dual Ethernet ports of 10/100/1000 Mbps.</td>
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<td>10.</td>
<td>The system should support X.21/V.35 WAN Interface.</td>
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<td>11.</td>
<td>The system should support internal MOH (Music on Hold), which should be uploaded using the .wav file and should have an audio input port for external MOH connectivity.</td>
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<td>12.</td>
<td>The system should be 19&quot; rack mountable [the rack/racks shall be from preferred make list] and to occupy the entire servers, switches, etc. Rack should have suitable number of power points.</td>
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<td>13.</td>
<td>Besides the normal Telephony features, the system should support the following features:</td>
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<td>a. Call Coverage</td>
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<td>b. Call Forwarding</td>
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<td>c. Call Hold</td>
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<td>d. Call Intrude</td>
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<td>e. Ring Back When Free</td>
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<td>f. Suspend Call Waiting</td>
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<td>g. Distinctive and Personalized Ringing</td>
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<td>h. Toggle Calls</td>
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<td></td>
<td>i. Account Codes</td>
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<td>j. Authorization codes</td>
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<td>k. Bridged Appearance</td>
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<td>l. Group Paging</td>
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<td>m. Hot Desking</td>
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<td>n. Mobile Twinning</td>
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<td>o. Intrusion Warning Tone</td>
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<td>p. Alternate Route Selection</td>
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<td>q. Flexible numbering Schemes</td>
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<td>r.</td>
<td>Time of Day and Date Routing of Calls</td>
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<tr>
<td>s.</td>
<td>Call Recording</td>
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<td>t.</td>
<td>Maximum Call Length</td>
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<td>u.</td>
<td>PIN Restricted Calling</td>
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<td>v.</td>
<td>Time Profiles</td>
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<td>w.</td>
<td>Queue announcements</td>
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<td>x.</td>
<td>Call Detail Recording</td>
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<td>y.</td>
<td>SMDR (Station Messaging Detail Record)</td>
</tr>
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</table>

14. The system should support CLI based routing, CLI based restriction, and Private call restriction. CLI should be there on the Analog Trunks and Analog/IP extensions.

15. Data Communication Features should be as follows:
   a. System should have in built-in DHCP Server, which should be able to given IP Addresses to the endpoints.
   b. System should support built-in IPSEC based VPN connectivity
   c. System should have built-in LAN and WAN supports

16. Terminal Support: System should support the following type of terminals
   a. Analog Phones
   b. IP Hard phones
   c. Wireless IP Phones
   d. 3rd party SIP Phones RFC3261 compliant

17. Voicemail Features:- System should support PBX integrated, Server or PC based Voice mail system with following:
   a. Voice mail system storage should be dependent on the PC hard disk storage capacity
   b. Voicemail to email option should be available
   c. System should support unified messaging with Microsoft Exchange or any IMAP compliant email application.
   d. System should support voicemail access through web-browser
   e. External Fax server integration should be available.
   f. Voice mail should support Text-to-Speech functionality
   g. Voice mail should support Dial-by-Name functionality
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<tr>
<td>h. VM should support Auto Attendant</td>
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<tr>
<td>i. Should be able to integrate with IVR</td>
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<td><strong>18.</strong> Conferencing Features: System should support Conferencing Features with following</td>
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<tr>
<td>a. The system should have built-in “4 party meet-me” conferencing bank.</td>
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<td>b. Multiple such meet me conferences with variable number of users should be possible.</td>
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<td><strong>19.</strong> Call Recording:</td>
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</tr>
<tr>
<td>a. System should have in-built capability to automatically as well as manually record and store calls into any voicemail box or a central database, for later retrieval, sorting, searching through a web-based browser interface</td>
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<tr>
<td>b. Recordings should be able to be made on the basis of:</td>
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<tr>
<td>Account code</td>
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<tr>
<td>User ID</td>
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<tr>
<td>Hunt Group</td>
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<td>Caller ID</td>
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<tr>
<td>Incoming call route</td>
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<td>Time profiles</td>
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<td>c. System should support automatic deletion of oldest recordings, if needed</td>
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<td>d. System should provide archival of recordings by automatically writing them to a DVD+RW drive</td>
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<tr>
<td>e. System should support G.726 16kbps ADPCM or better standard for compressing and storing recordings, providing the best compromise between CPU loading and storage space</td>
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<tr>
<td><strong>20.</strong> Mobility Support:</td>
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<tr>
<td>System should support Mobile Twinning, enabling an extension and an internal/ external number to operate together as a single telephone. It should be possible to set external mobile devices as twinning targets, even if the primary extension is logged out/unplugged.</td>
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</tr>
<tr>
<td><strong>21.</strong> Wireless Support:</td>
<td></td>
</tr>
<tr>
<td>a. System should support wireless IP Phones which will work through the Access Points which are being used for Wireless Data Network supporting 802.11a/b/g protocol.</td>
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<tr>
<td>b. System should support wireless IP, wherein the system and the Base Station are connected over the IP Network.</td>
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<tr>
<td><strong>22.</strong> SMDR (Station Management Detail Recording)</td>
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<tr>
<td>a.</td>
<td>System should be able to store SMDR data.</td>
</tr>
<tr>
<td>b.</td>
<td>SMDR should be able to be sent over LAN to a specified IP address and port number.</td>
</tr>
<tr>
<td>23.</td>
<td>TECHNICAL SPECIFICATIONS FOR IP PBX SERVER</td>
</tr>
<tr>
<td>a.</td>
<td>The communication server should offer BHCC (Busy Hour Call Completion) of at-least 20000 per server to ensure superior traffic handling capacities.</td>
</tr>
<tr>
<td>b.</td>
<td>The offered system should be modular in design. The architecture of IP PBX should be capable of seamless migration to its maximum capacity by simply adding peripheral cards on the set of control server without compromising on any functions/features of this system or any degradation of service.</td>
</tr>
<tr>
<td>c.</td>
<td>The system should be able to provide hybrid endpoints i.e. both IP and TDM. They should provide support for 100% TDM endpoints.</td>
</tr>
<tr>
<td>24.</td>
<td>The proposed communication system should have a highly secured, encrypted IP supporting hybrid Trunks e.g. Analog CO, Digital Trunks (BRI and PRI), IP Trunks (H.323/SIP)</td>
</tr>
<tr>
<td>25.</td>
<td>The system should provide techniques of storage media like Compact Flash, HDD, DVD, etc. for higher reliability.</td>
</tr>
<tr>
<td>26.</td>
<td>DESIRED FEATURES &amp; FACILITIES OF IP PBX: The offered solution should provide the following features as a part of its telephony functions.</td>
</tr>
<tr>
<td>a.</td>
<td><strong>Station Call</strong> – User can dial any extension anywhere in central location and other distributed location by dialling simple extension number.</td>
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<tr>
<td>b.</td>
<td><strong>Support Pulse as well as Tone dialling</strong> from an extension.</td>
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<tr>
<td>c.</td>
<td><strong>Authorization Codes</strong> - 5-7 digit authorization code to make outgoing toll calls for ensuring no misuse of the system.</td>
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<tr>
<td>d.</td>
<td><strong>Automatic Call Back</strong> – User can register ACB feature to any extension of the offered system.</td>
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<tr>
<td>e.</td>
<td><strong>Call pickup</strong> within the group as well as outside the group</td>
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<tr>
<td>f.</td>
<td><strong>Alternate Routing</strong> – Automatically re-route calls which encounter a busy trunks on the initial route. Automatic digital translation is carried out by the system. Provides the possibility of reaching external destinations via different routes.</td>
</tr>
<tr>
<td>g.</td>
<td><strong>Call Detail Recording</strong> – Records detailed call information on all incoming and outgoing calls on specified trunk groups and stations, including those administered for intra-switch recordings, and send this information to any printer of time/duration as and when required. Necessary hardware and software if required to be quoted separately.</td>
</tr>
<tr>
<td>h.</td>
<td><strong>Malicious Call Tracking/Record</strong> – Records detailed call information on all incoming calls (trunks &amp; stations) on any station at any station at any point of time. This information can be stored in any file and can be sent to any printer or other CORs in the system.</td>
</tr>
<tr>
<td>i.</td>
<td><strong>Class of Restriction</strong> – Defines different call origination and termination privileges. There should be support for minimum up to 50 CORs in the system.</td>
</tr>
</tbody>
</table>
| j. | **Class of Service** – Defines whether or not voice terminal users may access the
following features and functions:
Automatic Call-back, Call Forwarding, Call Forward, Busy/Don’t Answer, Data Privacy, Extended Forwarding, Extended Call Forward Busy/Don’t Answer, Priority Calling, Restrict Call Forwarding Off-Net, Personal Station Access, Trunk-to-Trunk, Transfer Restriction Override, Off-Hook Alert & Console Permission.

<table>
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<tr>
<th>k. DID/DOD (Direct Inward/Outward Dialling) – The proposed system must support direct inward dialling for external parties to call in.</th>
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<tr>
<th>l. Direct Inward Station Access – This feature must be optionally available, allowing an outside caller to access switch features by dialling a special telephone number without attendant assistance, it should permit access to the server and long distance facilities from off-premise stations. For security, there should be the option of turning off this feature.</th>
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<tr>
<th>m. Day/Night Trunk Control – To reduce cost and improve system security it should be possible to restrict the access to certain trunks depending on time of day.</th>
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<tr>
<th>n. Distinctive Ringing – To provide audibly different ringing patterns between internal, external and special feature calls.</th>
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<tr>
<th>o. Flexible numbering plan – Support up-to 5-10 Digit for an extension number and allow phone number assigned to a station to a station to be changed through software.</th>
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<tr>
<th>p. Music on Hold – To provide music and/or a recorded through software.</th>
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<tr>
<th>q. System Traffic Reports - Traffic statistics should be provided on incoming and outgoing trunk groups, attendant consoles, station hunt groups, and individual’s stations. The information reported must include the number of calls and call duration. The EPC Contractors must describe the proposed system’s traffic reporting capabilities.</th>
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<tr>
<th>r. System Abbreviated Dialling - To have the ability to store a list of frequently called numbers that will be available on a system-wide basis to all users.</th>
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<tr>
<th>s. Uniform Numbering Plan - The system shall permit a uniform numbering plan (Closed Numbering Plan) system to be used to simply access to all extensions of the network. The system must be able to implement a uniform numbering plan based on 5 digit extension numbers for all sites.</th>
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<tr>
<th>t. CLI (Caller Line Identification) facility (CLIP/CLIR) - Calling Numbers (internal &amp; external) should be displayed on all Analog extensions (FSK support phone).</th>
</tr>
</thead>
</table>

27. **TRAFFIC MANAGEMENT:** The system should generate real time ‘Call Record Details’ for incoming and outgoing connections of each Trunk and extensions. The system should also generate Call Records Details of STD/ISD connection availed by each user. The CRD data generated by the system should be available till the data is retrieved.

28. **GROUNDING:** The system shall be configured to be grounded electrically to a common ground point to prevent interference to the system from external and internal sources and to protect equipment and personnel.
### 29. POWER SUPPLY:
All the equipment, accessories and sub-systems shall operate with normal power supply of 230V, ± 10%, 50Hz AC supply.

**NOTE:**

i. All hardware offered should carry advance replacement during warranty, i.e. in case of failure of any module/sub-assembly, the EPC Contractor shall arrange to dispatch serviceable module/sub-assembly to station immediately for restoration of the system and the unserviceable module/sub-assembly shall be returned to EPC Contractor subsequently.

ii. The EPC Contractor shall ensure updating of system software as released by respective OEM during the warrantee period. Necessary cost for subscription is deemed to be included in quoted cost.

iii. Any additional hardware or software components such as servers, operating systems, cables, connectors, and interface converters, etc. required for completion of successful installation of IP EPABX system shall be supplied by EPC Contractor within the quoted cost.

iv. Any additional works such as cabling/conduiting from MDF to PBX, etc. necessary for completion of installation and to keep the aesthetics of the site should be carried out within the quoted cost.

### 30. Low End 2-Port IP Phones with 2 way speaker phone as per specifications:

- IP Phones and PBX should be of the same OEM make.
- 3 inches x 1.5 inches Monochrome display
- 8 Fixed/programmable keys
- Should have Permanently-labelled feature buttons: *Speaker, Mute, Headset, Contacts, Home, History, Message, Phone, Volume*
- Two switched Ethernet (10/100/) ports integrated with the IP phone
- Should support both H.323 or SIP
- Full duplex speakerphone
- Reversible wedge stand for desktop or wall-mount use and dual-position flip stand
- Should support IEEE 802.3 af POE, and external AC power adapter option.
- Support RJ-9 interface for headsets.
### 31. SITC of Management platform inclusive of Management software as per specifications:

**Management utilities:**

a. System should be able to be configured and administered using a GUI based application

b. System should support SNMP based network management

c. In case SNMP management is not available, system should be capable of sending event notifications to up-to 3 email addresses, each with a different set of alarms

### 32. SITC of PC based IP Operator Console as per specifications:

Should be a PC based operator console to manage calls for the site. All incoming PSTN calls from the external PSTN network will land onto the operator console and the operator will connect the end user following various policies. The operator console system should provide flexibility of mobility to the operator and it should meet the following specifications.

- Should have OEM or similar make and sturdy Headset and microphone

The operator console should have the following features -

- Alternate spellings & keyword search
- Alternate contact details
- Call hold (with notes)
- Call park/call park recall
- Call recall with flexible timeout
- Call re-establish
- Call retrieve
- Call toggle (brokers call)
- Camp on/indication
- Conference
- Customizable views
- Emergency mode
- Extended directory search
- Group speed dial
- Intelligent call routing
- Queue indicators
- Remote set/remove diverts on IP phones
- Screened/unscreened transfer
- Time of day routing management

### 33. SITC of PC based 6-Ports Voice Mail with 24 hours recording as per specifications below:

- The solution should provide voice mail for 250 users.
- Should have at least two Gigabit Ethernet interface for easy connectivity to the network.
- Should support G.711 and G.729 codecs.
- Should support at least four different types of recorded greetings for users so that users can record specific greetings for out of office, extension busy situation, etc.
- The system should provide option to user for customizing notification options, personal greetings and change passwords.
- Should provide web based system administration console for administration.
- Should provide call holding queue to manage user activities
- Should have different class of services to control user access to various features
- Should provide Message waiting indication to compatible phones
- Alternatively, the above functionality may be integrated with the offered PBX Server.

### 34. SITC of Call Billing Software as per specifications:

1. System shall have call billing software. It shall allow dedicated billing system for various complexes as well as centralized billing system. System shall provide flexible reporting i.e. by extension, department, section wise, authorization code, account code, top money utilizes, called number wise reports, date wise reports, etc.
2. System shall allow out-dial number privacy in call billing by suppressing partial or full digits for printing in the billing report.
3. This suppression shall be done at the system level itself and not at front-end software level to avoid manipulations.
iv. It shall provide graphical user interface for analysis of all such reports. Call billing software should work in background mode.

v. The system should be able to give detailed information for all the BSNL/Trunk lines.

vi. The billing software should be Traffic observation & performance observation features.

vii. The call billing will show details of calls made from any locations, remote/central and over any type of lines including Tie lines, BSNL lines, etc.

viii. It should be possible to debar a subscriber from using the facility if he exceeds the specified number of calls or monetary limit. Voice guided prompt should accordingly inform the subscriber when he attempts to use this facility.

**Reports:**

i) Expensive Calls Analysis, Excess Duration Call Analysis, Peak Hour of Day, Peak Day of Week/Month, Undefined Extensions, Calls Beyond office hours, Incoming Call Analysis, Answered, Unanswered cards, Operator performance, and Group performance reports.

ii) Extension-wise and Trunk-wise Hourly Usage reports, City-wise Extension-wise reports, Call Exceptions by Users/Departments should be designed using a flexible report designer.

iii) Trunk-wise Report – to cross check BSNL Bill.

iv) Special Reports for Basic Service Providers including bill designer, monthly billing cycles, outstanding analysis and Payment Adjustment Reports.

v) User definable reports should be generated by using Report Wizard.

vi) It should Run concurrently in background with other software applications, i.e. no dedicated computer required.

**Graphs** - All reports can be viewed in graphs. Each graph should be seen as a 2D Pie, 2D Bar, 3D Pie or 3D Bar, etc. The graphs should be zoomed and rotated by 90 degrees.

35. **SITC of Main Distribution Frame (MDF): 100 pairs as per specifications**

a. A suitable Krone MDF and IDF mounted in sheet steel enclosure to be supplied along with the exchange to accommodate all the lines/extensions, etc. Protection fuses & positive isolation facility shall be provided in the MDF for all Analog subscriber lines & junction lines. One MDF shall be installed at New Terminal Building and other shall be installed at Old Building or as per decision of the local Engineer In-Charge.

b. MAIN DISTRIBUTION FRAME & ACCESSORIES: Required sets of MDF accessories of required capacities shall be supplied, installed and commissioned satisfactorily. The job includes the supply, Erection, Testing and Commissioning of connection modules of suitable capacity, fitted with Integrated Protection Module (IPM) on all Analog lines and Stainless Steel back-mount with acrylic
cover on these modules. The job also covers termination of all MDF cables from proposed system (EPABX Side + Field Side = Old Terminal Bldg. Side). The job also includes necessary civil and fabrication job required to complete the project in all respect.

36. **SITC of Desktop Computer with Laser Printer (A4 size, 22 ppm or more) and UPS (1 KVA)** Licensed Latest Microsoft Windows, MS Office Professional & Antivirus with Media PC/Server FOR SYSTEM ADMINISTRATION & SOFTWARE BASED OPERATOR CONSOLE:

Make: HP/Dell/IBM/Lenovo/Sun/Fujitsu

The PCs shall be configured at least with the following:

- Intel i7/4 core Processor, 3 GHz or higher
- 3 GB or higher RAM
- 500 GB HDD
- Licensed Microsoft Windows Professional Latest OS (Windows 7 or higher)
- Licensed MS Office 2013 with Media DVD
- Licensed Anti-Virus for with media CD and update subscription
- Network Ethernet card/ On-board NIC support
- OEM DVD writer, OEM Keyboard and OEM Mouse and mouse pad
- 19" OEM TFT Display Monitor
- Computer table to house CPU, UPS, Printer, Monitor, with Keyboard Tray
- Laser Printer A4 size, 22 ppm, **Make: HP/Canon/Wipro/Toshiba**

38. **UNINTERRUPTED POWER SUPPLY (UPS)**

5 KVA/6 KVA Rack/Floor Mounted On-Line UPS 1+1 (single Phase AC Input & single Phase AC Output) with input/output Isolation Transformer (There shall be nothing common between input & output connections/ leads) and Individual SMF Battery Bank to provide **30 minutes Battery back-up** for each UPS, RS 232 Serial Port or RJ45 with Software for Computer Interface and Redundant Configuration.
UPS operation shall be configured in such a way that the failure of any one UPS shall result in total load to be automatically transferred to another UPS of the cluster.

**Specifications of UPS:**

**General**

- UPS shall be free from workmanship defects, sharp edges, nicks, scratches, burs, etc. All fasteners shall be fixed properly. The Equipment shall be complete with all parts and all parts shall be functional.
- By-pass facility shall be provided for maintenance of UPS.
- UPS shall supply output power and charging current at the same time.
- Switching device shall be IGBT and the same shall be confirmed in the Technical Bid.
- Digital Signal Processors (DSP) shall be used for all monitoring and control electronics of UPS.
- Switching frequency shall be above 10 KHz and shall be declared in the offer.
- UPS shall be free from workmanship defects, sharp edges, nicks, scratches, burs, etc. All fasteners shall be fixed properly. The Equipment shall be complete with all parts and all parts shall be functional.

**Input:** 180 V - 250V, 50 ±3%Hz single phase AC

**Output:** 230V ±1% (with alternative setting for 220V ±1%), 50 ± 5%. Voltage regulation from no load to full load shall be within ± 1% in both the cases. UPS shall also have facility for operation in synchronous mode in which output frequency shall be same as that of mains frequency.

**Total harmonics distortion at output:** 3% maximum for UPS on resistive load, if total input harmonics are less than or equal to 10%.

**Efficiency (at rated output voltage and frequency):** Overall efficiency (minimum): 90%

**UPS power factor at rated load:** 0.8 lagging or better.

**Over load:** UPS shall withstand 20% overload for 5 minutes and 50% over load for 10 seconds.

**Protections:** Following protection shall be provided in UPS:

- Over-voltage, short circuit, and overload at UPS output terminal.
b. Under voltage at Battery terminal.

**Indicators and meters:**

a. Following indicators shall be provided:-

(i) Mains presence.

(ii) Battery charging and discharging

(iii) Output overload

(iv) Low battery voltage.

b. Digital meter shall be provided for monitoring the following parameters in UPS:

(i) Input AC voltage.

(ii) Output AC Voltage, current and frequency

(iii) Battery voltage and current.

**Battery bank:**

a. UPS shall be supplied with Sealed Maintenance Free (SMF) battery with Fire Retardant enclosure.

b. EPC Contractors shall declare Battery AH capacity, Battery Voltage, Number of Batteries of each rating, Make and Model of batteries offered with each item of UPS.

c. Batteries for UPS shall be of the following makes: EXIDE, PANASONIC, AMAR-RAJA, GLOBAL, ROCKET, BASE, RITAR

d. The UPS shall be complete with Trolley for Battery Bank and the firm shall also connect the batteries with UPS to commission the same.

e. Minimum VAH rating of battery bank for the duration of back up time shall be as detailed below:

UPS rating in KVA: 5 KVA/ 6 KVA; Min. 30 minutes back up on full load: 12V X 24 AH or higher batteries should be supplied.

39. **EARTHING: - EPABX System**

. **EARTHING**
The system shall be configured to be grounded electrically to a common ground point to prevent interference to the system from external and internal sources and to protect equipment and personnel.

**Earthing of the System:** The contractor firm shall provide the earthing to each system separately by making the earth-pit as follows:

**Supply and installation of the copper plate - 600x600x3mm**

**GI (galvanized) pipe of 40 mm diameter is to be used**

The earth-pit to be dug for a depth of 3.75 mts.

Copper plate is to be properly fastened with nuts and bolts to the copper wire of size 14SWG. This copper strip/copper wire is laid up to the main distribution board of the centre.

The copper strip without GI pipe or thick copper wire with GI pipe should be laid up to the Server Room.

19 mm GI pipe to be laid for watering purposes. This will have a funnel at the top of the earth pit chamber.

Minimum 70 Kg. of salt and approx. 100 Kg. of coal are to be filled in the pit, in layers, after the plate and the pipes are laid in the pit.

Measurement the earth resistance at the pit should be less than 2 Ohms.

**Standard Chemical Earthing may be provided instead of above-mentioned Conventional Earthing in case of the rocky soil at site and/or 2 ohms resistance is not achieved.**

Contractor shall ensure proper grounding/earthing of all system equipment, cabinets and AC power supply outlet.

## 40. TRAINING & DOCUMENTATION

The EPC Contractor along with OEM partner firm shall provide following types of training as detailed below:

### 40.1 OPERATION, MAINTENANCE AND SYSTEM ADMINISTRATION TRAINING

On the Job operation, maintenance and system administration training of persons nominated by AAI. The training shall be designed and structured covering following parameters:

Basics of EPABX System.
a. System setting up and Configuration of offered system from Scratch.

Installation procedures for system hardware & software, configuration recovery, reloading of software drivers/modules of operating system and application software.

b. Configuration, optimization and alignment of the system with the help of the documents and software supplied along with the equipment/system.

c. Breakdown maintenance of the system.

d. Fault isolation up to Module level using diagnostic tools and general purpose test equipment,

e. Preventive maintenance of the system.

f. Installation Procedures for system hardware & software, configuration recovery, reloading of software driver/modules of operating system and application software.

40.2 **DOCUMENTATION**

**FOUR SETS OF HARD COPY ALONG WITH SOFT COPY IN PENDRIVE/CD**

OPERATIONS, TECHNICAL AND MAINTENANCE MANUAL, etc. shall be submitted to AAI Engineer-in-Charge.

All manuals and documents shall be in English language and in such a way that a qualified engineer/technician is able to fully understand and do the preventive as well as breakdown maintenance with the help of these manuals.

The Technical and Maintenance manual will cover:

- General technical description and theory of operation
- Block diagram of complete system
- Servicing/Maintenance instructions including preventive maintenance schedule
- Fault analysis and repair
- Installation procedures for software, configuration recovery, reloading of software modules of application software.
- Technical & operational manuals
- Maintenance manuals
• The cost for the Maintenance/Service during DLP period of 24 months is covered under the scope of work and quoted rates shall be deemed to cover regular examination of the installations by the trained technician of the contractor including necessary adjustments, cleaning including replacement of parts etc. to keep the equipment in excellent operational state.

• The contractor shall also provide 24 hour emergency repair service to attend the EPBAX at any time of the day or night including Sundays and Holidays.

• All Inclusive Comprehensive Maintenance Contract (AICMC) to be undertaken by the EPC Contractor for the next five years after completion of the guarantee / warranty & defect liability period of TWO year.

• The detailed terms and conditions of the all-inclusive Comprehensive Maintenance Contract for EPBAX are appended under SCC for Operation & All inclusive comprehensive Maintenance contract. The quoted amount for AICMC will be taken into consideration for evaluation of the bids.
PAVA SYSTEMS

SPECIAL CONDITIONS

1. SITE ACCEPTANCE TEST (SAT) & COMMISSIONING

1.1. It shall be the responsibility of the EPC Contractor to submit the system test procedure for conducting the post-installation site acceptance testing. The procedure submitted by the EPC Contractor shall be drafted in line with the standard practices followed in the industry and shall be in accordance with the test procedures. The acceptance test procedure on approval by AAI shall become the document for acceptance of the equipment after installation at the site.

1.2. The draft copy of system test procedure shall be made available to AAI before THIRTY calendar days of the schedule site acceptance date.

1.3. The EPC Contractor shall supply, install, test and commission all hardware and software as per the requirement of the tender with the system. EPC Contractor shall supply Technical documents (hard and soft copy - one set each) at site. The system shall be commissioned after successful completion of – SAT approval, operational & maintenance training and all the works under the scope of the tender.

1.4. After commissioning of the PA system, agency shall arrange tests from independent qualified PA system consultant having minimum 15 years of experience (consultant for acoustics and electro-acoustic/government approved Lab such as NPL), All India Radio or equivalent having measuring equipment to perform on site measurements, the measuring equipment’s must confirm to calibration from accredited institutions for Real Time Analysis (RTA), speech intelligibility, uniformity of loudness, frequency response measurement and all other relevant tests as mentioned in the technical specification. In case of the variations between parameters given in technical specification and measured values being outside specified acceptable limits, AAI shall forfeit the special performance guarantee submitted by firm for PA system work. In the above case, the system installed shall remain to be property of AAI & shall not be returned to the form. Special performance BG is the penalty for improper & wrong designs claims affecting the airport operation performance & consequential Pax inconvenience.
Successful EPC Contractor shall submit a special performance guarantee in the form of irrevocable bank Guarantee amounting to Rs. ______________ (15% of the amount quoted for PA system package to be decide by AAI). Special performance guarantee shall be furnished within one month after the approval of technical submittal of PA package failing which interest @ 10% shall be levied. The special performance guarantee BG shall be valid till the successful handing over and commissioning of the PA system work to AAI. Format of special performance guarantee BG shall be as per format enclosed in tender performance guarantee.

2. PATENTS, LIABILITY & COMPLIANCE OF REGULATIONS

2.1. EPC Contractor shall protect and fully indemnify AAI from any claims for infringement of patents, copy right, trademark or the like.

2.2. EPC Contractor shall also protect and fully indemnify AAI from any claims from EPC Contractor’s workmen/employees, their heirs, dependents, representatives, etc. or from any other person(s) or bodies/companies, etc. for any act of commission or omission while executing the order.

2.3. EPC Contractor shall be responsible for compliance with all requirements under the laws and shall protect and indemnify AAI completely from any claims/penalties arising out of any infringements by EPC Contractor or its workmen/employees.

3. PUBLIC ADDRESS & VOICE ALARM SYSTEM (PAVA)

A centralized Public Address& Voice Alarm System will be used to broadcast General Announcements - both manually and automatically to all areas of the facility and, Flight and Passenger Voice Announcements, and Background Music to Public Address Zones. The specified system shall be continuously supervised, monitored and automatically adjust the announcement signals sound level(s) relevant to the facility ambient noise. The specified system shall be integrated with the facility Telephone system enabling programmed facility DTMF (Dual tone multi frequency)/VOIP telephone sto access and make emergency announcement through PAVA system. The system shall be network based and shall operate over standard Ethernet topology using common switch components for both audio and control signals. System field devices such as microphone stations, amplifier mainframes, Ambient noise collectors, logic I/O collectors and Monitor/Test collectors shall be Ethernet network based and
shall connect to a dedicated VLAN of the house network through local Telecommunication (TC) rooms.

3.1. **LIFE SAFETY CODES, STANDARDS & REGULATIONS**

The proposed PAVA system equipment shall be certified by Recognized test laboratories & comply with any of one in the following life safety & voice alarm codes & standards.

a. EN 54-16: Voice alarm control and indicating equipment.
b. EN 54-4: Power supply equipment.
c. EN 54-24: Components of voice alarm systems – Passive Loudspeakers.
d. IEC 60849:1998 Sound systems for emergency purposes.
e. BS 5839-8:2013, Code of Practice for the design, Installation, Commissioning and maintenance of voice Alarm Systems.
f. BS 6259: 1997, Code of practice for the design, planning, installation, testing and maintenance of sound systems.
g. DIN VDE 833 Part 4 requirements for voice alarm systems in case of fire, Evacuation.
h. IEC 60268 -16: 2011, Objective rating of speech intelligibility by speech transmission index.
i. ISO 7240-16:2007, Sound System Control& Indicating Equipment.
k. EN 54-17: 2005, Fire detection and fire alarm systems Short-circuit isolators.

n. PH120 as per clause 26.2 BS 5839-1 of Circuit Integrity PH120, LPCB, Fire Survival armored Cable.
o. IEC 60065:Audio, Video and Similar electronic apparatus – safety requirements.
p. Approval from the AHJ & associated Civil Defense/Fire Dept. as applicable in the geographical region of the project.

3.2. **ABBREVIATIONS**

3.2.1. AAS - Automated Announcement System
3.2.2. CAN - Airport Communication Network
3.2.3. AHJ - Authorities Holding Jurisdiction
3.2.4. AODB - Airport Operational Database
3.2.5. AVC Automatic Volume Control
3.2.6. BMS-Building Management System
3.2.7. BSI - British Standards Institute
3.2.8. CPU - Central Processing Unit
3.2.9. dB - Decibel
3.2.10. DSP - Digital Signal Processor
3.2.11. EN - European Norm
3.2.12. FACP - Fire Alarm Control Panel
3.2.13. IEC - International Electrotechnical Commission
3.2.14. IP - Internet Protocol
3.2.15. ICD - Interface Control Document
3.2.16. ISO - International Standardization Organization
3.2.17. LAN - Local Area Network
3.2.18. MTBF - Mean time between Failure
3.2.19. MTTR - Mean time to Repair
3.2.20. NFPA - National Fire Protection Association
3.2.21. NTP - Network Time protocol
3.2.22. PAVA - Public Address & Voice Alarm System
3.2.23. SPL - Sound Pressure Level
3.2.24. STI - Speech Transmission Index
3.2.25. SNMP - Simple Network Management Protocol
3.2.27. TER - Telecommunication Equipment rooms
3.2.28. UPS - Uninterrupted Power Supply
3.2.29. V-LAN - Virtual Local Area Network
3.2.30. VE - Voice Evacuation
3.2.31. WAN - Wide Area Network
3.2.32. AA - Automatic Announcement
3.2.33. CA - Central Announcement
3.2.34. DGA - Digital Gate Announcement
3.2.35. DGAC - Digital Gate Announcement Client
3.2.36. QS - Queue Server
3.2.37. QC - Queue Client
3.2.38. ASS - Announcement Synthesis System
3.2.39. AST - Audio Streaming Server
3.2.40. URL - Uniform Resource Locator
3.2.41. GUI - Graphical User Interface
3.2.42. IATA - International Air Transport Association
3.2.43. PAX - Passengers

3.3. PERFORMANCE REQUIREMENTS

3.3.1. The system shall be based on distributed architecture with DSP control units processing digital audio with routing & switching features at the telecom equipment rooms. The DSP control units located in telecom equipment room shall have integrated synchronization for Audio & Control data via the LAN network.

3.3.2. There shall be no single point of failure as the system should have backup unit for amp and controller.

3.3.3. The DSP Control unit must have high MTBF parameters with a minimum of 250,000 hours of MTBF specified for continuous & uninterrupted operation.

3.3.4. Loudspeaker type & position shown on the drawing are indicative. The contractor shall be required to provide a 3D acoustic modelling & simulation in all the typical areas of the terminal building to determine the STI & SPL results expected for approval of Engineer In change (E.I.C) during the detailed design stages. Each Loudspeaker type, location & mounting height shall be coordinated with Architectural and Interior Design Consultants.

3.3.5. The Contractor shall be responsible to ensure that the proposed Loudspeaker type & location shall deliver the specified speech intelligibility index.

3.3.6. The PAVA sub contractor shall provide 3D Acoustic Modelling & Simulation for the typical areas of the AAI for the preemptive prediction of Speech Transmission Index. The sub-contractor may
utilize any one of the following software tools with latest available versions for the Acoustic Modelling & simulation works.

- Ease - AFMG, Germany
- Ulysses - IFB Soft, Germany
- Catt-Acoustic – CATT, Sweden
- Odeon - Bruel & Kjaer, Denmark
a. BRIEF OF CONCEPT DESIGN

1. PUBLIC ADDRESS SYSTEM (PAS)

1.1 Overview
The primary purpose of the PA system is to deliver clear intelligible speech to areas as designated in the drawings. The system shall be a state-of-the-art digital networked system and shall be scalable. The system shall interface with other systems at the airport such as FIDS, MTCS, AODB, Fire Alarm etc.

1.2 Audio Performance Criteria
Speech intelligibility is the key performance criteria for any public address system. Speech Intelligibility describes how much of the clearness and distinctiveness of spoken information is preserved when transmitted over a PA system. Speech Transmission Index (STI) is a measure of speech transmission quality. The absolute measurement of speech intelligibility is a complex science. The various factors that affect the STI are the speech levels, frequency response of the channel, non-linear distortions, background noise level, quality of the sound reproduction equipment, echo (reflections with delay > 100ms), the reverberation time, psychoacoustic effects (masking effects) etc.

STI is represented in a scale of 0 through 1 with 0 being the worst and 1 being the best. It is a non-linear representation. The scale can be realized as following.

<table>
<thead>
<tr>
<th>STI value</th>
<th>Quality according to IEC 60268-16</th>
<th>Intelligibility of syllables in %</th>
<th>Intelligibility of words in %</th>
<th>Intelligibility of sentences in %</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 – 0.3</td>
<td>bad</td>
<td>0 – 34</td>
<td>0 – 67</td>
<td>0 – 89</td>
</tr>
<tr>
<td>0.3 – 0.45</td>
<td>poor</td>
<td>34 – 48</td>
<td>67 – 78</td>
<td>89 – 92</td>
</tr>
<tr>
<td>0.45 – 0.6</td>
<td>fair</td>
<td>48 – 67</td>
<td>78 – 87</td>
<td>92 – 95</td>
</tr>
</tbody>
</table>
0.6 – 0.75  good  67 – 90  87 – 94  95 – 96  
0.75 – 1  excellent  90 – 96  94 – 96  96 – 100 

The system shall aim for uniform sound pressure level throughout the PA zones, the designers shall consider the SPL to be 10-15 dB above the ambient noise levels for clear intelligibility. However, the system shall also be limited to a maximum SPL.

1.3 Ambient Noise Analysis
In addition to be above mentioned audio performance criteria, the system shall have ambient noise analysis based automatic volume control. The system shall ensure that SPL is maintained within a defined range in key PA zones based on the noise levels. The Ambient noise sensors and controllers shall calibrate automatically and shall be by-passed in a case of emergency.

1.4 System Architecture
The PA system shall have a fault tolerant, redundant architecture with no single point of failure. The system shall have automatic fault monitoring a reporting system with end-to-end monitoring. The system shall have a server/controller based headend with network (LAN) based connectivity. The following shall comprise of the system key equipment. The system shall have multiple priority levels for each user.
1.4.1 **Network Controller**

The heart of the PA system shall be capable of routing audio channels, delivering power to the system, fault reporting and controlling of the system, playing pre-recorded messages and manage business rules. The unit shall be in an n+n hot standby configuration.

1.4.2 **Power Amplifiers**

The system shall use multichannel class-D amplifiers in a clustered fashion such that there’s n+1 hot standby. The amplifier shall have high efficiency and loudspeaker line monitoring with built in digital signal processing capabilities. The system shall be designed to not exceed 75% of its rated capacity.

1.4.3 **Paging Stations**

The system shall use various types of paging stations such as wall mount, desktop mount, keypad based and touch screen based etc. Paging stations in a PA system are the primary user interface for most users, thus it is necessary that the paging stations be easy to use, ergonomic with clear indications. The paging stations shall be freely configurable with expansion capabilities. The paging stations shall be connected via Ethernet.

1.4.4 **Loudspeakers**

The system shall have various loudspeaker types for individual areas, as per the requirement to achieve the best possible audio performance. The loudspeaker layout shall be uniform to achieve the SPL uniformity. All passive loudspeakers shall have multi-tap constant voltage transformers. The loudspeakers finish shall match that of the interior for better aesthetics. The system shall use horn speakers for car parking areas; cabinet loudspeakers for small rooms, corridors, VIP lounges etc.; ceiling loudspeakers for all areas with false ceiling less than 4m. The system shall use passive and/or active steerable line array column loudspeakers for acoustically challenging areas such as check-in hall, gate areas, baggage reclaim, arrival hall etc.

1.4.5 **Software & Management**

The PA system shall be a software driven system with business rules engines. There shall be operator workstations with manages access control. The system shall be accessible wither via a
provided application or through web-browser interface. The software shall be able to create new business rules or modify the existing ones, it shall be able to create/modify zone groups for paging stations. The software shall help define the priority levels, manage schedule of announcements etc.

1.1. SCOPE OF WORK

The contractor must employ a specialist voice alarm sub-contractor with adequate number of manufacturer certified engineers & technicians for the supply, installation, configuration, testing, commissioning & maintenance of an integrated high performance public address & voice alarm (PAVA ) system equipped with features for the broadcast of live announcements, prerecorded messages, emergency evacuation messages & automated flight announcements. The system shall be equipped to broadcast back ground music signals in certain areas of building as advised by the Engineer In change (E.I.C)/Airport Operation Manager. The system shall be designed & configured to deliver high performance digital audio with high speech intelligibility in all the areas of the Terminal Building.

The contractor scope of work is a turnkey solution with responsibility for fully provisioning for PA system including design, supply, installation, configuration and testing, commissioning, maintenance and defect liability for the following equipment:

a) PA Speakers
b) Acoustics Analysis from OEM/SI must provide the required details of their system.
c) TCP/IP PA Controller
d) TCP/IP Class D MultichannelAmplifiers with DSP with automatic single/multichannel channel backup switching
e) TCP/IP Digital Microphone Paging system
f) Server / Workstation based Automatic Flight Announcement
g) Ambient Noise Analysis System with digital signal processing technique including Noise Sensing Microphone
h) Background Music sources
i) Circuit Integrity PH120, LPCB, Fire Survival Cable
j) Public Address software integrate with Digital Automatic Announcement system
k) 42U, 19” Rack with Cable manager, required no. of Trays, Fan, Wheel, gland plate, cable glands, ferrule, thimble, lugs, cable tie, cable / equipment dressing material complete as required
l) Server/workstation as required
m) Public Address system should be so that it can integrate with Airport Common LAN network for distributed architecture
n) UPS power supply
o) Supply, Acoustic analysis, Installation, Integration, Testing, Commissioning, maintaining the system during DLP

1.2. INTERFACE OF PUBLIC ADDRESS SYSTEMS WITH FOLLOWING SYSTEMS/EQUIPMENT’S
   - VOIP/DTMF Telephone System
   - Automatic Announcement system
   - Flight Information Display System or Automatic Flight Announcement System
   - Fire Alarm System to ensure PA system sources (BGM and Flight Announcements) are muted in the event of an Emergency / Fire Alarm trigger and that emergency messages are played in affected/ all zones.

1.3. SYSTEM ARCHITECTURE
   The basis of design of this system is a networked distributed scheme intended to provide maximum flexibility and high performance. Different system architectures may be proposed if it can be proven to provide same or better features, performance, operational effect of equipment failure, flexibility for future expansion. Contactor shall include all costs for differences in hardware, cabling, and conduits caused by different system architectures.

1.4. TERMINAL BUILDING PA SYSTEM
1.4.1. The Terminal Building PA System for the announcements should be divided to multiple Zones.
1.4.2. The Terminal Building however should be divided initially in to Zones as given below but the system shall be scalable enough to accommodate additional zones by addition of amplifier’s in future. The terminal building drawing including indicating the areas for providing PA system and Car parking drawing, indicating the area where car calling system has to be provided.
a) Z1 Kerb - City Side - L1
b) Z2 Check In Hall L1
c) Z3A+Z3B Domestic Security - L1+L2
d) Z4A+Z4B Domestic Departure - L1+L2
e) Z5 International Security - L1
f) Z6A+Z6B International Departure - L1+L2
g) Z7 Swing Departure - L2
h) Z8 Domestic Arrival and BCA
i) Z9 Swing BCA - L1
j) Z10 International Arrival & BCA - L1
k) Z11A+Z11B Domestic & International Baggage Handling Area - L1
l) Z12+Z14 Airside Corridor & Aerobridge Fixed Links - L1+L2
m) Z13 Bus Boarding Gates - L1
n) Z15 Offices & Staff Areas

1.4.3. Please note that in the above Zones wherever the spaces have double or triple height and with width (throw distance for the loudspeaker) of the space is more than 20 meters and the ceiling height is more than 6m, the beam steering Digital Line Arrays with DSP technology with inbuilt/separate Class D amplifiers must be used with Network Connectivity RS-485 (Full Duplex)/RJ45, optically isolated, general status (DSP running, signal present etc.), amplifier monitoring and load monitoring schemes, external pilot tone detection (20kHz - 28kHz, level &ge; -22 dB), built-in ambient noise microphone, override through external ambient mic, frost protection, thermal overload protection. The 3D mapping of the proposed Digital Line Array by the EPC Contractor in the system integration should be possible, that is the software module file (.dll file) should be importable in the mapping software for the 3D mapping and computer simulation and 6-dBSPL head room calculation must be done while selecting the speakers and amplifier power.

1.4.4. In the above zones announcement could be made either individually or to all zones or a group of zones. Suitable marking should be provided in the announcement consoles for identifying the Zones. By selection, the user should be able to transmit announcement to particular Zone or zone groups in the terminal building.
1.4.5. The Terminal Building PA system should have system priority as under:
   a) Fire announcement / alarm: 1 No. with 1st priority
   b) Airport Manager’s office: 1 No. with 2nd priority
   c) PA System Control Room: 1 No. with 3rd priority
   d) Departure check-in area: 4th priority – only for local announcements
   e) SHA & Departure gates: 5th priority – only for local announcements
   f) Arrival Hall: 6th priority - only for local announcements
   g) Car parking area: 2 Nos. with equal 7th priority - only for local announcements

1.4.6. In addition to the above; the system shall be scalable for installation and upgradation of new zones and more announcing stations. The system should also have in-built provision of playing music & manual announcement and pre-recorded Announcements.

1.4.7. Priority should be user programmable.

1.4.8. The system should also be able to play different BGM (background music) in different zones. Normally music should be played through speaker network in all the selected Zones/areas. However, the system should automatically override music of the relevant zone for announcements to be heard. The announcements should not interrupt BGM (Back Ground Music) in other zones than the ones being paged.

1.4.9. The distribution network in the control room should receive the input signals from paging consoles/Stations and music input, and processes, then distribute it through speakers. Digital Signal Processing techniques should be used for equalization (RTA based) in the halls. Microphones meant for Noise sensing should be installed in various locations of the terminal to get noise level to regulate the volume in that area automatically and maintain signal to noise ratio about 10dB to 15dB while maintaining a minimum of 65dB and a maximum of 85dB SPL with + or - 3dB variation over 90% of each zone. The PA system shall allow modification of these parameters to set to desired levels as per site requirements. The system, in evacuation mode, should be able to override all settings and work in a pre-configured setting, including announcement level.

1.4.10. The PA system shall have the ability to accurately differentiate between ambient noise and actual program material to vary the attenuation only based on ambient noise. In event of failure of noise analysis system, shall reset the paging levels in affected zone to pre-set levels. OEM
must confirm on their Letter head / Data Sheets that proposed NSM (Noise sensing Microphone) are meant for the required purpose and not for Public Addressing purpose. For announcement purpose, microphones should be provided to ensure maximum isolation from the ambient noise so that the system delivers highly intelligible announcements and paging. In addition, the system should be capable to connect two or more NSM (Noise sensing Microphone) in one zone and should be monitor-able with the system logs.

1.4.11. AGC (Automatic gain Control) and AEC should be provided in all zones where NSM’s (Noise sensing Microphone) to be installed to maintain the sound level automatically in all the public announcement areas of the terminal of the terminal building. This should be programmable for day and night and should work automatically with Schedule or calendar logic once it programmed.

1.4.12. DSP/Controller shall have separate logic Processing and Logic objects, which should be freely programmable to make any kind of logic circuits using digital logic components (gate, truth tables, counters & comparator).

1.4.13. DSP shall have Speech sense feature to enhance the quality of announcement

1.4.14. The network control unit shall have extensive audio processing possibilities for audio inputs and audio outputs. 24 band parametric equalization, limiter, and gain can be adjusted with the configuration software.

1.4.15. System shall be capable to handle +5V unloaded logic output voltage up 6 connections to give visual LED indication for master paging operator for successful announcement notification

1.4.16. Sufficient number of loudspeakers should be provided to ensure essentially uniform distribution of sound meeting +/- 3dB uniformity in more than 90% all the Passenger/Visitor and staff areas as required. In offices, VIP Room, CIP room, restaurant etc., cabinet speakers with volume control should be used. For car call system, fully weather-proof Speaker speakers should be used. The type of speakers and locations of speakers, however, should be as per the performance requirements and simulation done and submitted by the EPC Contractors.

1.4.17. In the equipment room, all speakers’ cables should be terminated in the main junction box and should be clearly marked with cable ferrules.

1.5. DESIGN PARAMETERS AND FUNCTIONALITY REQUIREMENTS
1.5.1. The system should be capable of delivering distortion free audio output and Intelligibility meeting the target criterion of measured STIPA of minimum 0.6 or more in more than 90% of all the public area zones where the announcements are made.

1.5.2. The system should allow an undistorted speech reproduction of 75db (peak up to 85db) SPL at listening level. The system should also provide uniform coverage within +/-3dB across more than 90% the entire area of all public zones of the terminal for the octave band 125Hz to 8 KHz. However, the integrator shall tune the system and make use of equalizer, crossover and other available signal processing capabilities of system to optimize the system performance. The frequency response of the PA system DSP/Controller and amplifiers should be 20HZ to 20 KHz (+/- 3 dB)

1.5.3. All Data of the System Integration Criterion shall be verified by the AAI Engineer In-charge. The EPC Contractors should use calibrated Acoustical measuring equipment to satisfy the system integration criterion to the AAI Engineer In-charge as given in the tender document. The AAI Engineer In-charge would do the technical assessment of the system integration and all EPC Contractors should extend full cooperation to the AAI technical team. The system should be of programmable matrix type for sound system management and control having modular structure for future expansion and upgrade to increase the zones as may be required. Finishing schedule of terminal building is enclosed with “Annexure 6_Schedule_of_Finishes-A” to calculate the parameters in the 3D Simulation.

1.5.4. The offered system should support broadcasting and routing of the digital announcements by automatic announcement sub-system that is external to the PA system and should have necessary provision for input as well as processing the announcements. The system should have appropriate no’s potential free Analogue and Digital signal inputs for external audio feed.

1.5.5. The system architecture should be such that it allows for future expansion. The system should be modular for ease of maintenance.

1.5.6. The system should be programmable to provide for selection to allow a certain type of announcement to be routed to a specific zone in the terminal (such as fire, emergency etc.). The system should support minimum two announcement consoles in the control room/studio and also multiple remote announcement stations as may be required.
1.5.7. The system should have a provision for playing continuous soft background music round the clock in all public areas of the airport terminal with music level of 55-60 dB SPL max value should be maintained. For inviting attention of announcement a pleasing chime should precede every announcement. The tone of the chime should be programmable to be different for emergency announcements. The music should cut off during the announcements.

1.5.8. The PA system should support the broadcasting and routing of the alarm / speech generated by fire detection and alarm system (an independent system) with provision for connecting audio line for processing.

1.5.9. Reverberation time of each zone in the terminal should be considered and the Electro acoustical adjustments should be carried out to achieve the target criterion of measured STIPA 0.6 or more in 90% of each zone in all the public area where the announcements are made.

1.5.10. The system integration should take into consideration the height of the ceiling at various places critical distance and directivity factor of the loudspeaker system.

1.5.11. Utilization of the zones as per traffic and distribution of loudspeaker system respectively.

1.5.12. Capacity of amplifiers and the distribution network requirement with maintaining 6dB head room minimum.

1.5.13. Peak hour occupancy of the spaces in different areas.

1.5.14. Provision to avoid echo during announcement a suitable feedback suppressor/AEC and audio processor should be used in the system integration as may be required depending on the analogue or digital interface.

1.5.15. Amplifiers to give distortion-free announcements with minimum 6dB SPL headroom.

1.5.16. Provision of pink and white noise and test tone generator for testing the system should be provided to calibrate the system as may be required.

1.5.17. Monitoring facility through speaker for individual amplifier output should be provided in the PA Rack.

1.5.18. Facility for switching ON and OFF of the music from equipment rack to be given.

1.5.19. The control system should have total access matrix, completely programmable and expandable having several inputs and outputs, each input can be directed to one or more outputs according to the configuration and the priority levels defined.
1.5.20. The control system is to be of modular structure which can be assembled as per functions desired and subsequently expanded for future requirements.

1.5.21. The control system should be easily configurable and programmable through external PC.

1.5.22. The system should have facility for selective call for different zones with provision of avoiding priority conflicts.

1.5.23. Automatic pre-recorded announcement system shall be used for general announcement information in form of prerecorded messages in Hindi, English and local language. However, there should be provision for manual announcement. For the manual announcement professional microphones mounted on the announcement consoles should feed the distribution system controller. Each announcement console should be provided with zone selection button(s) that should be programmed to route the microphone inputs to one or several power amplifiers. These amplifiers in turn should feed the loudspeakers located in the geographical and / or functional zones with background music or announcements. However, the local announcement consoles installed in the terminal building should be programmed to automatically route the announcements originating from these local announcement consoles to the corresponding local area only.

1.5.24. All the boarding gates and car calling system shall have 4 button digital paging station, and AirporManager’s office and PA System Control Room shall have desktop type digital call station.

1.5.25. Controller and Audio Power amplifier shall be from same make/OEM.

1.6. TECHNICAL SPECIFICATIONS OF EQUIPMENT/ ITEMS

All materials and equipment shall conform to the relevant Standards and shall be of the approved make. Deviation, if any will be highlighted by the tendered at the time of submission of tenders.

1.6.1. TCP/IP DIGITAL SIGNAL PROCESSOR OR CONTROLLER (DSP)

1.6.1.1. The control unit is the heart of the public-address system & shall be capable of routing audio channels, fault reporting and controlling of the system. Unit shall be configured in 1+1 standby configuration with automatic changeover from Main controller to Standby controller in case of failure of Main controller. This unit can work either in stand-alone
mode or with a PC connected to it. The PC connected to the network controller unit shows all status changes in the system with the configuration and diagnostic & logging software.

1.6.1.2. The unit can be installed freestanding on a tabletop or mounted in a 19” rack.

1.6.1.3. There shall be control inputs, which should be freely programmable. These can be programmed for actions to be done in the system and assigned priorities.

1.6.1.4. The network controller shall have analog audio line Inputs for fire alarm signals, music sources etc.

1.6.1.5. The network controller shall have the capability to handle at least 20 levels of priorities and 50 zones or more, 20 call stations or more.

1.6.1.6. The network controller shall monitor the status of all Zones in the system and report status changes.

1.6.1.7. Attention and alarm tone definitions shall be stored in the network controller or recalled from an external storage device through control ports. These tones can be accessed by any call stations or control inputs for announcement broadcast or alarm broadcast.

1.6.1.8. The network control unit shall have extensive audio processing possibilities for audio inputs and audio outputs. Parametric equalization, limiter, and gain can be adjusted.

1.6.1.9. Technical Specifications:
   a) Frequency Response: 20 Hz to 20 KHz (+/- 3 dB)
   b) Distortion: <.05% @ Full Bandwidth (20Hz – 20kHz)
   c) Display: Front LCD/LED Display for Input/ Output/ Fault Monitoring/Programming
   d) Interface: Ethernet for PC connectivity, Systems connection for call station/Amplifier on Fiber/ CAT-6A/CAT 5
   e) The network controller/DSP shall have standby working controller for digital audio network unit also like CobraNet, Dante etc.
   f) DSP should have RS 232 port for integration with other System.

1.6.2. TCP/IP CLASS D MULTICHANNEL POWER AMPLIFIERS

1.6.2.1. The main function of the power amplifier is the amplification of audio signals for the loudspeakers. It shall be possible to select the output voltages of 70 or 100V. The power
amplifiers are provided with a LCD/LED display for fault monitoring and status display. The amplifier should be either single or multiple channel amplifier as per requirement of zone.

1.6.2.2. The Power amplifier should be capable for being monitored from the Central location in the Control room through Computer software.

1.6.2.3. The equipment shall be 19" rack mounting.

1.6.2.4. The amplifier monitoring and changeover facility shall be realized through the means of a dedicated switching unit or shall be incorporated within the power amplifier. In case of failure of any working amplifier, the standby amplifier shall automatically come in the circuit. Each amplifier cluster shell comprises of multichannel amplifiers + 1 backup amplifier channel/amplifier (8:1). The changeover from primary to backup and backup to primary amplifier shall be automatic without any human intervention.

1.6.2.5. Technical Specifications
   a) Frequency Response: 20 Hz to 20 kHz (+/- 3 dB)
   b) Amplifier Type: Class D
   c) Total Harmonic Distortion: <0.5% @ 20Hz to 20kHz
   d) Display: Front LCD/LED Display for status and Fault Display.
   e) Power Wattage (rms): >240W for each channel

1.6.3. AMPLIFIER RACK

1.6.3.1. All the control equipment and the power amplifiers shall be mounted in these standard 19” racks. The racks shall be located not less than 750 mm clear from the wall of the equipment room and shall have Cooling Fan, Mains panel On/OFF with required MCB and interconnectivity. If two or more racks are required, the racks shall be mounted side by side and bolted together.

1.6.3.2. All audio inputs and inter-connections shall be made with approved shielded cable and plug connections. Output connections may be screw terminal type. All power supply connections shall be provided with ISI approved plugs.
1.6.3.3. All inputs, outputs, inter-connections, test points shall be accessible at the rear of the equipment rack(s) for testing and maintenance. Each item of equipment shall be readily removable from the rack without disturbing other items and/or connections.

1.6.4. CONTROL WORKSTATION

1.6.4.1. The control workstation shall be used to control, program and Monitor the complete Digital Public address. Using the control software, it should be possible to program audio routing, amplifier level, music level, AVC, equalization, Call station microphone level, Chime tones, pre-recorded message, alarm inputs, define zone, priority level etc. It shall also be possible to view all systems operational and alarm/fault events log. The software should show log all announcement details with time, zone etc., amplifier failure, automatic amplifier standby status, amplifier overload/short-circuit/ground short, main failure, system restart, call station error/disconnection etc.

1.6.4.2. Control Software along with workstation of minimum configuration for complete administration:
   a) Intel Core i7 or better processor,
   b) 8GB RAM or higher,
   c) 500 GB HDD or higher, DVD RW,
   d) 19" LCD Monitor,
   e) Dual Network Interface Card-10/100/1000 MBPS
   f) Keyboard/Mouse,
   g) Sound card & Speakers
   h) Including all licenses of Windows, antivirus etc. valid Up to life time as required.

1.6.5. DESKTOP TYPE TCP/IP DIGITAL CALL STATION

1.6.5.1. The call station is used for making a manual or pre-recorded call to location or executing a predefined action. The call station shall have a gooseneck or handheld microphone to transmit speech over the network and a press-to-talk key.

1.6.5.2. Desktop Type Digital Call Station (CAT6A/better or fiber connectivity) with keypad or with touch-screen, configured for zone selection facility for local or zonal announcements along with high quality gooseneck or handheld type microphone.
1.6.5.3. The call station unit should be capable of extending the number of zones/facilities realized by addition of modules and/or through software programming.

1.6.5.4. The call station shall have 10 or more freely programmable buttons or a touch-screen and a dedicated press-to-talk key to make a manual or pre-recorded announcement to any pre-assigned zones or executing a predefined action.

1.6.5.5. The Paging station shall be powered locally or through Power-over Ethernet (PoE).

1.6.5.6. The Paging station shall have Cat6A/better or Optical connectivity for audio transmission, control and monitoring.

1.6.5.7. The call station shall be scalable and shall allow addition of keypad module/Buttons if required in future.

1.6.5.8. It should be possible to program different priority level for different announcement calls.

1.6.5.9. The call station keypad keys or the touchscreen user interface can be programmed for the following actions:
   a) Control system functions: live speech call, BGM off, BGM volume control.
   b) Select resources: BGM selection, pre-recorded message selection, attention and alarm tone selection.
   c) Zone selection, system control output selection.

1.6.5.10. The call station must show BUSY-indication as per priority announcements.

1.6.6. FLUSH MOUNT TYPE TCP/IP DIGITAL CALL STATION

1.6.6.1. The paging station (Network cable/Optical Connectivity) shall be installed on the wall/pole in the terminal boarding gates and Car calling location with 4 or more zone buttons.

1.6.6.2. The call station shall have a flush type or handheld microphone to transmit speech over the network and a press-total key. The paging station shall be used for car calling and should have equal priority. They should have clear/busy indication for indicating status. The call station shall be powered through Power-over-Ethernet (PoE)/Local Power as per manufacturer standard.

1.6.7. NOISE SENSING MICROPHONES

Noise sensing microphones should be installed in all passenger movement zones. These noise sensing microphones should have hemispherical polar pattern with a support
construction including mounting rod and/or junction box suitable for mounting on the ceiling/wall. The noise sensing microphones should sense the ambient noise level in the area in which they are installed. The average of this noise level, should be sampled continuously by the automatic gain control (AGC) circuit/algorithm for adjusting the output of its associated power amplifier in such a manner that the audio output from the corresponding power amplifier during the announcement is held at 10dB to 15dB above the ambient noise level in that area as may be required. These sensing microphones of each area should be connected through shielded microphones cables to the corresponding controller/DSP installed in control room equipment rack.

1.6.8. **MUSIC PLAYER**

1.6.8.1. All music transmitted from music Player will be routed through the Central Equipment rack to the zone /zones selected.

1.6.8.2. The music player shall support the latest MP3/MP4/WMA/AV1/WMV etc. format for playing music.

1.6.8.3. Music player shall be supplied with Minimum 500 GB Hard Disk with 2 USB port.

1.6.8.4. Music player shall have minimum configuration with 2 USB port and Sound card support the latest MP3/MP4/WMA/AV1/WMV etc. format for playing music.

1.6.9. **CEILING MOUNTED SPEAKERS (TYPE 3)**

1.6.9.1. The lower ceiling areas shall be supplied with Recessed Ceiling loudspeakers with a metal dome. The speaker is made up of metal housing, equipped with UL1480, UL2043 or (NFPA 90, /NFPA 70 /EN54) Rating. The ceiling loudspeakers shall be rated for 10 watts output power, with an integrated 100V line matching Transformer with multiple taps.

1.6.9.2. Power Handling: 20W peak

1.6.9.3. Rated Power: 10Watts or better

1.6.9.4. Power Tapping: 8/10W, 4/5W, 2/ 2.5W @ 100V/70V

1.6.9.5. Effective frequency range (-10 dB) : 90 Hz – 17 kHz

1.6.9.6. Driver Sensitivity: 84 dB

1.6.9.7. Opening Angle 2KHZ: 110 degree or better

1.6.9.8. Should have bare wire connection for easy installation
1.6.9.9. Speaker Driver: (5 in) or better

1.6.10. **15W HORN LOUDSPEAKER WITH IP 65 RATING (Type 4)**

1.6.10.1. Wall mount Horn loudspeaker with all mounting bracket supplied by same OEM of speakers. The loudspeakers shall be rated for 15W watts output power, with an integrated 100V line matching Transformer with multiple taps.

1.6.10.2. Should have Full-Range Driver 1.3" diameter

1.6.10.3. Rated Power: 15 Watts, Power Tapping: 15/7.5W @ 100V/70V

1.6.10.4. Effective frequency range(-10 dB) : 400 Hz – 5.5 kHz Voice Band

1.6.10.5. SPL at rated power : 125 Peak @ 1M

1.6.10.6. Opening Angle : 70° H x 80° V

1.6.10.7. Cabinet Material Rated : ABS

1.6.10.8. Outdoor Capability : IP-65

1.6.11. **120 W LINE ARRAY PASSIVE COLUMN LOUDSPEAKER -OUTDOOR RATED (Type 2)**

1.6.11.1. Wall mount passive line array loudspeaker with all mounting bracket supplied by same OEM of speakers. The loudspeakers shall be rated for 120W watts output power, with an integrated 100V line matching Transformer with multiple taps.

1.6.11.2. Should have Sixteen or more 2" or better Drivers

1.6.11.3. Rated Power: 120 Watts or better tapping at 100V

1.6.11.4. Effective frequency range(-10 dB) : 120 Hz – 16 kHz

1.6.11.5. SPL at rated power : 119 Peak

1.6.11.6. Opening Angle : 130 H x 14° V

1.6.11.7. Cabinet Material Rated : Fiberglass reinforced ABS cabinet

1.6.11.8. Outdoor Capability : IP-55

1.6.12. **DIGITAL LINE ARRAY SPEAKERS (TYPE 1)**

1.6.12.1. The Electronic Beam steering Active array Column Loudspeakers shall comply with the following specifications:

1.6.12.2. The Loudspeaker enclosure shall be made up of Aluminum design & the protection grille shall be ball impact. The Line Array speakers shall be suitable for dynamic speech and music
transmissions in rooms with demanding acoustics, long reverberation times and challenging architecture.

1.6.12.3. Connections shall be concealed with internal Phoenix/ Wago terminals within the loudspeaker enclosure.

1.6.12.4. The Active column speakers shall be equipped with 2.25” Medium Frequency (MF/LF) Loudspeaker Drivers and 1” horn loaded High Frequency (HF) tweeter.

1.6.12.5. The Active column speakers shall be suitable for dynamic speech and music transmissions in rooms with demanding acoustics, long reverberation times and challenging architecture.

1.6.12.6. The Line array column loudspeaker must report internal faults via RS485 /RJ45 port

1.6.12.7. The loudspeaker should compatible to work with pilot signal monitoring.

1.6.12.8. The Beam steering Column Loudspeaker shall comply with the following Electro-acoustical features

a) Acoustic design electronically steerable line array speaker
b) 10x 3” MF/LF Driver & 4 x 1” HF Tweeter
c) Max SPL (continuous) 89 dB
d) Max SPL (peak) 92 dB
e) Frequency range : 130 Hz -18 kHz
f) Dispersion (Horizontal) 130°
g) Dispersion (Vertical) Software defined
h) Amplifier Type: Class D
i) Amplifier Rated Power: 40W per channel
j) Sampling Rate: 48.8 kHz or better
k) Equalizer and Compensation Filtering

1.6.13. CABLES

1.6.13.1. Speaker Cable (In Conduit) C x 2.5 sq.mm fire survival cable (600/1000V) with class-2 Copper conductor having halogen free ceramified silicon insulation as per BS EN 50363 and low smoke zero halogen (LSZH) inner & outer sheath. Should comply to EN 61034-2 & EN 60754-1. LPCB-FPC certificate to be submitted. The cable should meet fire performance circuit integrity test as
per BS EN 50200:PH-120 & BS 6387 CWZ. Outer sheath should be in red colour with Anti-rodent & LSZH properties including end terminators.

**Speaker Cable (without Conduit)**
2 C x 2.5 sq.mm fire survival armored cable (600/1000V) with class-2 Copper conductor having halogen free ceramified silicon insulation as per BS EN 50363 and low smoke zero halogen (LSZH) inner & outer sheath. Should comply to EN 61034-2 & EN 60754-1. LPCB-FPC certificate to be submitted. The cable should meet fire performance circuit integrity test as per BS EN 50200:PH-120 & BS 6387 CWZ. Outer sheath should be in red colour with Anti-rodent & LSZH properties including end terminators.

**Microphone Cable (In Conduit)**
“Supply & commissioning of LPCB certified 3c x 1.5 sq.mm Fire Survival Circuit Integrity unarmoured screened cable of 300/500V rated, twisted with Class-2 annealed copper conductor having crosslinkable ceramified Silicon insulation as per BS EN 50363 along with ATC drain wire, aluminium tape screening and LSZH outer sheath. Should comply to EN 61034-2 & EN 60754-1. Should meet fire performance circuit integrity test as per BS EN 50200 & BS 6387 CWZ (950 Deg. C for 3 hrs). Outer sheath should be in red colour and have Anti-Rodent LSZH properties.
Make: AFW/INDIA-IMPEX/PRYSMIAN”

1.6.14. **UPS**

(a) Dedicated UPS for PA Equipment shall be considered. EPC Contractor shall size the UPS for the connected load plus additional 20% spare capacity.

(b) UPS shall be Floor Mounted On-Line type, 1+1 (Three Phase AC Input & single Phase AC Output) with input/output Isolation Transformer (There shall be nothing common between input & output connections/leads) and Individual SMF Battery Bank to provide 30 minutes Battery back-up for each UPS, RS 232 Serial Port or RJ45 with Software for BMS/Computer Interface and Redundant configuration.

(c) The UPS shall have the following specifications as a minimum:
i) By-pass facility shall be provided for maintenance of UPS. UPS shall supply output power and charging current at the same time.

ii) Digital Signal Processors (DSP) shall be used for all monitoring and control electronics of UPS.

iii) Total harmonics distortion at output: 3% maximum for UPS on resistive load, if total input harmonics are less than or equal to 10%.

iv) Efficiency (at rated output voltage and frequency): Overall efficiency (minimum): 90%

v) UPS power factor at rated load: better than 0.8 lagging or better.

vi) Over load: UPS shall withstand 20% overload for 1 minute and 50% over load for 30 seconds.

vii) Over voltage, short circuit, and overload at UPS output terminal.

viii) UPS shall be supplied with SMF VRLA battery only. EPC Contractors shall declare battery AH capacity, battery voltage, number of batteries of each rating, make and model of batteries offered with each item of UPS.

ix) The UPS shall be complete with Trolley for battery bank and the firm shall also connect the batteries with UPS;

(d) Power Distribution Panel (PDP) - The power distribution panels shall be provided to meet the system requirement along with UPS. The power distribution panel shall provide MCBs with proper ratings for all equipment including field equipment like Network Switches, Cameras, Workstations, and Displays etc. Sufficient numbers of Loops are required to be made to avoid high current passing in single loop – one MCB for each loop and one Mains Control Switch.

1.6.15. FREQUENCY RESPONSE OF THE SYSTEM
The PA system should be integrated so that it is capable to deliver all frequencies in the range of 20HZ to 20 KHz +/-3 dB in more than 90% area of each passenger zone. However, the
integrator shall tune the system and make use of equalizer, crossover and other available
signal processing capabilities of system to optimize the system performance.

1.6.16. TESTS TO BE CARRIED OUT BY THE EPC CONTRACTOR

The successful EPC Contractor shall carryout several tests to determine the quality and the
performance of the installed sound system. These tests should be carried out in all the
indoor passenger circulation zones of the building using professional measuring test
equipment. All the necessary test equipment required for measuring the various acoustic and
electroacoustic parameters should be arranged by the EPC Contractor and shall not be
provided by Airport Authority. A computerized test report showing the measured values for
the various acoustic parameters in all the zones should be submitted by the EPC Contractor,
failing which the work would not be treated as complete.

The EPC Contractor shall submit the measurement tool calibration certificate before the
testing to the AAI and measurement tool should comply the IEC/BS standards.

The different tests should be performed by the EPC Contractor to ascertain the audio quality,
intelligibility, function and performance of the system should be as under.

Sound Pressure Level (SPL) of all zones in different areas.

i) Intelligibility Tests of all zones in different areas.

ii) Reverberation Time of all zones in different areas.

iii) RTA of octave band 125Hz to 8 KHz at +/- 3 dB

iv) Any other relevant test as may be required by AAI for assessment of the PA system and its
   performance of all zones in different areas.

Note: All the tests should be measured in the presence of the AAI Engineer In-charge
and should be carried out to the satisfaction of AAI Engineer In-charge. If necessary AAI
team may ask some additional STIPA through STI &RTI measuring instrument, to carried out to
evaluate the performance of the audio system installation.
All the above measurements shall be verified by the Airport Authority of India by their own equipment or third party measurements shall be performed for verification of acoustical consultant from EPC Contractor side.

1.6.17. **GUIDELINE FOR REVERBERATION TIME MEASUREMENT: STI**

The EPC Contractors are required to measure the RT60 (reverberation time) of all the Zones and submit the following:

a) Name, Model Number, calibration certificate & accuracy of the equipment’s used to measure the RT60 should be submitted in tender.

b) Measurement report of the RT-60 measurement to be submitted to the Engineer in charge.

c) The Reverberation Time (RT-60) to be measured at the following frequencies.

   I. 125Hz -  
   II. 250Hz -  
   III. 500Hz -  
   IV. 1 KHz -  
   V. 2 KHz -  
   VI. 4 KHz -  
   VII. 8 KHz –

1.6.18. **GUIDELINE FOR STI MEASUREMENT:**

Measured data of the STIPA of all the Zones at 6 (Six) locations in each Zone to be submitted to AAI as and when the halls are ready.

a) STIPA at Listener location 1 –  
b) STIPA at Listener location 2 –  
c) STIPA at Listener location 3 –  
d) STIPA at Listener location 4 –  
e) STIPA at Listener location 5 –  
f) STIPA at Listener location 6 –
1.6.19. **GUIDELINE FOR RTA MEASUREMENT:**
Frequency Response curve at Six-listener zone to be measured & submitted.

1.6.20. **GUIDELINE FOR SPL MEASUREMENT:**
Total SPL shall me measured for all the passenger zone and submitted to AAI (Six location per Zone), SPL result should meet the System Design requirement.

2. **SUBMITTALS**

2.1.1. 3D mapping of the Zones as specified below shall be approved before starting the work to AAI/PMC. The name of the software used for this simulation should be clearly mentioned in the documents submitted by the EPC Contractor.

- Check In Hall L1
- Domestic Departure -L1
- International Departure -L1
- International Departure -L2
- Swing BCA - L1
- Domestic Baggage Handling Area -L1

2.1.2. EPC Contractor shall have to achieve following parameters in 3D simulations

- STI should be 0.6 or better in 90% of the area
- Direct SPL @ 1KHZ and 3150 HZ should be 85dB or better with +/- 3dB in 90% of the area
- Total SPL @ 1KHZ and 3150 HZ should be 85dB or better with +/- 3dB in 90% of the area
- SPL @ 250 to Broadband should be 85dB or better with +/- 3dB in 90% of the area
- 50dB Noise should be considered for the simulations

2.1.3. After successful completion of the computer simulation as per the parameter given below in this document, the EPC Contractor shall pack the project and submit the packed project file (in a CD) created on the simulation software. The EPC Contractor shall use commercially available software to do his 3D computer simulation. The packed project file should be importable in to the other commercially available software to evaluate and scrutinize by AAI/PMC.

2.1.4. Schedule of Finishes usually the Materials used in construction of Terminal Building are shall be provided by AAI/PMC.

2.1.5. Product data sheets
2.1.6. Layout plans with loudspeakers placement, NSM (Noise sensing Microphone) and paging stations location
2.1.7. Block Schematics with redundancy and zone details
2.1.8. Rack equipment’s layouts
2.1.9. Electrical load details with heat dissipation.
2.1.10 FIRE alarm interface document.

TECHNICAL SPECIFICATIONS OF FIRE ALARM SYSTEM

1. FIRE ALARM & DETECTION SYSTEM
   Fire Detection and Alarm System including Emergency Paging and Voice Alarm, Emergency Telephone and Smoke Control System

1.1 GENERAL
   Fire detection system shall be network fire detection system with distributed voice evacuation system. The network fire alarm system shall consist of all necessary hardware equipment and software programming to perform the following functions.

   Fire alarm and detection operation.

   Control and monitoring of Elevators, smoke control equipment, door hold open devices, fire suppression system, emergency call system etc.

   Two-way supervised firefighter’s phone operations.

   One-way supervised automatic voice alarm operations

   Network fire alarm control panel shall include all features for standalone FACP’s and shall have network communication capabilities.

   The material appliances equipment’s and devices shall be listed by EN54 as part of projected premises signaling system and smoke control system.

Fire Detection and Alarm System
   The fire detection and alarm system control panel shall monitor and display activation of each device in system, such as heat detector, smoke detector, manual pull unit, sprinkler water flow switch & sprinkler valve tamper switch or any other input device which may be required.
The system shall be of the addressable analog multiplexed type, completely supervised, such that a break in any wire(loop) shall not prevent any device from operating, with multiplexing cabinets installed in appropriate approved locations. The system shall be of the type such that each device connected to the system shall be provided with unique address and separately identified at the Main control panel(MCP).

**Equipment**

The Main control panel shall be located in the security room.

The location of the security room should preferably be in an area readily accessible from the outside, for easy access for fire rescue team. A remote repeater panel (RRP) in the form of video display unit(VDU) shall be installed in a location clearly visible to the operator and manned 24 hours per day. This remote unit shall repeat all alarm functions displayed at the main control panel. The silencing circuit shall be automatically reset when the fire alarm system is reset. The RCU will provide a summary indication of any alarm condition on the system.
Types of Detectors / Devices

Ceiling mounted photoelectric type smoke detectors shall be provided in all required areas.
Heat detectors shall be considered for areas such as electrical room, AHU room, panel rooms, plant room, pump room etc.
An optical/heat type sensor shall be installed in each lift lobby on each floor, activation of which will initiate the lift recall functions.
An optical beam smoke detector is a device that uses a projected beam of light to detect smoke across large areas, typically as an indicator of fire. They are used to detect fires in buildings where standard point smoke detectors would either be uneconomical or restricted for use by the height of the building.
Each fan system shall be provided with a duct-mounted smoke detector, which utilizes full width sensing probes and is suitable for the air velocities to which it is subjected. Duct mounted smoke detectors concealed from view shall be supplied with a remote indicator, located near the hidden detector, appropriately labeled the detector’s location.
Optical/heat sensor shall be provided above false ceiling where space between the false ceiling and the slab is 800mm and more as per IS code.
Break-glass stations (manual fire alarm stations) shall be located on the occupied side of the door to each exit stair and at intermediate locations as required (Maximum distance between pull stations shall not exceed 60m). Where available, double action break-glass stations shall be provided.
Voice alarm speakers shall be located throughout the building. All speakers shall have heavy gauge steel housing, a maximum power rating of 6 watts, and an input transformer with multiple taps and be capable of producing a sound level of 89dB at 3 meters.
Sprinkler water flow switch and valve tamper switch shall be provided at each sprinkler system valve location (the flow and tamper switches shall be furnished and mounted by the sprinkler system installer and wired by the fire detection alarm system installer).
Magnetic hold open devices shall be provided where required for the automatic release of smoke/fire doors.
Emergency telephone jacks will be provided in lift machine rooms, fire/sprinkler pumps rooms, and plant rooms, electrical switchboard rooms, standby generator rooms, escape stair lobbies, etc.
Emergency stair and exit doors shall be provided with magnetic door devices, if required for security reasons.

Emergency Public Address System for Emergency Evacuation and Voice Alarm

This system shall permit one-way communication in the form of emergency announcement from the main control panel to any floor or group of floors simultaneously. The system shall be capable of manual operation or automatic operation initiated by the
fire alarm system. Speakers shall be located as required to achieve acceptable audibility in all areas of the building.

Emergency Telephone

The emergency telephone system shall provide two way communications capability between the main control panel and jacks for emergency telephone. The emergency telephone shall be furnished as part of the overall system.

Co-Ordination with Other Systems

The fire detection and alarms system shall have interface with other building systems, which are described under other sections of the report, as follows:

Air-Conditioning (AC)

The quantity of duct type smoke detectors, their locations and the fan control sequences during alarm conditions shall be determined in conjunction with the air-conditioning system design.

Building Automation System (BAS)

The life safety system is required to initiate various fan control functions. These functions shall be wired directly from the Life Safety system to the motor controller so as to achieve the required fan and damper control. These functions shall be properly coordinated with the BAS to be certain that life safety system functions will override control initiated from the BAS control panel.

Sprinkler/ Pumps system

The life safety system is required to monitor fire hydrant/sprinkler pump status. The pump controller shall have the necessary volt free output signals available. Fire sprinkler pump installations have multiple valves in the immediate vicinity of the pump set. Isolation valves are also envisaged to be provided on sprinkler system (zone isolation) and wet riser of hydrant system. Each of these valves shall be provided with a tamper switch. The life safety system shall have provisions for wiring the correct number of tamper switches.

The tamper switches at anyone-pump location shall be arranged to appear as one trouble alarm at the MCP.
1. FIRE ALARM & DETECTION SYSTEM

1.1 GENERAL DESCRIPTION AND SCOPE OF WORK

1.1.1 This section covers the requirement of intelligent addressable fire alarm system for the proposed Imphal Airport as per the layout drawing enclosed, specification laid down below and as per description of item given under the schedule of quantities.

1.1.2 The work described in this specification consists of all labour, materials, equipment and services necessary and required to complete the Supply testing and commissioning of the fire detection and alarm system. Any material not specifically mentioned in this specification but required for proper performance and operation shall be provided and installed for a complete and operational system, by the contractor at no extra cost.

1.1.3 The contractor shall furnish, and install complete and ready for intended use and operation, an intelligent, addressable fire detection and alarm system including Fire alarm panel(s), initiating devices (manual pull stations, addressable photo & thermal detectors, beam detectors etc.) indicating devices (sounders, bells, visual warning signals, etc.) and supervisory devices, enunciators, wiring apparatus and accessories.

1.1.4 The installation and locations of equipment and devices in the building shall be governed by the code/publication with due regard to actual site conditions, manufacturers’ recommendations, ambient factors affecting the equipment and other operations in the vicinity. If any deviation from the specifications is necessary, approval shall be obtained from the Engineer-in-Charge before work is started thereon.

1.1.5 Materials and equipment shall be new, first grade, standard; current models of the manufacturer and shall be suitable for this system. Where two or more pieces of equipment performing the same function are required, they shall be exact duplicates produced by the same manufacturer.

1.1.6 All materials, devices, and equipment shall be compatible with the circuits or systems in which they are utilized.

1.1.7 Provision shall be made for maintaining Fire System Panel(s) through BMS. The panel shall be capable of inter-connected with BMS and shall have open code architecture.

1.1.8 In addition to SITC of Fire alarm system, the following work shall be deemed to be included within the scope of work to be executed by the EPC Contractor as this is being a turnkey job within his quoted cost.

i) It includes obtaining approvals from Chief Fire Officer and all other statutory authorities for complete scope of work as per relevant rules & regulations etc.
ii) The Fire Detection and Alarm System of the building shall be integrated with respective to the zoning of PA system so that, in case of fire, the PA system shall automatically come in announcement mode of that zone and play pre-recorded evacuation messages from PA system. For integration of the system if additional module(s) w.r.t. zoning are required shall be measured and paid separately.

iii) Suitable racks shall be provided for housing amplifiers, pre-amplifiers, CD player control equipments etc.

iv) AAI will provide Single phase AC Power supply in Fire Alarm Panel room and the contractor shall extend the power from these points for its panel etc. Therefore power supply to strobe cum hooter point shall be extended by the contractor from the nearest power point including cabling, protected flexible pipe/ casing capping to protect cable etc as approved by Engineer-In-Charge.

1.2 REQUIREMENTS

1.2.1 This installation shall be made in accordance with the specification, local codes and local fire authorities having jurisdiction over this project.

1.2.2 Fire Detection & Alarm System Installation work shall be carried out in accordance with Indian Standard Code of Practice for Electrical Wiring Installation IS: 732 - 1989, IS: 2274-1963 and IS 2189-2008 with up-to date amendment.

1.2.3 shall also be in conformity with the current Indian Electricity rules and regulations and requirements of the Local Fire Authority. Proposed Intelligent Addressable Fire Detection & Alarm system in general shall be carried out as per following CPWD Specifications with up-to date amendment.

1.2.4 Reference Standards

All equipment and installation shall be installed in compliance with the following codes and listing:

APPLICABLE CODES, STANDARDS AND APPLICABLE PUBLICATIONS

<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>IS : 2175</td>
<td>Heat Sensitive Detectors.</td>
</tr>
<tr>
<td>IS : 2189</td>
<td>Automatic Fire Detection and Alarm System.</td>
</tr>
<tr>
<td>IS : 11360</td>
<td>Smoke Detectors.</td>
</tr>
<tr>
<td>BS : 5445</td>
<td>Fire Detection and Alarm System.</td>
</tr>
</tbody>
</table>
Wherever these specifications calls for a higher standard of material and or workmanship than those required by any of the above mentions regulations and specification then the specification here under shall take precedence over the said regulations and standards.

1.2 Test at Site

i) All commissioning tests at site will be in line with EN.

ii) Following test shall be conducted:

- Loop Checking. All wiring shall be tested for continuity, shorts, and grounds before the system is activated. All test equipment, the installing contractor, shall make instruments, tools and labor required to conduct the tests available.

- Checking of multi criteria detectors, etc. by simulation/functional test by Aerosol Spray or as recommended by the manufacturer.

- Functional tests for fire alarm panel. The system including all its sequence of operations shall be demonstrated to the Owner, his representative, and the local fire inspector. In the event the system does not operate properly, the test shall be terminated. Corrections shall be made and the testing procedure shall be repeated until it is acceptable to the Owner, his representatives and the fire inspector.

At the final test and inspection, a factory-trained representative of the system manufacturer shall demonstrate that the system functions properly in accordance with these specifications. The representative shall provide technical supervision, and participate during all of the testing for the system.

- The Mock trial of the complete Fire Detection and Alarm system.

1.2.1 Tests at Manufacturer's Work

i) Tests certificates will be furnished for approval of all Fire alarm devices and system devices.

ii) All routine tests as per relevant codes for the Fire Alarm Panel, shall be conducted and results furnished to the Project Manager.

1.3 SHOP DRAWINGS

On the basis of GFC drawings issued by the department along with soft copy, the Contractor shall submit three (3) sets of Shop drawings contain the following within 30days of issue of GFC drawings for approval of Engineer –In – charge.
i) Block Diagram showing all detectors and devices area wise, their connectivity to the panel including wire description.

ii) Point-to-point wiring diagrams showing the points of connection and terminals used for all electrical field connections in each system, all equipment or systems which are supervised and controlled by the fire alarm system. Diagrams shall show all connections from field devices to the control panel initiating modules, output modules, switches, relays and terminals. Diagrams shall show interconnection of all devices, modules, output modules, switches, relays and terminals.

iii) The Contractor shall submit specific catalogue for each of the item specified in BOQ for approval from Engineer in charge before procurement.

1.4 POWER SUPPLY

a. The control panel shall drive from addressable 230 Volts from main power supply. In case of failure of main power supply, the panel shall be automatically switched over to standby power supply i.e. battery. The standby battery as secondary supply shall be such that when charged by associated battery charging equipment it can operate independently for a period of 24 hours for normal operation followed with 5 min. in alarm conditions. Batteries shall be of Lead Acid type sealed Maintenance free.

b. In addition to the batteries, a battery charger suitable for operation on the auxiliary power available in the plant as specified above. The capacity of the charger shall be such that the same can charge the battery (within 8 hrs) while supplying the rated load of the fire detection system. Facilities shall be provided to limit the voltage supplied to fire detection and alarm system to their rated values during the time of charging. The charger shall normally supply the battery trickle charging current and the DC load of the fire detection and alarm system. In case the AC supply on the input side of the charger fails the necessary power for the complete fire detection and alarm system shall be supplied by the battery.

c. Visible and audible annunciation for troubles or failure in the power supply system like "charger Failure", "Battery Low Voltage", etc. shall be provided.

d. Battery earth/fault indication/annunciation shall be included in the panel.

1.5 DESIGN REQUIREMENT

a. The system shall be provided with multiple loops and distributed as per GFC drawing issued by the department on award of work. All devices shall be connected directly to the loop with 2x1.5 sq. mm fire survival cable. The PA system shall be independent from the fire alarm system however system should be integrated with zoning of PA system. Each Floor shall have one or two loops depending upon number of detectors (sensors).
b. Addressable Multi-Criteria Detectors (smoke + rate of rise and with fix temp, both), Addressable Manual Pull Station, Fault Isolators, Control Modules, Monitor Module, Response Indicators, Hooters cum strobe etc.

c. The Panel shall have necessary Logic Software and Hardware built into it for time delay starting of strobe. Further, AHUs of each Floor shall be shut off only when any detector on that floor operates an alarm.

d. The PA system shall be integrated with existing Fire Detection and Alarm System of the building.

e. In case of fire, the PA system shall automatically come in announcement mode. It shall also be possible to play pre-recorded evacuation messages from PA system in case of fire.

f. Suitable racks shall be provided for housing control equipments etc.

1.6 SPECIFICATION

The design, supply and installation testing & commissioning of entire fire alarm system shall conform to BS: 5839. All devices including Main Fire Alarm Panel shall be EN listed.

1.6.1 ADDRESSABLE FIRE DETECTION & ALARM SYSTEM:

Fire detection and Alarm System shall consist of Fire Alarm Control Panels, various types of equipment’s like Detectors, hooters, Strobes, monitor & control modules, Repeater panel, and different types of cables located at various strategic locations of the building.

In case of a Fire alarm initiation by an alarm initiating device, the audio-visual fire alarm shall be generated at the respective Fire Alarm Control Panels and at Repeater panel located in the Control Room, various location and also initiate signal to operate hooters located in various locations.

All types of addressable detectors / interface units shall be compatible with the fire alarm panel.

All the alarm initiating devices that are asked for to be self addressable type shall be of self addressable type. In case of non addressable detectors the detector status shall be monitored through a Conventional Zone Interface Module (CZIM) to send the analogue information available from the detector to FACP. The EPC CONTRACTOR shall clearly indicate what are all the device / detectors which are not self addressable in type and shall include CZIM module to make that device / detector addressable. The CZIM module cost shall also be considered as included in the detector cost

The detector shall be suitable to connect to the control unit via a four wire circuit (Class –A wiring) as per NFPA.

The Fire Alarm System envisaged for this Building is “2-Wire Analog Addressable” type.
The communication between detectors and the FACP is by means of digital communication over 2-wire, which further provides power to the detectors, devices & Sounders. There shall be A/D and D/A conversion happening inside the detectors and FACP.

All the detectors shall be incorporated with microprocessors and shall be provided with Analog to Digital Converter (ADC), which enables the detector to provide linear output corresponding to the quantity of smoke or fire, the detector encounter.

All types of detectors offered will be of restorable type i.e. suitable for operating afresh after each actuation on alarm without replacement or adjustment.

The sensitivity of each sensor shall be individually adjusted from the FACP to suit the conditions of each location. Each detector shall have self-test facility, which is monitored in the FACP. Each detector shall have drift compensation.

The response sensitivity shall also be field adjustable and not only from fire panel over a wide range to suit site conditions. It shall be possible to test the sensitivity of a detector in the field. The sensitivity / threshold value of detectors which are cross zoned must be compatible.

The FACP shall also check each sensor for contamination of dust/dirt and give signal for “Service” in case of accumulation of dust/dirt reaches a preset limit.

The fire alarm system shall work without any problem both in networked mode and in standalone mode.

The electronic circuit shall be of solid state and of failsafe design and virtually hermetically sealed to have resistance to humidity and corrosion and to prevent its operation from being impaired by dust and dirt.

The circuit shall be protected against usual electrical transients, electromagnetic and electrostatic interference (EMI & RFI) present in the Building.

Reverse polarity or fault in the field wiring shall not damage the detector.

No moving parts subject to wear & tear shall be provided.

All types of detectors & devices offered shall have a inbuilt fault isolator. The fire detectors shall be plug in type. Suitable locking device shall be supplied along with each detector. It shall be inserted into or removed from the standard base by simple push twist mechanism to facilitate easy exchange / cleaning and maintenance.

The system shall have following self diagnostic features:
Detector cabling shall be completely supervised for open circuit and short circuit and exact location of fault shall be displayed in the panel under Trouble/Faults.

Unauthorized removal of a detector head from its base shall be supervised to give an alarm on the connected control panel.

Annunciation shall be provided for DC fuse blown and loss of main AC supply etc.

Alarm verification features.

1.6.2 **Analogue Addressable Fire Alarm Control Panel (FACP)**

The FACPs used in the Building shall confine to the EN54 standards having the following features:

- All the FACPs provided shall have the capacity to expand from 1 to 32 loops for future expansion.
- Each loop shall accommodate maximum 254 detectors and devices with a loop length capable up to 1.6 kms with 2C x 1.5 sq mm cable.
- It shall have facility to discriminate between a real fire alarm and a false alarms.
- FACP will function as fully stand-alone panel & also networked to other FACPs with peer to peer communication.
- Each FACP shall have a possibility of accommodating redundant controller to takeover in case of a Failure in the Primary Controller and also redundant loop card for each loop to takeover in case of a Failure in the Primary Loop Card.
- It shall have a provision for battery storage.
- In case of a Loop Card Failure, the FACP shall allow to replace the Loop card without switching off the panel and reprogramming.
- The FACP shall have facility such that alteration or access to the stored program shall be done through a pass-code, for protection against unauthorized personnel interference.
- The FACP shall be capable of PA Integration with the use of RS232 module or with the use of relays.
- FACP shall have provision to accept 230V single phase, 50 Hz supply.
- All the major components like processor, memory, etc., shall be available as spare in case of
emergency requirement.

- FACP shall have inbuilt buzzer to alert the personnel in case of maintenance requirement.
- FACP shall be programmed for sequence of events to happen in case of fire like closing of fire dampers, shutting down supply fans for HVAC, Deactivating the access control system and activating the hooters with the help of a control relay module provided near the system to be activated.
- The fire alarm control panel shall be suitable for Class-A type of wiring as per NFPA-72.
- The fire alarm control panel shall work on positive sequence as per NFPA – 72.
- The fire alarm control panel shall be capable of disabling an individual detector, a group and or zone of for building maintenance purposes. Facility shall be provided on the FACP for simulating the fire condition to enable testing of the various alarm circuits.
- The fire alarm control panel normal power supply failure shall be annunciated audio-visually.
- In case of multiple alarms the multiple alarm indication shall be ON. The multiple alarm indication shall be displayed in chronological order.
- FACP shall have the facility such that each detector can be identified as a separate zone.
- The FACP shall be reset only by authorized users after the clearance of a fault.
- Whenever there is a third party actuation to happen, like closing of fire dampers, switching off supply / exhaust units etc, the actuation shall happen only when the fire signal is received from two different initiating devices located in a zone connected to different fire alarm panels. The communication between the FACP shall happen with two pair cables and the fire alarm status of one panel shall be communicated to the second panel in which the control relay module of the third party device is connected to. Inter panel communication is a must and needs to be provided for controlled actuations. All the necessary systems to ensure reliable communications between panels are to be built into the FACP.
- FACP shall have the facility to silence / acknowledge / reset the alarm. Apart from the FACP, Repeater panel present in the control room shall have the facility to silence / acknowledge / reset the alarm of all FACP’s.
- The FACP shall have FALSE ALARM REDUCTION algorithms like: Alarm Verification, Dual Detector/Group Dependency, and Intermediate Alarm Storage to eliminate False alarms due to Dirt/Dust/Disturbance values.
When fire condition is confirmed, the following sequence of annunciation will take place on the FACP:

<table>
<thead>
<tr>
<th>Alarm Condition</th>
<th>Audible Alarm</th>
<th>Visual Alarm</th>
</tr>
</thead>
<tbody>
<tr>
<td>First Fire Condition</td>
<td>ON</td>
<td>ON FLASHING/Description of area of fire origin with detector type</td>
</tr>
<tr>
<td>Acknowledge (first Alarm)</td>
<td>OFF</td>
<td>ON STEADY</td>
</tr>
<tr>
<td>New Fire Alarm Condition (after acknowledge of first alarm)</td>
<td>ON</td>
<td>ON FLASHING</td>
</tr>
<tr>
<td>Acknowledge (New fire alarm)</td>
<td>OFF</td>
<td>ON STEADY</td>
</tr>
<tr>
<td>Back to normal</td>
<td>OFF</td>
<td>ON STEADY</td>
</tr>
<tr>
<td>Reset</td>
<td>OFF</td>
<td>OFF</td>
</tr>
<tr>
<td>Reset Before Normal</td>
<td>OFF</td>
<td>ON STEADY</td>
</tr>
</tbody>
</table>

1.6.3 Construction details
The housing containing the fire alarm control panel shall be of 2 mm thick steel construction finished in colour as per relevant standard.

It shall be capable of being surface, semi-flush or fully flush mounted with additional bezel. The fully flush bezels shall be painted to specification, stainless steel or brass as required.

The FACPs shall be provided with triplicated earthing terminals on the either side. The grounding terminal G1 shall be for safety grounding, G2 shall be for shield grounding and G3 shall be for signal grounding.

The panel shall be completely factory wired, absolutely ready-in all respects for installation at site and termination of all external cabling. The internal wiring of the panel shall be carried out with 650V grade, stranded copper wires of size rated for the current in the corresponding circuit. The minimum size of the wire shall not be less than 0.8 sq. mm for electronic circuits and 1.5 sq. mm for electrical circuits &16 SWG for grounding. All the wiring shall be done using
ferrules having indelible marking. Cable entry for the FACP from the bottom FACP shall mount in wall.

1.6.4 CPU
The FACP shall have a processor which shall be of at least 32 bit, which shall be designed to accept all the inputs and process the outputs within the time stipulated by the standards.

A redundant CPU shall be provided with the same configuration which shall be made as hot standby – in case of failure of the main CPU, the standby shall takeover without interrupting the system.

The CPU shall have the facility to communicate with other FACPs and process the fire signals received from other FACPs to actuate a third party device.

The capacity of the processor shall be adequately designed include all input / output signals and various functional requirements.

The processor shall be designed in such a way that the parameters in the repeater panels shall be refreshed in 1 sec.

It shall have its own, built in advanced microprocessor, sophisticated software and extensive memory for storing the logs of alarms, times and action taken report.

1.6.5 Loop Modules
The loop module shall have a microprocessor inbuilt & shall be capable of handling 254 detectors/devices; It shall have a line length up to 1600m or 3000m depending upon the configuration & cable type; It shall have an LED test button; The front fascia of the loop cards shall be visible for easy identification of faults.

In case of the failure of loop card, it should be replaced without the need of any additional programming.

1.6.6 Repeater Panels
It shall be a LCD display same as main panel. The MMI shall be the same as the main Controller.

Repeater panels shall be suitable for Wall mounting which will be displayed all the major entrances and stair cases which will enable the staff and fire fighting personnel to exactly locate the fire.

It shall be compatible to receive data from FACPs.
Audio visual Alarms during fire shall be generated in case of fire.

It shall connect to any of the Fire Panels in the Network using a 2 core – 1.5 sq.mm wire.

The Repeater Panel shall display Messages like Alarm & Fault similar to the Main Panel and shall be accessed only by Authorized Users through a passcode.

The Repeater Panel shall be connected to the Main Panel and other repeater panels in such a way – 1 pt Failure in the cable shall not affect the performance and shall intimate the exact location of failure in all Panels.

The Repeater Panel shall be equipped with a Key switch that allows Authorized users to Acknowledge/Reset Alarms.

The Repeater Panel shall be equipped with 2 different power inputs. On failure of primary power, the secondary shall take over.

The Repeater panel shall allow the users to login locally or login to the remote FACP.

The Repeater panel shall allow to create users with different access levels locally and shall also allow users of panels to login based on access levels.

The repeater panels shall integrate with the main panels without any additional interface or the EPC Contractor shall consider necessary accessories required to complete the system and quote as part of this model.

1.6.7 **Intelligent Addressable Dual Optical Smoke/Heat (Multi-sensor) Detector**

The Intelligent Addressable Multi-sensor Detector with 2 LED’s used in this Building shall confine to the relevant standards having the following features:

- It shall be combination of Smoke detection and heat detection. The smoke detection system shall work on Light scattering type principle using Infrared & Blue Led’s, and the Heat detection system shall be of Rate of rise of temperature and Fixed Temperature.
- The Intelligent Addressable Multi-sensor Detector shall be of Spot type and Addressable type.
- The Intelligent Addressable Multi-sensor Detector shall be addressed either by DIP switches or through Programming from the Panel.
- The Detector shall monitor EMC/EMI values in the surroundings on a continuous basis and
report the current & average values to the panel. The detector and the panel shall together avoid the possibility of false alarm caused due to interferences from sources such as Motors, power cables, Wi-Fi routers, fluorescent lamps, network switches, mobile signals...etc.

- All the detectors shall have a visible multi-color LED to indicate the healthiness / trouble / alarm condition of the detector. The LED shall be located in such a way that it shall be visible from all the 360 degree from below. In some cases where the visibility of the detector is obstructed by cable trays, false ceiling etc. Facility for connecting the detector to a response indicator has to be present. The response indicator derives the power to glow from the loop.

- It shall possess False alarm immunity and a superior signal to noise ratio; It shall have a Built in signal processor; it shall have drift compensation facility built in.

- The detectors shall communicate the ambient reading to the FACP on time to time basis, and the FACP shall make the decision about the current status of the detector, whether it is in fire/pre-alarm/maintenance requirement etc.

- The detector shall have at least 15 levels of sensitivity settings based on the application and room where it is installed.

- The detector shall provide a chamber maid plug to blow out the dust/dirt using a blower.

- In case of a failure, panel shall allow to replace the detector with the same type without the need of additional programming

- The detector shall be programmed to work as Optical only or Thermal only detectors. It shall a provision to switch off any component (optical or thermal) of the detector.

- The detector shall work with 2 different sensitivity settings at any point of time and the User shall have access to choose the desired settings without programming or Laptop/PC for configuration.

- The detector shall change sensitivity settings based on day/night mode or with schedules based on the programming.

- The detector shall have Intermediate Alarm Storage, Dual Detector Dependency, Dual group Dependency features that shall be programmed based on site application.

- The detector shall be capable of detecting both smoldering fires and open fires and shall be EN54 approved.
1.6.8 Intelligent Addressable Optical Smoke/ Heat (Multi-sensor) Detector

The Intelligent Addressable Multi-sensor Detector used in this Building shall confine to the relevant standards having the following features:

- It shall be combination of Smoke detection and heat detection. The smoke detection system shall work on Light scattering type principle using Infrared and the Heat detection system shall be of Rate of rise of temperature and Fixed Temperature.
- The Intelligent Addressable Multi-sensor Detector shall be of Spot type and Addressable type.
- The Intelligent Addressable Multi-sensor Detector shall be addressed either by DIP switches or through Programming from the Panel.
- The Detector shall monitor EMC/EMI values in the surroundings on a continuous basis and report the current & average values to the panel. The detector and the panel shall together avoid the possibility of false alarm caused due to interferences from sources such as Motors, power cables, Wi-Fi routers, fluorescent lamps, network switches, mobile signals...etc.
- All the detectors shall have a visible multi-color LED to indicate the healthiness / trouble / alarm condition of the detector. The LED shall be located in such a way that it shall be visible from all the 360 degree from below. In some cases where the visibility of the detector is obstructed by cable trays, false ceiling etc. Facility for connecting the detector to a response indicator has to be present. The response indicator derives the power to glow from the loop.
- It shall possess False alarm immunity and a superior signal to noise ratio
- It shall have a Built-in signal processor
- It shall have drift compensation facility built in.
- The detectors shall communicate the ambient reading to the FACP on time to time basis, and the FACP shall make the decision about the current status of the detector, whether it is in fire/pre-alarm/maintenance requirement etc.
- The detector shall have at least 15 levels of sensitivity settings based on the application and room where it is installed.
- The detector shall provide a chamber maid plug to blow out the dust/dirt using a blower.
- In case of a failure, panel shall allow to replace the detector with the same type without the need of additional programming.
• The detector shall be programmed to work as Optical only or Thermal only detectors. It shall a provision to switch off any component (optical or thermal) of the detector.

• The detector shall work with 2 different sensitivity settings at any point of time and the User shall have access to choose the desired settings without programming or Laptop/PC for configuration.

• The detector shall change sensitivity settings based on day/night mode or with schedules based on the programming.

• The detector shall have Intermediate Alarm Storage, Dual Detector Dependency, Dual group Dependency features that shall be programmed based on site application.

• The detector shall be capable of detecting both smoldering fires and open fires and shall be EN54 approved.

1.6.9 Intelligent Addressable Dual Optical Smoke Detector with 2 LED’s-Infrared & Blue

The Intelligent Addressable Photo electric smoke Detector with 2 LED’s-Infrared & Blue used in this Building shall confine to the relevant standards having the following features

• The smoke detection system shall work on Light scattering type principle using Infrared & Blue Led’s.

• The Intelligent Addressable smoke Detector shall be of Spot type and Addressable type.

• The Intelligent Addressable Smoke Detector shall be addressed either by DIP switches or through Programming from the Panel.

• The Detector shall monitor EMC/EMI values in the surroundings on a continuous basis and report the current & average values to the panel. The detector and the panel shall together avoid the possibility of false alarm caused due to interferences from sources such as Motors, power cables, Wi-Fi routers, fluorescent lamps, network switches, mobile signals...etc.

• All the detectors shall have a visible multicolor LED to indicate the healthiness / trouble / alarm condition of the detector. The LED shall be located in such a way that it shall be visible from all the 360 degree from below. In some cases where the visibility of the detector is obstructed by cable trays, false ceiling etc. Facility for connecting the detector to a response indicator has to be present. The response indicator derives the power to glow from the loop.
• It shall possess False alarm immunity and a superior signal to noise ratio
• It shall have a Built in signal processor
• It shall have drift compensation facility built in.
• The detectors shall communicate the ambient reading to the FACP on time to time basis, and the FACP shall make the decision about the current status of the detector, whether it is in fire/pre-alarm/maintenance requirement etc.
• The detector shall have at least 3 levels of sensitivity settings based on the application and room where it is installed.
• The detector shall provide a chamber maid plug to blow out the dust/dirt using a blower.
• In case of a failure, panel shall allow to replace the detector with the same type without the need of additional programming
• The detector shall work with 2 different sensitivity settings at any point of time and the User shall have access to choose the desired settings without programming or Laptop/PC for configuration.
• The detector shall change sensitivity settings based on day/night mode or with schedules based on the programming.
• The detector shall have Intermediate Alarm Storage, Dual Detector Dependency, Dual group Dependency features that shall be programmed based on site application.
• The detector shall be capable of detecting both smoldering fires and open fires and shall be EN54 approved.

1.6.10 Intelligent Addressable Optical Smoke Detector

The Intelligent Addressable Photo electric smoke Detector with Infrared LED used in this Building shall confine to the relevant standards having the following features

• The smoke detection system shall work on Light scattering type principle using Infrared Led’s.
• The Intelligent Addressable smoke Detector shall be of Spot type and Addressable type.
• The Intelligent Addressable Smoke Detector shall be addressed either by DIP switches or through Programming from the Panel.
• The Detector shall monitor EMC/EMI values in the surroundings on a continuous basis and report
the current & average values to the panel. The detector and the panel shall together avoid the possibility of false alarm caused due to interferences from sources such as Motors, power cables, Wi-Fi routers, fluorescent lamps, network switches, mobile signals...etc.

- All the detectors shall have a visible multicolor LED to indicate the healthiness / trouble / alarm condition of the detector. The LED shall be located in such a way that it shall be visible from all the 360 degree from below. In some cases where the visibility of the detector is obstructed by cable trays, false ceiling etc. Facility for connecting the detector to a response indicator has to be present. The response indicator derives the power to glow from the loop.
- It shall possess False alarm immunity and a superior signal to noise ratio
- It shall have a Built in signal processor
- It shall have drift compensation facility built in.
- The detectors shall communicate the ambient reading to the FACP on time to time basis, and the FACP shall make the decision about the current status of the detector, whether it is in fire/pre-alarm/maintenance requirement etc.
- The detector shall have at least 3 levels of sensitivity settings based on the application and room where it is installed.
- The detector shall provide a chamber maid plug to blow out the dust/dirt using a blower.
- In case of a failure, panel shall allow to replace the detector with the same type without the need of additional programming
- The detector shall work with 2 different sensitivity settings at any point of time and the User shall have access to choose the desired settings without programming or Laptop/PC for configuration.
- The detector shall change sensitivity settings based on day/night mode or with schedules based on the programming.
- The detector shall have Intermediate Alarm Storage, Dual Detector Dependency, Dual group Dependency features that shall be programmed based on site application.
- The detector shall be capable of detecting both smoldering fires and open fires and shall be EN54 approved.

1.6.11 Intelligent Addressable Heat Detector
The Intelligent Addressable Heat Detector used in this Building shall confine to the relevant standards having the following features

- The Heat detection system shall be of Rate of rise of temperature and Fixed Temperature.
- The Heat Detector shall be of Spot type and Addressable type.
- The Heat Detector shall be addressed either by DIP switches or through Programming from the Panel.
- The Detector shall monitor EMC/EMI values in the surroundings on a continuous basis and report the current & average values to the panel. The detector and the panel shall together avoid the possibility of false alarm caused due to interferences from sources such as Motors, power cables, Wi-Fi routers, fluorescent lamps, network switches, mobile signals...etc.
- All the detectors shall have a visible multi-color LED to indicate the healthiness / trouble / alarm condition of the detector. The LED shall be located in such a way that it shall be visible from all the 360 degree from below. In some cases where the visibility of the detector is obstructed by cable trays, false ceiling etc. Facility for connecting the detector to a response indicator has to be present. The response indicator derives the power to glow from the loop.
- It shall possess False alarm immunity and a superior signal to noise ratio
- It shall have a Built in signal processor
- It shall have drift compensation facility built in.
- The detectors shall communicate the ambient reading to the FACP on time to time basis, and the FACP shall make the decision about the current status of the detector, whether it is in fire/pre-alarm/maintenance requirement etc.
- In case of a failure, panel shall allow to replace the detector with the same type without the need of additional programming
- The detector shall work with 2 different sensitivity settings at any point of time and the User shall have access to choose the desired settings without programming or Laptop/PC for configuration.
- The detector shall change sensitivity settings based on day/night mode or with schedules based on the programming.
- The detector shall have Intermediate Alarm Storage, Dual Detector Dependency, Dual group
Dependency features that shall be programmed based on site application.

- The detector shall be capable of detecting both smoldering fires and open fires and shall be EN54 approved.

1.6.12 Addressable Ventilation Duct Smoke Detectors

The detector shall have a housing for accommodating a special detector that detects smoke in ventilation ducts, with input and output for air sample extraction, streamlined connection pipes for optimum air flushing of the detector, with dust-proof connection board for the loop outside the air flow, with air intake and exhaust pipe, seals and the required installation material.

The Duct smoke Detector used in this Building shall confine to the relevant standards having the following features:

- The smoke detection system shall work on Light scattering type principle using Infrared. The detector shall better false alarm immunity and shall have a processor inbuilt with ISP.
- Duct Detector shall be Addressable type.
- The Dual Detector shall be loop powered and addressed either by DIP switches or through Programming from the Panel.
- All the detectors shall have a visible multi-color LED to indicate the healthiness / trouble / alarm condition of the detector. The LED shall be located in such a way that it shall be visible from all the 360 degree from below. In some cases where the visibility of the detector is obstructed by cable trays, false ceiling etc. Facility for connecting the detector to a response indicator has to be present. The response indicator derives the power to glow from the loop.
- It shall possess False alarm immunity and a superior signal to noise ratio
- It shall have a Built in signal processor
- It shall be with inbuilt fault isolators. (Detectors without Inbuilt Isolators may be considered with separate Isolator Base)
- It shall have drift compensation facility built in.
- The detectors shall communicate the ambient reading to the FACP on time to time basis, and the FACP shall make the decision about the current status of the detector, whether it is in
The detector shall have at least 3 levels of sensitivity settings.

- The detector shall provide a chamber maid plug to blow out the dust/dirt using a blower.
- In case of a failure, panel shall allow to replace the detector with the same type without the need of additional programming.
- The detector shall work with 2 different sensitivity settings at any point of time and the User shall have access to choose the desired settings without programming or Laptop/PC for configuration.
- The detector shall change sensitivity settings based on day/night mode or with schedules based on the programming.
- The detector shall have Intermediate Alarm Storage, Dual Detector Dependency, Dual group Dependency features that shall be programmed based on site application.
- The detector shall have Air intake and exhaust pipe, extendable up to 3m.
- The detector shall have necessary filters in the air intake and exit pipes.
- The detector considered shall be a special detector designed for Duct applications and not a Spot type Optical detector.
- The detector shall be EN54 approved.

1.6.13 **Manual Call Points**

The Manual call points (MCP) used in the building shall confine to the relevant standards having the following features; Manual call points shall be of Double action - break glass type with Push Button; The mounted arrangement shall be such that it can be either surface mounted or flush mounted; Each addressable MCP will comprise of an electronic circuit built into it to provide addressing capability; The MCPs shall be provided with inbuilt fault isolator. (the EPC Contractor shall consider a external isolator if not inbuilt); The MCP shall have a LED to indicate Alarms; The MCP shall be EN54 approved.

1.6.14 **Control relay module(CRM)**

The Control Relay Modules used in this Building shall confine to the relevant standards having the following features:
The CRM shall provide a dry potential contact o/p for activating a variety of auxiliary devices and other fire fighting / ventilation equipment.

The CRM shall have inbuilt fault isolator module. (EPC Contractor shall consider external isolators if not inbuilt); It shall have a capability of handling at least 1A @ 30VDC to integrate with third party system.

The CRM shall be addressable either by Dip switch or by the Panel; The CRM shall be EN54 approved.

### 1.6.15 Monitor Module (Input module) (MM)

The Monitor Modules used in this Building shall confine to the relevant standards having the following features:

- The MM shall provide 2 inputs and these inputs shall work independently to monitor 3rd party devices and shall allow to program with different parameters.
- The MM shall have inbuilt fault isolator module. (EPC Contractor shall consider external isolators if not inbuilt).
- The MM shall be programmed to monitor contacts, Voltage and EOL resistor as per site applications.
- The MM when programmed to monitor contacts shall also allow to program to monitor either open/close contacts.
- The MM shall be addressable either by Dip switch or by the Panel; The MM shall be EN54 approved.

### 1.6.16 Addressable interface (Conventional Zone Interface module - CZIM)

The CZIM Modules used in this building shall confine to the relevant standards having the following features:

- Addressable interface units will be provided for all non-addressable detectors/devices such as beam detectors or to integrate existing conventional detectors, etc. to assign an address to such detectors and to be compatible with addressable FACP.
• Each conventional detector will have its own addressable unit in the form of CZIM Modules for individual address. The addressable unit will facilitate connection of non-addressable detectors in the same circuit/loop consisting of addressable detectors;
• It shall supervise the circuit of open dry contact I/P device & signal alarms during change of state of detectors;
• The interface device shall have an LED, which flashes during polling of the FACP
• It shall have inbuilt fault isolator module or the EPC Contractor shall consider additional isolator modules
• The CZIM shall be capable of powering the Detectors through the Aux Source and shall supervise the cable, aux power and the external power supply. The CZIM shall communicate Faults and Troubles related to Detector, Power supply to the Panel
• The CZIM shall allow to reset conventional detectors from the panel
• The CZIM shall offer 2 separate zones, 2 Aux power circuits and shall monitor the external power supply and supervise the zone cables
• The CZIM shall allow Intermediate Alarm Storage, Dual detector & Dual group dependency based on site applications
• The CZIM shall allow to configure the conventional zones with Different EOL and Alarm resistor based on the existing detector type
• The CZIM shall either be din rail mount or Surface mount
• The CZIM shall have the intelligence to detect faults like 4 wire short...etc; The CZIM shall be EN54 /VdS approved

1.6.17 Beam (Optical Beam) Smoke detector
• The Beam detectors used shall confine to the relevant standards having the following features:
• The beam detectors shall having a separate Transmitter (Tx) & receiver (Rx)
• Beam detectors shall be externally powered via Conventional Zone Interface module (CZIM). The module shall supervise the External Power Supply, Aux Power to the Transmitter and Receiver
• It will communicate to FACP through addressable CZIM so that each detector will have individual address. The CZIM shall have inbuilt fault isolators
The beam detector shall be suitable to protect the distance from 10 meters to 100 meters range
The beam detectors shall communicate the ambient reading to the FACP on time to time basis, and the FACP shall make the decision about the current status of the detector, whether it is in fire/pre-alarm/maintenance requirement etc
It shall have provision for Wall / ceiling mounting.
Beam detector shall have Response time less than 20sec
The response threshold values, tests shall be as per NFPA 72
It shall have feature such that in case of accidental change of alignment, it shall report an error, it shall raise a maintenance request to the FACP.

1.6.18 Sounder

The Sounder used in this Building shall confine to the relevant standards having the following features:

- The Sounder shall have audible sound of (EPC Contractor shall consider external power supply, cable, conduits, modules required for activating externally powered sounders and include the costing as part of the item – Sounders);
- The Sounder shall either be addressed by Dip switch or by the Panel; The Sounder shall be placed in the detection loop only and a separate loop or cables for sounders shall not be used; The sounder shall have a sound pressure level of 90dB and the volume shall be adjusted from the Fire Alarm Panel;
- The sounder shall be capable of programming at least 32 different tones for alarm detection in different floors or at different time intervals;
- The sounder shall be tested and maintained with ease from the FACP;
- The Volume levels for Testing and Drill shall be programmed as per site conditions.
- The Sounder shall consume a minimal current of <5mA and thus allowing to connect at least 25 loop powered sounders in the same loop;
- The Sounder shall be capable of either accommodating a Flasher or a Detector and shall work as Sounder cum strobe or Sounder cum detector base;
- The Sounder shall have a feature of synchronizing with other sounders in the loop; The Sounder
shall be loop powered and shall be EN54/VdS approved.

1.6.19 Strobe

The Strobe used in this Building shall confine to the relevant standards having the following features:

- The EPC Contractor shall consider external power supply, cable, conduits, modules required for activating externally powered Strobes and include the costing as part of the item – Strobes)
- The Strobe shall either be addressed by Dip switch or by the Panel;
- The Strobe shall be placed in the detection loop only and a separate loop or cables for Strobe shall not be used;
- The Strobe shall have a red flash light and shall flash at minimum of 1Hz;
- The Strobe shall be tested and maintained with ease from the FACP;
- The Strobe shall also be part of Testing and Drill and shall be programmed as per site conditions;
- The light output shall be at least 2 cd
- The Strobe shall consume a minimal current of 10mA and thus allowing to connect at least 10 loop powered strobes in the same loop;
- The Strobe shall be capable of either fixing it in a Sounder and shall work as Sounder cum strobe as per site conditions;
- The Strobe shall be loop powered and shall be EN54/VdS approved.

1.6.20 Remote Indicator

The Remote indicator used in this Building shall confine to the relevant standards. The remote indicator is used when the automatic detector is installed in a place hidden or not visible like in closed rooms, false ceilings or walls

SYSTEM DESIGN & TECHNICAL REQUIREMENTS

Details for submission of documents by the EPC contractor & it’s specialized agency/ agencies.
THE EPC CONTRACTOR SHALL PROPOSAL THAT MEETS THE “TECHNICAL SPECIFICATION” OF THIS TENDER DOCUMENT, INDICATING CLEARLY THE MAKE AND MODEL OF EQUIPMENT OF EACH ITEM, BEING OFFERED FOR THE APPROVAL OF ENGINEER-IN CHARGE BEFORE EXECUTION OF WORK.

1.6.21 OTHER PRODUCT OR ALTERNATIVE OFFER SHALL NOT BE ACCEPTED OR CONSIDERED FOR EVALUATION. IN RESPECT OF DIFFERENT ITEMS OF EQUIPMENT REQUIRED FOR THE SYSTEM, ONLY THE OFFERED ITEM OF EACH TYPE OF EQUIPMENT SHALL BE SUBMITTED IN THE TECHNICAL BID. ANY EPC CONTRACTOR WHO SUBMITS COMPLETE RANGE OF MODELS FOR EACH INDIVIDUAL ITEM OF EQUIPMENT OR OFFERS MULTIPLE ALTERNATIVES AS A CHOICE FOR INDIVIDUAL ITEM WITHOUT CLEARLY INDICATING THE MODEL THAT IS ACTUALLY OFFERED FOR THIS WORK, SHALL HAVE HIS TENDER OUT-RIGHTLY REJECTED WITHOUT ANY CORRESPONDENCE.

1.6.22 “TECHNICAL SPECIFICATION” OF EACH ITEM SHALL BE THE PRIMARY CRITERIA FOR TECHNICAL EVALUATION OF TENDER. HOWEVER, EPC CONTRACTOR HAS TO ENDORSE AGAINST ALL “TECHNICAL FEATURES” OF SYSTEM AND EQUIPMENT MARKING AS “COMPLIANCE” AS A TOKEN OF CONFIRMATION OF FEATURES OFFERED.

1.6.23 THE SPECIFICATIONS DETAILED HEREUNDER ARE THE MINIMUM REQUIREMENTS. EPC CONTRACTORS MAY OFFER SYSTEM/ EQUIPMENT/ ACCESSORIES/ SOFTWARE/ NETWORK EQUIPMENT/ CABLING OF BETTER SPECIFICATIONS AS PER SYSTEM DESIGN PROPOSED BY THE EPC CONTRACTOR. HOWEVER, NO PREFERENCE OR WEIGHTAGE SHALL BE GIVEN TO EPC CONTRACTOR FOR OFFERING SUCH SYSTEM/ EQUIPMENT/ ACCESSORIES/ SOFTWARE/ NETWORK EQUIPMENT/ CABELING OF SPECIFICATIONS HIGHER THAN THE TENDER SPECIFICATION.

1.6.24 THE EPC CONTRACTOR HAS TO FILL “TECHNICAL REQUIREMENTS ALONG WITH FEATURES STATEMENT” AS PER DIRECTION GIVEN BELOW:

i) FOR STATING COMPLIANCE: WRITE “C” IN THE THIRD COLUMN OF STATEMENT.
ii) FOR STATING NON-COMPLIANCE: WRITE “NC” IN THE THIRD COLUMN OF STATEMENT.

iii) FOR STATING PARTIAL COMPLIANCE OR CONDITIONAL COMPLIANCE: WRITE “PC” IN THE THIRD COLUMN OF STATEMENT.

iv) AGAINST EACH COMPLIANCE STATEMENT, WRITE SPECIFIC PARA AND PAGE OF SUPPORTING TECHNICAL DOCUMENTATION (FROM WHICH THE STATED COMPLIANCE COULD BE VERIFIED IN FOURTH COLUMN OF STATEMENT).

v) SPECIFICATIONS OF THE EQUIPMENT BETTER THAN THOSE MENTIONED IN “TECHNICAL REQUIREMENTS ALONG WITH FEATURES” SHALL BE ACCEPTED.

C. OPERATIONAL MAINTENANCE DURING WARRANTY PERIOD AND COMPREHENSIVE ANNUAL MAINTENANCE CONTRACT:

- The cost for the Maintenance/Service during DLP period of 24 months is covered under the scope of work and quoted rates shall be deemed to cover regular examination of the installations by the trained technician of the contractor including necessary adjustments, cleaning including replacement of parts etc. to keep the equipment in excellent operational state.

- The contractor shall also provide 24 hour emergency repair service to attend the Airport systems at any time of the day or night including Sundays and Holidays.

- All Inclusive Comprehensive Maintenance Contract (AICMC) to be undertaken by the EPC Contractor for the next five years after completion of the guarantee / warranty & defect liability period of TWO years.

- The detailed terms and conditions of the all-inclusive Comprehensive Maintenance Contract for Airport system are appended under SCC for Operation & All inclusive comprehensive Maintenance contract. The quoted amount for AICMC will be taken into consideration for evaluation of the bids.
1. **SCOPE OF TENDER**

   Fire suppression system is fire detection and quenching system. This is proposed for Server Room & UPS Room. The Cylinder Valve Assembly must be UL/FM approved with Seamless CCOE approved cylinder and an undertaking from manufacturer must be submitted with the tender to comply the same.

2. **SYSTEM DETAILS**

   a. The amount of FK-5-1-12 to be for provided shall be the amount required to obtain a uniform (minimum) design concentration Class 4.7% required to extinguish the fire at minimum anticipated temperature with the risk and as required by NFPA 2001, 2012 Edition with a hold time for 10 minutes. The system design shall not exceeds 10% for normally occupied areas, adjusted for maximum area temperature anticipated with provision for room evacuation before agent release. The system provided shall be Main and 100% reserve.

   b. Necessary warning signs shall be displayed in and near such risk (entry and exit) envisaged for clean agent Gas suppression.

   c. The Pipe used should be MS, ASTM Schedule 40.

   d. The Cylinder to be pressurized at 34.5 Bar and Cylinder Valve Assembly must be UL/FMListed.

   e. Each cylinder shall have pressure gauze and low pressure switch to provide visual and electrical supervision of the cylinder pressure. The low pressure switch shall be wired to the control panel to provide audible and visual trouble alarm in the event of drop of pressure at 20 Bars and below. The pressure gauze shall be color coded to provide an easy, visual indication of cylinder pressure.

   f. Furnish a welded steel bracket with each cylinder assembly for holding the cylinders in a saddle with a front bracket place that secures the cylinders depending on installation requirements.

   g. The cylinder shall have pressure relief provisions that automatically operate before the internal nominal pressure exceeds 60 Bars.

   h. **Extinguishing Agent:**
The Agent shall not contain any Hydrofluorocarbons (HFC).

The manufacture of Agent should give a 20 year of warrantee against any regulatory bans from Environment agency.

The Agent must be UL/FM approved.

i. Comply with requirements of the authorities having jurisdiction.

j. Filling facility should be UL Listed / PESO approved.

k. Design Criteria

2. Temperature of Risk : 20°C to 27°C
3. Design Concentration : 4.7%
4. Flooding Factor : As per Manufacturer
5. Discharge Time : 10 Seconds
6. Design Pressure : Upstream of pressure reducer 34.5 Bars
7. Design Pressure : Downstream of pressure reducer as per calculation
9. Nozzle Type : 360° / 180°
10. Altitude correction factor : As per Manufacturer
11. Hold Period : 10 Minutes

3. SUBMITTALS:

The Contractor must submit mechanical Working Drawing showing Pipe, Pipe Size, Bends, Reducer, Splits, Tee Connection, Valves, Fittings, Supports etc which should be supported with Hydraulic Flow Calculation. The Hydraulic Flow Calculation Software must be UL/UDS/FM approved.

4. Sequence of Operation

a) Activation of the First Smoke Detector (the crossed-zoned laser detector)
i) Illuminate the respective circuit lamp on the control unit.
ii) Energize a pre-alarm audible alarm bell.
iii) Treatment remote alarm to the building Fire Alarm Panel.
iv) Activation of the Second Smoke Detector (the cross-zoned laser detector).
v) Illuminate the respective circuit lamp on the control unit.
v) Energize an evacuation audible alarm horn device.
vii) Shut down the stand-alone air conditioning units serving the protecting area.
viii) Closes the supply and exhaust / return dampers serving the protected area.
ix) Activates a time delay mechanism which delays release of the clean agent for up to 20 seconds from the time the 2nd loop is activated. The Fire Suppression clean agent is released at the end of the time delay interval unless a “dead man” type abort switch is operated between the 1st and 2nd detection loops. A timed out system discharges upon abort disengagement unless the system is cleared and reset.

b) Discharge of the Fire Suppression Clean Agent.

i) Operates strobe light outside the protected area.
ii) The system may be activated by manual discharge switches located in the protected area. Operation of a manual discharge switch causes immediate discharge of the fire suppression agent and causes alarm and shut-down devices to operate the same as if the system had operated automatically operation of a manual discharge switch overrides all time delay and abort system devices in the system.

iii) SYSTEM DESIGN & TECHNICAL REQUIREMENTS

Details for submission of documents by the EPC contractor & it’s specialized agency/ agencies.

THE EPC CONTRACTOR SHALL PROPOSAL THAT MEETS THE “TECHNICAL SPECIFICATION” OF THIS TENDER DOCUMENT, INDICATING CLEARLY THE MAKE AND MODEL OF EQUIPMENT OF EACH ITEM, BEING OFFERED FOR THE APPROVAL OF ENGINEER-IN CHARGE BEFORE EXECUTION OF WORK.

1.6.25 OTHER PRODUCT OR ALTERNATIVE OFFER SHALL NOT BE ACCEPTED OR CONSIDERED FOR EVALUATION. IN RESPECT OF DIFFERENT ITEMS OF EQUIPMENT REQUIRED FOR THE SYSTEM, ONLY THE OFFERED ITEM OF EACH TYPE OF EQUIPMENT SHALL BE SUBMITTED IN THE TECHNICAL BID. ANY EPC CONTRACTOR WHO SUBMITS COMPLETE RANGE OF MODELS FOR EACH INDIVIDUAL ITEM OF EQUIPMENT OR OFFERS MULTIPLE ALTERNATIVES AS A
CHOICE FOR INDIVIDUAL ITEM WITHOUT CLEARLY INDICATING THE MODEL THAT IS ACTUALLY OFFERED FOR THIS WORK, SHALL HAVE HIS TENDER OUT-RIGHTLY REJECTED WITHOUT ANY CORRESPONDENCE.

1.6.26 “TECHNICAL SPECIFICATION” OF EACH ITEM SHALL BE THE PRIMARY CRITERIA FOR TECHNICAL EVALUATION OF TENDER. HOWEVER, EPC CONTRACTOR HAS TO ENDORSE AGAINST ALL “TECHNICAL FEATURES” OF SYSTEM AND EQUIPMENT MARKING AS “COMPLIANCE” AS A TOKEN OF CONFIRMATION OF FEATURES OFFERED.

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1.6.28 THE EPC CONTRACTOR HAS TO FILL “TECHNICAL REQUIREMENTS ALONG WITH FEATURES STATEMENT” AS PER DIRECTION GIVEN BELOW:

vi) FOR STATING COMPLIANCE: WRITE “C” IN THE THIRD COLUMN OF STATEMENT.

vii) FOR STATING NON-COMPLIANCE: WRITE “NC” IN THE THIRD COLUMN OF STATEMENT.

viii) FOR STATING PARTIAL COMPLIANCE OR CONDITIONAL COMPLIANCE: WRITE “PC” IN THE THIRD COLUMN OF STATEMENT.

ix) AGAINST EACH COMPLIANCE STATEMENT, WRITE SPECIFIC PARA AND PAGE OF SUPPORTING TECHNICAL DOCUMENTATION (FROM WHICH THE STATED COMPLIANCE COULD BE VERIFIED IN FOURTH COLUMN OF STATEMENT).

x) SPECIFICATIONS OF THE EQUIPMENT BETTER THAN THOSE MENTIONED IN “TECHNICAL REQUIREMENTS ALONG WITH FEATURES” SHALL BE ACCEPTED.

- The cost for the Maintenance/Service during DLP period of 24 months is covered under the scope of work and quoted rates shall be deemed to cover regular examination of the installations by the trained technician of the contractor including necessary adjustments, cleaning including replacement of parts etc. to keep the equipment in excellent operational state.

- The contractor shall also provide 24 hour emergency repair service to attend the Airport systems at any time of the day or night including Sundays and Holidays.

- All Inclusive Comprehensive Maintenance Contract (AICMC) to be undertaken by the EPC Contractor for the next five years after completion of the guarantee / warranty & defect liability period of Two year.
- The detailed terms and conditions of the all-inclusive Comprehensive Maintenance Contract for Airport system are appended under SCC for Operation & All inclusive comprehensive Maintenance contract. The quoted amount for AICMC will be taken into consideration for evaluation of the bids.
01. **SCOPE OF WORK:** This contract covers the following scope of work:

The scope of work includes the following-

i) Supply, Installation, Testing and Commissioning (SITC) of Boom Barriers and Bollards at entry and at exit of the Airport.

02 **LOCATION:** The work has to be carried out at Imphal Airport. The contractor should, in his own interest, visit the site and familiarize himself with the site conditions before execution, for any clarification, contractor may discuss with the Engineer-In-Charge.

03 **Technical Specifications -**

i. **Anti-terrorism automatic hydraulic bollard**

Crash-tested and certified by accredited third-party Laboratory according to IWA14-1:2013 with rating V/7200[N2A]/48/90:5.5, equivalent to PAS68:2013 with rating V/7500 [N2]/48/90:5.2

- Automatic hydraulic bollard with certified anti-terrorism protection
- Independent hydraulic pump for each bollard, access for simplified servicing, anti-tampering sensor (optional)
- Break-in-resistance : 667000J
- Impact resistance : 150000 J
- Worktime : risetime:<7.0s; loweringtime:<4.0s
- Max operating frequency : upto 2000 op./day
- MCBF : 3000000 cycles
- Sensors for bollard positions: fully up and fully retracted
- Obstaclesensing,configurable(with/without movement inversion)
- Bollardtopcover, cast-iron.LED lights and buzzer (optional)
- Interfaces for remote control (RS485-TCP/IP, optional)

Technical – Environmental features
<table>
<thead>
<tr>
<th>Feature</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tube height</td>
<td>Ø273 x h.800 mm (± 3 mm) x th. 10mm, steel Fe 510 (S 335 JR)</td>
</tr>
<tr>
<td>Buried structure</td>
<td>560 x 560 x h.1 140 mm (excluded pump)</td>
</tr>
<tr>
<td>Foundation</td>
<td>Reinforced concrete</td>
</tr>
<tr>
<td>Excavation pit</td>
<td>1 500x1 500 x1 400mm</td>
</tr>
<tr>
<td>Break-in resistance</td>
<td>667 000 J</td>
</tr>
<tr>
<td>Impact resistance</td>
<td>150 000 J</td>
</tr>
<tr>
<td>Tube treatment</td>
<td>Cataphoresis and coating RAL7031 standard, other color on request</td>
</tr>
<tr>
<td>Passive visibility</td>
<td>Reflective film H=100 mm</td>
</tr>
<tr>
<td>Flange</td>
<td>Cast iron, cataphoresis black</td>
</tr>
<tr>
<td>Top cover</td>
<td>Cast iron, cataphoresis black</td>
</tr>
<tr>
<td>Actuator</td>
<td>Hydraulic, biodegradable oil</td>
</tr>
<tr>
<td>Power</td>
<td>230 Vac ±10%, 50-60 Hz</td>
</tr>
<tr>
<td>Working time</td>
<td>rise time: ≤ 7.0 s (50 Hz); lowering time: ~ 4.0 s</td>
</tr>
<tr>
<td>Working temperature</td>
<td>-40°C +60°C</td>
</tr>
<tr>
<td>Operating humidity</td>
<td>up to 100%</td>
</tr>
<tr>
<td>IP grade</td>
<td>IP67</td>
</tr>
<tr>
<td>Manual operation</td>
<td>During power failure:</td>
</tr>
<tr>
<td></td>
<td>- Standard version STD: bollard goes down.</td>
</tr>
<tr>
<td></td>
<td>- Security version SCT: bollard stays up, bollard can be lowered by</td>
</tr>
<tr>
<td></td>
<td>means of a mechanical key accessible through the ground flange.</td>
</tr>
</tbody>
</table>

### Electric Feature-

<table>
<thead>
<tr>
<th>Feature</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control unit</td>
<td>CDS-K</td>
</tr>
<tr>
<td>Power</td>
<td>1-phase 230 Vac ±10%, 50-60 Hz (115 Vac with optional adapter)</td>
</tr>
<tr>
<td>IP grade</td>
<td>IP54</td>
</tr>
<tr>
<td>Working temperature</td>
<td>-40°C +60°C</td>
</tr>
<tr>
<td>Operating humidity</td>
<td>up to 95%, non condensing</td>
</tr>
<tr>
<td>Bollard driven</td>
<td>Max. 4 for each control unit. Parallel control wiring possible for driving many groups of bollards.</td>
</tr>
<tr>
<td>Power consumption, max</td>
<td>0.55 kW for each bollard</td>
</tr>
<tr>
<td>Power consumption, idle</td>
<td>28 W</td>
</tr>
<tr>
<td>Signalling</td>
<td>On the top with high intensity LEDs, and buzzer</td>
</tr>
<tr>
<td>Sensors</td>
<td>Open passage/ bollard down, closed passage/ bollard up, Overpressure/ Obstacle, anti tampering switch(optional)</td>
</tr>
<tr>
<td>Local/Remote control</td>
<td>· Digital inputs</td>
</tr>
<tr>
<td></td>
<td>· Radio remote control (receiver included, transmitter optional)</td>
</tr>
<tr>
<td></td>
<td>· RS485, TCP/IP (optional)</td>
</tr>
</tbody>
</table>

**ii. Automatic electro mechanical barrier-**
- Self-supporting steel structure, cataphoresis treated and powder paint coated / stainless steel
- Double exit shaft for easy left/right arm mounting
- Opening time: from 0.7 to 3.0s
- Maximum frequency: 20,000 operations/day for arm length up to 3m
  5,000 operations/day for arm length up to 5m
- MCBF: 5,000,000 cycles
- Slow down in opening and closing, three-phase inverter for motor speed adjustment
- Configurable obstacle detection (encoder)
- Rod/crank mechanism
- Supplied with installation template
- Self-cooled gear reduction in oil bath, ventilated, asynchronous motor, three-phase 230 V ac
- Opening manual with knob, inside the structure
- Compatible with automatic opening kit in case of power supply loss
- Internal control unit, option for TCP/IP and RS485 interfaces

**TECHNICAL-ENVIRONMENTAL FEATURES**

<table>
<thead>
<tr>
<th>Feature</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Barrier size</td>
<td>320x280xh.1110mm; steel</td>
</tr>
<tr>
<td>Road passage</td>
<td>1.7...5.0m</td>
</tr>
<tr>
<td>Finishing</td>
<td>Cataphoresis, powder paint RAL7031 standard,</td>
</tr>
<tr>
<td>Foundation</td>
<td>Concrete, 500x500xh.400mm</td>
</tr>
<tr>
<td>Motor</td>
<td>Self-cooled oil-bath gear reduction, rod/crank; Power: 0.18 HP; 24 V DC</td>
</tr>
<tr>
<td>Obstacle detection</td>
<td>Configurable (encoder)</td>
</tr>
<tr>
<td>Lock</td>
<td>Mechanic</td>
</tr>
<tr>
<td>Unlock</td>
<td>Manual with knob, inside the structure</td>
</tr>
<tr>
<td></td>
<td>Compatible with automatic opening kit in case of power supply loss</td>
</tr>
<tr>
<td>Opening time</td>
<td>From 0.7 to 3.0s (adjustable)</td>
</tr>
<tr>
<td>Operating ambient</td>
<td>-30°C + 60°C</td>
</tr>
<tr>
<td>temperature</td>
<td></td>
</tr>
</tbody>
</table>
### Operating Humidity
- Upto 100%

### IP Grade
- IP65

### Total Barrier Weight
- ~70 Kg

#### 04. Conformity with Statutory Acts, Rules Standard and Codes:

(I) All components of work shall confirm to relevant Indian Standard Specification wherever existing as amended to date.

(II) All electrical works shall be carried out in accordance with provisions of Indian Electricity Act, 2003 and Indian Electricity Rules, 1956 amended to date. They shall also confirm to CPWD General Specification for Electrical works, Part-I: Internal, 2005 Part-II: External 1994.

#### 05. The contractor shall be responsible for any damage resulting from his negligence to existing fixtures and will restore, replace or repair any such damage to the complete satisfaction of Engineer-in-charge free of cost.

#### 06. Completion Drawings: 04 sets of completion drawings i/c SLD, layout diagrams, control diagram, operation sequence, operation & maintenance manual, insulation & earthing values etc. shall be submitted. If the firm is failing to submit the above drawings & registers, the deduction from the final bill shall be made as per relevant clauses of GCC.

#### 07. The work shall be strictly carried out as per the specifications given in the schedule, special conditions, technical specifications or as per general specifications of respective work of AAI/CPWD or IS code or as per prevailing practice in that order. The decision of the Engineer-in-Charge shall be final and binding on the contractor.

#### 08. The contractor has to follow the local security/ safety rules and regulations and such instructions on restricted hours of work as may be imposed on him by the department/ local authorities, while working in security restricted zones and no claim whatsoever on account of loss of labour/ idle labour etc. will be entertained.

#### 09. The firm shall submit all relevant test certificates etc. wherever applicable as per CPWD/ IS/ manufacturer’s practice and the department reserves the right to get them independently checked.
10. Approval of the Engineer-in-charge shall be taken well in advance for all materials to be used for the works by the contractor. The contractor has to submit the required catalogues/literature/test certificates/technical information from the manufacturer/authorised dealer etc. wherever applicable along with the samples, if so desired by the Engineer-in-Charge.

11. Safety Code: - In respect of all workers employed directly and indirectly on the works, the contractor will have to arrange the safety provisions to comply with the prevailing statutory regulations and CPWD safety codes.

12. Details for submission of documents by the awarded EPC contractor & its specialized agency/agencies.

THE EPC CONTRACTOR SHALL PROPOSAL THAT MEETS THE “TECHNICAL SPECIFICATION” OF THIS TENDER DOCUMENT, INDICATING CLEARLY THE MAKE AND MODEL OF EQUIPMENT OF EACH ITEM, BEING OFFERED FOR THE APPROVAL OF ENGINEER-IN CHARGE BEFORE EXECUTION OF WORK.

13. OPERATIONAL MAINTENANCE DURING WARRANTY PERIOD AND COMPREHENSIVE ANNUAL MAINTENANCE CONTRACT:

- The cost for the Maintenance/Service during DLP period of 24 months is covered under the scope of work and quoted rates shall be deemed to cover regular examination of the installations by the trained technician of the contractor including necessary adjustments, cleaning including replacement of parts etc. to keep the equipment in excellent operational state.
- The contractor shall also provide 24 hour emergency repair service to attend the Boom barriers and Bollards at any time of the day or night including Sundays and Holidays.
- All Inclusive Comprehensive Maintenance Contract (AICMC) to be undertaken by the EPC Contractor for the next five years after completion of the guarantee/warranty & defect liability period of two year.
- The detailed terms and conditions of the all-inclusive Comprehensive Maintenance Contract for Boom barriers and Bollards are appended under SCC for Operation & All inclusive comprehensive Maintenance contract. The quoted amount for AICMC will be taken into consideration for evaluation of the bids.
SCHEDULE – D: Annexure - I (Part-IV)
CONSTRUCTION SPECIFICATIONS

SECTION-12: IT SYSTEMS FOR AIRPORT TERMINAL
BUILDING AND ATC CUM TECHNICAL BLOCK
iii. **GENERAL Guidelines:**

1.1 The IT network backbone shall have redundancy in fiber optic cable topology. All the structured cabling should be ANSI/IEIA/TIA approved for appropriate work.

1.2 Offered OEM of all Active Networking/Security Components should be in leader quadrant of Gartner Report.

1.3 There should be compatibility of network with existing equipments at the airport.

1.4 The density of data Nodes (I/Os) shall be approximately one per 15 Square meter of covered area. Data nodes shall be required for all IP / Network based application e.g. CCTV, FIDS, POS, Access Control System, Cute/CUSS, Wireless LAN/Internet/Telephony and other administrative and commercial applications etc. for all users of various agencies working at Airport.

1.5 Quantity and Capacity of the Racks shall be as per requirement however minimum three racks (One: Network Rack and Two: Server Rack) shall be provided for server room in addition to racks requested for specific application server and storage.

1.6 OEM of all active components must have net profit in last Seven (7) years.

1.7 Power supply (UPS) is required for each and every active networking components.

1.8 EPC Contractor should provide separate LAN Segment for CCTV with the other applications. Dedicated edge switching shall be required for CCTV. The laying of passive Cabling shall be as per BICSI standard.

1.9 The connectivity between Edge switch to DS shall be through 10 G SFP Modules.

1.10 The Connectivity between Edge switches shall be through stacking module or 10 G SFP Modules.

1.11 The connectivity between/among Core switch and Distribution switch shall be through 40G SFP+ Modules.

1.12 No Ethernet (UTP/Copper) cable shall be used between switch to switch connectivity.

1.13 All Covered Cable Trays, concealed Conduit and other accessories shall be provided by the EPC Contractor for the passive cabling works.

1.14 The offered equipment by the EPC Contractor shall be fully complied with the specifications to full fill the requirements. Higher specifications suitable to requirement can be accepted.

1.15 The design and selection of the offered IT networking components by the EPC Contractor shall be consistent with the requirements of long term trouble free operation with highest degree of reliability and maintainability.

1.16 The offered equipment by the EPC Contractor shall be designed for continuous operation (24-hours a day and 365-days a year).

1.17 All active components should be standard proven product already available in the market. Offered Item should not be end of life or end of sale.

1.18 MAF & a letter from OEM shall be submitted in regards of warranty support & Non –Refurbished items.

1.19 All Active Components shall have minimum seven years of comprehensive OEM warranty from the date of Commissioning.

1.20 This life shall be achievable through normal and regular maintenance.
1.21 All types of spares and spare modules of the offered equipment shall be readily available with the EPC Contractor during life-time of the equipment, for maintenance, repairs and up keep of the equipment during warranty & CAICMC period, if applicable.

1.22 The offered equipment by the EPC Contractor shall furnish the details of EMI and Safety Standards met by his equipment and built-in safety features.

1.23 The offered equipment shall be constructed on a modular basis, using plug-in type units and components to the extent possible. Parts subject to failure, wear, corrosion or other deteriorations or requiring occasional inspection, adjustment or replacement shall be made accessible and capable of convenient inspection and removal.

1.24 All Hardware system/component and Software supplied by EPC Contractor shall be licensed, as applicable, in favour of Airports Authority of India and valid for lifetime of the offered system.

1.25 Installation shall be carried out by technically well qualified and certified personnel as per the requirements.

1.26 Contractors shall not outsource any part of the contract to any other EPC Contractor/third party contractor without prior permission of AAI.

1.27 Liability, if anything, arising out of such third party contracts to any other EPC Contractor by contractor shall be to the contractor’s account.

1.28 AAI shall not be liable on behalf of contractor to any other third party contractor/ Government of India/State/Regulatory Authorities.

1.29 Any liabilities arising out of such third party contracts by contractor or its men working at site shall be only to contractor’s account and shall be deducted out of its running bills.

1.30 Contractor shall submit Police Verification Certificates and obtain necessary Airport Entry Permits, for allowing its men to work at AAI restricted premises.

1.31 The capacity given in the specification is minimum and EPC Contractor has to provide as per requirement.

1.32 All Electrical / Power Requirement shall be designed accordingly.

1.33 In Server Room, Dedicated Earthing, Fire alarm System, Access Control System shall be provisioned as per requirement.

1.34 EPC Contractor has to survey for final bill of quantity before implementation of work or procurement or approval from AAI Site Incharge.

1.35 All LAN Switching components should be of same make / brand.

1.36 VLANs need to be created on the basis of user group / application based and access between VLANs shall be provided as per the security of the data and systems. OEM managed service is required for Design, vetting of Installation and configuration, creation of VLANs, Implementation of IP Schema, proper Documentation etc.

1.37 For design of VLAN, IP Schema and other Installation & Execution Services as per AAI requirement for all application and group of users should be provided by OEM.

1.38 Network Operation Center (NOC) shall be provided for the monitoring and controlling of the network operations with requisite equipments and 2x2 Video wall (55” or higher) of reputed brand (Samsung, LG, Panasonic, Planar, Christie, BARCO or Equivalent).

1.39 All switches shall be in a switch room within closed and secure environment. No Open Rack should be provided.

1.40 OEM shall be responsible for the training, documentation of the IT system deployed.

1.41 Structured Cabling should be provided with full redundancy in star Topology.

1.42 No other network for any IP based application shall be allowed at the Airport.
1.43 The specifications are given as per the minimum specification mentioned in Bill of material. EPC Contractor shall offer as per the requirement of AAI to meet the functional requirement as per NIT.
1.44 EPC Contractor has to provide source code for Biometric Access Control System (BCAS approved).
1.45 EPC Contractor has to provide hardware for applications offered.

2. SITE ACCEPTANCE TEST (SAT) & COMMISSIONING

2.1 It shall be the responsibility of the EPC Contractor to submit the system test procedure for conducting the post-installation site acceptance testing. The procedure submitted by the EPC Contractor shall be drafted in line with the standard practices followed in the industry and shall be in accordance with the test procedures & practices specified by the OEM. The acceptance test procedure on approval by AAI shall become the document for acceptance of the equipment after installation at the site.

2.2 The draft copy of system test procedure shall be made available to AAI before THIRTY calendar days of the schedule site acceptance date.

2.3 The EPC Contractor shall supply, install, test and commission all hardware and software as per the requirement of the tender with the system. EPC Contractor shall supply Technical documents (hard and soft copy - one set each) at site. The system shall be commissioned after successful completion of – SAT approval, operational & maintenance training and all the works under the scope of the tender.

3 PATENTS, LIABILITY & COMPLIANCE OF REGULATIONS

3.1 EPC Contractor shall protect and fully indemnify AAI from any claims for infringement of patents, copyright, trademark or the like.

3.2 EPC Contractor shall also protect and fully indemnify AAI from any claims from EPC Contractor’s workmen/employees, their heirs, dependents, representatives, etc. or from any other person(s) or bodies/ companies, etc. for any act of commission or omission while executing the order.

3.3 EPC Contractor shall be responsible for compliance with all requirements under the laws and shall protect and indemnify AAI completely from any claims/penalties arising out of any infringements by EPC Contractor or its workmen/employees.
4. DOCUMENTATION & TRAINING

Two set each of soft copy and hard copy of Installation, Operations including theory of operation, Technical Manual, Maintenance manual; Troubleshooting of the system, procedure for loading of the system and application software, etc. shall be supplied at site. The Operation, Technical and Maintenance manual will cover:-

(a) Handing Over Document – details of each active and passive material, serial no., IP address, Login Id and Password, version reports, configuration reports, Detail Bill of Material, spares etc.

(b) General technical description, Block Diagram, Schematic/ flow diagrams (I/O level)

(c) Preventive maintenance procedures & Support Escalation Matrix

(d) Fault analysis - schematic diagrams

Technical & operational manuals with user Operational Training.

5. BRIEF CONCEPT DESIGN

The following details specify the scope of work, design & technical specification for all the IT Works in the building & other works outside building within campus as mentioned in the scope. It comprises the systems listed out in this document and defines a turnkey solution.

A) Set up of LAN, WLAN & WAN by providing Passive and Active Networking Components such as OFC, UTP Cabling, Routers, Firewall, Core Switch, Distribution Switches, Edge Switches (PoE & Non-PoE).

Brief: At the Airport campus Integrated Local Area Network shall be provided for all the Voice, Data & Video Data requirement for all the agencies working at the airport. No other line for communication shall be allowed by the other agency. The EPC Contractor has to provide Integrated LAN Points for CCTV, WLAN, Access Control System, Internet, FIDS, IPABX and PoS, CUTE, CUSS or any other applications required internet or AAI Inranet for all users at Airport in redundant mode. CAT 6A cable shall be used for connectivity.
Active Networking Equipment shall be provided by the EPC Contractor as per the requirement in **HA Mode in Server Room and all Edge Switches should be provided with Redundant Power Supply**. EPC Contractor should have the provision for separate LAN Segment for CCTV with the other applications. Dedicated edge switching shall be required for CCTV.

**Note**: Raceways, Covered Cable Trays & Conduit work shall be provided by Engg Departmen.

**B) Setup of Server Room (for Servers, Storage, Networking and Other Security Devices) and NOC (Network Operations & Control) Room**

**Brief**: Required space for Central Server Room shall be marked in the drawing and the locations of Edge switches and distribution switches. Requisite no. of Server & Network Racks alongwith PDU, Modular UPS with half an Hour Battery Back up, Precision Air Cooling System, Access Control, CCTV, FSAS, Gas Supresson System, Anti Rodent, WLD, Dedicated Earthing, Dual Power Sources etc shall be provided in the Server Room by the EPC Contractor.

**Set up NOC**: Required space for NOC Room shall be marked in the drawing with the locations of Display Terminals.

**C) Access Control system at Airport Campus, as per BCAS Requirement**.

AAI has to setup centralised Access control System for Staff and Airport Vehicles (Other Than Passengers) in the building and Apron/runway Area. EPC Contractor has to provide end to end solution (Hardware & Software) for all components of Access Control System as per BCAS guidelines.
6. **SCOPE OF WORK**

The Airport Campus will be having passive works like laying of OFC backbone, UTP and voice cabling, installation of racks and cables and cable trays. Active works like wired LAN, WLAN, Voice, Surveillance for Intranet and Internet with Data nodes, PoE+ ports required for wireless access points, CCTV, Voice, Bio-Metric Access Control system and other applications (At Airport) which have been distributed across various floors of the Airport building and surroundings.

The Ethernet switches shall have interconnection to the Distribution switches located in the Data Centre or Switch Room in HA mode through 12 Core Single mode 10G Fibre Connectivity. The distribution switches is then connected to the centrally located Core Switches in HA Mode. Distribution Switches interconnection shall be on 40G optical fibre cable (OFC) while the wireless Access Points wired user nodes, servers, security gateways shall connect to the switching backbone using UTP/Fiber cables as per requirement.

The design recommendations and considerations for the Airport building network infrastructure which are briefly discussed herein cover the following scope of work:

- Design of Passive –Fibre Cabling in redundant mode, and in ring topology. And thereafter SITC of 12 core fibre network. SITC of Passive Components (Cat6A Cabling U/UTP or F/UTP Solution and Fiber cable solution)
- SITC of Active Components (Router in HA mode, Core Switch in HA mode, Distribution Switch in HA mode & L2 Access Switches, Firewall in HA mode, Wireless LAN Controller in HA mode & Wireless AP’s). The POE Edge Switches shall be dedicated for CCTV i.e. separate LAN segment for CCTV.
- Establishment of NOC: SITC of Enterprise Monitoring System (EMS) with required Server and (2*2) Videowalls 55” display system for EMS, in NOC). For the centrally managed, monitoring, troubleshooting & debugging the Airport IT Network.
- SITC of Server based pure IP-PBX System with distribution of IP phones should be grade wise to different levels.
- SITC of Access Control within the Airport building i.e. area in the scope of work.
- SITC of Network Access Control & AAA Server.
• One I/O Node per 15 Sq Meter covered Space or as per requirement.

• **Support:** 2 Network engineers (One of L3 Support & One of L1 Support) are required till the warranty period for 7 years.

• The key requirement for Airport campus is to design the LAN network for their building which is redundant, robust, scalable & secure. The building LAN would also be connected via redundant 10G OFC cables with the Distribution Switch and DS with core switch placed at server room with 40G. The requirements mentioned above for Airport campus also require critical applications to deliver information and data in real time. These key features may be briefly outlined as:

• **Guaranteed Application Response:** The network backbone shall ensure that there is no delay in the flow of information and data, irrespective of file size or amount of network traffic at any given point in time.

  o **Scalability:** The network shall be scalable as well as flexible so that future expansions.

  o In addition to the requirements previously mentioned, the following trends must be considered in a LAN design:

    • Energy efficient network hardware with small network footprint for ensuring lower cost of operation and Green technology that reduced carbon footprint.

    • All switches can run the same version, which helps deploy, operate and maintain your entire network and reduce operating costs.

**Design Recommendations**

• A tiered or zone based network architecture has been recommended for simplifying the design, implementation and management operations:

• **Structured Cabling:** The LAN Structured cabling should be of CAT 6A UTP / F/UTP. All user nodes of passive cabling should be on CAT 6A (10G) networks with 20 / 25 years warranty certificate. Third party test should be done for certification of Copper and Fiber nodes. Fiber cable should support 10G & 40G transmission.

• **Core Network:** The core network aggregates the connections from access network switch in a high availability configuration. The core network shall comprise of two Layer-3/4 Gigabit
Ethernet switches that are configured and deployed via 40G interconnect. These switches are high density 10G SFP switches with a non-blocking architecture.

- **Distribution Layer**: Two distribution switch will be placed in Server Room or Data Center along with Core Switches. The distribution layer is connected to core layer from one side and access layer to another side.

- **Access Network Zone**: The access network consists of 24 port and 48 port POE+ switches, which will give 1G connectivity to the end-points in the building eg. PC, laptops, network printers, access points etc, cctv, fids etc. Each location will have at least one PoE switch in each stack for connecting access points, IP phones etc, in addition to Dedicated PoE+ switch to cater CCTV requirement.

- The access switches will have min 2 10G uplink ports which will be used to connect the switches to the distribution network. In case of local connectivity among access switches, Stackable switch and stacking accessories shall be used.

- Fire wall connectivity for Internet.

- OEM Managed services for Design and Implementation of VLAN system for all user departments and group of Equipments. Implementation of IP Schema for Connectivity of network between existing Airport Infrastructure and AAI Central Data Center at Delhi.

**Core / Distribution Layer**

- The Distribution layer comprises of a set of two modular Layer-3 Ethernet switches configured to operate in a redundant cluster to which all the uplinks from Access/Edge switches, Security Gateway and Server zone switches Storage connect.

- The Core layer forms the heart of the network and is responsible for all Layer-3 forwarding within the Airport building network. Access Policies, Quality of Services to control and manage bandwidth, etc., all are applied at this Core layer.

- Wireless Controller, used for centralized control, provisioning and management of the Wireless network shall be located in the distribution / Core layer and will be connected to the Distribution / Core switches over Gigabit UTP links.

- Network Management (appliance based) for centralise monitoring and life-cycle management of the network devices shall be installed in the Core layer and will also connect to the Core switches.

**Access / Edge Layer**:

The Edge / Access layer consists of Wired & Wireless devices to which User nodes shall connect.
Wired Edge

The Layer-2 Gigabit PoE switches (24-port & 48-port) shall be deployed at this Edge/Access layer. These switches shall be up linked to the redundant distribution switches using dual 10GbE optical links.

The user-end devices like – PC / Workstation, network printers & plotters, IP-Phones, IP based Surveillance Camera’s, FIDS, and Bio-Metric Access Control System etc. shall connect to these Edge switches over CAT-6A UTP links.

Wireless Access Points shall also connect to these Edge Switches for network connectivity and for drawing PoE based power.

**SITC of following Active Networking Equipment**

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Internet Router in HA mode</td>
</tr>
<tr>
<td>2</td>
<td>Internet UTM Firewall in HA mode</td>
</tr>
<tr>
<td>3</td>
<td>Core Switch in HA mode</td>
</tr>
<tr>
<td>4</td>
<td>24 Port Distribution Switch in HA mode</td>
</tr>
<tr>
<td>5</td>
<td>48 Port Access Switch PoE+</td>
</tr>
<tr>
<td>6</td>
<td>24 Port Access Switch PoE+</td>
</tr>
<tr>
<td>7</td>
<td>Wireless Controller in HA mode</td>
</tr>
<tr>
<td>8</td>
<td>Wireless A P Indoor</td>
</tr>
<tr>
<td>9</td>
<td>SFP modules 40G, 10G as per requirement</td>
</tr>
<tr>
<td>10</td>
<td>Stacking cable with Pair Stacking module</td>
</tr>
<tr>
<td>11</td>
<td>EMS</td>
</tr>
<tr>
<td>12</td>
<td>OEM Managed Services</td>
</tr>
</tbody>
</table>
### Passive Cabling Components

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>13</td>
<td>Optical Fibre Cable 6/12 core (SM)</td>
</tr>
<tr>
<td>14</td>
<td>End to End Passive Cabling Solution as per BICSI Guidelines.</td>
</tr>
<tr>
<td>15</td>
<td>Fibre LIU Loaded</td>
</tr>
<tr>
<td>15 – a</td>
<td>Fibre Patch Cords, UTP Patch Cords</td>
</tr>
<tr>
<td>16</td>
<td>CAT 6A 4 pair UTP Cable</td>
</tr>
<tr>
<td>16 – a</td>
<td>Cat 6A UTP Patch Panels, I/O, Face Plates- Single, Double and Quad Face Plates, GI Box, as per Requirement.</td>
</tr>
<tr>
<td>17</td>
<td>12U/15U Wall mount Network Racks Server Racks fully loaded with PDUs (with required Depth.)</td>
</tr>
<tr>
<td>17 – a</td>
<td>42U Floor Mount Network Racks Server Racks fully loaded with PDUs (with required Depth.)</td>
</tr>
<tr>
<td>18</td>
<td>Covered Cable Try, Raceways &amp; Cancelled Conduit, HDPE pipe and accessories</td>
</tr>
</tbody>
</table>

### Server Room Equipment

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>19</td>
<td>Network &amp; Server Racks with PDU</td>
</tr>
<tr>
<td>20</td>
<td>Servers for Applications.</td>
</tr>
<tr>
<td>21</td>
<td>Modular UPS with half an Hour Battery Back up</td>
</tr>
<tr>
<td>22</td>
<td>Precision Air Cooling System</td>
</tr>
<tr>
<td>23</td>
<td>Access Control</td>
</tr>
<tr>
<td>24</td>
<td>CCTV for Server Room</td>
</tr>
<tr>
<td>25</td>
<td>FSAS, Gas Suppression System</td>
</tr>
<tr>
<td>26</td>
<td>Anti Rodent</td>
</tr>
<tr>
<td>27</td>
<td>WLD</td>
</tr>
</tbody>
</table>
NOC Room Equipment

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>29</td>
<td>VW Displays (2X2) 55” or higher</td>
</tr>
<tr>
<td>30</td>
<td>Server for EMS solution</td>
</tr>
<tr>
<td>31</td>
<td>EMS for monitoring and management of network</td>
</tr>
<tr>
<td>32</td>
<td>Room shuld have minimum 4 seating arrangement as per industry standards</td>
</tr>
</tbody>
</table>

Access Control System

The detailed specification and scope of work is mentioned in Access Control System Package
### TECHNICAL SPECIFICATIONS

**Router for Terminal Building and ATC cum Technical Block**

<table>
<thead>
<tr>
<th>S. No</th>
<th>Generic Requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>The Router should support modular architecture, multi-core Processor, internal redundant field replaceable power supply (from Day1). The Router Should have capabilities to seamless field upgrade/replacement (without interrupting running processes and services) for modular interfaces.</td>
</tr>
<tr>
<td>2</td>
<td>Router should have 4 x 1G SFP/Base-T (combo or dedicated) port.</td>
</tr>
<tr>
<td>3</td>
<td>The Router should support interfaces supported by router like Channelized E1/T1, V.35, G.703, LTE, Gigabit and 10G Ethernet modules to accommodate field upgrades without rebooting the router.</td>
</tr>
<tr>
<td>4</td>
<td>The Router should have 4 empty slot for future use</td>
</tr>
<tr>
<td>5</td>
<td>Router should have minimum 6 GB of on-board/inbuilt DRAM/RAM for data plane + control plane processes and 2 GB Flash from Day 1. Should support expandability for 8 DRAM and 4 GB Flash.</td>
</tr>
<tr>
<td>6</td>
<td>The router must support IKEv1, IKEv2, GRE and IPSEC from day 1. The proposed solution in AAI should serve the GRE encryption for traffic from any location to other location on demand and also should able to create GRE tunnel with existing core router at SHQ.</td>
</tr>
<tr>
<td>7</td>
<td>Router should support 1000 K IPv4 and IPv6 routes, with 4000 GRE and IPSEC tunnel.</td>
</tr>
<tr>
<td>8</td>
<td>The router should support 1.6 Gbps of IPSEC Bandwidth, in case required in the future</td>
</tr>
<tr>
<td>9</td>
<td>Router should support IGMP v1/v2/v3 and PIM multicast routing</td>
</tr>
<tr>
<td>10</td>
<td>Router should support static Routes, OSPFv2, OSPFv3, BGP4, MBGP, BFD, Policy based routing, IPv4 and IPv6 tunnelling</td>
</tr>
<tr>
<td>11</td>
<td>The Router should support Zone Based Firewall feature or an external appliance for the same functionality can be provided.</td>
</tr>
<tr>
<td>12</td>
<td>Router should Support Traffic Optimization feature built in the router operating system or an external appliance for the same functionality can be provided.</td>
</tr>
<tr>
<td>13</td>
<td>Shall have 802.1p class of service and marking, classification, policing and shaping.</td>
</tr>
<tr>
<td>14</td>
<td>Router should support SSHv2, SNMPv2c, SNMPv3 and NTP</td>
</tr>
</tbody>
</table>
15. Routers should support AAA using RADIUS and TACACS+

16. Should have extensive support for IP SLA and best path selection for metrics like delay, latency, jitter, packet loss to assure business-critical IP applications from Day1.

17. The router should support cRTP to compress voice (RTP) streams

18. Router should support monitoring of network traffic with application level insight with deep packet visibility into web traffic, RTP-Based VoIP traffic.

19. Router should have traffic load balancing capability on dual WAN Links based on based on advanced criteria, such as reachability, delay, loss, jitter and bandwidth utilization.

20. Router shall have capability to add on demand IPSec VPN tunnels dynamically established multipoint-to-multipoint IPSEC based spoke-to-spoke VPN tunnels matching traffic conditions

21. Router shall conform to UL 60950 or IEC 60950 or CSA 60950 or EN 60950 Standards for Safety requirements of Information Technology Equipment.

22. Router shall conform to EN 55022 Class A/B or CISPR22 Class A/B or CE Class A/B or FCC Class A/B Standards for EMC (Electro Magnetic Compatibility) requirements.

23. Router/Router’s Operating System should be tested and certified for EAL 3/NDPP or above under Common Criteria Certification

24. Router should be IPv6 Certified/IPv6 logo ready

### Internet Firewall for Terminal Building

<table>
<thead>
<tr>
<th>S. No</th>
<th>Generic Requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>The UTM/NGFW solution should be hardware based and should not be proprietary ASIC based in nature. Should be open architecture based on multi-core CPU’s to protect &amp; scale against dynamic latest security threats.</td>
</tr>
<tr>
<td>2</td>
<td>The appliance hardware should be a multicore CPU architecture with a hardened 64-bit operating system to support higher memory.</td>
</tr>
<tr>
<td>3</td>
<td>UTM/Firewall should have minimum 128 GB RAM and 8 GB Flash from day 1</td>
</tr>
<tr>
<td>4</td>
<td>Should support 1:1 high availability and stateful failover.</td>
</tr>
<tr>
<td>5</td>
<td>Should have minimum 4 x 10G supporting SFP+ interfaces ports to cater to connectivity from multiple service providers via routers. The firewall should support of 1G, 10G and 40G.</td>
</tr>
<tr>
<td></td>
<td>Description</td>
</tr>
<tr>
<td>---</td>
<td>-------------</td>
</tr>
<tr>
<td>6</td>
<td>The Firewall should support IPSEC &amp; SSL VPN, inbound and outbound both. The IPSEC VPN should deliver at least 5 Gbps throughput to ensure connectivity with catering to Data / Voice traffic over IPSEC tunnel.</td>
</tr>
<tr>
<td>7</td>
<td>The Firewall should be able to handle very high concurrent sessions like 10 Million or above and at least 150,000 of new sessions per second.</td>
</tr>
<tr>
<td>8</td>
<td>The proposed solution should have integrated IPS module with at least 10Gbps of throughput for deep pack inspection of traffic and also should be able to inspect encrypted SSL traffic.</td>
</tr>
<tr>
<td>9</td>
<td>The solution should have at least 10 Gbps of Threat Protection throughput and the so that the entire traffic is scanned before reaching the end user. NGFW/UTM should be able to inspect the encrypted traffic like HTTPS, SMTPS, POP3s, IMAPs, FTPs etc.</td>
</tr>
<tr>
<td>10</td>
<td>Should support more than 3000 (excluding custom application signatures) distinct application signature as application detection mechanism to optimize security effectiveness.</td>
</tr>
<tr>
<td>11</td>
<td>The solution must be capable of passively gathering details unique to mobile devices traffic to identify a wide variety of mobile operating systems, mobile applications and associated mobile device hardware.</td>
</tr>
<tr>
<td>12</td>
<td>The device should be able to identify attacks based on Geo-location and define policy on the basis of Geo-location.</td>
</tr>
<tr>
<td>13</td>
<td>The proposed system should have integrated Web Content Filtering solution which can be used to block any unwanted sites / category of sites to adhere to Convention Centre’s IT guidelines.</td>
</tr>
<tr>
<td>14</td>
<td>Firewall should support creating access-rules with IPv4 and IPv6 objects simultaneously.</td>
</tr>
<tr>
<td>15</td>
<td>The proposed system should have modules/Licenses for integrated Web Content Filtering along with IPS, Application Control, Malware Protection and Spam blocking facility. The solution should have dedicated Sandboxing appliance for the same.</td>
</tr>
<tr>
<td>16</td>
<td>EPC Contractor to proposed dedicated Management appliance for managing the Firewall/UTM with at least 2x10 G ports with highly customizable dashboard. The management platform must provide multiple report output types or formats, such as PDF, HTML, and CSV. The management platform must provide centralized logging and reporting functionality.</td>
</tr>
<tr>
<td>17</td>
<td>UTM/NGFW / UTM/NMFW’s’s Operating System should be tested and certified for EAL4/NDPP or above under Common Criteria Certification or FIPS Level-2 Certification or equivalent.</td>
</tr>
<tr>
<td>18</td>
<td>UTM/NGFW should be IPv6 Certified/IPv6 logo ready/USGv6.</td>
</tr>
<tr>
<td>19</td>
<td>Switch shall conform to UL 60950 or IEC 60950 or CSA 60950 or EN 60950 Standards for Safety requirements of Information Technology Equipment.</td>
</tr>
<tr>
<td>20</td>
<td>Switch shall conform to EN 55022 Class A/B or CISPR22 Class A/B or CE Class A/B or FCC Class A/B Standards for EMC (Electro Magnetic Compatibility) requirements.</td>
</tr>
<tr>
<td>S. No</td>
<td>Generic Requirements</td>
</tr>
<tr>
<td>-------</td>
<td>----------------------</td>
</tr>
<tr>
<td>20</td>
<td>Should have direct OEM 24x7x365 TAC support and hardware replacement warranty for 7 Years.</td>
</tr>
</tbody>
</table>

### Core Switch/ Distribution Switch - L3 for Terminal Building

<table>
<thead>
<tr>
<th>S. No</th>
<th>Generic Requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Switch OEM should be in the Gartner’s Leaders quadrant for Wired and Wireless LAN Access Infrastructure published in 2017 or later</td>
</tr>
<tr>
<td>2</td>
<td>Switch should be Chassis based, with minimum 48 no. of 10 Gig SFP+ ports, 24 nos. 10/100/1000 Base-T ports, additional 2 nos. of 40 Gig QSFP + ports or 4x10G SFP+ in future. Switch should be provided with redundant supervisor engine (control, management and forwarding engine) from day-1. Switch should have at least two additional slots for future expansion after equipping Day-1 requirement.</td>
</tr>
<tr>
<td>3</td>
<td>Switching system shall have minimum 1.2 Tbps of switching fabric and minimum 900 Mpps of forwarding rate.</td>
</tr>
<tr>
<td>4</td>
<td>Switch should have hot swappable 1:1 redundant internal power supply.</td>
</tr>
<tr>
<td>5</td>
<td>Power supply, fan modules and modules should be hot swappable.</td>
</tr>
<tr>
<td>6</td>
<td>Switching system shall have minimum 60K MAC Addresses and 4K active VLANs.</td>
</tr>
<tr>
<td>7</td>
<td>Switch should support minimum 2K ACLs, 4K Multicast and 32K Unicast Routes for IPv4 and IPv6.</td>
</tr>
<tr>
<td>8</td>
<td>Should support IEEE Standards of Ethernet: IEEE 802.1D, 802.1s, 802.1w, 802.1x, 802.3ad, 802.3x, 802.1p, 802.1Q, 802.3, 802.3u, 802.3ab, 802.3z and 802.1AE 256 MACsec encryption.</td>
</tr>
<tr>
<td>9</td>
<td>Should have static routing, Rip, Rip-ng OSPF, OSPFv3, BGP, VRRP for IPv6/VRRPv3, VRF (Virtual routing and forwarding), MPLS, IGMP v1/v2/v3 and PIM multicast routing.</td>
</tr>
<tr>
<td>10</td>
<td>Shall have 802.1p class of service, marking, classification, policing and shaping. Should support strict priority queuing.</td>
</tr>
</tbody>
</table>

### Core Switch - L3 forATC cum TechnicalBlock

<table>
<thead>
<tr>
<th>S.No</th>
<th>Generic Requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Switch OEM should be in the Gartner’s Leaders for Wired and Wireless LAN Access Infrastructure published in 2017 or later</td>
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</table>
Switch should be Chassis based, with minimum 48 no. of 10 Gig SFP+ ports, 24 nos. 10/100/1000 Base-T ports, additional 2 nos. of 40 Gig QSFP + ports or 4x10G SFP+ in future. Switch should be provided with redundant supervisor engine (control, management and forwarding engine) from day-1. Switch should have at least two additional slots for future expansion after equipping Day-1 requirement.

Switching system shall have minimum 1.2 Tbps of switching fabric and minimum 900 Mpps of forwarding rate.

Switch should have hot swappable 1:1 redundant internal power supply.

Power supply, fan modules and modules should be hot swappable.

Switching system shall have minimum 60K MAC Addresses and 4K active VLANs.

Switch should support minimum 2K ACLs, 4K Multicast and 32K Unicast Routes for IPv4 and IPv6.

Should support IEEE Standards of Ethernet: IEEE 802.1D, 802.1s, 802.1w, 802.1x, 802.3ad, 802.3x, 802.1p, 802.1Q, 802.3u, 802.3ab, 802.3z and 802.1AE 256 MACsec encryption.

Should have static routing, Rip, Rip-ng OSPF, OSPFv3, BGP, VRRP for IPv6/VRRPv3, VRF (Virtual routing and forwarding), MPLS, IGMP v1/v2/v3 and PIM multicast routing.

Shall have 802.1p class of service, marking, classification, policing and shaping. Should support strict priority queuing.

<table>
<thead>
<tr>
<th>S. No</th>
<th>Generic Requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Switch should be 1RU with minimum 24 no. of 10 Gig SFP+ ports and 4x40G/100G with 2 numbers 40G QSFP28 upgradable should be support.</td>
</tr>
<tr>
<td>2</td>
<td>The switch should support stacking or Virtual stack technologies to create two Switches as a one Virtual switch</td>
</tr>
<tr>
<td>3</td>
<td>Switching system shall have minimum 1.2Tbps of switching bandwidth and minimum 800 Mpps of forwarding rate.</td>
</tr>
<tr>
<td>4</td>
<td>Switch should have hot swappable 1:1 redundant internal power supply.</td>
</tr>
<tr>
<td>5</td>
<td>Power supply, fan modules and interface modules should be hot swappable.</td>
</tr>
<tr>
<td></td>
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</tr>
<tr>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>Switching system shall have minimum 60K MAC Addresses and 4K active VLANs.</td>
<td></td>
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<td>Switch should support minimum 2K ACLs, 4K Multicast and 32K Unicast Routes for IPv4 and IPv6.</td>
<td></td>
</tr>
<tr>
<td>Should support IEEE Standards of Ethernet: IEEE 802.1D, 802.1s, 802.1w, 802.1x, 802.3ad, 802.3x, 802.1p, 802.1Q, 802.3, 802.3u, 802.3ab, 802.3z.</td>
<td></td>
</tr>
<tr>
<td>Should have static routing, Rip, Rip-ng OSPF, OSPFv3, BGP, VRRP for IPv6/VRRPv3, VRF (Virtual routing and forwarding), MPLS, IGMP v1/v2/v3 and PIM multicast routing.</td>
<td></td>
</tr>
<tr>
<td>Shall have 802.1p class of service, marking, classification, policing and shapin. Should support strict priority queuing.</td>
<td></td>
</tr>
<tr>
<td>Switch should support management features like SSHv2, SNMPv2c, SNMPv3, NTP, RADIUS and TACACS+.</td>
<td></td>
</tr>
</tbody>
</table>

### 48 Port Access Switch for Terminal Building and ATC cum Technical Block

<table>
<thead>
<tr>
<th>S. No</th>
<th>Generic Requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Switch should be 1RU with minimum 48 nos. 10/100/1000 Base-T ports with PoE+ capability and minimum 1440W of PoE/POE+ Power and 4 nos. SFP+ uplinks ports loaded with 2 nos. of LR module from day 1.</td>
</tr>
<tr>
<td>2</td>
<td>Switch should support slot/ports (excluding uplinks) for minimum 80 Gbps of stacking bandwidth with dedicated stacking ports and cables with minimum 8 switch in stack.</td>
</tr>
<tr>
<td>3</td>
<td>Switch should support field replaceable internal redundant power supply.</td>
</tr>
<tr>
<td>4</td>
<td>Switch shall have minimum 176 Gbps of switching bandwidth and 130 Mpps of forwarding rate.</td>
</tr>
<tr>
<td>5</td>
<td>Shall have minimum 16K MAC Addresses and 512 active VLANs.</td>
</tr>
<tr>
<td>6</td>
<td>Should support IEEE Standards of Ethernet: IEEE 802.1D, 802.1s, 802.1w, 802.3ad, 802.3x, 802.1p, 802.1Q, 802.3, 802.3u, 802.3ab, 802.3z.</td>
</tr>
<tr>
<td>7</td>
<td>Shall have 802.1p class of service, marking, classification, policing and shaping. Should support strict priority queuing.</td>
</tr>
<tr>
<td>8</td>
<td>Switch should support management features like SSHv2, SNMPv2c, SNMPv3, NTP, RADIUS and TACACS+.</td>
</tr>
<tr>
<td>9</td>
<td>Switch should support port security, MACSEC, DHCP snooping, Dynamic ARP inspection, IP Source guard, BPDU Guard, Spanning tree root guard.</td>
</tr>
<tr>
<td>S.No</td>
<td>Generic Requirements</td>
</tr>
<tr>
<td>------</td>
<td>--------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>10</td>
<td>Switch should have L3 functionality like static routing, RIP, PIM, OSPF and PBR from Day1</td>
</tr>
<tr>
<td>11</td>
<td>Switch should support IPv6 neighbour Binding, IPv6 Snooping, IPv6 RA Guard, IPv6 DHCP Guard, IPv6 Neighbour Discovery and IPv6 Source Guard.</td>
</tr>
<tr>
<td>12</td>
<td>Should support 802.1x authentication and accounting, IPv4 and IPv6 ACLs and Dynamic VLAN assignment.</td>
</tr>
<tr>
<td>13</td>
<td>Switch shall support application visibility and traffic monitoring with minimum 16 K netFlow/sFlow/jFlow entries.</td>
</tr>
<tr>
<td>14</td>
<td>Switch shall conform to UL 60950 or IEC 60950 or CSA 60950 or EN 60950 Standards for Safety requirements of Information Technology Equipment.</td>
</tr>
<tr>
<td>15</td>
<td>Switch shall conform to EN 55022 Class A/B or CISPR22 Class A/B or CE Class A/B or FCC Class A/B Standards for EMC (Electro Magnetic Compatibility) requirements.</td>
</tr>
<tr>
<td>16</td>
<td>Switch / Switch’s Operating System should be tested and certified for EAL 2/NDPP or above under Common Criteria Certification.</td>
</tr>
<tr>
<td>17</td>
<td>Switch should be IPv6 Certified/IPv6 logo ready.</td>
</tr>
</tbody>
</table>

### 24 Port Access Switch for Terminal Building and ATC cum Technical Block

<table>
<thead>
<tr>
<th>S.No</th>
<th>Generic Requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Switch should be 1RU with minimum 24 nos. 10/100/1000 Base-T ports with PoE+ capability and minimum 740W of PoE/POE+ Power and 4 nos. SFP+ uplinks ports loaded with 2 nos. of LR module from day 1.</td>
</tr>
<tr>
<td>2</td>
<td>Switch should support slot/ports(excluding uplinks) for minimum 80 Gbps of stacking bandwidth with dedicated stacking ports and cables with minimum 8 switch in stack.</td>
</tr>
<tr>
<td>3</td>
<td>Switch should support field replaceable internal redundant power supply.</td>
</tr>
<tr>
<td>4</td>
<td>Switch shall have minimum 128 Gbps of switching bandwidth and 95 Mpps of forwarding rate.</td>
</tr>
<tr>
<td>5</td>
<td>Shall have minimum 16 K MAC Addresses and 512 active VLANs.</td>
</tr>
<tr>
<td>6</td>
<td>Should support IEEE Standards of Ethernet: IEEE 802.1D, 802.1s, 802.1w, 802.3az, 802.1x, 802.3ad, 802.3x, 802.1p, 802.1Q, 802.3, 802.3u, 802.3ab, 802.3z.</td>
</tr>
<tr>
<td>7</td>
<td>Shall have 802.1p class of service, marking, classification, policing and shaping. Should support strict priority queuing.</td>
</tr>
<tr>
<td></td>
<td>Requirement</td>
</tr>
<tr>
<td>---</td>
<td>--------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>8</td>
<td>Switch should support management features like SSHv2, SNMPv2c, SNMPv3, NTP, RADIUS and TACACS+.</td>
</tr>
<tr>
<td>9</td>
<td>Switch should support port security, MACSEC, DHCP snooping, Dynamic ARP inspection, IP Source guard, BPDU Guard, Spanning tree root guard.</td>
</tr>
<tr>
<td>10</td>
<td>Switch should have L3 functionality like static routing, RIP, PIM, OSPF and PBR from Day1.</td>
</tr>
<tr>
<td>11</td>
<td>Switch should support IPv6 neighbour Binding, IPv6 Snooping, IPv6 RA Guard, IPv6 DHCP Guard, IPv6 Neighbour Discovery Inspection and IPv6 Source Guard.</td>
</tr>
<tr>
<td>12</td>
<td>Should support 802.1x authentication and accounting, IPv4 and IPv6 ACLs and.</td>
</tr>
<tr>
<td>13</td>
<td>Switch shall support application visibility and traffic monitoring with minimum 16 K netFlow/sflow/jFlow entries.</td>
</tr>
<tr>
<td>14</td>
<td>Switch shall conform to UL 60950 or IEC 60950 or CSA 60950 or EN 60950 Standards for Safety requirements of Information Technology Equipment.</td>
</tr>
<tr>
<td>15</td>
<td>Switch shall conform to EN 55022 Class A/B or CISPR22 Class A/B or CE Class A/B or FCC Class A/B Standards for EMC (Electro Magnetic Compatibility) requirements.</td>
</tr>
<tr>
<td>16</td>
<td>Switch / Switch’s Operating System should be tested and certified for EAL 2/NDPP or above under Common Criteria Certification.</td>
</tr>
<tr>
<td>17</td>
<td>Switch should be IPv6 Certified/IPv6 logo ready.</td>
</tr>
</tbody>
</table>

**WIRELESS LAN CONTROLLER for Terminal Building and ATC cum Technical Block**

<table>
<thead>
<tr>
<th>S. No</th>
<th>Generic Requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Must be compliant with IEEE CAPWAP or equivalent IETF standard for controller-based WLANs.</td>
</tr>
<tr>
<td>2</td>
<td>WLAN Controller should have license for asked access points in a single 1 RU chassis from day 1. Controller should be scalable to minimum 150 AP in same hardware and minimum 3000 clients.</td>
</tr>
<tr>
<td>3</td>
<td>WLAN controller must have at least 4 x 10/100/1000 Base-T auto sensing uplink interfaces.</td>
</tr>
<tr>
<td>4</td>
<td>Should have minimum 2 Gbps Encrypted throughput. DES, 3DES/AES based encryption.</td>
</tr>
<tr>
<td>5</td>
<td>Must support 1:1 redundancy model</td>
</tr>
<tr>
<td>6</td>
<td>Must support an ability to dynamically adjust channel and power settings based on the RF environment</td>
</tr>
<tr>
<td>No.</td>
<td>Requirement</td>
</tr>
<tr>
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</tr>
<tr>
<td>7</td>
<td>Must support coverage hole detection and correction that can be adjusted on a per WLAN basis.</td>
</tr>
<tr>
<td>8</td>
<td>WLC should support L2 and L3 roaming of IPv6 clients.</td>
</tr>
<tr>
<td>9</td>
<td>WLC should support First hop security features in IPv6 network like Router Advertisement guard, DHCPv6 guard.</td>
</tr>
<tr>
<td>10</td>
<td>WLC should support IPv6 access control lists and guest-access functionality for IPv6 clients.</td>
</tr>
<tr>
<td>11</td>
<td>Should adhere to the strictest level of security standards, including 802.11i, WPA2, WPA, 802.1X with multiple Extensible Authentication Protocol (EAP) types, PEAP, EAP-TLS, EAP-TTLS.</td>
</tr>
<tr>
<td>12</td>
<td>Should support Management frame protection for the authentication of 802.11 management frames by the wireless network infrastructure.</td>
</tr>
<tr>
<td>13</td>
<td>Controller should have rogue AP detection, classification and automatic containment feature.</td>
</tr>
<tr>
<td>14</td>
<td>Controller should be able to detect attacks like detect management frame impersonation, mac address spoofing, Detect Internet sharing, Detect adhoc connection from day 1 for all access points.</td>
</tr>
<tr>
<td>15</td>
<td>Should provide a snapshot of Air quality/RF in terms of the performance and impact of interference on the wireless network identifying the problem areas.</td>
</tr>
<tr>
<td>16</td>
<td>Should provide real-time charts showing interferers on a per-radio, per-channel basis.</td>
</tr>
<tr>
<td>17</td>
<td>Must support 802.11e and WMM.</td>
</tr>
<tr>
<td>18</td>
<td>Should have Voice and Video Call Admission and Stream prioritization for preferential QOS.</td>
</tr>
<tr>
<td>19</td>
<td>To deliver optimal bandwidth usage, reliable multicast must use single session between AP and Wireless Controller.</td>
</tr>
</tbody>
</table>

**WIRELESS ACCESS POINT (INDOOR) for Terminal Building and ATC cum Technical Block**

<table>
<thead>
<tr>
<th>S. No</th>
<th>Generic Requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Access Points proposed must include radios for 2.4 GHz and 5 GHz with 802.11ac Wave 2. Access Point must have controller functionality to control minimum 15 access points on same LAN.</td>
</tr>
<tr>
<td>2</td>
<td>Must have a robust design for durability, without visible vents.</td>
</tr>
</tbody>
</table>
Mounting kit should be standard from OEM directly.

Must support 4x4 multiple-input multiple-output (MiMo) with four spatial streams

Must support data rates Up to 450 Mbps on 802.11n and 1.3 Gbps on 802.11ac on 5 GHz

Must support up to 22dbm of transmit power in both 2.4Ghz and 5Ghz radios.

Must have 2 nos. of 10/100/1000 Base-T (least one with PoE/PoE+ powering) port and one management console port.

Must have minimum 16 SSIDs.

Should support detecting wireless interferences

Should support Radio resource management for optimum wireless performance.

Must operate as a sensor for wireless IPS.

Access Points must support a distributed encryption/decryption model.

Must be plenum-rated (UL2043).

Should support 802.11e and WMM.

### 40G QSFP MODULES for Terminal Building and ATC cum Technical Block

<table>
<thead>
<tr>
<th>S.No</th>
<th>Generic Requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Connector types LC / MPO12</td>
</tr>
<tr>
<td>2</td>
<td>40G Base-LR / 40G Base-SR</td>
</tr>
<tr>
<td>3</td>
<td>Support 40 Gbps up to 10 KM on SMF / up to 150 M on MMF</td>
</tr>
<tr>
<td>4</td>
<td>Should be from same OEM of switches.</td>
</tr>
</tbody>
</table>

### 10G SFP+ MODULES for Terminal Building and ATC cum Technical Block

<table>
<thead>
<tr>
<th>S.No</th>
<th>Generic Requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Connector types LC</td>
</tr>
<tr>
<td>2</td>
<td>10G Base-LR / 10G Base-SR</td>
</tr>
</tbody>
</table>
Support 10 Gbps up to 10 KM on SMF / up to 300 M on MMF

Should be from same OEM of switches.

### Stacking cable with Pair Module for Terminal Building and ATC cum Technical Block

<table>
<thead>
<tr>
<th>S.No</th>
<th>Generic Requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Minimum 48 Gbps of stacking bandwidth with dedicated stacking ports and cables with minimum 8 switch in stack.</td>
</tr>
<tr>
<td>2</td>
<td>Should be from same OEM of switches.</td>
</tr>
</tbody>
</table>

### Enterprise Monitoring System (EMS) for Terminal Building and ATC cum Technical Block

<table>
<thead>
<tr>
<th>S.No</th>
<th>General Features</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>The solution should be scalable to monitor &amp; manage more than 10000 devices and minimum 3 reference case studies should be provided. The management platform should have fault monitoring, Configuration management, Performance monitoring, User management functionality</td>
</tr>
<tr>
<td>2</td>
<td>The solution should be capable of running in Linux platform with open source database as backend</td>
</tr>
<tr>
<td>3</td>
<td>EPC Contractor to provide software and hardware for managing Wired and wireless devices. The management platform should be in 1+1 HA mode.</td>
</tr>
<tr>
<td>4</td>
<td>Both IPv4 and IPv6 supported for monitoring</td>
</tr>
<tr>
<td>5</td>
<td>Provides multiple user specific dashboards and personalized views in web GUI</td>
</tr>
<tr>
<td>6</td>
<td>Server for application with OS and required License.</td>
</tr>
</tbody>
</table>
OEM managed Services for Terminal Building and ATC cum Technical Block

As per requirement for various services like Design, vetting of installation and configuration, creation of VLANs, implementation of IP schema, proper documentation etc.

Passive Components

<table>
<thead>
<tr>
<th>S.No</th>
<th>Generic Requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>6 &amp; 12 core OFC, Multi tube, double HDPE Sheath, Single Mode Cable</td>
</tr>
<tr>
<td>2</td>
<td>(Fiber Optic Cable: ISO/IEC-1180, 9/125μ, OS2 Outdoor, AS PER ITU/T 652D/ UL Listed. BELLCORE GR 20 / IEC 794-1, Qualifies as per ICEA-640,</td>
</tr>
<tr>
<td>3</td>
<td>Gel-Filled Outdoor Cable is tested in accordance with Telcordia GR-20. RoHS Compliance, Corrugated Steel tape Armor</td>
</tr>
<tr>
<td>4</td>
<td>The Tensile rating: 2600 N, The Crush Resistance: 3000 N; The Attenuation be 0.34dB/km @ 1310nm and .22dB/km @ 1550nm.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>S.No</th>
<th>Generic Requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>12F, 1U, LC SM, with Pigtail, loaded with Splice tray &amp; Couplers &amp; Splice Protectors (Fiber Optic LC style fully loaded Patch Panel (FOPP), Pigtauls shall comply: G.652.D, G.657.A1 and OS2</td>
</tr>
<tr>
<td>2</td>
<td>19&quot; Rack Mount with min 12 nos. of OS2 9/125μ Pigtauls).</td>
</tr>
<tr>
<td>3</td>
<td>Metal/Alloy housing, fully powder coated, Splice tray and cable spools, grooves for fixing splice protective sleeves (inbuilt or additionally). No. of OSP Cables for termination Minimum 2</td>
</tr>
<tr>
<td>4</td>
<td>1 Nos. of Earthing lugs (inbuilt or additionally), pre-loaded Front and rear cable management rings, 6-port / 12 Port adapter plates.</td>
</tr>
</tbody>
</table>
### Fibre/UTP Patch Cord for Terminal Building and ATC cum Technical Block

<table>
<thead>
<tr>
<th>S.No</th>
<th>Generic Requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>LC-LC Style Single mode, LSZH, Sheath, Duplex Patch Cord, 3 &amp; 5 Meter Fiber Optic Patch Cable (LC-LC), 1/2/3 Mtrs. Long, ISO/IEC-11801-OS2 9μ Duplex,</td>
</tr>
<tr>
<td>2</td>
<td>RoHS compliant fiber optic patch cords shall include simplex or duplex LC, SC connectors on both ends.</td>
</tr>
<tr>
<td>3</td>
<td>Cable Shall comply ANSI/ICEA S-83-596 and Telcordia GR-409</td>
</tr>
</tbody>
</table>

### Cat 6A , U/UTP Cable Box -305 Mtrs. for Terminal Building and ATC cum Technical Block

<table>
<thead>
<tr>
<th>S.No</th>
<th>Generic Requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>4-pair, Cat 6A UTP Cable, Channel performance up to 500 MHz or more, Category-6A with 4 connector.23 AWG bare solid copper</td>
</tr>
<tr>
<td>3</td>
<td>Worst Case Cable Skew: 45 nsec/100 meters Characteristic Impedence: 100±6 Ω@ 1-500 MHz DC Resistance Max: 7.61 Ohms/100m, LSZH</td>
</tr>
<tr>
<td>4</td>
<td>Sheath Fire retardant PVC Compound (FRPVC) Flame Rating : 60 deg. C As per UL 1685 CM, LSZH, Operational Temp: -20º to 60º</td>
</tr>
<tr>
<td>5</td>
<td>PAIRS with Standard Color Code &amp; length: 305 Mtrs (1000 ft.),</td>
</tr>
</tbody>
</table>

### Cat 6A UTP Information Outlet with Faceplate & Box for Terminal Building and ATC cum Technical Block

<table>
<thead>
<tr>
<th>S.No</th>
<th>Generic Requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Cat 6A UTP Jack PCB based Information Outlet (I/O) RJ45, TIA-568 C.2 Category-6A. UL Listed</td>
</tr>
<tr>
<td>2</td>
<td>High-impact, flame-retardant, UL- RATED 94v 0 thermoplastic – ABS</td>
</tr>
<tr>
<td>3</td>
<td>Contact Resistance: 100milli ohms; Insulating resistance 500 Mega ohms minimum ;Current Rating : 1.5 A (max) , Contact : 50u&quot; gold over 100u&quot; nickel)</td>
</tr>
<tr>
<td>4</td>
<td>Meets and exceeds ISO/IEC 11801:2002 Category 6 ,EIA/TIA 568-C.2 Category 6A ROHS compliant</td>
</tr>
</tbody>
</table>
5. Single Port / Dual Port Faceplate of size 3x3. Material should be ABS/UL94 V-0 with spring shutter. Faceplates shall accept all Modules for UTP, STP, fiber-optic, and audio/video applications.

---

<table>
<thead>
<tr>
<th>Wall Mount 15U/12U Rack for Terminal Building and ATC cum Technical Block</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>S.No</strong></td>
</tr>
<tr>
<td>1</td>
</tr>
<tr>
<td>2</td>
</tr>
<tr>
<td>3</td>
</tr>
<tr>
<td>4</td>
</tr>
</tbody>
</table>

---

<table>
<thead>
<tr>
<th>Floor Mount Network 42U Rack for Terminal Building and ATC cum Technical Block</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>S.No</strong></td>
</tr>
<tr>
<td>1</td>
</tr>
<tr>
<td>2</td>
</tr>
<tr>
<td>3</td>
</tr>
<tr>
<td>4</td>
</tr>
<tr>
<td>5</td>
</tr>
</tbody>
</table>
### Covered Cable Tray, Raceways & Concealed Conduiting, HDPE pipe and accessories for Terminal Building and ATC cum Technical Block

<table>
<thead>
<tr>
<th>S. No</th>
<th>Generic Requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>AS Per Site Requirement &amp; Best Practices Adopted</td>
</tr>
</tbody>
</table>

**Server Room Components**

### Servers Rack for Terminal Building and ATC cum Technical Block

<table>
<thead>
<tr>
<th>S. No</th>
<th>Generic Requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Modularity and Scalability, conforms to DIN 41494, Load rating go 850 Kgs, Aluminum and CRCA construction, depth: 800mm</td>
</tr>
<tr>
<td>2</td>
<td>Door Steel 800W, 42 U, Perforated with Hex Perforation.</td>
</tr>
<tr>
<td>3</td>
<td>Castor Ft Brake 100Kg.</td>
</tr>
<tr>
<td>4</td>
<td>Fan housing Unit with 4 Fans 90CFM 230VAC</td>
</tr>
<tr>
<td>5</td>
<td>PDU 5x15AMP with 10 Socket, Earthing Kit</td>
</tr>
</tbody>
</table>

### Servers for Terminal Building and ATC cum Technical Block

<table>
<thead>
<tr>
<th>S. No</th>
<th>Generic Requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>As per requirement &amp; Best Practices Adopted</td>
</tr>
</tbody>
</table>

### 30 kW Modular UPS with Accessories for Terminal Building and ATC cum Technical Block

<table>
<thead>
<tr>
<th>S. No</th>
<th>Generic Requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>UPS Capacity: 20/30 kVA.</td>
</tr>
<tr>
<td>2</td>
<td>Power Factor should be Unity i.e. kVA=kW for Temperature under 30 Deg C (UPS Room Temperature will be maintained under 30Deg C). In case the EPC Contractor does not comply, next higher rating shall be provided to meet 20/30 kW.</td>
</tr>
</tbody>
</table>
3. PCBs inside the UPS Cabinets shall be provided with Conformal Coating.

4. User Replaceable Dust Filter with each UPS Cabinet shall be provided.

5. For doing Performance Test UPS should have inbuilt Smart Power Testing capabilities to test UPS at 100% Load without the external Load Bank, but In-case the feature is not available, EPC Contractor need to consider 100m of cable for each rating of UPS along with 100% Load Bank along with Input/output MCCBs.

6. UPS EPC Contractor to provide Waveform Capturing devices as a separate or built in within the UPS for Fault Analysis i.e. Root Cause Analysis.

7. AC-AC Efficiency in Double Conversion Mode of Operation: Up to 96%.

   Overload Capacity at Output should be: 110% for 60 minutes, 125% for 10 minutes, 150% for 1 minute and Overload capacity at Bypass should be: 125% - Continuous, 150% for 1 minute. Incase EPC Contractor does not meet the Overload Capability among any of the above 3 Percentage Loadings, next Higher Rating shall be proposed.

8. Input, Output & Bypass Breakers shall be provided in the UPS Cabinet itself along with the EPO i.e. Emergency Power Off switch.

---

### 10 kW Modular UPS with Accessories for ATC cum Technical Building

<table>
<thead>
<tr>
<th>S.No</th>
<th>Generic Requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>UPS Capacity: 10 kVA. With 30 minutes backup</td>
</tr>
<tr>
<td>2</td>
<td>Power Factor should be Unity i.e. kVA=kW for Temperature under 30 Deg C (UPS Room Temperature will be maintained under 30Deg C). In case the EPC Contractor does not comply, next higher rating shall be provided to meet 10kW.</td>
</tr>
<tr>
<td>3</td>
<td>PCBs inside the UPS Cabinets shall be provided with Conformal Coating.</td>
</tr>
<tr>
<td>4</td>
<td>User Replaceable Dust Filter with each UPS Cabinet shall be provided.</td>
</tr>
<tr>
<td>5</td>
<td>For doing Performance Test UPS should have inbuilt Smart Power Testing capabilities to test UPS at 100% Load without the external Load Bank, but In-case the feature is not available, EPC Contractor need to consider 100m of cable for each rating of UPS along with 100% Load Bank along with Input/output MCCBs.</td>
</tr>
<tr>
<td>6</td>
<td>UPS EPC Contractor to provide Waveform Capturing devices as a separate or built in within the UPS for Fault Analysis i.e. Root Cause Analysis.</td>
</tr>
</tbody>
</table>
AC-AC Efficiency in Double Conversion Mode of Operation: Up to 96%.

Overload Capacity at Output should be: 110% for 60 minutes, 125% for 10 minutes, 150% for 1 minute and Overload capacity at Bypass should be: 125% - Continuous, 150% for 1 minute, incase EPC Contractor does not meet the Overload Capability among any of the above 3 Percentage Loadings, next Higher Rating shall be proposed.

Input, Output & Bypass Breakers shall be provided in the UPS Cabinet itself along with the EPO i.e. Emergency Power Off switch.

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<tr>
<th>S.No</th>
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</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>For a 30kVA heat load, 10Tr PAC needs to be installed</td>
</tr>
<tr>
<td>2</td>
<td>The structure of the unit shall be constructed by a metal framework which should shall be 1.2 mm thick powder coated CRCA sheet outer skin +15 mm PU foam so that the noise levels are controlled.</td>
</tr>
<tr>
<td>3</td>
<td>The units shall be equipped with the latest generation EC (Electronically Commutated) fans. This type of fan shall have blades made high-tech compound material with optimized flow control and high-efficiency Green Tech EC motors with a low moment of inertia.</td>
</tr>
<tr>
<td>4</td>
<td>Compressor should be either Digital/Inverter/Tandem which permits staples adaptation of the output in partial load condition, in case of multiple compressors in a unit all should be of same type like Digital/Inverter/Tandem, mix of compressors are not permitted.</td>
</tr>
<tr>
<td>5</td>
<td>Copper piping should be designed in such a way that vibration isolators not required to be added in the discharge and suction pipes.</td>
</tr>
<tr>
<td>6</td>
<td>A non-return valve shall be included in each refrigerant circuit on the compressor discharge. The scope of the non-return valve shall be to avoid the liquid migration from high-pressure to low-pressure side after compressor is switched off.</td>
</tr>
<tr>
<td>7</td>
<td>Liquid receiver should be with on-off valve and safety valve. A dedicated control function shall be activated with the electronic expansion valve (EEV) integrated in the unit.</td>
</tr>
<tr>
<td>8</td>
<td>During humidification process the air flow should not be reduced at any time and under any circumstance.</td>
</tr>
<tr>
<td>S.No</td>
<td>Generic Requirements</td>
</tr>
<tr>
<td>------</td>
<td>----------------------</td>
</tr>
<tr>
<td>9</td>
<td>Regulation system shall base on relative humidity or moisture in the room with the goal of minimizing the humidification and dehumidification processes and maximizing energy efficiency.</td>
</tr>
</tbody>
</table>

### Access Control for Terminal Building and ATC cum Technical Block

<table>
<thead>
<tr>
<th>S.No</th>
<th>Generic Requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Complete solution for restricting the movement inside the server room premises for authorized persons only. The access control system based on the finger printing based biometric system for providing physical security. Records are maintained in biometric system and report file can be generated from system based on date, time and authorized id.</td>
</tr>
<tr>
<td>2</td>
<td>Hardware Specifications: Intelligent Field Panel (IFP)</td>
</tr>
<tr>
<td>3</td>
<td>The panels should be with UL,FCC and CE regulations:</td>
</tr>
<tr>
<td>4</td>
<td>IFP shall utilize a fully distributed intelligence controller architecture whereby access decisions are made locally at the controller.</td>
</tr>
<tr>
<td>5</td>
<td>IFP shall utilize flash firmware for easy upgrades.</td>
</tr>
<tr>
<td>6</td>
<td>IFP shall support two access points.</td>
</tr>
<tr>
<td>7</td>
<td>IFP should be capable of expanding the functionality of the two access points to two access points IN/OUT, making the IFP a 4 reader controller.</td>
</tr>
<tr>
<td>8</td>
<td>IFP shall support local means of control through system and panel links as well as reader and reader/keypad input.</td>
</tr>
<tr>
<td>9</td>
<td>IFP shall support field interface to access control readers of various types.</td>
</tr>
<tr>
<td>10</td>
<td>IFP shall support field interface to eight variously configured alarm inputs.</td>
</tr>
<tr>
<td>11</td>
<td>IFP shall control four relay and four voltage outputs.</td>
</tr>
<tr>
<td>12</td>
<td>The Server software package (host computer) shall download panel specific data, including up to 3,000 cardholders &amp; expandable up to 8000, to the IFP on the network. This data shall be stored within each panel and contain all pertinent information relating to the panel’s functionality.</td>
</tr>
<tr>
<td>13</td>
<td>Host computer shall communicate global links and anti-pass back messages between panels.</td>
</tr>
<tr>
<td></td>
<td>Should communication with the Server software package (host computer) be lost, up to 1500 time-stamped events shall be stored in panel’s buffer, until communication is restored. Upon restoration of communications all event data shall be automatically uploaded to the host computer including the actual time of occurrence.</td>
</tr>
<tr>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td></td>
<td>This functionality shall enable any off line controller to maintain full access control processing capability. A card user shall not be aware of the off line condition.</td>
</tr>
<tr>
<td></td>
<td>A system that does not buffer event information when communications are lost will not be acceptable.</td>
</tr>
<tr>
<td></td>
<td>Controller will have 8 Input &amp; 8 Output</td>
</tr>
<tr>
<td></td>
<td>Biometric Reader with Keypad &amp; card</td>
</tr>
<tr>
<td></td>
<td>Templates : 9,500</td>
</tr>
<tr>
<td></td>
<td>Integrated Proximity Reader : 125KHz Multi-technology</td>
</tr>
<tr>
<td></td>
<td>PC to Reader / Panel to Reader : Ethernet (CAT5) / Wiegand (6 Cond. Shielded 18 AWG)</td>
</tr>
<tr>
<td></td>
<td>Dimensions / Weight : 5.7” (145 mm) Wide X 4.92” (125 mm) High X 1.3” (33 mm) Deep / 12 oz. (340 g.)</td>
</tr>
<tr>
<td></td>
<td>Operating temperature / Humidity : 32°F to +131°F (0°C to +55°C) / 0 - 95% RH</td>
</tr>
<tr>
<td></td>
<td>Power Requirements : DC 9~24V, 1A</td>
</tr>
<tr>
<td></td>
<td>Sensor (Resolution) / Template size : Optical (500 DPI) / 352 bytes</td>
</tr>
<tr>
<td></td>
<td>Authentication time Speed : ≤ 4 sec</td>
</tr>
<tr>
<td></td>
<td>False Rejection / Acceptance Rate 0.01% / 0.001%</td>
</tr>
<tr>
<td></td>
<td>Features : LCD Display : 128 X 64 pixels; 2 LEDs; 10 number keys;</td>
</tr>
<tr>
<td></td>
<td>FUNCTION KEYS- 1 BELL BUTTON</td>
</tr>
<tr>
<td>a.</td>
<td>Fail safe operation in case of no-power condition and abnormal condition such as fire, theft, intrusion and loss of access control etc.</td>
</tr>
<tr>
<td>b.</td>
<td>Inbuilt card reader</td>
</tr>
<tr>
<td>c.</td>
<td>Day, Date, Time and duration-based access rights for user</td>
</tr>
<tr>
<td>d.</td>
<td>Adequate number of smart cards should be provided</td>
</tr>
<tr>
<td>e.</td>
<td>Interface with EM locks to manage the access to Server room</td>
</tr>
</tbody>
</table>
# Server Room CCTV for Terminal Building

<table>
<thead>
<tr>
<th>S.No</th>
<th>Generic Requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>The EPC Contractor should propose a solution for IP enabled Closed Circuit Television System (CCTV) which will provide on-line display of video images on monitor. Cameras should be used to view specific areas of interest and create a record for post event analysis.</td>
</tr>
<tr>
<td>2</td>
<td>The system must be supplied with suitable number of cameras and Management Software to cover the server room. The system should have the facility of remote viewing over IP network and recording for at least 30 days</td>
</tr>
<tr>
<td>3</td>
<td>The system should be fitted with an Hemispheric IP indoor camera for ceiling mounting, surveillance system for monitoring of activity outside the IT Server room. The system must be supplied with 2nos of Hemispheric</td>
</tr>
<tr>
<td>4</td>
<td>Hemispheric Camera</td>
</tr>
<tr>
<td>5</td>
<td>IP indoor camera for ceiling mounting The system should have Image sensor: 1/2.5\text{&quot;} CMOS, 5 megapixel, color (day), Internal SD Card: 4-GB Micro SD - Integrated microphone, Temperature sensor, Illumination sensor, movement sensor, Activity Sensor, Analytics, 0.5-m Ethernet patch cable, Interfaces: Ethernet 10/100 (RJ45), remote viewing over IP network and recording</td>
</tr>
</tbody>
</table>

# FSAS, Gas Suppression System for Terminal Building and ATC cum Technical Block

<table>
<thead>
<tr>
<th>S.No</th>
<th>Generic Requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>AS Per Site Requirement &amp; Best Practices Adopted</td>
</tr>
</tbody>
</table>

# Server Room Anti Rodent System for Terminal Building and ATC cum Technical Block

<table>
<thead>
<tr>
<th>S.No</th>
<th>Generic Requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>A Rodent repellent System solution with compact, safe, environmentally friendly and non-irritating pest repelled Very High Frequency Oscillator (VHFO) units are to be installed in Server room. The entry of Rodents and other unwanted pests should be controlled using non-chemical, non-toxic devices. Ultrasonic Frequency sound wave based replant system has been proposed at Server room. The device installed should emit intensive ultrasound that is audible and painful to rodents, but is inaudible and harmless to humans. The rodent repellents will be provided in the false flooring and ceiling to repel the pests without killing them. The installed</td>
</tr>
</tbody>
</table>
units must withstand high temperatures in false ceilings and low temperatures in cold storages and air locks.

2. The pest Repellent System should consist of one master console & suitable number of satellites/transducers. The successful EPC Contractor shall make detailed working drawings and coordinate with user and other agencies at site.

3. Specification:
   a. Microcontroller based console embedded with power electronic circuits to generate a pattern of ultrasound waves at 800mW power per transducer
   b. Alpha numeric LCD and smart keypad
   c. Configurable start frequency, end frequency, sweep time, wave pattern
   d. Should cover the complete DC area

### WLD & Dedicated Earthing & Dual Power Sources for Terminal Building and ATC cum Technical Block

<table>
<thead>
<tr>
<th>S.No</th>
<th>Generic Requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>AS Per Site Requirement &amp; Best Practices Adopted</td>
</tr>
</tbody>
</table>

### Chairman Boundary layer Microphone Systemfor ATC cum Technical Block

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Specifications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type</td>
<td>Boundary Layer Flush type</td>
</tr>
<tr>
<td>Polar pattern</td>
<td>Cardioid / Omni</td>
</tr>
<tr>
<td>RFI</td>
<td>Should be RFI proof</td>
</tr>
<tr>
<td>Button</td>
<td>Should have Mic On/OFF button, Priority/clear button to deactivate all delegate mics,</td>
</tr>
<tr>
<td>Connectivity</td>
<td>Two RJ45 / 6Pole connectivity to connect to other microphone/control unit, Headphone output.</td>
</tr>
<tr>
<td><strong>Accessories</strong></td>
<td>Should be supplied with all interconnectivity cables, OEM Buttons panel, accessories etc</td>
</tr>
<tr>
<td>----------------</td>
<td>------------------------------------------------------------------------------------------</td>
</tr>
</tbody>
</table>

**Delegate Boundary layer Microphone Systemfor ATC cum Technical Block**

<table>
<thead>
<tr>
<th><strong>Parameters</strong></th>
<th><strong>Specifications</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Type</strong></td>
<td>Boundary Layer Flush type</td>
</tr>
<tr>
<td><strong>Polar pattern</strong></td>
<td>Cardioid / Omni</td>
</tr>
<tr>
<td><strong>RFI</strong></td>
<td>Should be RFI proof</td>
</tr>
<tr>
<td><strong>Button</strong></td>
<td>Should have Mic On/OFF button</td>
</tr>
<tr>
<td><strong>Connectivity</strong></td>
<td>Two RJ45 / 6Pole connectivity to connect to other microphone/control unit, Headphone output,</td>
</tr>
<tr>
<td><strong>Accessories</strong></td>
<td>Should be supplied with all interconnectivity cables, OEM Buttons panel, accessories etc</td>
</tr>
</tbody>
</table>

**Conference Controller Unitfor ATC cum Technical Block**

<table>
<thead>
<tr>
<th><strong>Parameters</strong></th>
<th><strong>Specifications</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Microphone Support</td>
<td>50 or more microphones</td>
</tr>
<tr>
<td>Frequency Response</td>
<td>Frequency Response 25Hz to 15KHz (+/-3dB)</td>
</tr>
<tr>
<td>Quality</td>
<td>16 bit digital</td>
</tr>
<tr>
<td>Features</td>
<td>Microphones can be connected in two lines or ring</td>
</tr>
<tr>
<td>operating mode</td>
<td>Automatic audio channel allocation of the microphone unit</td>
</tr>
<tr>
<td></td>
<td>Each participant can turn on or off the microphone, Voice Activation: microphone is activated when someone speaks into it, when the number of open microphones is exceeded, the microphone which was activated first, will be deactivated</td>
</tr>
</tbody>
</table>
### Control

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Specifications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Microphone</td>
<td>Condenser Lavaliere, Omnidirectional</td>
</tr>
<tr>
<td>Frequency Response</td>
<td>35 Hz-15 kHz or better</td>
</tr>
<tr>
<td>Receiver Type</td>
<td>1-channel true diversity receiver (UHF)</td>
</tr>
<tr>
<td>Features</td>
<td>Auto scan/ ACT function</td>
</tr>
<tr>
<td>RF Power</td>
<td>30mW or better</td>
</tr>
<tr>
<td>S/N Ratio</td>
<td>&gt; 105 dB(A) or better</td>
</tr>
<tr>
<td>Audio Output</td>
<td>1 x XLR, 1 x 6.35mm jack with Mic/line level switch</td>
</tr>
<tr>
<td>Features</td>
<td>Gain control for input level adjustment</td>
</tr>
<tr>
<td>Presets</td>
<td>12 or more</td>
</tr>
</tbody>
</table>

### Wireless Handheld Microphone for ATC cum Technical Block

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Specifications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Microphone</td>
<td>Condenser Lavaliere, Omnidirectional</td>
</tr>
<tr>
<td>Frequency Response</td>
<td>35 Hz-15 kHz or better</td>
</tr>
<tr>
<td>Receiver Type</td>
<td>1-channel true diversity receiver (UHF)</td>
</tr>
<tr>
<td>Features</td>
<td>Auto scan/ ACT function</td>
</tr>
<tr>
<td>RF Power</td>
<td>30mW or better</td>
</tr>
<tr>
<td>S/N Ratio</td>
<td>&gt; 105 dB(A) or better</td>
</tr>
<tr>
<td>Audio Output</td>
<td>1 x XLR, 1 x 6.35mm jack with Mic/line level switch</td>
</tr>
<tr>
<td>Features</td>
<td>Gain control for input level adjustment</td>
</tr>
<tr>
<td>Presets</td>
<td>12 or more</td>
</tr>
</tbody>
</table>

### Wireless Lapel Microphone for ATC cum Technical Block

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Specifications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Microphone</td>
<td>Condenser Lavaliere, Omnidirectional</td>
</tr>
<tr>
<td>Frequency Response</td>
<td>35 Hz-15 kHz or better</td>
</tr>
<tr>
<td>Receiver Type</td>
<td>1-channel true diversity receiver (UHF)</td>
</tr>
<tr>
<td>Features</td>
<td>Auto scan/ ACT function</td>
</tr>
<tr>
<td>RF Power</td>
<td>30mW or better</td>
</tr>
<tr>
<td>S/N Ratio</td>
<td>&gt; 105 dB(A) or better</td>
</tr>
<tr>
<td>Audio Output</td>
<td>1 x XLR, 1 x 6.35mm jack with Mic/line level switch</td>
</tr>
<tr>
<td>Features</td>
<td>Gain control for input level adjustment</td>
</tr>
<tr>
<td>-------------------</td>
<td>----------------------------------------</td>
</tr>
<tr>
<td>Presets</td>
<td>12 or more</td>
</tr>
</tbody>
</table>

### Two Way ceiling Speakers for ATC cum Technical Block

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Specifications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type</td>
<td>Two-way ceiling speaker</td>
</tr>
<tr>
<td>Voltage</td>
<td>70V/100V operation</td>
</tr>
<tr>
<td>Woofer</td>
<td>6&quot; or better</td>
</tr>
<tr>
<td>Tweeter</td>
<td>0.75&quot; or better</td>
</tr>
<tr>
<td>Frequency Range</td>
<td>75 Hz to 18 kHz or better</td>
</tr>
<tr>
<td>Nominal Sensitivity</td>
<td>86 dB SPL or more</td>
</tr>
<tr>
<td>Power capacity</td>
<td>30W or more with various Tap settings</td>
</tr>
<tr>
<td>Conical Coverage</td>
<td>100 deg or better</td>
</tr>
</tbody>
</table>

### Amplifier for ATC cum Technical Block

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Specifications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type</td>
<td>Dual Channel Class D / TD or equivalent</td>
</tr>
<tr>
<td>Audio Inputs</td>
<td>2 balanced/unbalanced</td>
</tr>
<tr>
<td>Audio output</td>
<td>2 channels 100 V / 70V</td>
</tr>
<tr>
<td>Frequency Response</td>
<td>50 Hz to 18 kHz or better</td>
</tr>
<tr>
<td>Output Power</td>
<td>100 watts or more rms per channel @ 100 V/70V</td>
</tr>
<tr>
<td>Other Feature</td>
<td>Should be energy efficient</td>
</tr>
<tr>
<td>---------------</td>
<td>---------------------------</td>
</tr>
<tr>
<td>Protection</td>
<td>Thermal, DC output, Output Short/Short circuit</td>
</tr>
</tbody>
</table>

| **Audio Digital Signal Processor for ATC cum Technical Block** |
|-----------------|--------------------------------------------------|
| Parameters      | Specifications                                    |
| Input           | 5 or more Balanced or unbalanced Mic/line, with Phantom power |
| Output          | 4 or more line level                              |
| Frequency Response | 20-20000 Hz or better                           |
| A/D, D/A conversion | 24 bit, 48 kHz sampling                        |
| S/N Ratio or Dynamic Range | > 102 dB or better                             |
| Other Features  | AEC/POTS level control, dynamics, mixers, delays |
| Controls        | Rs232/ Ethernet                                  |

<p>| <strong>AV Controller for ATC cum Technical Block</strong> |
|-------------------|--------------------------------------------------|
| Parameters        | Specifications                                    |
| AV Controller     |                                                   |
| Memory            | Minimum 512 MB SDRAM, 4 GB Flash or more         |
| Interfaces        | Minimum 6 x RS-232 bidirectional (acceptable with additional modules) |
|                   | Minimum 1 x RJ-45 for Ethernet controllable devices |
|                   | 2 or more x IR/Serial                            |
|                   | 4 or more x Relay ports                          |</p>
<table>
<thead>
<tr>
<th>Feature</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Others: Programming, Digital I/O</td>
<td></td>
</tr>
<tr>
<td>IR Learner</td>
<td>Inbuilt or supplied with external IR learner.</td>
</tr>
<tr>
<td>Other Features</td>
<td>Should support &amp; provide with license/software for using wireless device like iPad for primary control interface for different control options than 10inch touch control panel</td>
</tr>
</tbody>
</table>

### Four Zone Lighting Control System for ATC cum Technical Block

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Specifications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lighting Zone support</td>
<td>4 zone or more</td>
</tr>
<tr>
<td>Light types</td>
<td>Should support CFL, LED, 0-10V DALI</td>
</tr>
<tr>
<td>Button Panel</td>
<td>Should be supplied with 6 or more button control panel</td>
</tr>
<tr>
<td>Controls</td>
<td>Ethernet/ IR/ RS 232 / RS485 for controls via third party control system</td>
</tr>
</tbody>
</table>

### 17 inch or more annotation Full HD resolution monitor for ATC cum Technical Block

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Specifications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Panel &amp; Size</td>
<td>LED/LCD, 17” (Diagonal) or larger touch monitor</td>
</tr>
<tr>
<td>Resolution</td>
<td>HD or better</td>
</tr>
<tr>
<td>Aspect Ratio</td>
<td>16:09</td>
</tr>
<tr>
<td>Brightness:</td>
<td>200 cd/m2 (typical)</td>
</tr>
<tr>
<td>Response time</td>
<td>5-8ms or better</td>
</tr>
<tr>
<td>Viewing Angle</td>
<td>better than 160 degree (Vertical &amp; Horizontal)</td>
</tr>
<tr>
<td>Touch Technology</td>
<td>Capacitive Touch</td>
</tr>
<tr>
<td>Ports</td>
<td>HDMI/ DVI / DP, USB (for annotation control)</td>
</tr>
<tr>
<td>-------</td>
<td>---------------------------------------------</td>
</tr>
<tr>
<td>Accessories</td>
<td>Touch Pen, Stand, USB Cable, Software etc</td>
</tr>
<tr>
<td>Lift</td>
<td>Should be supplied with Monitor Lift sleek built with embedded buttons for Monitor UP/Down, providing certain angle of tilt to the monitor while in on position. Controls: RS232/ RS422/RS485 for control via third party control system</td>
</tr>
</tbody>
</table>

### Hardware based Annotation Processors for ATC cum Technical Block

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Specifications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inputs</td>
<td>1x HDMI /DVI/ Display port and 1x VGA input</td>
</tr>
<tr>
<td>Output</td>
<td>1x DVI/HDMI, 1 Twisted Pair on RJ 45 (Inbuilt or External)</td>
</tr>
<tr>
<td>Features</td>
<td>Capability of live annotation on presentation as well as video, Scaling and auto input switching between the inputs</td>
</tr>
<tr>
<td>Touch Monitor Support</td>
<td>support of atleast 10 or more devices on USB for annotation</td>
</tr>
<tr>
<td>Graphical annotation interface</td>
<td>Annotation tools such as drawing freehand or lines, adding rectangular or elliptical shapes, typing text, highlighting an area of an image, pointing to an object on-screen, and using the screen as a whiteboard.</td>
</tr>
<tr>
<td>HDCP &amp; EDID</td>
<td>Should be HDCP &amp; EDID compliance &amp; have inbuilt management</td>
</tr>
<tr>
<td>Resolution Support</td>
<td>Minimum 1920 x1200 or more</td>
</tr>
<tr>
<td>Storage</td>
<td>Internal memory a network location</td>
</tr>
<tr>
<td>Control</td>
<td>USB, RS 232/ Ethernet</td>
</tr>
<tr>
<td>Compliance</td>
<td>CE, UL</td>
</tr>
</tbody>
</table>
### Laptop Connectivity Point for ATC cum Technical Block

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Specifications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type</td>
<td>Flush mountable into a table or flat surface with tilt up lid / Flip top, Powder Coated/ Anodized, metal enclosure</td>
</tr>
<tr>
<td>Power socket</td>
<td>1x Multi-region AC outlet &amp; 1 x USB outlets or more</td>
</tr>
<tr>
<td>Connectivity Options</td>
<td>Should have pass through holes/ connectors for AV cables like HDMI, VGA, Audio , LAN</td>
</tr>
</tbody>
</table>

### Multi Format Transmitter for ATC cum Technical Block

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Specifications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Video Inputs:</td>
<td>2x HDMI, 1 x VGA</td>
</tr>
<tr>
<td>Video Output</td>
<td>1x RJ45, twisted pair</td>
</tr>
<tr>
<td>Audio Inputs:</td>
<td>1 x stereo analogue audio, 1x embedded audio on HDMI input</td>
</tr>
<tr>
<td>Auto switching</td>
<td>Should have Automatic switching between inputs</td>
</tr>
<tr>
<td>Transmission</td>
<td>For audio, video - 100Mtrs</td>
</tr>
<tr>
<td>Distance</td>
<td></td>
</tr>
</tbody>
</table>

### Modular Digital Matrix Switcher for ATC cum Technical Block

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Specifications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type</td>
<td>Modular Digital Matrix with scalability to minimum 16 input &amp; 16 output or more</td>
</tr>
<tr>
<td>Resolution Support</td>
<td>4K or more at 60 Hz</td>
</tr>
<tr>
<td>Digital Backplane Bandwidth</td>
<td>18 Gbps or more</td>
</tr>
<tr>
<td>Power supply</td>
<td>It should be with redundant power supply</td>
</tr>
<tr>
<td>---------------------------</td>
<td>------------------------------------------</td>
</tr>
<tr>
<td>Inputs</td>
<td>8 nos x HDMI, 8nos Twisted pair/HDbaseT (RJ45), Input cards should be hot swappable</td>
</tr>
<tr>
<td>Outputs</td>
<td>8 nos x HDMI, 8 nos or more Twisted pair, 2or more analog Audio output. Output cards should be hot swappable</td>
</tr>
<tr>
<td>I/O card type</td>
<td>Hot swappable</td>
</tr>
<tr>
<td>Audio</td>
<td>Should have HDMI audio de-embedding feature</td>
</tr>
<tr>
<td>HDMI input &amp; output</td>
<td></td>
</tr>
<tr>
<td>Resolution Support</td>
<td>Upto 4K or more at 60 Hz</td>
</tr>
<tr>
<td>HDCP &amp; EDID</td>
<td>Should be HDCP 2.2 compliant &amp; have EDID management</td>
</tr>
<tr>
<td>Input &amp; Output Signal management</td>
<td>Should have automatic HDMI cable equalization at input &amp; automatic output signal re-clocking at the output</td>
</tr>
</tbody>
</table>

**HDMI & Control twisted pair Scaling receiver for ATC cum Technical Block**

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Specifications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Input</td>
<td>Twisted Pair/ HD BaseT output on RJ 45 port</td>
</tr>
<tr>
<td>Output</td>
<td>1 HDMI, 1x RS 232/ IR</td>
</tr>
<tr>
<td>Audio Input</td>
<td>1 Digital / analog stereo</td>
</tr>
<tr>
<td>Scaling</td>
<td>Should have inbuilt scaling or scaling provided in the twisted pair output of the modular matrix switcher upto 4K resolution</td>
</tr>
<tr>
<td>Resolution Range</td>
<td>Up to 4K (4096x2160) @ 30 Hz</td>
</tr>
<tr>
<td>Chroma Sampling</td>
<td>4:4:4, 4:2:2, or 4:2:0</td>
</tr>
</tbody>
</table>
### Signal transmission distance
- Minimum 330’ (100 m) using shielded twisted pair cable for audio, video, controls, power & Ethernet

### HDCP & EDID Management
- Yes

### Compatibility
- Compatible to Modular Digital matrix Switcher

---

#### HDMI Twisted Pair transmitter for ATC cum Technical Block

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Specifications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Input</td>
<td>1xHDMI, 1xAnalog Audio, 1xControls (RS 232/IR)</td>
</tr>
<tr>
<td>Output</td>
<td>1 x Twisted pair/ HDbaseT on RJ 45</td>
</tr>
<tr>
<td>Range</td>
<td>For audio, video, power, control: Atleast 70mtrs or more on a single CAT x cable</td>
</tr>
<tr>
<td>HDCP &amp; EDID</td>
<td>Should be HDCP &amp; EDID compliant</td>
</tr>
<tr>
<td>Resolution Support</td>
<td>4K or more</td>
</tr>
<tr>
<td>Remote Powering</td>
<td>Should have remote powering capability</td>
</tr>
</tbody>
</table>

#### HDMI Twisted Pair receiver for ATC cum Technical Block

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Specifications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Input</td>
<td>1 x Twisted pair/ HDbaseT on RJ 45</td>
</tr>
<tr>
<td>Output</td>
<td>1xHDMI, 1xAnalog Audio, 1xControls (RS 232/IR)</td>
</tr>
<tr>
<td>Range</td>
<td>For audio, video, power, control: Atleast 70mtrs or more on a single CAT x cable</td>
</tr>
<tr>
<td>HDCP &amp; EDID</td>
<td>Should be HDCP &amp; EDID compliant</td>
</tr>
<tr>
<td>Resolution Support</td>
<td>4K or more</td>
</tr>
<tr>
<td>--------------------</td>
<td>---------------------</td>
</tr>
<tr>
<td>Remote Powering</td>
<td>Should have remote powering capability</td>
</tr>
</tbody>
</table>

**Video Conferencing System End Point for ATC cum Technical Block**

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Specifications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type</td>
<td>FHD Video Conference Systems having 1+3 Party connectivity on FHD Resolution</td>
</tr>
<tr>
<td>Cameras</td>
<td>12x Optical zoom, 10x Digital Zoom PTZ Cameras – 23 nos</td>
</tr>
<tr>
<td>Features</td>
<td>Minimum 50 presets, Microphone, 2 or more Video outputs, Inbuilt SD card/Pen Drive Recording feature, PC connectivity for presentation sharing, necessary hardware, software, license, programming complete.</td>
</tr>
</tbody>
</table>

**Itemno.:49 for ATC cum Technical Block**

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Specifications</th>
</tr>
</thead>
<tbody>
<tr>
<td>System Capacity</td>
<td>MCU should support portsat 1080p60fps on IP in continuous presence mode with 60fps and H.264 resolution and AES encryption.</td>
</tr>
<tr>
<td></td>
<td>Multi-point video Conferencing Solution should be capable of offering Full High Definition 1080p60fps in real-time for 10 number of Concurrent ports/users in single calling continuous presence and voice activation mode &amp; within intelligent built-in capability for dynamic.</td>
</tr>
<tr>
<td><strong>MCU Features</strong></td>
<td><strong>Video Standards and Content Standards and Resolutions</strong></td>
</tr>
<tr>
<td>------------------</td>
<td>----------------------------------------------------------</td>
</tr>
<tr>
<td>The MCU shall support aspect ratio of 16:9 and 4:3.</td>
<td>The MCU should support content sharing using standard-based H.239 and BFC Power SIP with HD1080 resolution.</td>
</tr>
<tr>
<td>The MCU shall support a mix of resolutions in both Voice Activated mode and Continuous Presence. Each endpoint shall receive at the maximum of its capacity without reducing the capacity of another.</td>
<td>The MCU should support H.263, H.264, and SVC encoding in SIP &amp; H.323 modes.</td>
</tr>
<tr>
<td>Dynamic CP layout adjustment (MCU will choose the best video layout according to the number of participants in the conference).</td>
<td>It should support G.711, G.722.</td>
</tr>
<tr>
<td>The MCU should support distributed architecture with intelligent and automatic call routing. It must support load balancing such that in case there are two instances of MCU, conference participants can be distributed across these two MCUs based on their location.</td>
<td>The MCU should support H.263, H.264, and SVC encoding in SIP &amp; H.323 modes.</td>
</tr>
</tbody>
</table>

**MCU must be scalable to 45 ports at 1080p 30fps in future, without any change in hardware. It should also provide network flexibility for a reliable distributed architecture and cost-effective operation.**

**MCU must have in-built hot swapable redundant power supply from day one.**

**MCU should be on secure platform.**

**Audio Standards and MCU Features**

- The MCU should support H.263, H.264, and SVC encoding in SIP & H.323 modes.
- It should support G.711, G.722.
- The MCU shall support aspect ratio of 16:9 and 4:3.
- The MCU shall support a mix of resolutions in both Voice Activated mode and Continuous Presence. Each endpoint shall receive at the maximum of its capacity without reducing the capacity of another.
- Dynamic CP layout adjustment (MCU will choose the best video layout according to the number of participants in the conference).
- The MCU should support distributed architecture with intelligent and automatic call routing. It must support load balancing such that in case there are two instances of MCU, conference participants can be distributed across these two MCUs based on their location.
<table>
<thead>
<tr>
<th><strong>Conference Feature</strong></th>
<th>The MCU should be able to natively register and authenticate with H.323 gatekeeper / SIP registrar.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Network and security features</strong></td>
<td>The MCU shall support conferences that permanently exist but use no resources if no participants are in the conference</td>
</tr>
<tr>
<td><strong>Network and security features</strong></td>
<td>The MCU shall support AES encryption 128 bit or above for every participant without affecting any other feature, functionality or port count.</td>
</tr>
<tr>
<td><strong>Interoperability &amp; Open Standards</strong></td>
<td>The MCU must support TLS for SIP</td>
</tr>
<tr>
<td><strong>Interoperability &amp; Open Standards</strong></td>
<td>MCU must be open standards based and not based on proprietary protocols.</td>
</tr>
<tr>
<td><strong>Interoperability &amp; Open Standards</strong></td>
<td>MCU must inter operate on all 10 ports at 1080p 60fps from day one using standards based video and audio compression with other open standards based VC endpoints from various OEMs. Any additional hardware / software required should be supplied day one.</td>
</tr>
</tbody>
</table>

### Professional Ceiling Document Camera for ATC cum Technical Block

<table>
<thead>
<tr>
<th><strong>Parameters</strong></th>
<th><strong>Specifications</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Type</strong></td>
<td>Ceiling mount document camera</td>
</tr>
<tr>
<td><strong>Zoom</strong></td>
<td>20x or more Optical Zoom</td>
</tr>
<tr>
<td><strong>Resolution</strong></td>
<td>Full HD (1920x1080) or better</td>
</tr>
<tr>
<td><strong>Output</strong></td>
<td>HDMI/ DVI</td>
</tr>
<tr>
<td>Parameters</td>
<td>Specifications</td>
</tr>
<tr>
<td>-----------------------------</td>
<td>-------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Inputs Signal</td>
<td>1 x HDMI / DVI digital video (HDCP compliant), 1x HDMI/DVI/ HD-SDI, 1 x analog input</td>
</tr>
<tr>
<td>Input resolution support</td>
<td>640x480 upto at least 1920x1200 including 1080p/60</td>
</tr>
<tr>
<td>Output</td>
<td>1 HDMI for local output, 1 RJ45 streaming &amp; network recording output</td>
</tr>
<tr>
<td>Audio Input</td>
<td>1 or more stereo</td>
</tr>
<tr>
<td>Recording</td>
<td>30 GB or more HDD / through Memory card, USB for external drive and defined network storage directory</td>
</tr>
<tr>
<td>PIP</td>
<td>Should have two HD input PIP and picture by picture capability and have high quality inbuilt scaling</td>
</tr>
<tr>
<td>Streaming Capability</td>
<td>Yes with resolution support upto 1080p, H.264 or better compression supporting protocol RTP/RTSP/RTMP</td>
</tr>
<tr>
<td>Controls</td>
<td>RS232/ Ethernet, Front button panel</td>
</tr>
</tbody>
</table>

**Full HD Recorder cum streaming processor for ATC cum Technical Block**

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Specifications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inputs Signal</td>
<td>1 x HDMI / DVI digital video (HDCP compliant), 1x HDMI/DVI/ HD-SDI, 1 x analog input</td>
</tr>
<tr>
<td>Input resolution support</td>
<td>640x480 upto at least 1920x1200 including 1080p/60</td>
</tr>
<tr>
<td>Output</td>
<td>1 HDMI for local output, 1 RJ45 streaming &amp; network recording output</td>
</tr>
<tr>
<td>Audio Input</td>
<td>1 or more stereo</td>
</tr>
<tr>
<td>Recording</td>
<td>30 GB or more HDD / through Memory card, USB for external drive and defined network storage directory</td>
</tr>
<tr>
<td>PIP</td>
<td>Should have two HD input PIP and picture by picture capability and have high quality inbuilt scaling</td>
</tr>
<tr>
<td>Streaming Capability</td>
<td>Yes with resolution support upto 1080p, H.264 or better compression supporting protocol RTP/RTSP/RTMP</td>
</tr>
<tr>
<td>Controls</td>
<td>RS232/ Ethernet, Front button panel</td>
</tr>
</tbody>
</table>

**Wireless Presentation System for ATC cum Technical Block**

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Specifications</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Inputs:</strong></td>
<td>1 or more USB, 1 RJ 45 Ethernet</td>
</tr>
<tr>
<td>------------</td>
<td>----------------------------------</td>
</tr>
<tr>
<td><strong>Output</strong></td>
<td>1 or more HDM/ Display port /DVI-I</td>
</tr>
<tr>
<td><strong>Output Resolution Support</strong></td>
<td>Microsoft windows 7/8 , Mac OS 10.7 or above, Apple, Android 4.0 or above</td>
</tr>
<tr>
<td><strong>Simultaneous Display</strong></td>
<td>Full screen or four window Simultaneous display of content from 4 different sources through dongle/software app</td>
</tr>
<tr>
<td><strong>Wireless Video Playback</strong></td>
<td>Should support any media file playback wirelessly at min1080p at 30 fps</td>
</tr>
<tr>
<td><strong>Controls</strong></td>
<td>Should have feature of control via RS 232 or Ethernet from a third party AV control system</td>
</tr>
<tr>
<td><strong>Concurrent Connectivity</strong></td>
<td>Should support connectivity of 30 or more participants</td>
</tr>
<tr>
<td><strong>WAP</strong></td>
<td>Should have inbuilt WAP or supplied with external WAP</td>
</tr>
</tbody>
</table>

### 10 inch or more table mount touch control panel for ATC cum Technical Block

<table>
<thead>
<tr>
<th><strong>Parameters</strong></th>
<th><strong>Specifications</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Type</strong></td>
<td>10.1&quot; or more Diagonal, TFT touch screen or better with table top mounting, of the same make of Control system for proper compatibility</td>
</tr>
<tr>
<td><strong>Touch Screen</strong></td>
<td>Capacitive / Resistive</td>
</tr>
<tr>
<td><strong>Resolution</strong></td>
<td>1280x800 or better</td>
</tr>
<tr>
<td><strong>Brightness</strong></td>
<td>350 nits (cd/m2) or better</td>
</tr>
<tr>
<td><strong>Contrast</strong></td>
<td>700:1 or better</td>
</tr>
<tr>
<td><strong>Backlit</strong></td>
<td>LED</td>
</tr>
<tr>
<td><strong>Speakers &amp; Sensors</strong></td>
<td>Should have built in speakers &amp; Motion/light sensors</td>
</tr>
<tr>
<td><strong>Memory</strong></td>
<td>SDRAM: 2GB or more, Flash: 4GB or more</td>
</tr>
<tr>
<td>Regulatory Compliance</td>
<td>CE, UL, FCC</td>
</tr>
<tr>
<td>-----------------------</td>
<td>-------------</td>
</tr>
</tbody>
</table>

### All Interconnecting cables & Equipment Rack for ATC cum Technical Block

<table>
<thead>
<tr>
<th>Specifications</th>
</tr>
</thead>
<tbody>
<tr>
<td>All Interconnecting Cables &amp; Accessories</td>
</tr>
<tr>
<td>Equipment rack</td>
</tr>
</tbody>
</table>

### 85” Professional Display for ATC cum Technical Block

<table>
<thead>
<tr>
<th>S.No.</th>
<th>Parameters</th>
<th>Specifications</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Panel Size; Aspect Ratio</td>
<td>85” Diagonal</td>
</tr>
<tr>
<td>2</td>
<td>Brightness (Typ/Min)</td>
<td>300cd/m or better</td>
</tr>
<tr>
<td>3</td>
<td>Native Resolution</td>
<td>4K (UHD) or Better</td>
</tr>
<tr>
<td>4</td>
<td>Orientation</td>
<td>Portrait</td>
</tr>
<tr>
<td>5</td>
<td>Touch Response Time</td>
<td>&lt;15ms</td>
</tr>
<tr>
<td>6</td>
<td>Internal Speaker</td>
<td>10W (x2) or better</td>
</tr>
</tbody>
</table>

**Note:** EPC Contractors Pre-Qualification Criterion for IT works: As per CVC & MEITY (Ministry of Electronics & Information Technology) Guidelines.
GENERAL GUIDELINES: And details for submission of documents by the awarded EPC contractor & it’s specialized agency/ agencies.

1.6.29 EPC CONTRACTOR SHALL SUBMIT ONE PROPOSAL THAT MEETS THE “TECHNICAL SPECIFICATION” OF THIS TENDER DOCUMENT, INDICATING CLEARLY THE MAKE AND MODEL OF EQUIPMENT OF EACH ITEM, BEING OFFERED.

- The cost for the Maintenance/Service during DLP period of 24 months is covered under the scope of work and quoted rates shall be deemed to cover regular examination of the installations by the trained technician of the contractor including necessary adjustments, cleaning including replacement of parts etc. to keep the equipment in excellent operational state.
- The contractor shall also provide 24 hour emergency repair service to attend the IT System at any time of the day or night including Sundays and Holidays.
- All Inclusive Comprehensive Maintenance Contract (AICMC) to be undertaken by the EPC Contractor for the next five years after completion of the guarantee / warranty & defect liability period of two years.
- The detailed terms and conditions of the all-inclusive Comprehensive Maintenance Contract for IT system are appended under SCC for Operation & All inclusive comprehensive Maintenance contract. The quoted amount for AICMC will be taken into consideration for evaluation of the bids.
TECHNICAL SPECIFICATIONS OF DISTRIBUTED ANTENNA SYSTEM

A. BRIEF CONCEPT DESIGN

1.1 Concept:

1.1.1 Proposed Active DAS should be State of Art design to meet the requirement of Imphal Airport and should be scalable for Coverage and Capacity needs inside all important buildings (existing and proposed)

1.1.2 Proposed solution should be Modular in Design with respect to addition of Operators/bands

1.1.3 Modular POI should have the flexibility to take SISO or MIMO card in the same sub rack to minimize space and sub-rack requirement

1.1.4 All Passive components should have at least -150dBC PIM@2x20W Carrier

1.1.5 Proposed solution should support 2x2 MIMO for all LTE bands including LTE850/ LTE1800/ LTE2300/ LTE2500

1.1.6 Budget and RSL/RSRP/RSCP to be shared for all supported technologies so as to justify the number of Remote Units and Antennas considered in the design

1.1.7 BOM should be offered at L3 level describing each card/module/component to have ordering flexibility as per requirement

1.1.8 Remote Network Monitoring System should be proposed for all Active Elements in the Active DAS network

1.1.9 All cables used in the project should be Fire Retardant Low Smoke Zero Halogen type

1.1.10 The proposed system design should generate minimum Uplink noise in 3G/4G Uplink paths

1. DISTRIBUTED ANTENNA SYSTEM: (Technical Specifications)

1.1 SISO POI

1.1.1 Supported Technologies:

LTE850/GSM900/GSM1800/LTE1800/UMTS2100/LTE2300/LTE2600

1.1.2 RF Input to POI: Max 30dBm

1.1.3 RF Input Per Modular Card:>4`

1.1.4 Power consumption:<75Watt

1.1.5 Weight:< 10Kg

1.1.6 Temperature Range:- 10deg C to +55 deg C
1.2 MIMO POI

1.2.1 Supported Technologies: LTE850/LTE1800/LTE2300/LTE2600
1.2.2 RF Input to POI: Max 30dBm
1.2.3 RF input Per Modular Card: 2 to 4
1.2.4 Power consumption: <75Watt
1.2.5 Weight: < 10Kg
1.2.6 Operating Temperature Range: -10deg C to +55deg C

1.3 Master Unit SISO

1.3.1 Supported Technologies:
LTE850/GSM900/GSM1800
/LTE1800/UMTS2100/LTE2300/LTE2600
1.3.2 Optical Power: +5dBm
1.3.3 Supported Fiber type: Single Mode Fiber
1.3.4 Optical Interfaces: 4
1.3.5 Optical Connectors: SC/APC
1.3.6 Max RF Input Power: +10dBm
1.3.7 RF interfaces: 2
1.3.8 Power consumption: <25Watt
1.3.9 Weight: <25Kg
1.3.10 Operating Temperature range: -10deg C to +55deg C

1.4 Master Unit MIMO

1.4.1 Supported Technologies: LTE850/LTE1800/LTE2300/LTE2600
1.4.2 Optical Power: +5dBm
1.4.3 Supported Fiber type: Single Mode Fiber
1.4.4 Optical Interfaces: 4
1.4.5 Optical Connectors: SC/APC
1.4.6 Max RF Input Power: +10dBm
1.4.7 RF interfaces: 2
1.4.8 Power consumption: <25Watt
1.4.9 Weight: <25Kg
1.4.10 Operating Temperature range: -10deg C to +55deg C

1.5 Remote Unit SISO+MIMO

1.5.1 Supported Technologies: LTE850/GSM900/GSM1800/LTE1800/UMTS2100/LTE2300/LTE2600
1.5.2 Optical Power: +5dBm
1.5.3 Supported Fiber type: Single Mode Fiber
1.5.4 Optical Interfaces: 2 (1 for SISO and 1 for MIMO)
1.5.5 Optical Connectors: SC/APC
1.5.6 RF Output power: 43 dBm Max.
1.5.7 RF interfaces: 2 (1 for SISO and 1 for MIMO)
1.5.8 Power consumption: < 550 Watt
1.5.9 Weight: < 50 Kg
1.5.10 Operating Temperature range: -10 degC to +55 degC

1.6 Omni Antenna MIMO
1.6.1 Frequency Range: 698-2690 MHz
1.6.2 Gain: 2dBi(698-960 MHz) & 4dBi(1710-2690 MHz)
1.6.3 Polarization: +/- 45 deg
1.6.4 Horizontal Beamwidth: 360 deg
1.6.5 Vertical Beamwidth: 65 deg
1.6.6 PIM: Lower than -150 dBc for 2x20W carrier
1.6.7 Connectors/Type: 2/ N(F)
1.6.8 Pigtail length: 300 mm

1.7 Panel Antenna MIMO
1.7.1 Frequency Range: 698-2690 MHz
1.7.2 Gain: 7dBi(698-960 MHz) & 9dBi(1710-2690 MHz)
1.7.3 Polarization: +/- 45 deg
1.7.4 Horizontal Beamwidth: 90 deg
1.7.5 Vertical Beamwidth: 65 deg
1.7.6 PIM: Lower than -150 dBc for 2x20W carrier
1.7.7 Connectors/Type: 2/ N(F)
1.7.8 Pigtail length: 300 mm

1.8 Attenuator 20dB
1.8.1 Frequency Range: DC-3000 MHz
1.8.2 VSWR: ≤ 1.3
1.8.3 Attenuation: 20 dB
1.8.4 PIM: Lower than -150 dBc for 2x20W carrier
1.8.5 Maximum Input Power: 100 Watt
1.8.6 Operating Temperature range: -10 degC to +55 degC
1.8.7 Connectors/Type: N(M)/ N(F)

1.9 Couplers
1.9.1 Frequency Range: 698-2700 MHz
1.9.2 VSWR: ≤ 1.3
1.9.3 Coupling loss: 7 dB/ 10 dB/ 15 dB/ 20 dB/ 30 dB
1.9.4 PIM: Lower than -150 dBc for 2x20W carrier
1.9.5 Maximum Input Power: 100 Watt
1.9.6 Operating Temperature range: -10 degC to +55 degC
1.9.7 Connectors/Type: N(F)

1.10 Splitters
1.10.1 Type: 2Way/3Way/4way
1.10.2 Frequency Range: 698-2700MHz
1.10.3 VSWR: ≤1.3
1.10.4 Splitting loss: 3dB/4.75dB/6dB
1.10.5 PIM: Lower than -150dBC for 2x20W carrier
1.10.6 Maximum Input Power: 100Watt
1.10.7 Operating Temperature range: -10degC to +55degC
1.10.8 Connectors/Type: N(F)

1.11 7/8" Low loss RF Cable(FRLSZH)
1.11.1 Inner conductor: Smooth copper tube
1.11.2 Outer conductor: Ring Corrugated Copper
1.11.3 Jacket: Fire Retardant Low Smoke Zero Halogen(FRLSZH) PE

1.12 1/2" Low loss RF Cable(FRLSZH)
1.12.1 Inner conductor: Copper clad Aluminium
1.12.2 Outer conductor: Ring Corrugated Copper
1.12.3 Jacket: Fire Retardent Low Smoke Zero Halogen(FRLSZH) PE

1.13 Optical Fiber cable 6/12/24 or 48 core LSZH
1.13.1 Single Mode Fiber
1.13.2 Outer Sheath: LSZH black
1.13.3 Armoring: Corrugated Steel Tape

1.14 Fiber Management System FMS 6/12/24/48 port
1.14.2 Height: 44.45mm (1u) Max
1.14.3 Key Technical Requirements (to be complied)
1.14.4 Proposed Active DAS should be State of Art design to meet the requirement of Imphal Airport and should be scalable for Coverage and Capacity needs inside all important buildings (existing and proposed)
1.14.5 Proposed solution should be Modular in Design with respect to addition of Operators/bands
1.14.6 Modular POI should have the flexibility to take SISO or MIMO card in the same sub rack to minimize space and sub-rack requirement

1.14.7 All Passive components should have at least -150dBC PIM@2x20W Carrier

1.14.8 Proposed solution should support 2x2 MIMO for all LTE bands including LTE850/ LTE1800/ LTE2300/ LTE2500

1.14.9 Budget and RSL/RSRP/RSCP to be shared for all supported technologies so as to justify the number of Remote Units and Antennas considered in the design

1.14.10 BOM should be offered at L3 level describing each card/module/component to have ordering flexibility as per requirement

1.14.11 Remote Network Monitoring System should be proposed for all Active Elements in the Active DAS network

1.14.12 All cables used in the project should be Fire Retardant Low Smoke Zero Halogen type

1.14.13 The proposed system design should generate minimum Uplink noise in 3G/4G Uplink paths

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**SYSTEM DESIGN & TECHNICAL REQUIREMENTS**

Details for submission of documents by the EPC contractor & it’s specialized agency/ agencies.

THE EPC CONTRACTOR SHALL **PROPOSAL THAT MEETS THE “TECHNICAL SPECIFICATION” OF THIS TENDER DOCUMENT, INDICATING CLEARLY THE MAKE AND MODEL OF EQUIPMENT OF EACH ITEM, BEING OFFERED FOR THE APPROVAL OF ENGINEER-IN CHARGE BEFORE EXECUTION OF WORK.**

- The cost for the Maintenance/Service during DLP period of 24 months is covered under the scope of work and quoted rates shall be deemed to cover regular examination of the installations by the trained technician of the contractor including necessary adjustments, cleaning including replacement of parts etc. to keep the equipment in excellent operational state.

- The contractor shall also provide 24 hour emergency repair service to attend the distributed antenna System at any time of the day or night including Sundays and Holidays.

- All Inclusive Comprehensive Maintenance Contract (AICMC) to be undertaken by the EPC Contractor for the **next five years** after completion of the guarantee / warranty & defect liability period of **TWO year**.

- The detailed terms and conditions of the all-inclusive Comprehensive Maintenance Contract for distributed antenna System are appended under **SCC for Operation & All inclusive comprehensive Maintenance contract**: The quoted amount for AICMC will be taken into consideration for evaluation of the bids.
A. BRIEF CONCEPT DESIGN

TMR system will be designed to provide effective radio coverage in terminal building and associated apron area, BHS spaces along with cabling system. Exact radio coverage schema can be developed based understanding of existing conditions as well as agreed architectural plans.

The TMR system will be designed to provide effective radio coverage inside the terminal building as well as associated landside areas and BHS spaces.

A dedicated digital trunk mobile radio (TMR) system shall be provided for:

2.1 Comprehensive radio coverage for both internal and external (landside - between approach road and terminal building) areas via a Central Radio Site and distributed antenna system.

2.2 The system shall be based on industry-standard TETRA technology

2.3 Secure digital communications for enhancement of public safety and freedom from interception by interlopers.

2.4 Multiparty closed-user-group communications for privacy

2.5 Private handset-to-handset and handset-to-telephone communications;

2.6 Command and control dispatcher workstations for major users to provide flexible voice, data messaging and telephony facilities;

2.7 Packet data facilities for productivity applications;

2.8 Digital recording of all communications for security purposes

2.9 The following types of TMR Handsets are proposed:

2.10 Ruggedized hand portable

2.11 GSM-style lightweight hand portable

2.12 Mobile for vehicle installation

2.13 Mobile for fixed desk-top installation

Portable equipment shall be designed to operate in an outdoors hostile airport environment. Portables shall incorporate as standard software template facilities to enable the implementation of customized Flight Number Calling facilities and other applications in future. Portables shall be offered complete with optimized whip antenna, desktop battery charger and belt-clip. Wideband portables shall cover the full UHF band 380-430MHz. TMR Handsets are proposed:
Lightweight GSM-style portable equipment is for use mainly inside passenger terminal buildings by management staff and others as an alternative to heavy duty handsets.

Mobile Radio Equipment shall have a large easy to read display with large keys able to be operated with gloved hands. Mobiles shall have a detachable front panel to enable flexible mounting in a wide variety of different vehicles. Mobiles shall have IP multi-slot packet data capability as a standard built-in feature.

For desktop mounting, mobiles shall have a desk-mount box or tray for integral ergonomic mounting plus a means of connecting accessories and data cables without unsightly cables on the desk-top.

**E OF WORK:**

The TMR System comprises design, procurement, installation testing and commissioning for the new Integrated terminal building and associated landside areas as per below specific scope of works:

i. Complete site survey, site/system plan approval for TETRA based Digital Radio Trunking System.

ii. Design, Supply, installation, testing & commissioning of IP based Digital Radio Trunking System including necessary accessories, equipment and furnishings including; conduit, RF cable, Remote Units, TMR Antenna, Connector, Coupler, Combiner & Splitter, power converter (for conversion of -48V DC supply) as necessary to achieve desired signal strength.

iii. Provision of TMR Head End for connection of Remote Units as required.

iv. Installation of supplied equipment, including all supporting works (e.g. Mounting arrangements) to locate the TMR.

v. Any additional cable tray other than that shown on the structured cabling system Cable Tray drawings which the Contractor requires;

vi. Coordination for licensing of frequencies

vii. interfacing works with other services like structural, electrical etc.

viii. TMR system based on TETRA network. A BTS located at a central radio site which houses multichannel digital radio transceiver equipment for providing shared mission critical wide area push-to-talk radio transmission service to multiple entities on a closed user group basis via an Omni-directional antenna system installed at the top of a building

ix. Several dispersed Despatcher Control PC Workstations, housed at several locations around the airport and connected to the BTS via the airport IP network, which provide dispatch operator monitoring, access and control of radio workgroups, individuals, telephony and data systems for command and control of mobile resources.

x. An RF power splitter system in the main RF feeder cable to provide a low power RF feed to an RF Master Distribution Unit which will convert the RF signal for transmission over fibre optic cable for distribution to airport terminal.

xi. Supply, installation & customization of licensed copy of operating system & application software required for system operation/maintenance/programming.
xii. Testing for Radio coverage, ensure the necessary coverage as per requirement
xiii. Testing, Commissioning and Acceptance of the entire system. A digital voice recording system for recording and archiving all calls and providing playback facilities on a flexible basis to authorized users.
xiv. A Network Management system to permit management of the subscriber database, configuration management of the network and alarm monitoring and control of network components.
xv. Gateways to various external fixed-line and wireless networks (VoIP PBX, Analogue radio, Cellular SMS and Alarm systems) Portable handsets, vehicle-mount mobiles and desk-top mount fixed radios for use by operatives on the airport for communicating over the TETRA network.
xvi. Galvanized Iron (GI) solid and flexible conduits from the cable trays to the final termination points, such that cabling is protected throughout from source (TMR equipment) to destination.
xvii. Earthing of the complete installation.
xviii. The TMR The Contractor shall coordinate with other sub-systems including architects, structural teams to determine final locations, mounting heights, civil works, set-outs, coordination with power outlets, for all data outlets

b. Technical Requirement
i. Design Standards
The system shall comply with the following minimum standards:

1. EN 300 392-1 v1.3.1 - Voice + Data (V+D)
3. EN 60 950-1: 2001, Low Voltage Directive
6. EN 61000-3-2:2000, Harmonic Current Emission

The TMR system shall meet all specifications, stipulations, requirements and regulations of the ETSI TETRA standard. The TMR shall employ TETRA-over-IP technology for interconnection of TMR system nodes, dispatcher control systems, servers and the like.

ii. Radio Coverage Requirements
The antenna network shall have a coverage of −90dBm on downlink signal path at the worst case, measured by a reference dipole at 1.2m above ground level and free from the effects of body and crowd losses for 98% of locations, effectively providing a 98% reliability within the areas of coverage. The maximum received signal level shall be −35dBm. A dynamic range of 70dB shall be allowed for the uplink signal.

Radio coverage acceptance shall be based on field strength measurements carried out to prove the standard of coverage attained.
Radio coverage acceptance shall not only depend on the standard of radio coverage attained but also on the absence of RF interference caused by inter-modulation, cross-modulation and selectivity problems.

Radio coverage to Mobile Command Post vehicles with antenna height of 2m AGL shall also extend to 95% of locations at a distance of 3kms from the airport boundary.

iii. Central Radio Site
The Central Radio Site shall house multi-channel digital radio Base Station Transceiver (BTS) equipment for providing shared mission critical wide-area push-to-talk radio transmission service to multiple entities on a closed user group basis.

The services shall be transmitted via an Omni-directional antenna system that is installed at the top of a tower/mast located adjacent to the radio site building. New location for Antenna to be considered that is suitable for comprehensive coverage of external areas Terminal Building, with an analysis of splitting the feed for IBS and external antenna.

iv. Particular requirements
The contractor shall propose In Building Solution (IBS) for coverage inside the buildings of terminal building. Further, the IBS solution should fulfil the following requirements.

Establish reliable and seamless indoor coverage throughout airport terminal for TETRA system RF coverage.

Design shall be in consideration with the RF coverage extension from TETRA BASE STATION by using a passive Distributed Antenna System (uses a combination of Combiner, RF cable, splitter, coupler & antennas)

IBS for TETRA shall be capable of supporting the frequency band of 380 - 430 MHz and the active equipment or optical Bidirectional amplifier for the TETRA IBS shall be compatible with the proposed TETRA network.

All passive components shall be capable of handling the total average and peak power levels emitted by the TETRA BTS equipment when under full load.

All Passive components shall meet VSWR of 1:5 to 1 based 50 ohm impedance with minimum insertion loss.

RF cables shall be low loss copper corrugated type and Low Smoke zero halogen type.

The Contractor shall complete a detailed RF survey of the required coverage areas to make a determination of planned equipment locations, antenna placement and RF cable routing needed to design the IBS. The RF survey shall show assumptions made for occupation of stands in operational use.
The Contractor shall submit the coverage predictions for TETRA IBS for describing the coverage level. Ensure the simulation plots are done with industry standards Software tool.

Contractor shall consider 99.9% system availability in the design to ensure the uninterrupted service.

No radiating element shall emit signal power levels that exceed current recommended maximum safe RF level guidelines by the ICNIRP.

The IBS shall be used 24 hours a day, 7 days a week, throughout the year.

Signal Coverage: The IBS shall satisfy the following signal coverage requirements:

Coverage level requirement for TETRA IBS shall be designed -85 dB or better in public and non-public area at 98% of location probability.

Indicated Coverage levels are on worst case and the system design should meet the coverage requirements for a complete system performance based on the airport operation requirement.

v. **TETRA Indoor Omni directional Antenna:**
   1. Frequency range : 380 MHz to 430 MHz
   2. Polarization : Vertical
   3. Gain : 2-4 dBi
   4. VSWR: < 1.5
   5. Power : 50 W
   6. Connector : N-F

vi. **TETRA Indoor Directional Antenna:**
   1. Frequency range : 380 MHz to 430 MHz
   2. Gain : 7 dBi
   3. VSWR : < 1.5
   4. Power : 50 W
   5. Connector : N-F

vii. **½ “ RF Cable**
    1. Copper Corrugated type
    2. Impedance : 50Ω
    3. Conductor Diameter : Inner – 4.80 ± 0.05 mm, Outer – 13.92 ± 0.25 mm
    4. Jacket diameter : 15.80 ± 0.20 mm
    5. Jacket Type : LSZH

viii. **7/8 “ RF Cable**
     1. Copper Corrugated type
     2. Impedance : 50Ω
     3. Conductor Diameter : Inner – 9.4 ± 0.05 mm, Outer – 25.2 ± 0.25 mm
     4. Jacket diameter : 27.90 ± 0.20 mm
     5. Jacket Type : LSZH
c. **System Components**
The antenna network shall not impart interference to other radio frequency (RF) systems both inside and outside the terminal building. Likewise, the network shall not itself incur any interference from existing RF systems.

System hardware may include RSX coaxial cable, leaky co-axial cable, bi-directional amplifiers, splitters, cross band couplers and antenna. Where employed, the hardware shall meet with the minimum requirements specified below:

d. **Indoor Antennas**
Indoor antennas shall be low profile, compact and lightweight. The colour and style shall match the architecture of the surroundings as approved by the client.

The antenna brackets shall be made of stainless steel and shall be capable of supporting the antenna securely to the mounting structure.

e. **Transmitter Combiners**
Transmitter combiners shall be with low loss and capable of consistent performance over the entire temperature and power range.

They shall be compact and modular in design and shall enable channel-by-channel expansion. Transmitter combiners shall meet the following performance characteristics:

f. **Receiver Multi-couplers**
Receiver multi-couplers shall use low noise amplifiers that offer high immunity to intermodulation and interference. It shall be modular in design and easily expandable in small channel increments.

Receiver multi-couplers shall have the following performance characteristics:

Unused ports of the receiver multi-coupler shall be terminated with suitable loads.

g. **Duplexers**
Duplexers shall be of compact design and capable of offering high isolation between transmitter and receiver ports to minimize interference. It shall be temperature compensated to ensure stability over the entire temperature range.

h. **Power Dividers**
The power dividers shall operate within the frequency band of 380 MHz to 430 MHz with the same bandwidth requirement. Two-way, three-way and four-way even-split power dividers shall be utilized as required.
i. **Coaxial Feeder Cables**
Coaxial feeder cables shall be of low attenuation and low VSWR type with great strength and flexibility. Coaxial feeder cables shall completely RFI/EMI shielded to protect against interference. Connector attachment shall be quick and reliable with excellent electrical contact. For cables installed in enclosed areas, the outer sheath or protective jackets for the cables shall be of low smoke zero halogen type.

j. **Bi-directional Amplifiers**
Bi-directional amplifiers provided shall be compact, lightweight and equipped for wall mount.

k. **Handsets/Radio Terminal Equipment**
The following types of handsets/radio terminals will be required for airport use:

- Ruggedized hand portable
- GSM-style lightweight hand portable
- Mobile for vehicle installation
- Mobile for fixed desk-top installation

i. Portable equipment shall be designed to operate in an outdoors hostile airport environment.

ii. Portables shall incorporate as standard software template facilities to enable the implementation of customized Flight Number Calling facilities and other applications in future.

iii. Portables shall be offered complete with optimized whip antenna, desktop battery charger and belt-clip.

iv. Wideband portables which cover the full UHF band 380-430MHz.

v. Lightweight GSM-style portable equipment is for use mainly inside passenger terminal buildings by management staff and others as an alternative to heavy duty handsets.

vi. Mobile Radio Equipment shall have a large easy to read display with large keys able to be operated with gloved hands. Mobiles shall have a detachable front panel to enable flexible mounting in a wide variety of different vehicles.

vii. Mobiles shall have IP multi-slot packet data capability as a standard built-in feature.

viii. For desktop mounting, mobiles shall have a desk-mount box or tray for integral ergonomic mounting plus a means of connecting accessories and data cables without unsightly cables on the desk-top.

ix. The following stakeholders of radio terminal equipment shall be provided: This will need to be assessed during detailed design stage based on inputs from stakeholders to cater operational requirements.

l. **Stakeholders:**
- Offices - Airline
- Offices – Retail
- Offices – AAI
- Ground Handler Room
- Security
-
m. System Reliability
Due to the mission critical nature of the airport, system reliability is paramount. The Contractor shall provide a redundant configuration for reliability as follows:

i. Dual redundant controllers (in hot standby mode), with N+1 transceivers, shall be provided.
ii. Redundancy of other critical elements (e.g. switches and routers) shall also be provided.

B. TRUNK MOBILE RADIO SYSTEM:

The TMR system will be designed to provide effective radio coverage inside the terminal building as well as associated landside areas and BHS spaces.

A dedicated digital trunk mobile radio (TMR) system shall be provided for:

- Comprehensive radio coverage for both internal and external (landside - between approach road and terminal building) areas via a Central Radio Site and distributed antenna system.
- The system shall be based on industry-standard TETRA technology
- Secure digital communications for enhancement of public safety and freedom from interception by interlopers.
- Multiparty closed-user-group communications for privacy
- Private handset-to-handset and handset-to-telephone communications;
- Command and control dispatcher workstations for major users to provide flexible voice, data messaging and telephony facilities;
- Packet data facilities for productivity applications;
- Digital recording of all communications for security purposes
- The following types of TMR Handsets are proposed:
  - Ruggedized hand portable
  - GSM-style lightweight hand portable
  - Mobile for vehicle installation
  - Mobile for fixed desk-top installation

Portable equipment shall be designed to operate in an outdoors hostile airport environment. Portables shall incorporate as standard software template facilities to enable the implementation of customized Flight Number Calling facilities and other applications in future. Portables shall be offered complete with optimized whip antenna, desktop battery charger and belt-clip. Wideband portables shall cover the full UHF band 380-430MHz. TMR Handsets are proposed:

Lightweight GSM-style portable equipment is for use mainly inside passenger terminal buildings by management staff and others as an alternative to heavy duty handsets.
Mobile Radio Equipment shall have a large easy to read display with large keys able to be operated with gloved hands. Mobiles shall have a detachable front panel to enable flexible mounting in a wide variety of different vehicles. Mobiles shall have IP multi-slot packet data capability as a standard built-in feature.

For desktop mounting, mobiles shall have a desk-mount box or tray for integral ergonomic mounting plus a means of connecting accessories and data cables without unsightly cables on the desk-top.

**SYSTEM DESIGN & TECHNICAL REQUIREMENTS**

Details for submission of documents by the EPC contractor & it’s specialized agency/ agencies.

**THE EPC CONTRACTOR SHALL PROPOSAL THAT MEETS THE “TECHNICAL SPECIFICATION” OF THIS TENDER DOCUMENT, INDICATING CLEARLY THE MAKE AND MODEL OF EQUIPMENT OF EACH ITEM, BEING OFFERED FOR THE APPROVAL OF ENGINEER-IN CHARGE BEFORE EXECUTION OF WORK.**

- The cost for the Maintenance/Service during DLP period of 24 months is covered under the scope of work and quoted rates shall be deemed to cover regular examination of the installations by the trained technician of the contractor including necessary adjustments, cleaning including replacement of parts etc. to keep the equipment in excellent operational state.
- The contractor shall also provide 24 hour emergency repair service to attend the TMRS System at any time of the day or night including Sundays and Holidays.
- All Inclusive Comprehensive Maintenance Contract (AICMC) to be undertaken by the EPC Contractor for the next five years after completion of the guarantee / warranty & defect liability period of two year.
- The detailed terms and conditions of the all-inclusive Comprehensive Maintenance Contract for TMRS System are appended under SCC for Operation & All inclusive comprehensive Maintenance contract. The quoted amount for AICMC will be taken into consideration for evaluation of the bids.
SCHEDULE–D: ANNEXURE-1(PART–IV)
CONSTRUCTION SPECIFICATION

SECTION-12A: ACCESS CONTROL SYSTEM
Access control System (BCAS): As per Annexure A.

NOTE:

At present at Imphal Airport, the BACS (Biometric Access Control System) is available.

The Scope of work includes the extension of existing BACS infrastructure at new Technical Block as per BCAS (Bureau of Civil Aviation & Security) guidelines and as per requirements of the site under consideration.

Application Software & License for Biometric Access Control System has been developed and provided by iSolus and is available for entire airport site. All other items for the BACS at new terminal building shall be provided by the EPC Contractor and shall be compatible with the existing application.

The EPC Contractor can also provide/develop application as per BCAS standards and as per the site specifications. The key specifications of the existing or proposed application shall be as per BCAS and as per Annexure-A.

1 Scope of work

General Section

1.1. Background
The proposed Biometric Access Control System (ACS) envisages biometric authentication in addition to identity verification for card holders to gain access to restricted areas at all aerodromes across the country. This would entail fingerprint readers, keyboard for PIN entry including read/write contactless smart card technology to manage access through implementation of access control system (ACS).

1.2 Objective

a) Issuance of smart card-based Airport Entry Card (AEC) to all valid personnel (users)
b) Authentication of personnel (users) at access control points based on matching live biometric against biometric template stored on contact-less smart card issued.
c) PIN shall be provided by the BCAS central system at the time of issue of card.
d) Issuance of RFID vehicle tags for all vehicles requiring entry to aerodrome
e) Automation of the existing AEC issuance process
f) Automation of existing vehicle entry permit issuance process
g) Real-time tracking and monitoring of airport access.

1.3. System Description – In Brief
The integrated Biometric Access Control System (ACS) is connected by a workflow subsystem, authentication sub-system and suitable ICT infrastructure to issue smart – card AECs/ RFID vehicle tags.
tags and allow access of personnel/vehicles to aerodrome premises based on biometric authentication and contactless smart-card based identity verification according to region, terminal, and zone and gate access privileges.

ACS needs to be implemented for Imphal airport, for effective control and monitoring of personnel (using ‘airport entry card’, AEC) and vehicles accessing the airport. The access control system shall encompass:

i) Automation of process and workflow for AEC and vehicle RFID tag issuance to personnel from various entities

ii) Smart card reader-controller sub-system (1 reader: 1 controller) installed at personnel access points will have SAM (secure access memory) that will hold master key to decrypt personnel & access privilege details in Real-time stored on contactless smart card. Personnel will be granted access based upon their authentication at access control points by matching access rights of the personnel stored on the card with the access privileges stored on smart card reader cum controller as well as verifying their live biometric template (fingerprints) against those stored on the card. Reader cum controller must have IOs to integrate minimum interfaces such as Server, E&M locks, gates and Cards etc. Tender has provision for separate reader for entry & exit on the same turnstile gate. Integration of card authentication infrastructure(card readercum controller) with physical access control apparatus like, turnstiles, gate openers at airports to enable entry using AEC only.

iii) Vehicle RFID reader - controller sub-system installed at vehicle access points to identify tags (affixed on vehicle windshield), allow/ deny access and capture access logs. The reader-controller sub-system should push the data to airport server and subsequently to central server. Each Airport shall have local Server. Central Server shall be available at BCAS.

iv) Ability to blacklist/hotlist personnel & vehicles (AEC numbers/ RFID tag numbers) at the central and or airport (local) level in order to block entry. The blacklist so created shall be consolidated at the centre and replicated across all airports to ensure that any blacklisted person is unable to gain access to airport. Capture of personnel access log by AEC card readers, temporary storage and transfer of access log to local airport server at a particular frequency. Chip Serial No. (CSN) shall be used for hot listing & blacklisting. This information shall be pushed by the BCAS server to the Airport server and then to the controller. The mode of communication between Airport server and controller is to be defined by the EPC Contractor.
v) Capture of photograph of personnel entering and driver photograph in case of vehicles (all / in case of alerts / interface to ACS application or standalone surveillance system – logs to be integrated / matched in airport control room). Alarms due to unauthorized access shall be passed on to Surveillance CCTV system for display of photograph of intruder captured through the available camera at the gate for monitoring & security purpose from CCTV control room. Integration of Access Control system with existing Surveillance CCTV system for above purpose is in the scope of EPC Contractor.

vi) Generate alarm in case of any atypical behaviour of access control barrier, unauthorized access attempt or malfunctioning of the access control system:
   - Generate alarm at gate or generate alarm at airport control room
   - Categorize alarms by severity and send SMS/ text to designated personnel as per defined severity levels from central system

vii) The solution should be web-based so as to be accessible for external stakeholders/ users on the World Wide Web and for internal users on the intranet.

viii) The solution should support offline and online mode of operations as required

ix) Offline business continuity capability in the system to allow manual operations

ACS shall be expandable in the following areas:

- Flexible and modular design shall provide ease of installation, robustness, reliability, and expansion. Flexible & Modular refers for expandability to meet future requirement in terms of more number of Gates.
- Additional hardware units shall easily be added without any modification to the existing hardware, software and network configuration. Software Changes shall be required and shall be carried out in the warranty & AICMC by the EPC Contractor. The warranty & AICMC shall cover the complete lifecycle of the System.

1.4. Key Features of ACS

The proposed ACS shall have the following features:

a. Consolidated and unified AEC database across the country. BCAS Database structure shall be intimated during Business Blue Print stage of the project.

b. Efficient and faster process for issuance and timely renewal of AECs

c. Improved compliance and controls to policies through increased transparency and accountability
d. Enhance the safety and security of the valuable infrastructure and prevent unauthorized entry into the airports.
e. To identify, categorize, verify and validate personnel data and biometric credentials in real time.
f. To minimize human error and opportunities for misuse/encroachment in operational and sensitive areas.
g. Alert authorities to an attempted intrusion or other irregularities.
h. Analyse incidents in real time and post event.
i. Use of advanced technology to minimize human intervention

1.5 Scope of work:

i) Supply, Installation, testing& Commission of Hardware & Software as per specifications.
ii) Seven years AICMC (including 2 years DLP).
iii) An end-to-end solution is being envisaged by AAI, wherein the EPC Contractor shall be responsible for supply, installation, testing & commissioning, comprehensive All Inclusive maintenance Contract (AICMC) for after warranty period.
iv) The proposed solution shall take into account AAI’s requirements of an integrated approach with internal and external stakeholders.
v) The EPC Contractor shall develop software for Biometric Access Control & Alarm management.
vi) The developed software shall be the property of AAI. The system integrator shall submit Source Code to AAI for changes to meet BCAS requirement in future.
vii) EPC Contractor shall also integrate Airport Access Control system with central system of BCAS & Airport interfaces such as CCTV & Fire alarm system. Open protocol envisaged for integration. Alarms due to unauthorized access shall be passed on to Surveillance CCTV system for display of photograph of intruder captured through the available camera at the gate for monitoring & security purpose from CCTV control room. The Access Control system in the alarm zone shall be deactivated automatically to provide free access In case of fire alarm from FAS. Integration of Access Control system with existing Surveillance CCTV system & FAS for above purpose is in the scope of EPC Contractor. Integration of access control system with boom barrier at designated place at airport.

(A) EPC Contractor shall be responsible for the following activities and any other activity required for the completion of activities mentioned in the following sub-sections:

i) Establishment of pass section
   • Install the following equipment’s (specifications for each provided in following sections):
   • Desktop /computers o Multi-function printer o Laser-jet network printer
   • Input devices for photograph & biometric capture web-camera & fingerprint enrolment scanner
   • AEC smart card printer or AEC encoder – smart card reader contact
   • RFID tag encoder for personalization
ii) Installation of hardware, Software & other infrastructure at access control points:

- Installation of smart-card readers and related infrastructure and procurement of biometric smart card readers and installation for authentication at all entry and exit terminal access points
- Installation and integration of turnstile gates & EM locks with card readers.
- Develop reader cum controller application, insert and install SAM those will be provided by BCAS for detection of valid AEC-smart cards. Undertake civil work for installation and mounting of the access control equipment, RFID transceivers, turnstiles, EM lock, etc.
- Development of software for Access Control & Alarm Management as per BCAS.
- Installation of RFID transceivers & related infrastructure
- Civil work for installation and mounting of the access control equipment, RFID readers, boom barriers, gates etc.
- Procurement and installation of RFID transceivers & related infrastructure and physical access control infrastructure including boom barriers or gates as required.
- Integration of RFID readers with physical access control equipment
- Development of a dashboard for the security control room (local) for alarm management and public announcement systems
- Establish integration/interface with the central BCAS system to share data and audit logs as per requirement

iii) Provision required connectivity & network

- Establish airport local area network (LAN) for access control system smart card readers, RFID transceivers and servers, routers and switches.

iv) Establish / develop interfaces for reporting to BCAS central server/ web-application

- Develop interface to transfer access/ event log data from smart card and long range RFID readers to local (airport) server. Data format & file structure shall be provided by EPC Contractor of BCAS central system during business blueprint & project. EPC Contractor to suggest the solution for data exchange between Central system and local system accordingly.
- Develop interface to transfer hot-list data from local server to card and tag readers
- Develop interface to update AEC, access privileges and photograph in reader-controller from local server
- Enable local servers to receive and send update to BCAS central servers in the following scenarios:
  - Offline connectivity (with batch transfers) needs to be established for receiving AEC numbers and related details from the central server to local servers. Transfers to take place once every 6 hours.
  - Offline connectivity (with batch transfers) to be established for pushing the access control logs from the local / airport servers to the central servers, transfers to take place twice daily.
- Real-time alerts are required for any un-authorized access at any airport zone at the local level and SMS based alerts to designated personnel at HQ through web application.
• Online connectivity to be established for transferring of blacklist data from local / airport servers to central servers and vice-versa in real-time to avoid any security breach
• In case online connectivity is not available, then an alarm must be generated on the server side (central and local) and any hotlist / blacklist data can be pushed manually.

(B) Supply, installation, testing and commissioning of following components/equipment under ACS:

a) Desktops
b) Web camera
c) Finger Print enrolment Scanner
d) Multifunction Printers
e) Laser Jet Network Printer
f) AEC Smart Card personalisation Printer
g) AEC Encoder
h) ACS Server
i) Development, Customization & Integration with BCAS software for Biometric Access Control & Alarm management for Airport
j) Health Monitoring and Asset Management tool
k) RFID tag Encoder
l) Smart Readers cum Controllers
m) RF ID Transceiver & Controller
n) Smart cards- contactless with neckline holder
o) Vehicle RFID tags
p) Barriers
q) EM Locks
r) Tripod Turnstile
s) Swing Gate
t) EM lock
u) Mechanical panic bar

1.6 SERVICE LEVELS
The EPC Contractor shall ensure continuity of the services at each of the airports from the date of formal operationalization as per the service level mentioned below. The EPC Contractor shall sign a service level agreement (SLA) to this effect. This section describes the service levels to be established for the Services offered by the EPC Contractor to AAI. The EPC Contractor shall monitor and maintain the stated service levels to provide quality service to AAI.
1.6.1 Definitions

(a) “Scheduled Maintenance Time” shall mean the time that the System is not in service due to a scheduled activity as defined in this SLA. Further, scheduled maintenance time is planned downtime with the prior permission of AAI.

(b) “Scheduled operation time” means the scheduled operating hours of the System for the month. All scheduled maintenance time on the system would be deducted from the total operation time for the month to give the scheduled operation time. The total operation time for the systems and applications within the AAI shall be 24x7x365.

(c) “System or Application downtime” means accumulated time during which the System is totally inoperable within the Scheduled Operation time but outside the scheduled maintenance time and measured from the time a call is logged with the OEM team of the failure or the failure is known to the OEM from the availability measurement tools to the time when the System is returned to proper operation.

(d) “Availability” means the time for which the services and facilities are available for conducting operations on the AAI system including application and associated infrastructure. Availability is defined as:

\[
\frac{(\text{Scheduled Operation Time} - \text{System Downtime})}{(\text{Scheduled Operation Time})} \times 100\% 
\]

(e) “Incident” refers to any event / abnormalities in the functioning of the any of IT Equipment’s / Services that may lead to disruption in normal operations of the Data Centre, System or Application services.

1.7 INFRASTRUCTURE

EPC Contractor shall provide the following –

A. Components for Pass section-
Desksopns, Printers, Smart card Printers, Encoders, Biometric Readers, Camera, RFID Encoders,
Smast card, RF ID Tags etc.

B. Biometric Access Control Components –

Smart card Readers cum Controllers, Server, Access switches, LAN Extenders & Media Convertors, RF ID Transceivers, Access Control & Alarm Management Software etc.. The final fully functioning application shall be the property of AAI.
C. Physical Infrastructures- Electronic Doors including Turnstiles, Barriers for Vehicles, E&M Locks  
D. Related Civil & Electrical works for Installation of Access Control System  
E. Passive cabling including UTP & OFC laying as per CPWD specifications.

2  Functional Requirements

2.1  Functional requirements of the access control system with respect to AEC smart-cards and their use at access gates is outlined below:

2.2  Requirements with respect to smart card:  
- Users will be granted access rights to specific airports and specific zones within the airports.  
- The smart card that is issued to a user will contain the user details and access rights (airports and zones) of the personnel encrypted using SCOSTA–CL operating system. SCOSTA-CL is open standard for Govt. of India applications. The smart cards proposed by the EPC Contractor must be certified by NIC.  
- A central key management system will be developed and managed by BCAS which will be used for the encryption and decryption of user data and access rights on the card. NIC shall provide the Key management Solution (KMS) for encryption and decryption.  
- When the smart card is presented to the card reader, the card reader application will decrypt the data on smart card using the master key stored on SAM. Once the card is authenticated, the controller will grant access to the user if the access rights defined on the card match the access rights stored on the reader cum controller memory.

2.3  Requirements with respect to card reader:  
- Reader cum controller will store Region, Gate ID, Zone and Airport details of the gate at which the reader cum controller is installed.  
- Each card reader cum controller installed at the airports card reader will hold the master key for the decryption of the user data on the card in the form of a Security Access memory “SAM”.  
- Airport operators can define authentication requirements (PIN based access, biometric authentication, PIN + biometric authentication) with respect to security requirements of various zones within airport.
• Once the access is authenticated, the card reader application will open the electromagnetic lock (EM lock) of the door or open turnstile gate for one entry.

• The photograph of the user accessing the gate (captured during enrolment) will be displayed on the smart card reader terminal screen for visual verification. Photograph captured during enrolment shall be stored in the local server. Reader cum Controller should have LCD display of size minimum 3"X3" either integrated or as attachment.

• The whole process from inserting/waving the card for opening of the electromagnetic lock should be completed within 5 seconds in case of a biometric match; and in 2 seconds without biometric match.

• A hot-list for all unauthorized/lost cards will be maintained in the central access control database. The same will be replicated at the local/Airport servers at all airports and all reader cum controllers from the local LAN in real time. The controller must deny access to individual card holders who are blacklisted in case they attempt to access the airport and alarm to be generated accordingly. The controller should work in offline mode also.

• The lockout/kill policy for black listed personnel can be initiated by the local airports or by the regional or central BCAS offices. The black list initiated at the airport must be replicated to the central and regional BCAS servers from where it will also be pushed to all other local airport servers in real time.

• The reader cum controller must store the logs of all personnel entering and exiting through the access control system along with their credentials and time stamp.

• These entry/exit logs will be transmitted in batches from reader cum controller to airport server and to central servers over LAN/WAN for MIS and analysis.

• In the event of exigencies or emergency, there shall be a mechanism to disable the electromagnetic lock manually and open the door. Such events shall be recorded by the system.

• The system should be capable of generating alarms in case of any atypical behaviour of access control barrier, authorized access attempt or malfunctioning of the access control system.
2.4 Requirements with respect to ACS application (Please refer Annexure B of BCAS Appendix J for detailed software requirements specifications.

- ACS shall provide a standard browser based Graphical User Interface (GUI) for central/regional/airport workflow processes, MIS, event log, alarm monitoring and management.

- The zone/gate master of the access control application will need to be integrated with AEC issuance to ensure that single master for the airport, zones/ gates and access privileges are maintained in the system. Any update to the same must be updated in other relevant modules as well.

- Airport shall upload access logs, alarm & event log to the central access control server at pre-defined regular intervals. Minimum information to be uploaded shall include entry / exit time along with Card Id.

- ACS shall be of a highly efficient and automated solution that allows operators to quickly identify an alarm scenario without frequently having to operate from one sub-system to the other during alarm activation.

- ACS shall be designed to allow security of the premises to be monitored from the local server and monitor at the airport.

- There should be provision to integrate various security subsystems to form a complete integrated security system via local network infrastructure.

- ACS shall be designed for multi-tasking, multi-users operation.

- ACS shall be designed such that any failure of any sub-systems shall not affect the other sub-systems. This shall also apply to any loss of power supply or suffer a loss in communications due to a break in the communication loop. In any case, each sub-system shall continue to function in a fully operational state with no loss of functionality.

3.0 Proposed Architecture – Block level (1/2)
The architecture should be scalable for the AAI and private airport operators such that in future additional airport sites should be supported by the AAI private cloud.

- Cost of the common router and the last mile connectivity from airports to the router and router to NICNET is to be borne by AAI and private airport operators.
- Last mile connectivity from the respective airports to AAI private cloud is to be borne by the private airport operators.

- BCAS HQ and Regional Offices (6) are to be connected to NICNET by NIC (excluding the last mile connectivity).
- AAI Private Cloud is to be connected to NICNET cloud through a secured and restricted line from BSNL/POCIL / RailTel service provider.
- All infrastructure related to Airports will be the Airport Operators (AAI and Private) responsibility.
- NIC to share a Public IP with AAI which AAI service provider should advertised to all the airport nodes in the airports including the private airports.
- AAI to provide the WAN IP of the AAI MPLS based VPN cloud to NIC.
- For security considerations, Firewalls and SSL is to be implemented.
3.1 As per the proposed architecture, the Access Control System shall have two parts –

1. Web based Central system for receipt of online applications for issue of Airport Entry passes with workflow-based approval process, control & monitoring alarms, logs, blacklist/hotlist data. This system is being procured by BCAS and shall be housed at NIC data centre at Delhi and is not in the scope of this tender. Data format & file structure shall be provided to the shortlisted EPC Contractor by BCAS EPC Contractor central system provider during business blueprint & project preparation stage.

Access Control System at Airport comprising Pass section for receiving & uploading AEP applications, capturing biometric & photograph, printing & programming of Biometric smart cards. Local server, Local Area Network, Turnstile gates, Reader

2. Reader Cum Controllers, Vehicle barriers etc. with associated software for access control as per specification. Integration of local access control system with central database of BCAS stated at above para No. 1 for updating of AEP issuance list, blacklist, hotlist and pushing of logs & alarm for monitoring & control shall also be in the scope of this tender.

BCAS has issued detailed guidelines on Access Controlled System as Appendix‘J’ Annexure-A & B. EPC Contractors are requested to go through these annexures for required solution.

The Network Connectivity Diagram is given below
### 3.2 Signal Sniffing for Airport side network:

i. Card reader cum controller connectivity should eradicate the risk of cloning or sniffing of the data signals transmitted to and from the central server side between access control server / host system on the airport local LAN.

ii. Encrypted communications on the local airport LAN connecting the terminal equipment (Smart card reader cum controller) should be used which are based on 128bit encryption standards without the use of any extra converters or 3rd party equipment.

iii. The airport side network must be secure in all respect such that the access control data is not tampered, modified and altered in any respect.
iv. Log files generated at the terminal end for entry /exit, alarms and alerts must have a seamless flow to the local airport server and pushed to the central server without any human intervention maintaining the data file structure as it is.

v. The Communication between the reader cum controller terminal & the local application Server should be encrypted to secure the Data Transmission.

3.3 Reporting of Reader log reports to central (BCAS) server

Airport will be responsible for the capture, storage and sharing of the audit logs of the access control and RFID systems. BCAS will be sharing the file structure formats for sharing the audit logs. Airports will be required to design and develop the system to share the logs at the established periodic intervals with BCAS. Airports should be responsible for receiving the hotlist, blacklist data from BCAS and remotely configuring the readers with the hotlist blacklist data.

3.4. Technical Requirements

This section details the Technical requirements which the proposed solution must be compliant with:

4. Technical Requirements:

4.1. Architecture Overview

The architecture of the system shall be based on New Generation Technology. A component-based model and a multi-tiered architecture is preferred. The framework shall be robust and capable of functioning in mission critical and highly demanding applications. The System Integrator is requested to provide the Technical architecture of the proposed solution.

The architecture shall enable easy portability of the business functions across different application servers and technologies. The system shall also have advanced Transaction Management capabilities. The system shall provide for easy interfacing with other systems and external applications using appropriate integration modes.

4.2. Architecture Highlights

4.2.1. Scalability

The system shall be scalable in respect of the modules and functionality both in respect of downsizing and upsizing; facilitating its installation at larger or smaller airports, as the case maybe. The architecture shall support increasing number of users and transaction volume without compromising on the overall response time. System should be capable of expansion at Airport for additional
gates/users in future. EPC Contractors make assumptions of 10% increase per annum for users and transactions volume.

4.2.2. Web enabled Internet Technology

Complete design of the system shall be Web based-enabled Technology should have provisions for sending/receiving the alerts & triggers through web application (SMS & email).

4.2.3. Flexibility

The system shall be highly flexible in nature and facilitate location independent deployment. The System shall support multiple users through a single deployment. Configurable elements like Message Formats, Roles and Privilege mappings, Report formats, Printer mapping, shall be considered.

4.2.4. Modularity

The system shall be modular and AAI shall be able to enhance the product functionality as and when required.

4.2.6. Inter-operability

The system shall be designed to have inter-operability with all the systems to be interfaced for the purpose of picking up data or replicating data, as also for flow of information among its own modules operative from Clients.

4.2.8. Standard Communication Mechanism:

Standard Intranet and Non-Intranet Communication Mechanism shall be used for inter Application Communication.

4.2.9. User Management

The system shall provide user interfaces to configure the role based access control. The User Interfaces shall provide functions like Privilege Maintenance (Add, Modify, Delete); Privilege group Maintenance (Add, Modify, Delete) etc.
4.2.10. Audit

The system shall have a full-fledged Audit process to log the information regarding transactions and changes to the data. Some of the examples are

1. Creation, modification and deletion of all master data, parameters, and configuration shall be audited.
2. Audit record shall contain information such as:
   - User Id - The staff or user who has performed the transaction.
   - Date and Time
   - Entity Name (AEP, Airport, Zone)
   - Transaction Name (Manifesting, build-up, etc.)
   - Major business data elements that are affected
   - The values of data elements before and after the transaction

4.2.11. Usability

The system shall have High usability functions. The System Integrator is free to describe the Usability features available in the system.

4.2.12. Availability

The architecture shall ensure high availability (application & database level) at server level by eliminating the single point of failure.

4.2.13. Reliability

The system shall be highly reliable. It is also preferred to have a robust failure recovery mechanism and automatic recovery process for some critical errors.

4.2.14. Health & Asset Management

The system shall be capable of monitoring health of Biometric Access Control System Imphal Airport from central location at AAI Data Centre at Delhi along with Asset management. The standard SNMP
based tools or other market standard IT infrastructure management tools may be used and factored in the proposal.

4.2.15 Information Security

The system shall be secured from virus threats, spyware threats, hacking, phishing etc. The solution should include the required software tools & techniques for protection of data & safeguard of application. Security audit of the system from authorized agencies such as STQC etc. shall be the responsibility of the EPC Contractor. Development of Access Control & Alarm management software shall be based on the SRS document to be prepared during business blue print stage of the project. Under which EPC Contractor selected for BCAS central system and EPC Contractor selected for the work under this tender shall interact for meeting the system requirement specified in this tender and BCAS Circular No. 15/2013 Appendix-J (Restricted) containing Annexure A & B regarding implementation of biometric Access Control System.

4.3. Infrastructure Requirements

4.3.1. Hardware and Software

The EPC Contractor shall provide detailed information about various hardware and software requirements for the proposed ACS to be operational. This shall include the Servers, Desktops, Mono Laser Printers, Readers cum Controllers, Access Control & Alarm Management software.

4.4. Interfaces

The system shall follow an open architecture with the proposed solution being able to integrate with other systems and external applications. The system should be able to communicate with industry leading open system protocols such as, HTML, XML, OPC, ONVIF etc. The Access Control System (ACS) shall be integrated with the web based centrally managed Airport Entry Pass Issuance system of BCAS. The solution shall be designed in such a way that the business layer has no dependency on the type of protocol used in the interface layer.

4.4.1. Interface with AAI systems

a) Fire Alarm System Integration: System shall interface with existing Fire Alarm System of AAI to provide free access in case of fire.
b) CCTV Integration: System shall interface with existing CCTV system of AAI to provide information required for investigation like monitoring of the entry/exit of staff at access control zones and vehicle entry/exit zones as per the access control logs available to identify staff/vehicles.

c) Boom barrier Integration

All the specifications of the product offered shall be as per the requirement of BCAS and as per BCAS guidelines.

Source Code of the application (BACS) shall be provided by the OEM for further necessary amendments.