GENERAL CONDITIONS OF CONTRACT

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SIGNATURE OF TENDERER WITH SEAL

EMPLOYER
Project: “Civil, Electrical and other utility services for package -Civil- II (Rotable complex)"

PART- I - GENERAL CONDITIONS OF CONTRACT 1. DEFINITIONS AND INTERPRETATIONS

Abbreviations

ASTM – American Society for testing and materials material code
A/C – Air conditioning
AWS – American welding society
AHU – Air handling unit BOQ – Bill of quantities C/C – Center
to Center CD/DVD – Compact disc / Digital video disc

DG U/S EOT crane – Double girder underslung electric overhead traveling crane DL – Dead load

DFT – Dry film thickness EIC – Engineer-in-charge FFL – Finished floor level IS – Indian standards, presently Bureau of Indian standards (BIS)

LL - Live load
Mt. – Meter
MT - Metric tonne
PEB – Pre-Engineered Buildings
RCC – Reinforced Cement concrete

SG U/S EOT crane – Single girder underslung electric overhead traveling crane SL – Seismic load

TCT – Total coat thickness
UPVC pipe – Un-plastisized poly vinyl chloride

SIGNATURE OF TENDERER WITH SEAL

EMPLOYER
PART I - GENERAL CONDITIONS


1. DEFINITIONS AND INTERPRETATIONS

1) In the Contract, as hereinafter defined, the following words and expressions shall have the meanings hereby assigned to them, except where the context otherwise requires:

Definitions

a) "Employer" or “Owner” means M/S HINDUSTAN AERONAUTICS LTD., AIRCRAFT DIVISION, NASIK, who will employ the Contractor and the legal successors in title to the Employer, but not, except with the consent of the contractor, any assignee of the Employer.

b) HINDUSTAN AERONAUTICS LIMITED, AIRCRAFT DIVISION, NASIK, hereinafter referred to as “HAL” shall means the Board of Directors, General Manager or other Administration Officers of the said company. The Chief Manager (Works & Services), Sr. Manager (Works & Services) are authorized to invite tenders and enter into contract for works on behalf of the company.

c) "Contractor" means the persons, firm or company whose tender has been accepted by the Employer & includes the Contractor's personal, representative’s successors and permitted assigns.

d) Consultant means M/s SEMAC Limited, Conjeevaram House, 2nd Floor, 6-1 - 276, Padmaranagar, Secunderabad, 500 025 (India), its permitted assigns or its successors who shall act through it’s accredited representatives as the Agents of the Employer for the Contract.

e) “THE ENGINEER IN CHARGE” (EIC) means the Officer deputed by the Senior / Chief Manager (Works) to supervise the work or part of the work.

f) "Engineer In Charge’s Representative" means any engineer or assistant of the EIC or any person appointed from time to time by the EIC to perform the duties set forth in the tender document on behalf of the Engineer In Charge.

g) "Consultant's Representative" means any Project Manager, resident engineer or assistant of the Engineer or any clerk of works appointed from time to time by the Consultant to perform the duties set forth in the tender whose authority shall be notified in writing to the Employer by the "Consultant.

h) The `Work' or `Works' means the work described in the Tender Documents, Drawings and Specifications as may be issued from time to time to the Contractor by the Engineer In Charge, Consultants or the Engineer, including all modifications, extra and additional works and obligations to be carried out either on site or at any factory, or workshop or any other place for subsequent incorporation, as required for performance of the Contract.

i) "Contract” means the contract between the Employer and the Contractor to execute, complete and maintain the work / works and shall consist of Tender Notice, Form of Tender, Appendices to Form of Tender; other Appendices / Annexures / Formats of Bank Guarantee etc. as included in the Tender Document, General Conditions of Contract, Special Conditions, Specifications, Drawings, priced Bill of Quantities / Schedule of Rates, “Common set of Deviations” / Addendum / Corrigendum etc. as issued by the Employer before or after Pre-bid meeting but before last date of submission of tender, Contract Data and any other document as may be listed in the Tender as part of the contract, Letter of Intent / Acceptance, Contract Agreement between the Employer and the Contractor and Works order.
j) “PROVISIONAL SUM” means a lump sum included by HAL in the tender documents and represents the estimated value of the work for which details are not available at the time of inviting the tender.

k) "Contract Sum" means the sum named in the letter of Intent / Acceptance subject to such additions thereto or deductions there from as may be made under the provisions of the Contract during execution.

l) The “FINAL SUM” means the actual amount payable under the contract by HAL to the contractor for the entire execution on full completion of the work.

k) "Constructional Plant" means all appliances or things of whatsoever nature required for the execution or maintenance of the Works but does not include consumable materials or other things intended to form or forming part of the Works.

l) "Specifications" means the specification included and referred to in the Tender and any modification thereof or addition thereto as may from time to time be furnished or approved in writing by the Engineer In Charge.

m) "Drawings" means the drawings referred to in the specification and any modification of such drawings approved in writing by the Consultant and Engineer In Charge and such other drawings as may, from time to time, be furnished and approved in writing by the Engineer In Charge and Consultant.

n) ‘Site’ means the land and/or other places on, in, into, under or through which the Work(s) are to be executed under the contract or any adjacent or any nearby land, path or street which may be allotted or used for the purpose of carrying out the Contract.

o) "Approved" means approved in writing, including subsequent written confirmation of previous verbal approval and "approval" means approval in writing, including as aforesaid.

p) "I.S.” means `Indian Standards' issued by the Bureau of Indian Standards.


r) A “Week” means seven days without regard to the number of hours worked or not worked in any day in that week.

s) A “Day” means a day of 24 hours irrespective of number of hours worked or not worked in that day.

t) A “WORKING DAY” means a day other than prescribed by the Negotiable Instruments Act as being holiday and consists of the number of hours of labour as commonly recognized by good employers in the trade in the Nashik District where the work is carried out or as laid down in the HAL Regulations.

u) “DEVIAITON ORDER” means an order given by the Manager (Works) or Sr. Manager (Works & Services) or Chief Manager (Works & Services) or Engineer-in-charge which become necessary to effect an alteration, addition or deduction or deletion, which does not radically affect the scope of nature of the contract.
v) “EMERGENCY WORKS” means any urgent measures, which in the opinion of the Engineer-in-charge become necessary during the progress of the work to obviate any risk or accident or for security.

w) “ACCEPTING OFFICER” means the Chairman, HAL or any other officer nominated by him.

x) ENGINEER-IN-CHARGE” or “MANAGER (WORKS), or “SENIOR MANAGER (WORKS AND SERVICES)” or “CHIEF MANAGER (WORKS & SERVICES)” means the Engineer-in-charge, Manager (Works), Sr. Manager (Works & Services) or Chief Manager (Works & Services) of HAL Aircraft Division, Nasik.


z) The “APPROVAL” and “DIRECTED” means the approval or direction of the Engineer in Charge / Employer.

aa) The “DATE” of completion is the date or dates for completion of the whole or any part of the work as set out in or ascertained in accordance with the individual work order or any subsequent agreed amendments thereto.

2) Words imparting the singular only also include the plural and vice versa where the context requires. Male also means Female or neuter and the other way around where context so requires.

3) The headings and marginal notes in these Conditions of Contract shall not be deemed to be part thereof or be taken into consideration in the interpretation or construction thereof or of the Contract.

2. CONSULTANT AND CONSULTANT’S REPRESENTATIVE

1) The Consultant and his representative shall carry out such duties as are specified in the Contract like giving instructions regarding execution of entire work as per the Engineering standards, issue of working drawings, providing clarifications on the drawings and specifications, quality control measures, guidance on all technical matters, scrutiny of claims, suggestion of modifications/changes as per the requirement of owner, all documentation works whatsoever required and connected with the execution of the subject work.

The consultant shall have no authority to relieve the Contractor of any of his obligations under the Contract.

3. ASSIGNMENT AND SUB-LETTING

1) The contractor shall not, assign or transfer the contract or any part thereof or any share, or interest therein to any other persons without the prior written approval of the employer. No sum of money which may become payable under the contract shall be payable to any person other than the contractor.
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circumstance.
The contractor shall carry out the work directly by themselves and shall not sub-let any part of
the Work(s) without the prior written consent of the Employer and such consent, if given shall
not relieve the Contractor from any liability or obligation under the contract and he shall be
responsible for the acts, defaults and neglects of any sub-contractor, his agents, servants or
workmen as fully as if they were the acts, defaults or neglects of the contractor, his agents, servants
or workmen. Sub letting of the contract will be allowed only for specialized items at the
discretion of HAL. The contractor shall co-ordinate and shall be responsible for all aspects of his
sub-contractor(s), without being relieved of any of his obligation under the contract.

4. CONTRACT DOCUMENTS

1) (a) The ruling language for the contract and related aspects shall be English. Language’s
and Law

The contract shall be Governed by and construed in accordance with the law of
India and no suit or other proceeding relating to the Contract shall be filed or taken by the
Contractor in any Court of Law which shall not have exclusive jurisdiction to hear and
determine all actions and proceeding in connection with and arising out of the Contract,
and the Contractor shall not submit to the jurisdiction of the aforesaid Court of Law for
the purpose of any such action and proceedings.

2) The several documents forming the Contract are to be taken as mutually explanatory of one another, but in case of ambiguities or discrepancies the same shall be explained and adjusted by the Consultants who shall there upon
issue to the contractor instructions thereon through the Consultant’s representative. In
such event, unless otherwise provided in the contract, the priority of documents for
execution of works shall be as follows:

- Description of items of work given in Bill of Quantities.
- Drawing
- Detailed Technical specifications.

5. DRAWINGS

1) The Drawings shall remain in the sole custody of the Engineer In Charge, but two copies thereof shall be provided to the Contractor free of charge. Custody of Drawings
The contractor shall not use the said drawings for any purpose other than execution of the
work till completion of the work in all respect.

2) One copy of the Drawings, furnished to the Contractor as aforesaid, shall be kept by the Contractor on the Site and the same shall at all reasonable times be available for inspection and use by the Engineer in Charge, his representative and the consultant or consultant’s representative and by any other person authorised by the Engineer In Charge in writing. The drawing shall be
protected, preserved and safely kept at site office.

3) The Engineer In Charge or his representative and the Consultants shall have full power and authority to supply to the Contractor from time to time during the progress of the Works, such further drawings and instructions as shall be necessary for the purpose of the proper and adequate execution and maintenance of the Works. The Contractor shall carry out the work according to the drawings and instructions issued by the Engineer In Charge and Consultant from time to time and the contractor is bound by the same.
The Contractor shall give written notice to the Consultant and Engineer In Charge whenever the planning or progress of the Works is likely to be delayed or disrupted unless any further drawing or order, including a direction, instruction or approval, is issued by the Engineer In Charge or consultant within a reasonable time. The notices shall include details of the drawing or order required and of why and by when it is required and of any delay or disruption likely to be suffered if it is late.

6. GENERAL OBLIGATIONS

1) The Contractor shall, subject to the provisions of the Contract, and with due care and diligence, execute, complete and maintain the Works and provide all labour, including the supervision thereof, materials, Constructional Plant and all other things, whether of temporary or permanent nature, required in and for such execution, and maintenance, so far as the necessity for providing the same is specified in or is reasonably to be inferred from the Contract.

2) The Contractor shall take full responsibility for the adequacy, stability and safety of all site operations and methods of construction. Provided that the Contractor shall not be responsible, except as may be expressly provided in the Contract, for the design or specification of the Permanent Works, or for the design or construction specification of any Temporary Works prepared by the Consultant. If the works contract expressly provides that any of the Permanent works shall be designed by the Contractor, he shall be fully responsible for such works, notwithstanding any approval given by the Consultant.

The contractor shall promptly inform the Consultant of any error, omission, fault and other defects in design, drawing or specifications for the Works which are discovered while reviewing the contract documents or in the process of execution of Works.

3) The Contractor shall, when called upon to do so, enter into and execute a Contract Agreement; to be prepared and completed in the form annexed with the Tender document and with modification as may be necessary by the Employer.

4) If, for the due performance of the Contract, the Tender shall contain an Performance Guarantee / a scheduled and/or nationalized bank to be bound with the Contractor to the Employer in a sum not exceeding that stated in the clause 24 of Instructions to Tenderers and agreed to as per the Letter of Acceptance or Letter of Intent / Work Order for such bond or guarantee, the said bank and the terms of the said bond or guarantee shall be such, as approved by the Employer. Obtaining of such bond or guarantee or the provision of such sureties and the cost of the bond or guarantee to be so entered into, shall be borne in all respects by the Contractor. Performance Guarantee shall be valid up to the completion of works (including time for extension if granted) plus three months. During defects liability period 50 % of the Security Deposit i.e. Retention money shall be retained till the Defect liability period is over.
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5) The Contractor shall be deemed to have inspected and examined the Site and its Inspection surrounding and information available in connection therewith including the of Site prevailing security environment and incumbent requirements of the employer and to have satisfied himself, before submitting his Tender, as to the form and nature thereof, including the subsurface conditions, the hydrological and climatic conditions, the extent and nature of the work, accommodation & facilities he may require and, in general, shall be deemed to have obtained all necessary information as mentioned above, as to risks, contingencies and all other circumstances which may influence or affect his Tender.

The Contractor is further deemed to have taken particular notice of approaches and way leaves etc. connecting the site. The Employer does not undertake to improve the same any further & the Contractor will have to improve the same or make new approaches and way leaves, at his own cost, if the existing approaches & way leaves are considered inadequate and unsuitable by the Contractor. Use of such new or improved approaches and way leaves shall be afforded to the Employer, the Engineer, the Consultants and any other concerned person, without any restrictions or compensation.

6) The Contractor shall be deemed to have satisfied himself before tendering as to Sufficiency of Tender the prevailing site conditions, the correctness and sufficiency of his Tender for the Works and of the rates and prices stated in the priced Bill of Quantities and the Schedule of Rates and Prices, if any, which Tender rates and prices shall, exception, so far as it is otherwise provided in the Contract, cover all his obligations under the Contract and all matters and things necessary for the proper execution and maintenance of the Works, risks, contingencies and all other circumstances which may influence or affect his Tender. No claim in this regard shall be entertained at any point of time.

7) Contractor shall not enter or take possession of the site (other than for inspection Possession of Site purposes) unless permitted to do so by the Engineer In Charge.

Contractor may provide temporary access to the site if necessary or required, at his cost. After completion of the work or after determination of the contract for whatsoever reasons it may be, the contractor shall remove and clear away the access route restoring the area to its original conditions as directed by the Engineer In Charge failing which the Employer shall clear the temporary access and the expenses incurred by Employer shall be borne by the contractor. Also Employer shall not be responsible nor is liable to account for any materials / property of the contractor in such an event.

Employer shall have right to order execution of other works (whether or not Additional connected with the work in the contract) on the site contemporaneously with the execution of the original work and the contractor shall give reasonable facilities for this purpose and execute those items.

Employer reserves the right of taking over at any time any portion of site, which Taking over it may required and the contractor shall at his own expense clear such portion forthwith.

No photographs, diagram etc. of the site or of the work or any part of thereof Prohibition of Photography shall be taken, published or otherwise circulated without the prior written approval of the Employer.

Employer’s officials connected with the contract will have the right of entry to the site at all times. The Employer shall have the power to exclude from the site any person whose admission or presence thereto may lead to threat, in his opinion, be undesirable for any reasons whatsoever

SIGNATURE OF TENDERER WITH SEAL EMPLOYER
8) The Contractor shall execute and maintain the Works in strict accordance with the Contract, to the entire satisfaction of the Employer and shall comply with and adhere strictly to the consultant’s and Engineer In Charges instructions and directions, or any matter whether mentioned in the contract or not, touching or concerning the works. Instructions and directions given by the consultant or the Engineer in Charge, if any, will be acted upon, on the same forwarded to the Contractor, in writing by the Engineer in Charge.

9) Within 15 days of award of the Contract, Contractor shall, submit to the Engineer for his approval, the following:
   - Organization chart detailing the responsibilities of individuals at site.
   - “CPM / PERT” chart showing all activities, their interdependence and resource allocation.
   - Construction and Execution, commissioning Procedure, inspection, test plans with various formats for the works to be executed.
   - Quality Control Manual & Quality plan.
   - Safety and Environment management procedures.
   - Warehousing procedures.

10) The Contractor shall whenever required by the consultant and Engineer in Charge, submit a revised programme showing the modifications to the approved programme necessary to ensure completion of the Works within the time for completion as defined in contract conditions. The Contractor may have to revise the programme depending upon the requirements of the Employer. It must be clearly understood that the Contractor may have to induct additional resources contingent to the requirement of the Employer so as to enable the Employer to meet his target of commissioning the project. Nothing extra shall be paid to the Contractor on account of such contingencies. If at any time the Engineer in Charge and the consultants observe that the actual progress of the works does not conform to the approved programme referred to above, the Contractor shall produce, a further revised programme showing modifications to the approved programme (including additional resource allocation schedule) necessary to ensure completion of the works within the time for completion.

The submission of revised programmes as detailed above shall neither relieve the Contractor of any of his duties or responsibilities under the Contract, nor entitle the Contractor to any enhancement of the Contract Sum on this account.

11) The Contractor shall give or provide all necessary superintendence during the execution of the Works that may be considered necessary for due fulfillment of the Contractor's obligations under the Contract. The Contractor or a competent and authorized representative approved by the consultant and Engineer In Charge is to be constantly on the Works and shall give his whole time to the superintendence of the same. If such approval is withdrawn owing to whatsoever reasons, and after receiving written notices of such withdrawal, the Contractor shall remove the representative from the Works and shall not thereafter employ him again on the Works in any capacity and shall replace him by another representative approved by the Engineer in Charge, as soon as is practicable. Such authorized representative shall receive, direction, and instructions from the consultant and Engineer In Charge on behalf of the Contractor.
12) The Contractor shall provide and employ:
   a) Sufficient & qualified technical staff on Site in connection with the execution and maintenance of the Works and
   b) Only such technical assistants who are skilled and experienced in their respective fields, foremen and leading hands who are competent to give proper supervision to the work and they are required to supervise, and
   c) Such skilled, semiskilled and unskilled labour as necessary for proper and timely execution and maintenance of the works.

The Engineer In Charge shall be at liberty to object to and ask the Contractor to remove forthwith from the Works any person employed by the Contractor in or about the execution or maintenance of the Works who, in the opinion of the Engineer In Charge, misconducts himself, or is incompetent or negligent in the proper performance of his duties, or whose employment is otherwise considered by the Engineer in Charge to be undesirable and such person shall not be again employed upon the Works without the written permission of the Engineer In Charge. Any person so removed from the Works shall be replaced as soon as possible by a competent substitute approved by the Engineer In Charge.

13) As the works are being executed in a sensitive and restricted defence services layout, the contractor shall thoroughly screen the work force to be deployed and check their antecedents, if required through police verification before deploying them at site. Every effort shall be taken by the contractor that persons having bona fide character only is employed in connection with the above work and the contractor shall be responsible to vouch for the character of the persons employed by them in connection with the subject contract.

The Contractor, shall take all steps necessary to ensure that the persons employed on any work in connection with the contract have noticed that the Indian Official Secrets Act 1923 (XIX 1923) applies to them and will continue to apply even after the execution of such works under the contract.

14) The work shall be executed in a workman like manner and to the satisfaction, in all respects to the Consultant and Engineer In Charge. The contractor is entitled for payment of any work or items of works executed by him only after passing the said executed works by the consultant and Engineer-in-charge and upon entering the measurements of such passed work in the measurement book and accepted by the contractor. The consultant/ Engineer-in-charge will communicate or confirm his instructions to the contractor in respect of the execution of the work in a site order book maintained at his office and the contractor shall visit his office daily and shall confirm receipt of such instructions by signing the relevant entries in the said book. Such entries will rank as orders or notices in writing within the intent and meaning of those conditions. Failure or refusal to sign the said book does not absolve the contractor of his responsibilities to give effect to any orders noted therein. Signature made on subsequent pages of the site order book or any of the registers maintained in connection with the contract shall be considered that he has is in full knowledge of all the entries made till that place and deemed to have accepted the content therein.

15) The Contractor shall be responsible for the true and proper setting-out of the Works in relation to original points, lines and levels or reference given by the consultant or EIC in writing and for the correctness, subject as above mentioned, of the position, levels, dimensions and alignment of all parts of works and for the provision of all necessary instruments, appliances and labour in connection therewith. If, at any time during the progress of the works, any error appears or
arise in the position, levels, dimensions or alignment of any part of the Works, the Contractor, on being required to do by the Engineer in Charge, shall at his own cost, rectify such error/(s) to the satisfaction of the Consultant or the Engineer In Charge. The checking of any setting out or of any line or level by the consultant or EIC shall not in any way relieve the Contractor of his responsibility for the correctness thereof and the Contractor shall carefully protect and preserve all bench marks, sight-rails, pegs and other markings, points, things used in setting-out the Works. Any rectification works required to be done by the Contractor shall be at the Contractor's own cost.

16) If, at any time during the execution of the Works, the consultant or EIC require the Contractor to make boreholes to carry out exploratory excavation, such requirement shall be ordered in writing and shall be deemed to be an addition ordered under the provisions, unless a provisional sum in respect of such anticipated work shall have been included in the Bill of Quantities. Core cutting of concrete pavement is required to be performed to ascertain the strength of the concrete minimum to the extent specified in the BOQ and no additional payment will be admissible for the same. The contractor shall perform this action at any point of time till expiry of defect liability period.

17) The Contractor shall in connection with the Works shall provide and maintain at his own cost all lights, guards, fencing and watching when and wherever necessary or required and also as directed by the Consultant or EIC, or by any duly constituted authority, for the execution and for the protection of the Works/environment, and/or for the safety and convenience of the public or others. The contractor shall have full regard for the safety of all persons entitled to be on the site and keep the site, which is under his control and the works, which are not completed and taken over by the Employer in an orderly state appropriate to avoidance of any danger to such persons.

18) From the commencement of the Works, until the date stated in the Certificate of Completion for the whole of the Works pursuant to Clause 11-sub clause 12 hereof, the Contractor shall take full responsibility for the care thereof. If the Engineer In Charge issue a Certificate of Completion in respect of any part of the Works, the Contractor shall cease to be liable for the care of that part of works from the date stated in the Certificate of Completion in respect of that part and the responsibility for the care of that part shall pass to the Employer.

19) Blank

20) The contractor shall, within 15 days after the date of the Letter of Acceptance, provide to the Engineer In Charge for his information, a detailed cash flow estimate, in quarterly period, of all payments to which the Contractor will be entitled under the Contract and the Contractor shall subsequently supply revised cash flow estimates, if required. The submission to and consent by the Engineer In Charge of such flow estimates shall not relieve the contractor of any of his duties or responsibilities under the contract.

21) The Contractor shall give all notices and to pay all fees required to be given or paid by any National or State Statute, ordinance, or other Law, or any regulation, or bye law or any local or other duly constituted authority in relation to the execution of the Works and by the rules and regulations of all public bodies and companies whose property or rights are affected or may be affected in any way by the Works during the currency of contract or after completion of the work.
22) The Contractor shall conform in all respects with the provisions of any such statute, ordinance or Law as aforesaid and the regulations or bye laws of any local or other duly constituted authority which may be applicable to the Works and with such rules and regulation of public bodies and companies as aforesaid and shall keep the Employer indemnified against all penalties and liability of every kind for breach of any such Statute, Ordinance or Law, regulation or bye-law during the currency of contract or after completion of the work.

7. INSURANCE, INDEMNITY ETC.

1) Without limiting his obligations and responsibilities under Clause 6 sub clause 17 above, the Contractor shall insure in the joint names of the Employer and Contractor against all loss or damage from whatever cause arising, for which he is responsible under the terms of the Contract and in such a manner that the Employer and Contractor are covered for the period till completion of the work in all respect, for any loss or damage occasioned by the Contractor in the course of any operations carried out by him for the purpose of complying with his obligations in execution of the work in all respect. Under the Clause 12 for:

a) The Works executed or being executed to the estimated contract value thereof plus 10% (to allow for any additional costs resulting from the loss or damage) which includes the value of materials required for incorporation in the work.

Such insurance shall be affected with an insurer and in terms approved by the Employer, and the Contractor shall submit the insurance policy or policies along with receipts for payment of premiums to the Engineer in Charge and the contractor shall keep the policy current and effective till completion of the work in all respect.

Alterations to the terms of insurance shall not be made without the approval of the Engineer In Charge.

Both the parties shall comply with all conditions of the insurance policies as may be applicable to the parties.

2) The Contractor shall, except if and so far as the Contract provides otherwise, indemnify the Employer against all losses and claims in respect of injuries or damage to any person or material or physical damage to any property whatsoever which may arise out of or in consequence to the execution of the Works and against all claims, proceedings, damages, costs, charges and expenses whatsoever in respect of or in relation thereto.

3) Before commencing the execution of the Works the Contractor, but without limiting his obligations and responsibilities under sub clause 2 of this Clause, shall insure against his liability for any material or physical damage, loss or injury which may occur to any property, including that of the Employer, or to any person, including any employee of the Employer and of the Consultant, by or arising out of the execution of the Works or in the carrying out of the Contract.

4) Such insurance shall be made with an insurer and in terms approved by the Employer, and for the amount stated in the contract data of tender. The Contractor shall, whenever required, submit to the Employer, the policy or policies of insurance and the receipts for payment of the premiums. The contractor shall keep the policy current and effective till completion of the work.
5) The terms shall include a provision whereby, in the event of any claim in respect of which the Contractor would be entitled to receive and be indemnified under the policy being brought or made against the Employer, the insurer will indemnify the Employer against such claims and any cost, charges and expenses in respect thereof.

6) The Employer shall not be liable for or in respect of any damages or compensation payable at law in respect or in consequence of any accident or injury to any workman or other person in the employment of the Contractor, save and except an accident or injury resulting from any act or default of the Employer, his agents, or servants. The Contractor shall indemnify and keep indemnified the Employer against all such damages and compensation, save and except as aforesaid, and against all claims, proceedings, costs, charges and expenses whatsoever in respect thereof or in relation thereto.

7) The Contractor shall insure against such liability of the nature referred to in sub-clause 6 of this Clause with an insurer approved by the Employer, and shall continue such insurance during the whole of the time that any persons are employed by him on the Works and shall when required, produce to the Employer, such policy of insurance and the receipt for payment of the current premiums. Provided always that, in respect of any persons employed by any subcontractor (if approved by HAL) the Contractor's obligation to insure as aforesaid under this sub-clause shall be satisfied if that subcontractor shall have insured against the liability in respect of such persons in such a manner that the Employer is indemnified under the policy, but the Contractor shall require such subcontractor to produce to the Employer, such policy of insurance and the receipt for the payment of the current premium. The contractor shall keep the policy current and effective till completion of the work.

The insurances shall be generally covered but not limited to the following:

1. Workmen's Compensation policy at the work site.

2. Personal Accident Policy for Supervisors, Engineers, and other employees who are not workers, working at site. This policy should also cover all liability at common Law and under the amendments thereof.

3. Third party insurance as detailed at contract data.

4. Contractor’s All Risk Insurance, insuring Employers, Contractor and its subcontractors (if approved by HAL) against physical loss and damage to the materials, equipment, apparatus and machinery and all work to be performed. The insurance coverage shall be of the amount equivalent to contract-sum plus 10% of contract price including fully insuring properties and works.

The contractor shall keep all the policies current and effective till completion of the work handing over to employer.

Each of the above policies shall cover Employer and Contractor as their interest may appear and all policies of insurance affecting the Works shall provide that there shall be no subrogation as against consultant and Employer.
8) If the Contractor fail to effect and keep in force the insurances referred to in this Clause above, or any other insurance which he is required to effect under the terms of the Contract, and statutory provisions, then and in any such case the Employer may effect and keep in force any such insurance and pay such premiums as may be necessary for that purpose and from time to time deduct the amount so paid and any other expenses incurred by the employer as aforesaid from any monies due or which may become due to the Contractor, or recover the same as a debt due from the Contractor. The Contractor shall however, be fully responsible for any consequence arising out of his failure to effect and keep in force the insurances irrespective of whether the Employer effects the insurance as above or not.

9) Policies and certificates of insurance shall be delivered by the Contractor to the Engineer in Charge before commencing the execution of works commencing the insurance coverage from the date of commencement of the work or otherwise specified. All such insurance shall provide for compensation to be payable in the types and proportions of currencies required to rectify the loss or damage incurred.

8. MISCELLANEOUS ITEMS.

1) All gold, silver, oil and other minerals of any description and all precious stones, coins, treasures, relics, antiquities and other similar items, all fossils, articles of value or antiquity and structures and other remains or things of geological or archaeological interest discovered on the site of the works shall as between the Employer and the Contractor be deemed to be the absolute property of the Employer. The Contractor shall not take any such article or thing and shall immediately upon discovery thereof and, before removal, acquaint the Engineer in Charge of such discovery and carry out his orders as to the disposal of the same. Whole of the excavated materials shall be the property of the Owner and shall be used or disposed off only as directed by the consultant and the Engineer in Charge in accordance with the related provisions in the Contract.

2) The Contractor shall save harmless and indemnify the Employer from and keep the Employer indemnified against all claims and proceedings for or account of infringement or any patent rights, design trademark or name or other protected rights in respect of any Constructional Plant, machine, work, or material used for or in connection with the Works or any of them and from and against all claims, proceedings, damages, cost charges and expenses whatsoever in respect thereof or in relation thereto Except where otherwise specified, the Contractor shall pay all tonnage and other royalties, rent and other payments or compensation, if any, for getting stone, sand, gravel, clay or other materials whatsoever required for execution of the Work.

It shall be the responsibility of the contractor to pay all royalties whatsoever whether / arising out of the deeds and actions on the part of the contractor either on HAL’s property or otherwise to the authorities concerned. In case HAL is required to pay such royalties due to failure on the part of the contractor in paying the same, HAL shall recover the same from the contractor in a manner as deemed fit by it.

3) All operations necessary for the execution of the Works shall, so far as compliance with the requirements of the Contract permits, be carried on so as not to interfere unnecessarily or improperly with the public Convenience, or the access to use and occupation of public or private roads and foot paths or to or of properties whether in the possession of the Employer or of any other person. The Contractor shall save harmless and indemnify the Employer in respect of all claims, proceedings damages, cost, charges and expenses whatsoever arising out of, or in relation to any such matter in
so far as the Contractor is responsible therefore.

4) The Contractor shall use every reasonable means to prevent any of the routes communicating with or on the routes to the Site from being damaged by any traffic of the Contractor or any of his sub-contractors (if approved by HAL) and in particular, shall select routes, choose and use any such extraordinary traffic as will inevitably arise from moving of plant and material from and to the Site shall be limited, as far as reasonably possible, and so that no unnecessary damage or injury may be occasioned to such routes.

5) In case any damages are caused to pathway/road/highway or bridges consequent to unsafe and unusual method of transportation to move Constructional Plant, machinery or pre-constructed units or any other material required for the execution of the work and is reported by the appropriate authority, the contractor shall make good the damages as per the requirement of respective authorities or pay the charges or penalties imposed by them. In case the contractor fails to do so and on advice of the respective authorities HAL will deduct such charges or penalties from the contractors bill and paid to the respective govt. bodies.

6) Where the nature of the Works is such as to require the use by the Contractor of waterborne transport, the foregoing provisions of this clause shall be construed as though "Road / highway" including a dock, sea wall or other structure related to a water way and "vehicle" included craft, ferry or any transport related to water borne traffic and shall have to effect accordingly.

7) The Contractor shall, in accordance with the requirements of the Engineer In Charge, afford all reasonable opportunities for carrying out their work to:

   a) Any other contractor/(s) or agencies employed by the Employer and their workmen

   b) The workmen of the Employer and of any other duly constituted authorities who may be employed in the execution on or near the Site of any work not included in the Contract or of any contract which the Employer may enter into in connection with or ancillary to the Works. The Contractor will not be paid any compensation on this account.

8) During the progress of the Works the Contractor shall keep the Site reasonably free from unnecessary stores or dispose off any Constructional Plant not in use and surplus material and clear away and remove from the Site any wreckage, rubbish or Temporary Works no longer required. The contractor shall ensure that none of the materials of the contractor or excavated materials or plant shall be stacked / placed on or in such vicinity of existing Roads, Pavement, access to buildings/hangars, runway or taxiway that it will affect the movement vehicles, aircrafts or aircraft parts or damage any assets of the Employer.

9) On the completion of the works or from time to time as may be directed during execution of works, the Contractor shall clear away and remove from the site, all constructional plant, surplus materials, rubbish and Temporary Works of every kind, and leave the whole of the Site and Works clean and in a workmanlike condition to the satisfaction of the consultant and Engineer In Charge. However during execution, the plant and equipment brought by the Contractor cannot be withdrawn / taken away from the site without the permission of the Engineer In Charge. In the event of completion of the work part by part or building/hangar wise, such area of the work or buildings completed shall be cleared off all debris and surplus materials and give peaceful vacant possession to Employer for use.

9. LABOUR

1) The Contractor shall make his own arrangements for the engagement of all labour and workmen, local or otherwise, and save, in so far as the Contract
The Contractor shall strictly comply with all the labour laws, regulations, etc. in force and applicable to the labour employed by him or his sub-contractors (if approved by HAL) including those working on labour-rate basis on the Works. The contractor shall obtain the labour licence and maintain all records and documents in compliance to various provisions of labour laws.

2) The Contractor shall provide potable drinking water for the use of the Contractor's staff and workers. The contractor shall provide water both for domestic and works purpose.

3) The Contractor shall not, otherwise than in accordance with the Statutes, Ordinances and Government Regulations or Orders, for the time being in force, consume, import, sell, give, barter or dispose any alcoholic liquor or drugs by himself or his sub-contractors (If approved by HAL), or employees.

4) The Contractor shall not give, barter or otherwise dispose off to any person or persons, any arms or ammunition of any kind or permit or occupy the same as aforesaid.

5) The Contractor shall in all dealings with labour and workmen in his employment, have due regard to all recognized festivals, day of rest and religious or other customs.

6) In the event of any outbreak of illness of an epidemic nature, the Contractor shall comply with and carry out such regulations, orders and requirements as may be made by the Government, or the Local medical or sanitary authorities for the purpose of dealing with and overcoming the same at his own cost.

7) The Contractor shall at all times take all reasonable precautions to prevent any unlawful, riotous or disorderly conduct by or against his employees and for the preservation of peace and protection of persons and property in the neighborhood of the Works against the same.

8) The Contractor shall be responsible for observance by his sub-contractors (if approved by HAL) of the foregoing provisions.

9) The contractor shall employ labour in sufficient number to maintain the required rate of progress and of the quality required to ensure workmanship of the degree required by the specifications, Engineering standards and to the satisfaction of the Engineer-in-charge.

The contractor shall remain liable for the payment of all wages or other moneys to his work people or employees under the payment of wages Act, 1936, Employer's liability Act, 1938, workman’s Compensation Act, 1923, or any other Act or enactment relating there to and rules framed there under from time to time. The contractor shall work only on and during the hours or working day, unless he obtains the prior written approval of the Engineer-in-charge to do otherwise. Even if such approval is given, there shall be no liability in respect of any excess cost arising thereof upon the Employer and the contractor shall follow all provisions of labour law.

10) The Contractor shall, always maintain all labour records as per statutory provisions and, furnish a return in detail in such form and at such intervals as the Engineer in Charge may prescribe showing the supervisory staff and the numbers of the several classes of labour from time to time employed by the Contractor on the Site and such information regarding Constructional Plant. Further the contractor shall be promptly in attendance and submit all records and
Project: “Civil, Electrical and other utility services for package -Civil- II (Rotable complex)

documents as may be required during inspection by the respective labour officials of state, central or other statutory bodies and shall comply all the provisions covered under the respective law.

11) The salient features of some labour laws applicable to establishments engaged in building and other construction works are mentioned in SP 34 for contractor’s general guidance. However the contractor shall comply all the provisions covered in the labour law.

10. MATERIALS, PLANT AND WORKMANSHIP

1) All materials and workmanship shall be of the respective kinds described in the contract and testing of the same shall be in accordance with relevant standard prescribed including the method of testing. The contractor shall also perform such tests as may be required and as directed by the Engineer In Charge from time to time at the place of manufacture or fabrication or on the Site or at such other place or places as maybe specified in the Contract, or at all or any of such places. The consultant shall witness/attend the tests, interpret the results and recommend to the Employer for acceptance. The Contractor shall provide such assistance, instruments, machines, labour and materials as normally required for examining, measuring and testing any work and the quality, weight or quantity of any material used and shall supply samples of materials before incorporation in the Works for testing as may be selected and required by the Consultant and Engineer In Charge.

2) The Contractor shall supply samples of all the materials and the approved samples shall be kept at site office for verification on bulk supply. The cost all samples and the expenditure for sampling for testing shall be borne by the contractor.

3) The cost of making any test shall be borne by the Contractor if such test is clearly intended by or provided for in the Contract or is necessary for ascertaining the quality of materials intended to be used by the Contractor in the Works, and any other test to establish compliance of the design parameters.

The testing shall be conducted by or from authorized Govt. laboratories only. In case the Govt. laboratories at Nasik-Pune-Mumbai area do not conduct the specified test, such tests shall be carried out at laboratories having NABL accreditation.

4) If any test is ordered by the Engineer In Charge which is either

a) not so intended by or provided for, or

b) is additional or repetition to that specified in the preceding para for re Confirmation

In such case the cost of such test shall be borne by the Contractor, if the test result shows that the workmanship or materials are not in accordance with the provisions of the Contract or as per the instructions of Consultant’s or Engineer In Charges, otherwise (if the test result found to be in accordance with the requirement) the cost shall be borne by the Employer.

5) The Consultant, the Employer and any person authorized by them shall at all times have access to the Works and to all workshops and places where work is being prepared or from where materials, manufactured articles or machinery are being obtained for the Works and the Contractor shall afford every facility for and every assistance in obtaining the right to such access.

6) No part of the Works shall be covered up or put out of view without the approval Examination
of the Consultant or the Engineer In Charge and the Contractor shall afford full opportunity for the Consultant or the Engineer In Charge to examine and measure any work which is about to be covered up or put out of view and to examine foundation strata before permanent work is placed thereon. The Contractor shall give due notice to the Consultant or the Engineer In Charge whenever any such work such as foundation, service lines, pipes etc. are ready or about to be ready for examination and the Consultant shall, attend for purpose of examining and measuring such works.

7) The Contractor shall uncover any part or parts of the Works or make openings in or through the same or take out cores from the same as the Consultant / Employer may from time to time direct and shall reinstate and make good such part or parts, openings to the satisfaction of the Consultant / Employer. If any such part or parts have been covered up or put off view after compliance with the requirements of sub clause 6 above and are found to be executed in accordance with the Contract, the expenses of uncovering, making, openings in or through, reinstating and making good the same shall be borne by the Employer (Paid under respective items in BOQ). In the event of detection that the material or work is not conforming to the specifications the costs for uncovering shall be borne by the Contractor including the rectifications.

8) The Consultant and the Engineer In Charge shall during the progress of the Works have power to order in writing from time to time for:

   a) the removal from the Site, of any materials, which, in the opinion of the Consultant or the Engineer In Charge, are not in accordance with the Contract, within such time or times as may be specified in the order,
   b) the substitution of proper and suitable materials,
   c) the removal and proper re-execution, not-withstanding any previous test thereof or interim payment therefore, of any work which in respect of materials or workmanship is not, in accordance with the Contract, in the opinion of the Consultant or the Engineer In Charge.

9) In case of default on the part of the contractor in carrying out such order as specified in preceding para, the Employer shall be entitled to employ and pay other persons to carry out the same and all expenses consequent thereon or incidental thereto shall be recoverable from the contractor by the Employer or may be deducted by the Employer from any monies due or which may become due to the Contractor.

10) The contractor shall for the purpose of testing the materials establish a field laboratory.

11) The contractor shall for the purpose of making concrete for the works has to set up a centralised batching plant with computerised controls of capacity of approx. 30 cum. per hour, at a location approved by the consultant / Employer. The contractor shall have to make arrangements for any development or access to the said location or from the said location to the site of works entirely at his own cost. Such land made available by the Employer will be free of rent.

11. COMMENCEMENT, DELAYS AND SUSPENSION

1) The Contractor shall, on the written order of upon being so required by the Employer, suspend the progress of the Works or any part thereof for such time or times and in such manner as the Employer may consider necessary and shall during such suspension properly protect and secure the work, so far as it is necessary in the opinion of the Engineer in Charge. The extra cost incurred by the Contractor in giving effect to the above Employer's instructions under this Clause...
shall be borne by the employer except in following cases:

a) if not provided for in the Contract, or (ie. staggered period specified in the contract or due to technical reasons etc)

b) necessary by reason of some default on the part of the Contractor, or

c) necessary by reason of climatic conditions on the Site, or

d) necessary for the proper execution of the Works or for the safety of the Works or any part thereof in so far as such necessity does not arise from any act or default by the Employer and in cases where insurance cover exists.

Provided that the Contractor shall not be entitled to any such extra cost unless he gives written notice of his intention to claim to the Engineer In Charge within fifteen days of the Employer’s order. The Employer shall settle and determine such extra payment and/or extension of time to be made to the Contractor in respect of such claim as shall, in the opinion of the Employer be fair and reasonable, and provided the Contractor has taken all steps to mitigate the losses.

2) If the progress of the Works or any part thereof is suspended on the written order of the Employer and if permission to resume work is not given by the Employer within a period of ninety days from the date of suspension thereof, unless such suspension is within paragraph a), b), c) and d) of sub clause 1 of this Clause, the Contractor may serve a written notice to the Employer requiring permission within fifteen days from the receipt thereof to proceed with the Works or that part thereof in regard to which progress is suspended.

3) The Contractor shall commence the works physically on site within 15 days from the receipt by him of a written order to this effect from the Employer and shall proceed with the same with due expedition and without delay. The Contractor shall complete the construction of temporary offices, stores, laboratory, labour establishment etc. and mobilise required resources substantially during this period.

4) Save in so far as the Contract may prescribe, the extent of portions of the Site of which the Contractor is to be given permission from time to time and the order in which such portions shall be made available to him and subject to any requirement in the Contract as to the order in which the Works shall be executed, the Employer will along with the written order to commence the Works, give to the Contractor possession of so much of the Site as may be required to enable the Contractor to commence and proceed with the execution of the Works in accordance with the programme or revised programmes referred to in the Clause 6, if any, and otherwise in accordance with such reasonable proposals of the Contractor as he shall, by written notice to the Engineer in Charge, make and will, from time to time as the Works proceed, give to the Contractor possession of such further portions of the Site as may be required to enable the Contractor to proceed with the execution of the Works in accordance with the said programme or proposals, as the case may be. If giving possession of the work site is delayed by the Employer due to any reasons, the Employer shall consider grant of extension of time for the completion of the work. However, the contractor will not be entitled for any monetary compensation or other concessions other than grant of extension of time.

5) The Contractor shall bear all costs and charges for special or temporary right of way required by him in connection with access to the Site. The Contractor shall make arrangements at his own cost for any additional accommodation outside the Site as required by him for the purposes of the Works.
6) Subject to any requirement in the Contract as to completion of any section of the Works before completion of the work as a whole, the whole of the Works shall be completed, in accordance with the provisions of the Clause 11 sub clause 12 hereof, within the time period specified in the tender notice and Price bid from the stipulated date of commencement specified in the letter of acceptance. Time is the Essence of the Contract.

7) Should the amount of extra or additional work of any kind or any cause of delay referred to in these Conditions or exceptional adverse climatic conditions or other special circumstances of any kind whatsoever which may occur, other than through a default of the Contractor, which entitle the Contractor to an extension of time for the completion of the Works, the contractor shall make a written request detailing all facts and data to the Employer and the Employer shall determine the amount of such extension and shall notify the Contractor accordingly. However the employer may not account any extra or additional work or other special circumstances unless the contractor had notified with detailed particulars regarding such circumstances to the Consultant and Engineer In Charge from time to time and such submissions may be investigated at that point of time.

8) Subject to any provision to the contrary contained in the Contract, none of the Permanent Works shall, save as hereinafter provided, be carried on during the night or on Sundays, if locally recognized as days of rest or their locally recognized equivalent days, without the permission in writing of the Engineer In Charge except when the work is unavoidable or absolutely necessary for the saving of life or property or for the safety of the Works, in which case the Contractor shall immediately intimate the Consultant or Engineer In Charge. The provisions of this Clause shall not be applicable in the case of any work, which it is customary to carry out by rotary or double shifts.

9) If for any reason, which does not entitle the Contractor to an extension of time, the rate of progress of the Works or any section is at anytime, in the opinion of the Engineer In Charge, too slow to ensure completion by the prescribed time or extended time for completion, the consultant or Engineer In Charge shall so notify the Contractor in writing and the Contractor shall thereupon take such steps as are necessary and the Engineer in Charge may approve to expedite progress so as to complete the Works or such section by the prescribed time or extended time. The Contractor shall not be entitled to any additional payment for taking such steps. If, as a result of any notice given by the Engineer in Charge under this Clause, the Contractor shall seek his permission to do any work at night or on Sundays, if locally recognised as days of rest or their locally recognised equivalent days which may be considered by the Engineer In Charge considering the project schedule, progress schedule and other factors.

10) If the Contractor fails to achieve completion of the Works within the time prescribed in the sub clause 6 of Clause 11 then the Contractor shall pay to the Employer the sum stated in Part II – Special Conditions as liquidated damages for such default and not as a penalty for every day or part of a day which shall elapse between the time prescribed in sub clause 6 of Clause 11 hereof and the date of certified completion of the Works. The Employer may, without prejudice to any other method of recovery, deduct the amount of such damages from any monies in his hands, due or which may become due to the Contractor. The payment or deduction of such damages shall not relieve the Contractor from his obligations under the contract to complete the Works or from any other obligations and liabilities under the Contract.
11) When the whole of the Works have been substantially completed and have satisfactorily passed all the tests that maybe prescribed in the Contract, the Contractor may give a notice to that effect to the Employer through the Consultant accompanied by an undertaking to finish any outstanding work within a time frame. Such notice and undertaking shall be in writing and shall be deemed to be a request by the Contractor to the Employer to issue a Certificate of Completion in respect of the works. Thereafter the contractor shall be present by himself for inspection of the entire work along with the consultant and Engineer In charge on the specified time notified by the Engineer In Charge. The Employer on recommendation of the consultant shall, within twenty-one days of the date of delivery of such notice either issue to the Contractor, with a copy to the Consultant, a Certificate of Completion stating the date on which, in his opinion, the Works were substantially completed in accordance with the Contract or give instructions in writing to the Contractor specifying all the work which, in the Employer’s and consultant’s opinion, requires to be done by the Contractor before the issue of such Certificate. The Employer shall also notify the Contractor of any defects in the works affecting substantial completion that may appear after such instructions and before completion of the Works specified therein. The Contractor shall be entitled to receive such Certificate only on making good of any defects so notified.

12) Similarly, in accordance with the procedure set out in sub clause 11 above, the Contractor may request and the Employer shall issue a Certificate of Completion (for part of the work) in respect of:

   a) any section of the Works in respect of which a separate time for completion is provided in the Contract: and

   b) any substantial part of the Works or buildings which has been both, completed to the satisfaction of the Engineer in Charge and occupied or used by the Employer.

Provided always that a Certificate of Completion given in respect of any section or part of the Works before completion of the whole of the work shall not be deemed to certify completion of any ground or surfaces requiring reinstatement, unless such Certificate shall expressly so state.

By issuing completion certificate building wise (Part work) does not relive the contractor in fulfilling the obligations under the contract as a whole. The defect liability period will be reckoned from the date on which the final completion dates of the contract as whole.

12. DEFECTS LIABILITY

1) The defect liability period for the works executed under this contract shall be 18 months from the date of completion of the work as a whole. However for specialized items like water proofing, antitermite treatment etc. will have longer defect liability period as specifically indicated against respective items in the BOQ or Technical specifications or other parts of the tender documents. Even in case of part completion of work and taking over by employer, the defect liability period (18 months or longer periods in case of specialized items as specified in the tender) will be reckoned from the date of completion of the work as a whole.

2) Any defects, shrinkage, settlement, cracks or any other faults which may appear or be noticed within the Defect Liability Period, and arising in the opinion of the consultant and Engineer in Charge, shall be rectified and

Certification of Completion of Works

Certification Of completion by Stages

Definition of Defects Liability Period

Execution of Work of Repair etc.
made good by the contractor at his own cost within reasonable time as informed to the contractor.

3) All such work shall be carried out by the Contractor at his own expense if the necessity thereof shall, in the opinion of the Engineer In Charge, be due to the use of materials or workmanship not in accordance with the Contract, or due to neglect or failure on the part of the Contractor to comply with any obligation, expressed or implied, on the Contractor's part under the Contract.

4) If the Contractor fails to do any such work as aforesaid required by the Employer or Consultant, the Employer shall be entitled to employ and pay other persons to carry out the same and if such work which, in the opinion of the Engineer, the Contractor was liable to do at his own expense under the Contract, then all expenses consequent thereon or incidental thereto shall be recoverable from the Contractor by the Employer or may be deducted by the Employer from any monies due or which may become due to the Contractor.

5) The Contractor shall, search under the directions of the Consultant or Engineer In Charge for the cause of any defect, imperfection or fault appearing during the progress of the Works or during the Defects Liability Period. If such defect, imperfection or fault shall be one for which the Contractor is liable as aforesaid, the cost of the work carried out in searching as aforesaid shall be borne by the Contractor and he shall in such case, repair, rectify and make good such defect, imperfection or fault at his own expense in accordance with the provision of this Clause.

6) During defect liability period, The contractor shall arrange for site inspection of entire work (Civil, Electrical and entire utility services) on a quarterly basis. The contractor shall depute minimum 2 Engineers, one of Civil and allied works and the other for Electrical and utility services, having adequate experience in attending maintenance works. After inspection a detailed list of items needs rectifications or repairs is to be listed out and make immediate arrangement to attend the repairs and maintenance satisfactorily. On attending the repairs and maintenance the contractor shall submit a detailed compliance report and shall be in attendance for joint verification with the consultant or Engineer in Charge. If the contractor fails to depute suitable persons for periodic survey as detailed above and the defects noticed are not attended in time a penalty of Rs. 50,000.00 will be recovered towards inspection charges for each quarter. This Rs.50,000.00 per quarter will be in addition to the expenditure whatsoever may be incurred by Employer for getting the rectifications done through other sources.

13. A ALTERATONS/ADDITIONS/OMMISIONS

The EIC shall make any variation of the form, quality & quantity of the work or any part ther of that may in his opinion, be necessary and for that purpose of if for any other reason it shall in his opinion be desirable, he shall have power to order the contractor to do and the contractor shall do any of the following:

a) Increase or decrease any work included in the work
b) Omit any such work
c) Change the character or quality or kind of any such work
d) Change the levels, lines, positions and dimensions of any part of the works and
e) Execute additional work of any kind necessary for the completion of the works

And no such variation shall in any way vitiate or invalidate the contract, but the price, if any of all such variations shall be taken into account in ascertaining the amount of the contract sum. The contractor shall not be entitled to any
compensation on account of omission or decrease in work under this clause.

13 **B DEVIATIONS**

1) The contractor shall carry out the deviations as may be ordered up to a maximum of +10% of the contract sum at the same terms, conditions and rates. There will not be any lower deviation limit. The Engineer-in-charge may delete or reduce any items of work at his sole discretion and the contractor will not have any claim whatsoever on this issue and the contractor shall be entitled for payment against the actual work done at the contract rates only.

Ordering of the deviations will be subject to the following conditions:

a) The net sum of all deviations is less than the permissible deviations limit

b) The arithmetical sum of all additions and deletions should not exceed twice the deviation limit.

c) Deviation ordered in respect of any individual trade item included in the contract shall not exceed 50 percent of the value of that trade item in the contract as a whole or half of the deviation limits for the contract whichever is less.

d) The value of additions of items of any individual trade item not already in the contract shall not exceed 10 percent of the deviations limit.

The contractor shall not make alternations, additions or omissions from the works as described in the contract except with written instructions of the Engineer-in-charge. No such deviations from the work described in the tender documents be valid unless the same has been specifically confirmed and accepted by the Engineer-in-charge in writing and incorporated in the contract.

Variations shall include additions (extra items), alterations which shall be included in the updated programme of execution of works.

2) The Engineer-in-charge may deviate either by way of addition or deduction from the work so described provided that the contract sum be not thereby varied on whole by more than the percentage set out in the contract. The value of all additions and deletions will be added to or deducted from the contract sum. Whenever the Accepting Officer intends to exercise such a right, his intention shall specify the deviation which are to be made, lump sum assessment or the proposed basis of payment, the extra time allowed, if any and the date for completion of the entire contract. Any objection by the contractor to any matter concerning the order shall be notified by him in writing to the Engineer-in-charge, within seven days from the date of such order but under no circumstances, shall the work be stopped unless so ordered by the Engineer-in-charge owing to differences or controversy that may arise from such objection. In the absence of such modifications of objection by the contractor, he shall be deemed to have accepted the order and the condition stated therein. In the event of the contractor failing to agree with the Engineer-in-charge regarding the items of the proposed deviations, the objection shall be referred to the Engineer-in-charge whose decision shall be final and conclusive and binding on the contractor.

3) All extra or additional work done by the order of the Consultant or Engineer in Charge shall be priced at the rates and prices set out in Part II – Special Condition
14. PROCEDURES OF CLAIMS

1) Notwithstanding any other provision of the contract, if the contractor intends to claim any additional payment pursuant to any clause of these conditions or otherwise, he shall give notice of his intention to the consultant, with a copy to the Employer, within one month after the event giving rise to the claim has first arisen.

The Contractor shall submit to the Consultant (with a copy to the Engineer in Charge) once in every month a full and detailed account of all claims for any additional payment to which the Contractor may consider himself entitled and of all extra or additional work ordered by the Engineer in Charge which he has executed during the preceding month. No final or interim claim for payment for any such work or expense will be considered which has not been included in such account of claim, provided always that the Consultant shall be entitled to recommend payment for any such work or expense, notwithstanding the Contractor's failure to comply with this condition if the Contractor has, at the earliest practicable opportunity, notified the Consultant and Engineer In Charge in writing that he intends to make a claim for such work.

2) All the claims are to be approved by the Employer before releasing payment. No payment will be released till the time Employer approves the matter.

15. PLANT, TEMPORARY WORKS AND MATERIALS

1) All Constructional Plant, Temporary Works and materials provided by the Contractor shall, when brought on to the Site, be deemed to be exclusively intended for the execution of the Works and the Contractor shall not remove the same or any part thereof except for the purpose of moving it from one part of the Site to another, without the consent, in writing of the Consultant, which shall not be unreasonably withheld. Upon receiving the consent of the Consultant, the Contractor shall apply for issue of Gate Pass etc. to the Employer so as to observe the administrative and security procedures, set by the Employer.

2) Upon completion of the Works, the Contractor shall remove from the Site all the said Constructional Plant and Temporary Works remaining thereon and any unused materials provided by the Contractor.

3) The Employer shall not at any time be liable for the loss or damage to any of the said Constructional Plant and temporary works or materials.

4) The operation of sub clause 1 to 3 above shall not be deemed to imply any approval by the Consultant, of the materials or other matters referred to therein nor shall it prevent the rejection of any such materials at any time by the Consultant/ Employer.

16. VALUATION OF PAYMENT

1) The quantities set out in the Bill of Quantities are the estimated quantities of the Work but they are not to be taken as the actual and correct quantities of the Works to be executed by the Contractor in fulfillment of his obligations under the Contract. The quantities are likely to be reduced/increased/deleted and the contractor shall not have any claim on such variation in quantity.
The contractor is required to submit the detailed measurements of all the works executed under the contract. This submission of measurements shall be based on physical measurements taken jointly with the consultant, of the actual work performed or executed by the contractor. The authorised representative of the contractor shall be in attendance for taking the measurements and shall provide all assistance, appliances required in taking the measurements.

2) The Consultant shall, except as otherwise stated, ascertain and determine by measurement the value in terms of the Contract of work done in accordance with the Contract. He shall, when he requires any part or parts of the Works to be check measured, give notice to the Contractor's authorised agent or representative, who shall forthwith attend or send a qualified agent to assist the Consultant in making such measurement and shall furnish all particulars required by them. Should the Contractor not attend or neglect or omit to send such billing Engineer, then the measurements checked by the Consultant or approved by him shall be taken to be the correct measurement of the work. For the purpose of measuring such permanent work as is to be measured by records and drawings, the Consultant’s Representative shall prepare records and drawings month by month of such work and the Contractor, as and when called upon to do so in writing shall, within five days, attend to examine and agree such records and drawings with the Consultant's Representative and shall sign the same when so agreed. If the Contractor does not so attend to examine and agree such records and drawings, they shall be taken to be correct. If, after examinations of such records and drawings, the Contractor does not agree the same or does not sign the same as agreed, they shall nevertheless be taken to be correct, unless the Contractor shall, within five days of such examination, lodge with the Engineer In Charge, for decision by the Engineer in Charge, notice in writing of the respects in which such records and drawings are claimed by him to be incorrect.

2.a) The measurements will be further verified and certified by the Engineer In Charge. The contractor’s representative shall attend immediately for verification of the measurements whenever called for. Taking of measurements, recording and certification by the consultant shall be carried out regularly as the work progress and all hidden items shall be measured, recorded and certified before covering the same. The measurements taken shall be signed and dated by the authorized representative of the contractor and consultant and the same day. It will be the responsibility of the contractor to have regular measurements, certification and billing. If the contractor or contractor’s representative fails to attend when required the Engineer-in-charge shall have power to proceed by himself to the measurements, and in that case these measurements shall be deemed to have been accepted by the contractors as final and no further claim will be entertained.

3) The Works shall be measured net, notwithstanding any general or local custom except where otherwise specifically described or prescribed in the Contract. The mode of measurements specified in the bill of quantities, technical specifications, MES SSR and IS codes will be followed. The MES SSR and IS codes to be followed in case there is no specific mention in the BOQ or Technical specifications.

For expedition of recording of measurements & billing, contractor shall adopt latest computer software packages and shall provide such packages to the Consultant and Engineer In Charge for their approval and implementation.

3.a) The contractor will be entitled for payment of the work done after fulfilling the requirement of recording the measurements in MB and submission of his bill.
3.d)HAL prescribed proforma. Running bills will be paid for the work completed to the entire satisfaction of the Engineer-in-charge, after making the following deductions, if any:

a) All previous running account payments
b) Cost of entire stores issued by HAL whether incorporated in the work or not
c) Full value of the advances paid against the materials whether incorporated in the work or not
d) Mobilisation advance
e) Hire charges, for electricity and water supplied by HAL
f) All statutory deductions
g) Any other dues recoverable by HAL from the contractor under the present contract or any other contract.

4 Material advances to an extent of 75% of the cost of material (other than perishable items) which in the opinion of the Engineer-in-charge which are reasonably required for incorporation in the work and which are actually brought to the site, will be considered for payment subject to the following conditions.

a) No material advance will be paid on such materials which will not go into the work such as shuttering, centering, scaffolding, plant, tools and equipments, etc.
b) No material advance against self-life items will be paid
c) For the purpose of evaluating the cost of the materials the contractor’s bills towards the purchase of the materials will be compared with the derived rate of those materials from the item rates under the contract and 75% of the cost as per the bills or such derived rates whichever is less, will be considered for payment of materials advance.
d) The contractor shall execute an indenture bond/hypothecation deed on required stamp paper in favour of HAL in the format prescribed under this contract for claiming advance on materials.
e) All such materials shall be insured against theft, loss fire, damages, etc. as may be prescribed by the Engineer-in-charge and endorsed in favour of HAL.
f) Payment in respect of materials collected at site will be made only upon giving a certificate by the Engineer-in-charge stating that:

- The stores have been physically brought to site and have not been incorporated in the work.
- The stores are required for the work
- The stores have been stored satisfactorily and are not likely to deteriorate in stock
- The quantities of stores tally with the quantities of the contract items
- They have been valued as stated in Clause No. (c) above
- The materials conform to the specifications and are of the tested quality.
The contractor shall be responsible for the safe custody of the materials and shall not remove them from site without written permission of Engineer IN Charge.

The contractor shall once in every month submit to the Engineer-in-charge of his claim in detail for the work done by him upto and including the previous months which are not covered by his contract agreement in any of the following respect.

5) Deviation from the items and specification provided in the contract documents.
   Extra items/new items of work
   Quantities in excess of those provided in the contract schedule
   Items in respect of which rates have not been settled.

He should in addition, furnish a clear certificate to the effect that the claims submitted by him as aforesaid cover all his claims and that no further claims shall be raised by him in respect of the work done upto and including the period under report.

17 ENTRUSTING SPECIALIZED WORKS TO OTHER AGENCIES.

17.1) The contractors shall execute the work directly by themselves. However for execution of specialized items, the contractor may seek the assistance of such parties who are having expertise in the respective field and their services will help the contractor to execute those items to the best quality and standards specified. In such cases the contractor shall seek permission from Employer specifically indicating the nature and items of work for which the services of specialized firm is proposed to be availed.

17.2) The contractor shall submit the Credentials, to the Consultant and Engineer In Charge., of the specialized parties covering their technical know how and expertise in the respective field, experience having performed similar nature of work of value nearer to that of the item The contractor shall then furnish all the documents whatsoever required to ascertain the technical capability of those firms to take up the specified part of the work, as called for by the Consultant or Engineer in Charge.

17.3) On verification of the data and documents submitted by the contractor as described in the preceding para, by the Consultant or adopting any other means for verification of the technical capability of the party, the Engineer In Charge, will communicate the approval or otherwise.

17.4) The engagement of specialized party and communicating the approval by the Employer for the same shall in no way relieve the contractor from his responsibilities for completing the work as per the terms of contract. The liabilities whatsoever may arise in executing that specified part of the work by the specialized agencies should be borne by the contractor.

17.5) The contractor shall submit an undertaking on a stamp paper of Rs. 100.00 value stating that all liabilities or issues whatsoever may arise in execution of the specified part of the work entrusted to specialized firms will be absolved by the contractor and at any point of time HAL will not be made a party to whatsoever issues, claims arising thereof. The contractor shall also be

SIGNATURE OF TENDERER WITH SEAL

EMPLOYER
required to obtain a bond from those parties who have been entrusted with execution of specialized works, indemnifying the employer from any liability or claim whatsoever may arise during execution or thereafter in connection with that part of work or any other consequential issues. The bond in original shall be submitted to the Engineer in Charge before commencement of the work and the party shall be allowed to perform the work only after obtaining the requisite bond.

17.6) For all purpose, the work got executed from the specialized agencies as described in the preceding paras will be deemed to have been executed by the contractor and the contractor will be responsible for any defects arising in the work during the defect liability period.

18. CERTIFICATES AND PAYMENT

1) The contractor may submit Running Account bills at an interval not less than seven days subject to a maximum of four bills in a month in order to expedite the progress of work. The contractor shall ensure that the bill submitted shall be based on the measurements taken jointly at site, recommended by the consultant and certified by the Engineer in Charge and shall also comply with all contract provisions regarding submission of documents, registers, test results etc. in connection with the same.

2) Where advances are to be made by the Employer to the Contractor in respect of Constructional Plant and Materials, the conditions of payment and repayment shall be as set out in the Special Conditions of Contract.

3) No certificate other than the Certificate of Final Completion referred to in sub clause 4 of this Clause shall be deemed to constitute approval of the works.

4) The Contract shall not be considered as complete until a Certificate of Final Completion shall have been signed by the Employer stating that the Works have been completed and maintained to his satisfaction.

5) The Employer shall not be liable to the Contractor for any matter or thing arising out of or in connection with the Contract or the execution of the works, unless the Contractor shall have made a claim in writing in respect thereof as per sub clause 1 of Clause 14, before giving of Certificate of Final Completion.

6) Notwithstanding the issue of the Certificate of Final Completion, the Contractor and, subject to sub clause 5 of this Clause, the Employer shall remain liable for the fulfillment of any obligation incurred under the provisions of the Contract prior to the issue of the Certificate of Final Completion which remains unperformed, at the time such certificate is issued and, for the purposes of determining the nature and extent of any such obligation, the Contract shall be deemed to remain in force between the parties hereto.

19. REMEDIES AND POWERS

1) If the Contractor shall become bankrupt or have a receiving order made against him, or shall present his petition in bankruptcy, or shall make an arrangement with or assignment in favour of his creditors, or shall agree to carry out the contract under a committee of inspection of his creditors or, being a corporation, shall go into liquidation (other than a voluntary liquidation for the purposes of amalgamation or reconstruction), or if the Contractor shall assign the Contract, without the consent in writing of the Employer first obtained, or shall have an execution levied on his goods, or if the Consultant shall certify in writing to the
Employer that in his opinion, the Contractor:

a) Has abandoned the Contract, or
b) Without reasonable excuse, has failed to commence the Works or has suspended the progress of the Works for twenty-eight days after receiving from the Consultant’s/Engineer In Charge’s written notice to proceed, or
c) Has failed to remove materials from the site or to pull down and replace work for twenty eight days after receiving notice from the Consultant/Engineer In Charge that the said materials or work had been condemned and rejected by the Consultant or Engineer In Charge under these conditions, or
d) Despite previous warnings by the Consultant, in writing, is not executing the Works in accordance with the Contract, or is persistently or flagrantly neglecting to carry out his obligations under the Contract, or
e) Has, to the detriment of good workmanship, or in defiance of the Consultant’s or Engineer In Charge’s instructions to the contrary, sublet any part of the Contract
f) In the opinion of the Consultant, the progress of work achieved by the contractor is so poor that the contractor shall not be able to complete the work within the specified time.

Then the Employer may, after giving fourteen days notice in writing to the Contractor, enter upon the site and the Works and expel the Contractor there from without thereby voiding the Contract, or releasing the Contractor from any of his obligations or liabilities under the Contract, or affecting the rights and powers conferred on the Consultant or Employer by the Contract, and may himself complete the Works or may employ any other agency to complete the Works. The Employer or such other agency, may use for such completion, so much of the Constructional Plant, amenities and materials, which have been deemed to be reserved exclusively for the execution of the Works, under the provisions of the Contract, as he or they may think proper. The Employer, at his option, may sell or choose to return to the Contractor, without prejudice to any of his rights under the Contract, the said Constructional Plant, amenities and unused materials. In case of sale, the sale proceeds shall be applied towards the satisfaction of any sums due or which may become due from the Contractor under the Contract. The return of the Constructional Plants, amenities and unused materials to the Contractor by the Employer, shall be without prejudice to the right of the Employer to recover his dues from the Contractor by any other means available to the Employer.

2) The Engineer shall, as soon as may be practicable, after any such entry and expulsion by the Employer, fix and determine ex parte, or by or after reference to the parties, or after such investigation or inquiries as he may think fit to make or institute and shall certify what amount, if any, had at the time of such entry and expulsion been reasonably earned by or would reasonably accrue to the Contractor in respect of work actually done by him under the Contract and the value of any of the said unused or partially used materials, any Constructional Plant and any amenities brought into existence exclusively for execution of the Works.

3) If the Employer shall enter and expel the Contractor under this Clause, he shall not be liable to pay to the Contractor any money on account of the Contract, until the expiration of the Defects Liability Period and thereafter until the costs of execution, damages for delay in completion, if any, and all other expenses incurred by the Employer have been ascertained and the amount thereof certified by the Engineer. The Contractor shall then be entitled to receive only such sum or sums, if any, as the Consultant may certify would have been payable to him upon due completion by him after deducting the said amount. If such amount shall exceed the sum which would have been payable to the Contractor on due
completion by him, then the Contractor shall, upon demand, pay to the Employer the amount of such excess and it shall be deemed a "debt due" by the Contractor to the Employer and shall be recoverable accordingly.

4) If, by reason of any accident, or failure, or other event occurring to or in connection with the Works, or any part thereof, either during the execution of the works, or during Defects Liability period, any remedial or other work or repair, shall, in the opinion of the Consultant or Engineer In Charge, be urgently necessary for the safety of the Works and the Contractor is unable or unwilling at once to do such work or repair, the Employer may employ and pay other persons to carry out such work or repair as the Consultant or Engineer In Charge may consider necessary. If the work or repair so done by the Employer is the work which, in the opinion of the Consultant or Engineer In Charge, the Contractor was liable to do at his own expense under the Contract, all expenses properly incurred by the Employer in so doing shall be recoverable from the Contractor by the Employer, or may be deducted by the Employer from any monies due or which may become due to the Contractor.

Provided always that the Consultant or Engineer In Charge, as the case may be, shall, as soon after the occurrence of any such emergency as may be reasonably practicable, notify the Contractor thereof in writing.

20. Blank
21. Blank

22. SETTLEMENT OF DISPUTES

1) Wherever, in any of the documents forming part of the Contract, the Engineer In Charge has been vested with the final powers, his decision, opinion, certificate or any other discretion shall be final conclusive and binding on the parties and shall be without appeal. All other matters shall be subject to the right of arbitration.

2) Except for matters stated above all other disputes and difference arising out of or in connection with the contract, whether during the progress of work or after completion, shall be referred to and settled by Arbitration by Arbitrator to be nominated by the Employer. Arbitration shall be as per provisions of sub-clause 15 of SP 32 (Misc.).

23. NOTICES

1) All certificates, notices or written orders to be given by the Employer or by the Consultant to the Contractor under the terms of the Contract shall be served by sending by registered post or by Courier or delivering the same to the Contractor's principal place of business, or office established at site, such other address as the Contractor shall nominate for this purpose.

2) All notices to be given to the Employer or to the Consultant under the terms of the Contract shall be served by sending by registered post or by Courier or delivering the same to the respective addresses nominated for that purpose in respective conditions.

3) Either party may change a nominated address to another address in the country by prior written notice to the other party and the Consultant may do so by prior written notice to both parties.

24. CHANGES IN COSTS

1) It is a fixed price contract and hence there will not be any adjustments to the Contract Sum consequent to rise or fall in the cost of labour and / or materials, taxes or any other matters affecting the cost of the execution of the Works.
25. MEETINGS

The Contractor is required to attend all the management meeting as called for. The business of shall be to review the progress of work and plans for remaining work and to deal with matters rose in accordance with the early warning procedure. The Consultant shall record the business of management meetings and shall provide copies of the said record to those attending the meeting and to the Employer. The responsibility of the parties for actions to be taken is to be decided by the Consultant in consultation with Engineer-in-charge.

26. CANCELLATION CONTRACTS

1) The Accepting Officer, whose decision shall be final and conclusive shall without prejudice to any other right or remedy which shall have accrued or shall accrue thereafter to HAL, cancel the contract in any of the following cases and the contractor shall be liable to make payment to HAL for any loss or damage resulting from any such cancellation to the same extent as provided in the case of cancellation for default.

If the contractor:

a) Offer or give or agree to give to any person in HAL service any gift or consideration of any kind as an inducement or reward for doing or for bearing to do or for having done or for borne to do any act in relation to the obtaining or execution of this or any other contract for HAL service or

b) Enter into a contract with HAL in connection with which commission has been paid or agreed to be paid by his or with his knowledge unless the particulars of any such commission and the terms of payment thereof have previously been disclosed in writing to the Accepting Officer.

c) Obtain a contract with HAL as a result of ring tendering or by non-bona fide methods of competitive tendering without first disclosing the fact in writing to the Accepting Officer.

d) Misrepresent any fact while tendering for any work or create conditions favourable for acceptance of his tender.
2) The Accepting Officer may without prejudice to any other right or remedy which shall have accrued or shall accrue there after HAL, shall cancel the contract in any of the following cases:

Being an individual, or if a firm, any partner thereof shall at any time be adjudged bankrupt or have a receiving order or order for administration of his estate made against him or shall take any proceeding for liquidation of compensation under any Bankruptcy Act for the time being in force or make any conveyance or assignment of his effects or composition or arrangement for the benefit of his creditors or propose to do so, or if any application be made under any Bankruptcy Act for the time being in force for the sequestration of his estate or if a trust deed be rented by him on behalf of his creditors of.

a) Being a company shall pass a resolution or the court shall make an order for the liquidation on its affairs, or a receiver or Manager on behalf of the debenture holders shall be appointed or circumstances shall arise which entitle the court or debenture holders to appoint a receiver or Manager or.

b) Assigns, transfers, sublets or attempts to assign, transfer or sublet any portion of the work without the prior written approval of the Accepting Officer. Whenever the Accepting Officer exercises his authority to cancel the contract under this condition, he may complete the work by any means at the contractor’s risk and expense provided always that in the event of cost of completion (as certified by the Engineer In Charge which is final & conclusive) being less than the contract cost, the advantage shall accrue to the HAL and that if the cost of completion exceeds the moneys due to the contractor the contractor shall either pay the excess amount ordered by the Engineer In Charge or the same shall be recovered from the contractor by other means.

3) a) In case the HAL completes the work under the provisions of this conditions, the cost of such completion to be taken into account in determining the excess cost to be charged to the contractor under this condition shall consist of the cost of material purchased and labour provided by the HAL with an addition of such percentage to cover superintendence and establishment charges, as decided by the Engineer In Charge whose decision shall be final and conclusive.

3) a) If the contractor makes default in commencing the work within a reasonable time or within the time specified, or having taken over the site does not commence the work within a reasonable time, or if the contractor, in the opinion of the Manager (Works)/Sr. Manager (Works & Services) during the currency of the contract makes default in proceeding with the work, or progress of work is slow, or in the opinion of the Manager (Works)/Sr. Manager (Works & Services) the workmanship is poor, or if the contractor fails to comply with any of the terms and condition of the contract, or fails to complete the work in full or part and clears the site on or before the date of completion, or fails to achieve the progress as set out under the contract or fails to carry out the orders issued by the Engineer-in-charge/Manager (Works)/Sr. Manager (Works & Services) or Deputies or abandons the contract or otherwise commits any breach of contract, the Accepting Officer or Sr. Manager (Works & Services)/Manager (Works) or any other officer nominated by the Accepting Officer shall cancel the
contract as a whole or in part or any items of work under the contract without any prior notice to the contractor at the sole cost, risk and expense of the contractor and get the balance work executed either by HAL itself, or by another contract or through any other agency as deemed fit. In such an event, the contractor shall be liable to make to make good and compensate all losses, expenses whatsoever, incurred or to be incurred, by the HAL.

b) In case HAL completes the work by itself, the cost of such completion to be taken into account in determining the excess cost to be charged to the contractor shall consist of cost of all materials and labour provided by HAL with an addition of such percentage to cover superintendence and establishment charges, as may be decided by the Manager (Works)/Sr. Manager (Works & Services) of HAL, whose decision shall be final, conclusive, and binding on the contractor.

c) In the event of completion of the work either by HAL or by another contractor or through any other agency, if the cost of completion works out less than the cost under this contract, advantage shall accrue to the HAL.

If at any time after acceptance of the tender HAL feels that for any reasons whatsoever, if the whose or any part of the work is not required to be carried out, the Engineer In Charge shall give notice in writing of the fact to the contractor and upon receipt of such notice the contractor shall stop the execution of such work as indicated in the notice forthwith. The contractor shall have no claim to any payment of compensation or otherwise whatsoever on account of any profit or advantage which he might have derived from the execution of the work in full, but which he did not derive in consequence of the foreclosing of the work. He shall be paid at contract rates for the full amount of the work executed including such additional work (e.g. clearing of site etc) as may be rendered necessary by said foreclosing. He shall also be allowed a reasonable payment (as decided by the Accepting Officer, which shall be final and binding on the contractor) for any expenses sustained on account of labour and materials collected, brought to site or for which the contractor is legally bound to accept delivery from the supplies, but which could not be utilised for the work as verified by the Engineer In Charge.

4) In the event of cancellation of the work under the terms of the contract, the contractor shall, within 10 days from the date of receipt of such cancellation order, come forward and complete measurements and recording thereof the unmeasured work and also recording of list of materials unused, jointly with the Engineer-in-Charge or his authorised representative, failing which, Engineer-in-charge shall complete the aforesaid work in the absence of the contractor in the presence of any person unconnected with the work, which shall be final, conclusive and binding on the contractor.
PART - II – SPECIAL CONDITIONS

(Reference of the Clause of Part-I- General Conditions is mentioned against clauses of this part.)

SP.1 SPECIAL CONDITIONS of this PART-II shall be read in conjunction with GENERAL CONDITIONS (PART-I), and both shall form an integral part of the contract. Where these are at variance, the conditions stipulated in this PART, as Special Conditions shall supersede the relevant provision in the General Conditions.

ENGINEER

SP.2 The Consultant shall be:
M/s SEMAC LIMITED, 6-1-276, 2nd Floor, CONJEEVARAM HOUSE”,
Padmaraonagar, Secundrabad

SP.3 The Consultant has been appointed by and duly authorized by the Employer to supervise, test, examine any materials and/or works, to order, cancel, alter, modify, any of the materials, items or works within the framework of the Contract. To approve / reject requests for modifications in works or schedule whether or not such orders, approvals, rejections, etc.
The Consultant is further authorized to administer the Contract, check, correct, modify and certify or reject any bill or requests for payment for the materials, items or works in accordance with the terms of contract.

SP.4 The Ruling language for the Contract and related aspects shall be ENGLISH.
The Contract shall be governed by and construed in accordance with Laws of India.

The Contractor shall on his own and at his own expense obtain all necessary permits, permissions, certifications under the statutory provisions and to complete the execution of various items and the contract as a whole, including required registrations, certifications, and shall indemnify the Employer in all related matters.

SP.5 CONTRACTOR’S RESPONSIBILITY

SP.5.1 The Contractor shall furnish to the Consultant full particulars, drawings, etc. of all temporary works necessary for the execution of the works and shall allow sufficient time for Consultant to consider the same. The Consultant reserves the right to comment on the Contractor's proposals if they consider that modifications should be made. The Contractor shall be solely responsible for the stability and safety of all temporary works including obtaining statutory approvals and payment of statutory fees, if any. The Consultant will indicate the site(s) for such temporary works and the Contractor will have to restrict his requirements to the same. Should it be necessary to shift the temporary works to some other allotted place during the executions of the works, the Contractor shall do so, when informed by the Consultant, at his own cost and without delay or demur. Such shifting of temporary works may be in part or in full.

SP.5.2 The Contractor shall be responsible for the clearance of the site of all scrub, debris, rubbish, etc. to be removed off site to allocation to be provided by the Contractor and approved by the Consultant. However, no trees shall be removed without the prior permission of the Engineer In Charge. The structures, services and works required to be demolished and removed shall also be removed off site to a location as mentioned above. The Contractor shall obtain necessary
permissions and approvals from local authorities for such disposals. The demolition shall include digging, excavating and removal of substructures, foundations and buried works. The cost of all this shall be borne by the Contractor.

The above is applicable for all site offices, labour camps, and godowns etc., which are not required after the Work is finally completed.

**SP 5.3** The Contractor shall at all the times during construction keep the Site clean and free from all debris and unwanted materials as per instructions of the Consultant. Storage of materials shall be in an organised manner and in proper compartments.

Storage on suspended floors shall not be permitted unless specifically approved in writing by the Engineer In Charge for specific materials in specific locations and in approved manner. The Engineer IN Charge shall be furnished with load details, if requested, before seeking approval for storage.

Regular cleaning operations shall be undertaken to remove all dust, debris, waste materials, etc. A cleaning schedule shall be maintained.

Contractor shall make his own arrangement for storage of those materials, which cannot be accommodated at site. Contractor shall be fully responsible for safe custody of the same. Materials shall be considered as the Consultant verifies “Delivered at Site” only after the physical presence of materials at site. Stores elsewhere shall not be eligible for being considered as "Delivered at Site”.

Contractor shall be responsible to keep entire site free from water due to water coming from any source at any level and shall protect all materials and works from being damaged by the water from any source. Contractor shall make proper arrangements for drainage prior to use of water for curing, testing, cleaning etc.

Any expenditure incurred by the Contractor in fulfilment of his obligations under this sub-clause shall be deemed to have been included in the Contract Sum.

**SP 5.4** The contractor shall co-ordinate with the activities of other agencies appointed by or permitted by the Employer, which may be simultaneously working in the working area of the contractor. The contractor shall not shift, remove / disturb, demolish any work or plant / equipment / material of any such agency without prior approval of Engineer-in-charge.

**SP 6** Within 15 days of the Award of Contract, the contractor shall submit to the Consultant and Engineer In Charge for approval a Programme showing the order of procedure in which he proposes to carry out the works and other documents as set out in Clause 6 sub clause 9 of Part I.

The Programme shall be prepared taking into account the activities of various other agencies involved in the project and shall be submitted for the Approval of the Consultant and Engineer In Charge. The Programme shall be reviewed by the Engineer in Charge from time to time and revisions if necessary shall be made for well co-ordinated and expedient implementation of the project. A separate Programme shall be prepared for each building/structure. The Employer will have the right to indicate priorities for execution of various items included in the Works. The Contractor will mobilize or re-mobilize or adjust his resources according to the priorities set by the Employer at no extra cost to the Employer. Even though overall period of the Contract shall be as stated in the CONTRACT DATA; the Consultant or the Employer may have to fix different periods of phase
wise completion keeping in view the targeted date for commissioning.

The Contractor shall abide by such different dates of completion, which shall be within the overall stipulated period of completion and will provide the contractor with a shorter duration within which the Contractor will have to complete such works. The Contractor will not be entitled any extra payment on this account.

**SP7**

All the Insurance shall be arranged by Contractor directly from any first class Insurance Company having a branch at Ojhar or Nasik and can deal with all matters pertaining to the subject. The insurance policies shall be in the joint names of the Employer and the contractor.

The following policies shall be maintained for the duration of the contract, or the extended period if required.

- Contractor's All-risk Insurance Policy covering loss, damage, theft, burglary etc. of all materials and equipment, temporary works and the Works shall be insured for a total sum equal to the value of all such items plus ten percent of such value.

- The Contractor shall make available the insurance policy in original before the commencement of work, and shall notify any change in the nature or extent of the works and also make available Additional Insurance of works if required in Special Circumstances.

- Third Party Insurance shall be for a minimum amount upto Rs.5.00 lakhs per occurrence for 4 occurrences in contract period.

- Contractor shall provide for adequate cover to his employees as per provisions of Workmen's Compensation Act.

- Contractor shall indemnify the consultant and Employer from all claims that may arise on account of Contractor's operations at Site.

**SP8**

The Contractor shall comply with all rules, regulations and laws including safety of workmen for labour directly or indirectly engaged by the Contractor, his representative and sub-contractors if any approved by HAL. The Contractor at their own cost shall register themselves wherever and whomsoever required in this connection at local and state level.

**SP9**

The Contractors shall at their cost provide samples of all the materials for the approval of the Consultant and Engineer In Charge and shall provide alternative samples until the sample provided is as per the specifications and standards specified and an approval has been conveyed.

The Contractor shall at his cost provide one set of approved standards and codes to which the Proposed materials, items and works to be executed shall conform. Such a set shall be handed over to the Engineer In Charge for ready reference. All materials, items and works, when submitted for approval shall have reference of Tender Specifications and drawings and of clauses of relevant standard and codes for acceptance criteria.
The Contractor shall, at his own cost, provide testing facilities at site and also arrange and bear the cost of testing from outside laboratories as stipulated in the tender and as directed by the Engineer in Charge.

**SP 10** The whole of the Works shall be completed within the contract period specified in the contract data and tender notice.

**SP 11** The contractor shall pay at the rate of 1/2% of the contract price per week of delay to the Employer as liquidated damages for the time, which shall lapse between the time prescribed in the tender notice and contract data, and the date of certificate of final completion of the works. Such liquidated damages shall be subject to a maximum limit of 10% of contract value or final sum.

**SP 12** The Employer shall issue Certificate of Completion of Works upon request from the Contractor as per Clause 11 sub clause 11 and 12, only if in the opinion of the Employer and the consultant the work is satisfactorily completed.

**SP 13** The Defects Liability Period shall be as specified in the contract data.

**SP 14** The Works shall be measured as given in the technical specifications or Bill of Quantities. If for a particular item of work, the mode of measurement is not given in the technical specifications or in the bill of quantities, then such work shall be measured as per the latest edition of Indian Standards IS : 1200.

**SP 15** The contractors shall execute the work directly by themselves. However for execution of specialized items, the contractor may seek the assistance of such parties who are having expertise in the respective field and their services will help the contractor to execute those items to the best quality and standards specified. However approval for engagement of such agencies will be at the discretion of the Engineer In Charge.

**SP 16 CERTIFICATES & PAYMENTS**

**SP 16.1** The Contractor may submit weekly running bills in approved format for materials and works along with required details and measurements as directed by the Engineer in Charge. The Contractor shall submit Monthly Progress Report in triplicate in approved format. Failure to submit reports may result in holding up of Payment Certificate.

The bills shall be checked/verified and certified by the Consultant and the Engineer In Charge for Interim Payments for amounts, which in the opinion of the Consultant are due to the Contractor, based on actual executed quantities. Only the quantities of work executed, which correspond to the full description stated in the Bill of Quantities, shall be considered for payment. No part-rated items of work will be considered for payment in the bills.

All interim payments made to the Contractor during the progress of the works and thereafter against various running bills shall deem to be on account payments to be adjusted in the Pre-final or final bill submitted after the issue of Completion Certificate and handing-over of the Works to the Employer and further adjusted, if necessary at final account stage after the completion of Defects Liability Period and before release of the defect liability deposit.

Pre-final Bill shall be submitted within one month of issue of the Completion Certificate.
## TERMS OF PAYMENT

**Sp 16.2**
Interest bearing Mobilisation advance as stipulated in CONTRACT DATA excluding sums of contingencies shall be payable to the Contractor against an irrevocable Bank Guarantee of like amount in the same currency, ie amount of advance and estimated interest liability as detailed at contract data, from a scheduled and/or Nationalized Bank.

Recovery of Advance shall be:
- A percentage (as stipulated in the CONTRACT DATA applicable on the gross Interim Certificate amount.
- PLUS
  - The interest (as specified in CONTRACT DATA).

**Sp 16.2.1**
Payment as stipulated in CONTRACT DATA for the value of the materials delivered at site for incorporation in the Works shall be included in Running Bills after due certificate by the consultant and Engineer in Charge. The Engineer In Charge’s assessment on the value shall be taken as final. Material advance will be recovered from next immediate running bill in full. In each running account bill material advance will be allowed based on the assessment of actual quantity of material available at site and actually required for incorporation in the work as certified by the Consultant and Engineer In Charge.

**Sp 16.2.2**
The Contractor may be paid weekly on the certificate of the Engineer in Charge, such sum or the price of the Works executed up to the end of the previous week after adjusting payments made in earlier bills and recovery of advances etc.

Pre-final bill will be certified after verification by the consultant and Engineer In Charge of all the required details, 'as-built' drawings and duly checked the final measurements.

The contractor may submit the final bill after completion of the entire works and services, certification of all the items of works executed, completion of all measurements of works actually executed at site and certified by the consultant and Engineer In Charge, completion of all testing and inspections, submission of all required documents, statements, registers, approval of all deviations and additional items, approval of extensions etc. by the Employer.

The contractor shall consider and include all his claims whatsoever in the final bill which shall construe and mean that the contractor shall not have any other claims whatsoever against HAL under this contract other than those indicated in the final bill. For this purpose the contractor shall enclose to the final bill a No demand Certificate, stating that he has no any other claims whatsoever against the company under this contract except the claims indicated in the final bill and defect liability amount if any.

On receipt of the final bill duly signed by the contractor with all the aforesaid enclosures, the same will be scrutinised by the Engineer-in-charge to see whether the claims are in order. He will also examine the cost recovered and to be recovered, total material advances paid, recovered any to be recovered, mobilisation advances paid, amount, recovered with interest and yet to be recovered total hire charges, electricity and water charges, already recovered and yet to be recovered & other particulars as may be necessary.

No claims of the contractor whatsoever shall be entertained after payment of the final bill.

**Sp 16.2.4** Percentage of Retention Money and the Security Deposit, shall be as detailed in Sr. No. 5 and 6 of Contract Data.

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<thead>
<tr>
<th>Sp</th>
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<tr>
<td>16.2</td>
<td>TERMS OF PAYMENT</td>
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**SIGNATURE OF TENDERER WITH SEAL**

**EMPLOYER**
Notwithstanding anything contained elsewhere in this contract, the security deposit will be adjusted/refunded as follows:

a) The Performance Guarantee of 5% of contract sum will be returned to the contractor, along with the final bill only, duly discharged if necessary.

b) The Retention Money will be retained as defect liability deposit, which will be refunded on receipt of claim from the contractor after completion of the defect liability period and on rectification of all the defects (if any) pointed out during the defect liability period satisfactory and on certification by the consultant and Engineer In Charge.

c) In case of any of the defects are not attended by the contractor and as such the same are rectified by the Employer, the cost towards the rectification of those defects same will be recovered from the contractor from the defect liability deposit along with any other dues.

d) The security deposit i.e. Performance Guarantee & Retention Money shall be forfeited if the work is not completed in all respects by the contractor or the contractor withdrawing or abandons the work during the course of execution.

SP 16.2.5 On submission of RA bills 75% of net value of work done will be paid on certification by Engineer In Charge along with recommendation of head of works department within 2 days and balance 25% payment shall be effected after detailed scrutiny within a week. Payment will be made through Account Payee cheques or Credited to the specified banks at HAL Township Ojhar or through RTGS.

SP 17 APPROVAL AND ACCEPTANCE

17.1 The work shall deem to have been accepted after fulfillment of all the following by the Contractor.

1. Obtaining certification from the competent and regulatory agencies, departments regarding completion of items wherever required for occupation and use of the Works and services and on handing over such certificates to the Employer.

2. Submitting As-Built Drawings, Catalogues, Brochures, Data Sheets, manuals as directed by the Engineer.

3. Submission of all registers, documents, and test results and all other documents as required to be maintained as per contract terms.

4. Completion of all measurements, verification and certification by the Consultant and the Engineer In Charge.

5. Obtaining Certificate of Completion, from the Employer.

5 Handing over of all the Works and services to the Employer.
SP 18 Notwithstanding anything contained elsewhere in any of the clauses of the tender, the prices/rates quoted for each item/work in the Bills of Quantities shall be firm and fixed and shall be inclusive of all direct and indirect costs, duties, taxes, sales tax, consignment tax, Octroi / local tax, work contract tax, service tax, over heads, profits etc. on any of inputs, royalty on quarried items, incidental expenses for obtaining approvals etc. that may be involved in completing the item/work as required in the fulfillment of all obligations under the contract and to the satisfaction of the Engineer In Charge. Any variation in taxes, duties, levies, fees, charges etc. during the tenure of the contract shall be borne by the contractor and no claim for increase in prices / rates shall be accepted by the Employer. No additional expenses on this account shall be borne by the Employer.

Sales Tax on Works Contract shall be borne by the Contractor but the Employer has the right to deduct equivalent amount from running bill of Contractor and deposit the same directly with competent authority. The Contractor ought to be registered with Sales Tax Department.

The Employer has further right to deduct any and all of the Taxes deductible at source, including surcharge, if any and deposit the same with the competent Authority.

SP 19 The Contractor shall supply, erect and satisfactorily maintain in good repair until final completion of works, well lighted, temporary, burglar proof two Site Offices of 25 sq.m. Carpet area each viz. one for Employer and one for Consultant as per approved layout for use at all times. The contractor shall provide adequate access to the offices. The Contractor shall be responsible during the continuance of the contract for the security of the offices and for all plans, documents and papers etc. contained therein. The offices shall be constructed to approved standards, well ventilated and adequately weather proofed and with sufficient general office furniture, fans and lockable steel cup-board in each office. The Contractor shall provide uninterrupted electric power and water to the Offices as directed for 24 hours. Contractor shall provide one brand new Computer of latest version of Compaq or Lenovo make along with required softwares & accessories, as decided by EIC, one laser printer of Brother or HP make, along with computer trolley, UPS etc. On completion of the work, the computer and printers shall become HAL property.

The Contractor shall provide at all times for the duration of the contract all staff men, workmen and survey instruments for the exclusive use of the consultant and Engineer In Charge as directed by the Engineer in Charge for carrying out of his duties in connection with the contract. The contractor shall ensure that his survey team possesses the adequate knowledge and experience in their field to perform the work. Such survey and distance measuring instruments, which must be approved by the Engineer in Charge shall include but not be limited to the following:

1. One Levelling instrument/Theodolite with horizontal circle and tripod.
2. Two metric levelling staffs not less than 3.5 metres high.
3. Two 100-metre (Freemans brand) rust less steel tape, three 30 meter (Freemans brand) rustless steel tapes, two 30 metre linen tapes and three 5 metres rustles steel tapes of Freemans brand.
4. Adequate number of ranging rods, drop arrows, wooden setting-out pegs, etc.
The contractor shall be solely responsible for all such instruments and equipments and shall ensure that they are at all times in good repair and adjustment.

On final completion of works, the entire offices along with all facilities provided by the Contractor except computers and printers and its connected units, as stipulated in clause SP 19 in Vol.I of tender documents shall be taken back by the Contractor at his own cost. The cost of providing the facilities stated in SP 19 and SP 19.1 are to be borne by the Contractor.

**SP 20** The Contractor shall arrange accommodation for his staff and labour outside the HAL factory premises. No accommodation / labour hutsments can be allowed within the Factory premises. Necessary land for Labour colony / camp for the construction work will be given outside the factory premises free of charges. Maintaining labour camp by providing fencing, security, sanitation, water and lighting arrangements etc, will be the responsibility of the contractor.

Residential accommodation contractors Engineers may be provided as per the availability and as per the terms of HAL, In Township area.

**SP 21** All staff and labour shall be given identity badges of approved design by the **Identity** contractor and these shall be worn whenever the person is moving on the Site.

**SP 22** The Contractor shall arrange for power for construction of temporary buildings / works at his own cost and nothing extra shall be payable on this account. Alternatively, the Employer may, at his sole discretion, provide construction power at one point at site. Contractor shall arrange and install all distribution cabling / wiring etc. Power shall be metered at the point of supply by Employer. Cost of power supply (single & three phase) shall be recovered by the Employer from bills of the contractor @ Rs 4.20 for units 0-200, Rs 5.90 for units above 200, Rs 6.20 for units 20KW-50KW, Rs 8.10 for units above 50KW or Current rate prevailing as decided by CM (Maint.). Providing of construction power point under this clause by the Employer is entirely at the option of the Employer’s and is subject to availability.

The Contractor shall also install a set of mobile Diesel Generators of suitable capacity for construction, temporary buildings and temporary lighting in order to take care of power failure and in adequate / fluctuating supply of power. These shall be provided from the date of mobilization upto the commissioning. This will act as stand by power.

The contractor shall provide all accessories and cabling as required along with Gen-sets. The contractor shall provide the installation and shall maintain the same in good order for entire duration of work.

The contractor shall then remove and take away all the equipments and accessories and the likes.

The Contractor at his own cost shall arrange water for construction and the same is deemed to be included in the quoted rates.

Alternatively, the Employer may at his sole discretion provide water for construction at one or more point at site at absolute discretion of the Engineer in Charge. Contractor shall arrange and install all taping and distribution piping, water meter etc. The cost of taping, piping network and the cost of water meter shall be borne by the contractor. The water used will be metered and charged @ Rs. 20.60 per 1000 litres or Current rate prevailing as decided by SM(works)/EIC. Recovery will be made from the RA bills or any amount due to
Project: “Civil, Electrical and other utility services for package -Civil- II (Rotable complex) the contractor. Providing of water under this clause is at the option of the Employer and is subject to availability.

**SP 23** The Contractor shall provide sanitation and drainage facilities on the Site as stated subsequently, at his own cost.

The Contractor shall strictly control the labour so that the Site is not polluted, made dirty or littered with debris, wastes or the likes.

Any person found creating mess or litter or pollution should be removed from the Site immediately at Contractor’s cost.

The Contractor shall provide sanitation facilities at convenient locations on Site top reserve the cleanliness of the Site. The effluent shall be directed as follows:

1. Waste Water: Collection and pumping out and disposal off the Site in approved manner.

   Sewage

   Septic tank provision – sludge to be collected and disposed off at intervals as directed.

   The locations of the above provisions shall be as marked on the Site Mobilization Scheme drawing to be submitted by the Contractor for approval by the consultant and Engineer in Charge.

**SP 24** The Contractor shall take note of the Site conditions and shall obtain any further details about ambient conditions on his own and take into account while pricing his tender.

All items and equipments quoted shall be suitable for satisfactory working under the ambient conditions.

**SP 25** The Contractor shall provide at his own cost, two Site sign Boards, of overall size 1 meter wide and 2 meters height and of approved design at directed location. The names of the Project, Employer, Consultants, and Contractor etc. shall be exhibited as directed.

**SP 26 DRAWINGS AND DOCUMENTS**

**SP 26.1** The drawings and documents prepared for the project shall be treated as confidential documents and must not be copied or loaned to any other party without the express permission of the Engineer/employer.

**SP 26.2** The tender drawings furnished by the Consultant are for Tender Purpose only and are intended as a guide to the Contractor and give general layout of buildings and structures and general positions of utilities, services and equipment only and in measuring from these drawings and preparing tender quotes the contractor must make due and proper allowance for all necessary diversions from the straight line, rises or falls as may be required for the proper execution of the works.

Detail drawings in all cases shall be worked to in preference to those of a more general nature and figured dimensions where indicated shall be followed in preference to scaled dimensions.

Should any item of equipment, materials or labour which would reasonably and obviously be inferred as necessary for the complete, safe and satisfactory usage of the Works or part thereof, not be expressly specified, the contractor shall provide and execute such work as a part of the contract at no extra cost to the Employer.
SP 26.3  The consultant shall issue from time to time free of charge two sets of Contract Drawings, Approved for Construction, to the Contractor and one copy thereof to the Employer. Additional copies as and when required shall be supplied by the Consultant and costs shall be reimbursed by the Contractor. In case the issue of drawings does not conform to the Programme as planned and approved, the contractor shall immediately submit a revised Programme so that, by deployment of adequate resources, the Work is completed within the stipulated time period.

The Consultant may from time to time during the course of contract issue the Contractor with revised contract drawings and the Contractor shall ensure that all superseded drawings are removed from site and stored in a lockable cabinet as directed by the Consultant and replaced by revised contract drawings.

The Contractor shall ensure that a complete up to date Register of Drawing is maintained at Site indicating the date of receipt, the title of drawing, revisions etc. All Contract Drawings shall be properly filed and indexed for ready reference.

The Contractor shall ensure that only the valid up to date contract drawings are used for preparation of working drawings, setting out, construction etc.

SP 26.4  Working drawings shall mean any or all drawings, required for satisfactory execution of the work, in addition to the contract drawings and shall be prepared and got approved by the contractor at his own cost.

Working drawings shall include Shop and Fabrication Drawings for Wood work, Steel / Metalwork, False ceiling, partitions, clamping and fastenings, all utility and services, Bar Bending Schedules etc. as required by the consultant and Engineer In Charge.

The Contractor shall be entirely responsible for co-ordination of entire work at site including the work carried out by Sub-Contractors (if approved by HAL) and shall ensure that all necessary working drawings are properly prepared by the Contractor and are submitted to the Consultant for approval in sufficient time so as not to cause any delay in the expeditious execution of the works as per the Programme. Such approval shall not absolve the contractor from his responsibility.

Working drawings to be prepared by the Contractor and his Sub-contractor(if approved by HAL) shall be such that all details are included as required by the Consultant at an appropriate scale to ensure that the Works are properly executed, co-ordinated, fabricated and installed in accordance with contract drawings and specifications.

The Contractor shall make a general check of all physical sizes and details of plant and equipment required and/or specified for the project and shall inform the Consultant of any matter that may come to his notice with which he disagrees. Any comments by the Contractor on the difficulty in incorporating the plant, materials and equipment in the project and the time required for the completion of the work shall be made to the Consultant.
The Contractor shall bring to the notice of the Consultant any discrepancies within or between contract drawings and/or the other contract documents prior to preparation of working drawings and commencement of work and shall not proceed with work until the Consultant gives clarifications and instructions to proceed.

"As Built Drawings" shall be provided by Contractor at the time of Pre-final bill and shall be prepared by the Contractor at his own cost.

As-built drawings shall be under preparation from the onset of the contract, in order that all minor amendments and discrepancies from the "Working Drawings" are incorporated. To ensure that this requirement is complied with, the Consultant shall inspect the drawings on his request as the Works proceed. 3 sets of "As-Built" drawings shall be submitted by the Contractor along with soft copy in CD or DVD.

At the discretion of the Consultant and subject only to his express agreement certain working drawings may be modified and submitted to the Consultant as the "As Built" drawings.

The Contractor shall also provide the Engineer in Charge through the consultant with two copies in a durable plastic case of the operating and Maintenance Instruction Manuals in respect of all equipments, machines etc.. The arrangement of these manuals shall be as follows:

SECTION A: Index

SECTION B: Description and details of materials, items, fittings and fixtures used for the project along with Catalogues & Addresses of the Suppliers.

SECTION C: Planned maintenance instruction and dates for order replacements.

SECTION D: List of recommended consumables.

SECTION E: List of "As-Built" Drawings

Until the Record Drawings, prints, transparencies and manuals referred to above have been received and approved by the Consultant, the Contract shall not be considered as complete and payment of monies will be withheld until such drawings, etc. have been submitted to and approved by the Consultant and the cost of providing such records including proper submission thereof is deemed to be included in the Contract Sum quoted by the Contractor.
20) Time is the essence of the contract and the contractor shall be required to complete the work in all respects within the time stipulated in the contract, since the contractor’s tender depends upon the time allowed. However, if in the opinion of the Engineer In Charge, the work is delayed by reasons of:

a) Abnormally bad weather, or  
b) By reasons of serious loss or damage by fire, or  
c) By reason of Civil commotion, local combination of workmen strike or lock out affecting any of the trades employed on the work, or 
d) By delay on the part of the agency or tradesmen engaged by HAL in executing the work not forming part of this contractor, or 
e) By reason of any other cause which is the absolute discretion of the Engineer In Charge is beyond the contractor’s control, then in any such case the Accepting Officer on the recommendations of the Engineer-in-charge, may make fair and reasonable extension of time in the completion date of the individual items of work or the contract as a whole, and such extension which will be communicated to the contractor by the Employer in writing shall be final and binding on the contractor. No claim whatsoever in this respects either for compensation or otherwise shall be admissible.

Upon the happening of any such event causing delay, the contractor shall immediately give notice thereof in writing to the Engineer in Charge, but shall nevertheless use constantly his best endeavor to prevent or make good the delay and shall do all that may reasonably be required to the satisfaction of the Engineer in Charge.

21) Contractor shall submit all check lists, pour cards etc. as per the format approved by the consultant/Engineer in Charge before commencement of the works. The formats are to be submitted along with the Quality plan, which shall also include methodology.

22) Reconciliation of materials for Cement & Steel is to be made by the Contractor on monthly basis.

SP 33 PROTECTION OF ENVIRONMENT

The contractor shall take all reasonable steps to protect the environment on and off the Site and to avoid damage or nuisance to persons or to property of the public or other resulting from pollution, noise or other cause arising as a consequence of his method of operation.

During continuance of the contract, the contractor and his sub-contractors shall abide at all times by all existing enactments on environmental protection and rules made there under, regulations, notifications and bye-laws of the State or Central Government, or local authorities and any other law, bye-law, regulations that may be passed or notification that may be issued in this respect in future by the State or Central Government or the local authority.

Ensure that all lights provided by the contractor shall be screened so as not to interfere with signal light on the railways or with any traffic or signal lights of any local or other authority.

Take all reasonable steps to implement the environmental mitigation measures

SIGNATURE OF TENDERER WITH SEAL

EMPLOYER
provided for in the “Environmental Management Plan” to be submitted by the contractor in accordance with objectives, procedures and other provisions set forth therein and shall not take any action, which would prevent or interfere with such implementation.

Salient features of some of the major laws that are applicable are given below

a) **The water (Prevention and Control of Pollution) Act, 1974**, This provides for the prevention and control of water pollution and the maintaining and restoring of wholesomeness of water. ‘Pollution’ means such contamination of water or such alteration of the Physical, Chemical or Biological properties of water or such discharge of any sewage or trade effluent or of any other liquid, gaseous or solid substance into water (whether directly or indirectly) as may, or is likely to, create a nuisance or render such water harmful or injurious to public health or safety, or to domestic, commercial, industrial, agricultural or other legitimate uses, or to the life and health of animals or plants or of aquatic organisms.

b) **The Air (Prevention and Control of Pollution) Act 1981**, This provides for prevention, control and abatement of air pollution, ‘Air Pollution” means the presence in the atmosphere of any ‘air pollutant’, which means any solid, liquid or gaseous substance (including noise) present in the atmosphere in such concentration as may be or tend to be injurious to human beings or other living creatures or plants or property or environment.

c) **The Environment (Protection) Act, 1986**, This provides for the protection and improvement of environment and for matters connected therewith, and the prevention hazards to human beings, other living creatures, plants and property. ‘Environment’ includes water, air and land and the inter-relationship which exists among and between water, air and land, and human beings, other living creatures, plants, micro-organism and property.

d) **The public Liability Insurance Act, 1991**, This provides for public liability insurance for the purpose of providing immediate relief to the persons affected by accident occurring while handling hazardous substances and for matter connected herewith or incidental thereto. Hazardous substance means any substance or preparation, which is, defined as hazardous substance under the Environment (Protection) Act 1986, and exceeding such quantity as may be specified by notification by the Central Government.

SP – SALIENT FEATURES OF SOME MAJOR LABOUR LAWS APPLICABLE TO ESTABLISHMENTS ENGAGED IN BUILDING AND OTHER CONSTRUCTION WORKS.

a) **Workmen Compensation Act 1923**: The Act provides for compensation in case of injury by accident arising out of and during the course of employment.

b) **Payment of Gratuity Act 1972**: Gratuity is payable to an employee under the Act on satisfaction of certain conditions on separation if an employee has completed 5 years service or more or on death the rate of 15 days wages for every completed year of service. The Act is applicable to all establishments employing 10 or more employees.
c) **Employees P.F. and Miscellaneous Provision Act 1952:-** The Act provides for monthly contributions by the employer plus workers @ 10% or 8.33%. The benefits payable under the Act are:

i) Pension or family pension on retirement or death, as the case may be.

ii) Deposit linked insurance on the death in harness of the worker.

iii) Payment of P.F. accumulation on retirement / death etc.

d) **Maternity Benefit Act 1951:-** The Act provides for leave and some other benefits to women employees in case of confinement or miscarriage etc.

e) **Contract Labour (Regulation & Abolition) Act 1970:-** The Act provides for certain welfare measures to be provided by the Contractor to contract labour and in case the Contractor fails to provide, the same are required to be provided, by the Principal Employer by law. The Principal Employer is required to take certificate of Registration and the Contractor is required to take license from the designated Officer. The Act is applicable to the establishments or Contractor of Principal Employer if they employ 20 or more contract labour.

f) **Minimum Wages Act 1948:-** The Employer is supposed to pay not less than the Minimum Wages fixed by appropriate Government as per provisions of the Act if the employment is a scheduled employment. Construction of Buildings, Roads, Runways are schedule employment.

g) **Payment of Wages Act 1948:-** It lays down as to by what date the wages are to be paid, when it will be paid and what deductions can be made from the wages of the workers.

h) **Equal Remuneration Act 1979:-** The Act provides for payment of equal wages for work of equal nature to Male and Female workers and for not making discrimination against Female employees in the matters of transfers, training and promotions etc.

i) **Payment of Bonus Act 1965:-** The Act is applicable to all establishments employing 20 or more employees. The Act provides for payments of annual bonus subject to a minimum of 8.33% of wages and maximum of 20% of wages to employees drawing Rs. 3500/- per month or less. The bonus to be paid to employees getting Rs. 2500/- per month or above upto Rs. 3500/- per month shall be worked out by taking wages as Rs. 2500/- per month only. The Act does not apply to certain establishments. The newly set-up establishments are exempted for five years in certain circumstances. Some of the State Governments have reduced the employment size from 20 to 10 for the purpose of applicability of this Act.

j) **Industrial Disputes Act 1947:-** The Act lays down the machinery and procedure for resolution of Industrial disputes, in what situations a strike or lock-out becomes illegal and what are the requirements for laying off or retrenching the employees or closing down the establishment.

k) **Industrial Employment (Standing Orders) Act 1946:-** It is applicable to all establishment employing 100 or more workmen (employment size reduced by some of the States and Central Government to 50). The Act
provides for laying down rules governing the conditions of employment by the Employer on matters provided in the Act and get the same certified by the designated Authority.

1) **Trade Unions Act 1926**: The Act lays down the procedure for registration of trade unions of workmen and employers. The Trade Unions registered under the Act have been given certain immunities from civil and criminal liabilities.

m) **Child Labour (Prohibition & Regulation) Act 1986**: The Act prohibits employment of children below 14 years of age in certain occupations and processes and provides for regulation of employment of children in all other occupations and process. Employment of Child Labour is prohibited in Building and construction Industry.

n) **Inter-State Migrant workmen’s (Regulation of Employment & Conditions of Service Act 1979)**: The Act is applicable to an establishment which employs 5 or more inter-state migrant workmen through an intermediary (who has recruited workmen in one state for employment in establishment situated in another state). The Inter-State migrant workmen, in an establishment to which this Act becomes applicable, are required to be provided certain facilities such as housing, medical aid, traveling expenses from home upto the establishment and back, etc.

o) **The Building and Other Construction workers (Regulation of Employment and Conditions of Service) Act 1996 and the Cess Act of 1996**: All the establishments who carry on any building or other construction work and employs 10 or more workers are covered under this Act. All such establishments are required to pay cess at the rate not exceeding 2% of the cost of construction as may be modified by the Government. The Employer of the establishment is required to provide safety measures at the Building or construction work and other welfare measures, such as Canteens, First-Aid facilities, Ambulance, Housing accommodations for workers near the work place etc. The Employer to whom the Act applies has to obtain a registration certificate from the Registering Officer appointed by the Government.

p) **Factories Act 1948**: The Act lays down the procedure for approval at plans before setting up a factory, health and safety provisions, welfare provisions working hours, annual earned leave and rendering information regarding accidents or dangerous occurrences to designated authorities. It is applicable to premises employing 10 persons or more with aid of power or 20 or more persons without the aid of power engaged in manufacturing process.

**SP-35 CONTRACTOR’S SUPERVISION**

The contractor shall appoint a responsible and Competent Engineer holding a Power of Attorney to act on his behalf in execution of the contract.

If the contractor fails to appoint suitable Engineer as aforesaid the EIC shall have full powers to suspend the execution of work and stop payment of any advances / bills that may have become due until such date a suitable Engineer is appointed and the contractor shall be held responsible for the delay caused to the work and no extension of time on this account shall be
Orders given to the contractor’s authorized Engineer shall be considered to have the same force, as if they had been given to the contractor himself. The authorized Engineer of the contractor shall be in attendance at the site during all working hours and shall monitor the execution of work with such additional assistance in each trade as detailed hereinafter or as the Engineer In charge may consider necessary.

The contractor or his accredited Engineer shall attend when required and without making any claim for doing so, either the office of the Engineer-in-Charge or the work site to receive instructions.

The Engineer In Charge shall have full power and without assigning any reasons, advice the contractor immediately to cease to employ in connection with the contract if any agent/servant or employee whose continued employment is in his opinion is undesirable. The contractor shall not be allowed any compensation on this account.

The contractor shall deploy an accredited representative holding power of attorney to monitor the work. The qualification and experience of the Engineers shall be as detailed below to receive instructions from the Engineer-in-Charge.
Additional Special Conditions.

ASP-1: Contractor shall obtain entry permits from the Employer for his staff, labour, sub-agencies and vehicles.

ASP-2: The work at flight hangar area may interrupt due to testing schedule of Aircrafts and the Contractor should prepare his schedule taking in to consideration the obstruction during such period and arrange working in different shifts. Contractor will not be paid anything extra on this Account, but

ASP-3: Contractor should take into consideration that he may be required to work in split shift basis in Morning and evening hours avoiding noon peak temperature period for concreting of pavement.

ASP-4: Employer, in his absolute discretion upon the request of the contractor may permit the contractor to work during night hours if the employer is satisfied with the working arrangement made and the methodology proposed by the contractor.

ASP-5: The Employer may spare some suitable piece of land to the contractor free of any charges for installing his establishment and concrete weigh batching plant. The decision with regard to the location of land shall be exclusively that of the employer and shall be final, conclusive and binding upon the contractor.

ASP-6: Since the work is in a high security zone, the contractor will have to ensure that his representatives and the specialized agencies engaged by him do not have any criminal background and the authorized representative of the contractor shall produce an affidavit attested by notary public confirming his harmlessness and produce the particulars as may be required by the security department of the Employer and shall comply with all the requirements as may be directed.

The tenderer should get himself acquainted with all the formalities and procedures in this regard prior to submission of tender.

ASP-7: The contractor shall not be permitted to change the Technical staff designated for the project without prior approval of Engineer-in-charge. The permission shall not be withheld without valid reasons. In the event such permission is requested, the request shall be made at least 15 days prior to effecting such a change and the contractor shall depute a person of equal qualification and experience as a replacement as may be approved by the Engineer-in-charge. In case, the contractor replaces the technical staff without permission or is unable to comply with the other provisions of this clause, a penalty of Rs. 25,000/- per replacement shall be imposed upon the Contractor in addition to the penalties specified in SP_35

ASP-8: The cut trees, if any shall be the property of HAL. The contractor shall have to stack the same neatly within the HAL premises, at his cost.

ASP-9: For blasting operations if required the contractor shall obtain approval from HAL authorities as well as from statutory bodies. Blasting is not permitted for dismantling. The contractor has to demolish the same carefully without disturbing foundation and adjoining structure.

ASP-10: The hard rock obtained from excavation will have to be stacked at locations as directed by the Engineer In Charge.

ASP-11: The contractor has to directly pay the royalties / fees / rents as may be applicable for the work, to concerned authorities and produce proof of the same on demand. If the authorities make any demand of the same to HAL and if the contractor does not produce satisfactory documentary proof to establish that the payment as stipulated in the demand is made by the
contractor, HAL shall have the liberty to make the payment directly to the concerned authority and recover the same from the contractor.

ASP-12: The contractor may be allowed to bring Ready Mix Concrete from outside RMC plants in extreme emergencies, due to failure of plant erected at site and the progress of work is substantially affected and the consultant and EIC is satisfied about the arrangements especially in respect of infrastructure, location, lead etc. However, the contractor shall be responsible for the quality of the product. The consultant and Engineer In Charge including their representatives shall be given all the opportunities and facilities to inspect the said plant and infrastructure as and when required. The permission to bring RMC from outside RMC plant shall be exclusively at the discretion of EIC to attend emergencies.

ASP-13: The specifications and technical details in MES SSR PART-I, Specifications and the relevant IS codes or in the absence of IS codes the respective international codes shall be followed for all the materials, workmanship, sampling, testing, quality control measures irrespective of the fact that those are specified in the technical specifications or BOQ. The MES SSR, IS codes or any other codes wherever specified shall be the latest version.

ASP-14: The work is to be carried out in close co-ordination with Pre-Engineered Building contractor who has been engaged by HAL for the PEB structure. The Civil/Electrical and utility services activities shall be well planned and coordinated considering the PEB structure work.

ASP-15: The contractor shall follows environmental friendly activities, waste management, and energy saving measures, green building concepts in execution of the work.
procurement.

4) Equipments approved and supplied shall have local servicing facilities available in the region.

5) In case of non-availability of the first indicated makes, the contractor shall opt for the other makes after getting approval from the Consultant/Client jointly. If the difference of amount is on the lower side, the same shall be passed on to the Clients.

AIR CONDITIONING & VENTILATION SYSTEM

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GENERAL REQUIREMENTS

3.1.1 GENERAL.

These specifications are for the HVAC works only. However, the Instructions to Tenderers, Form of Tender, Conditions of contract, Note on Pricing, Preliminaries Section and any Supplementary Conditions of Contract applicable to Main Contract shall be applicable to this contract also.

The terms Contractor and Subcontractor used in these documents and drawings are to be considered to be meant as Contractor for HVAC works.

3.1.2 INTENT.

Contractor shall be responsible for proper performance of all HVAC systems in accordance with relevant IS standards and codes and design parameters listed hereinafter. Contractor shall ensure that execution of total work is in accordance to this.

Provide all items, articles, materials, operations, sundries, labour, supervision, guarantees, allowances for overhead and profit, etc., to achieve a fully functional and acceptable.

The precedence of documents and drawings shall be as determined in the Main Contract. However, considering the specifications as an integral part of the work together with the drawings and any item or subject omitted from one, but mentioned or reasonably implied on the other as properly and sufficiently indicated and provide the same under the work.

The Contractor is responsible for developing his own take off of materials and is to make available as approved by Consultant /Client.

3.1.3 EXAMINATION OF SITE AND DRAWINGS.

Visit the site of the proposed works and obtain all information assess the existing conditions and limitations and all proposed works on adjacent sites and in adjacent areas which might affect the works on this site, whether by Private Individuals or by Government Authorities or others.

Examine the documents including the Specifications and Drawings of all before bidding and again before commencing any portion of the work.

Neither Client nor the Consultant shall be responsible for any claim for extra work or expenses resulting from the failure of the Contractor having fully aware of Site Conditions.

3.1.4 PERMITS FEES AND INSPECTIONS.

Arrange for inspection of all works by the external agencies as and where applicable. This is to occur on an on-going basis throughout construction to avoid delays to the project.

Pay fees/charges as levied by the Local Authorities for inspections, approvals, temporary services, connections, etc. at no additional cost to contract.

3.1.5 CONTRACT DRAWINGS

The drawing, specifications and bill of quantities shall be considered, as a part of this contract and any work or materials shown on the drawings and not called for in the specification or vice-versa, shall be executed as if specifically called for in both.

The drawings for services works are design drawings, diagrammatic, and intended to convey the scope of work and indicate general arrangement and approximate locations of equipments, fixtures, pipe and duct
runs, etc. The drawings do not intend to indicate architectural or structural details. These cannot be used as shop drawings. The contractor shall examine all architectural, structural, plumbing and sanitary and electrical equipment before starting the work and prepare execution drawing containing all details mentioned under. Contractor must develop own detailed shop drawings based on actual site conditions for work at site, the same shall be submitted to consultant/Client for approvals prior to commencement of erection activities at site.

Any discrepancies, which in his opinion appear on them, have to be reported to the consultant/Client and get them clarified. He shall not be entitled to any extras, for omissions or defects HVAC drawings or when they conflict with other work.

Do not scale drawings. Obtain accurate dimensions to structure and architectural items from drawings of those trades. Confirm by site measurement. Verify location and elevation of all services before proceeding with the work.

Make at no extra cost, any changes or additions to materials, and/or equipment necessary to accommodate structural conditions (pipes or ducts around beams, columns, etc.)

Install all ceiling mounted components (Diffusers, grilles etc.) in accordance with the reflected ceiling drawings, which are to be prepared by the Contractor, and coordinated with all trades/agencies engaged at site. These must be submitted for approval and be approved before any work commences on site.

Leave space clear and install all work to accommodate future materials and/or equipment as indicated and/or supplied by other agencies of work of the contract. Install all pipe runs, conduit runs, cable trays, etc., to maintain maximum headroom and clearances, and to conserve space in shafts and ceiling spaces and under floors, and to provide adequate space for service and maintenance.

Confirm on the site the exact location of outlets and fixtures.

3.1.6 SHOP DRAWINGS, BUILDER’S WORK DRAWINGS AND MATERIAL SUBMITTALS

After award of Contract, submit programme of works in bar chart schedule and action plan along with the programme, submit a schedule detailing proposed submission dates for all Material Submittals, Shop drawings and Builder’s work drawings. Allow few days to review by the Consultant/Client for each such submission.

Contractor must obtain, from the Consultant/Client, approvals of all materials, equipment and drawings within appropriate time to facilitate progress of work at site.

Prepare drawings in conjunction with all trades concerned, showing sleeves and openings for all passages through structure and all insert sizes and locations.

Prepare composite construction drawings, fully dimensioned, of piping and equipment in shafts, mechanical equipment rooms and areas, and all other critical locations to avoid any conflict arising thereof.

Shop drawings should include all details pertaining to access, cleanouts, tappings, sleeves, electrical connections, drains, location and elevation of pipes, ducts, conduits, etc., obtained from consultation with, and agreement of, all trades involved.

Prepare drawings of equipment foundation or support as the case may be. Prepare drawings for the support of ducts, pipes, electrical cabling with all details. Drawings for wall openings, trenches etc must be submitted for approvals.

Prepare all drawings to scale as agreed with the Consultant/Client. Generally, the scale shall be 1:50 for layouts and 1:20 for Details and Sections, etc. Forward these drawings, approved by all trades concerned to the Consultant /Client for review/records.

The Consultant/Client will only consider shop drawings bearing the stamp of the Contractor and all Subcontractors involved, check for all pertinent information such as physical dimensions, make, performance, electrical characteristics and indicate the intended use and location before submitting these drawings.

Assume responsibility for accuracy of equipment dimensions related to space available, accessibility for maintenance and service. Ensure that shop drawings indicate working weights of all related equipments.
Submission of technical submittals for all equipment and materials covered in the contract to be made upon finalization of the contract for approvals of Consultant/Client. The submission of samples, wherever raised by Consultant/Client, will be subject to the same procedure as that of shop drawings. One set of such samples shall be required to be brought and kept at site till completion of entire work.

The Consultant /Client will mark the drawings "Approved / Approved with comments / Revise and Resubmit / Not Approved. Same practice will be followed for the material submittals. Contractor will take action based on the comments accordingly.

The Consultant's/Client review shall not relieve the Contractor from responsibility for deviations from the Contract documents, unless he has, in writing, called the Consultant's/Client attention to such deviations at the time of submission of drawings. The Consultant's/Client approval shall not relieve the Contractor from the entire responsibility. Any approval by the Consultant/Client shall be on the understanding that any item submitted shall be ordered with options and modifications to fully meet the specification. Any fabrication, erection, setting out or other work done in advance of receipt of stamped drawings shall be done entirely at the Contractor's risk and cost. Contractor shall submit one complete set of original drawings, as built drawing with updated details as per site conditions.

Contractor shall indicate foundation, water supply & electric power supply for HVAC equipment on drawing and same shall be coordinate with other respective agency in coordination with Consultant/Client before execution of work.

Furnish prints of the reviewed details to all other parties who may require them for proper coordination of their work, and furnish all information necessary for the work as a whole.

Obtain Manufacturers' installation directions to aid in the proper execution of the work.

3.1.7 OPERATION AND MAINTENANCE MANUALS

Upon successful Testing & commissioning, submit one draft of Operation and Maintenance Manuals for review and approval of Consultant /Client.

The minimum information required is as follows:

(a) Catalogs highlighting the Make, Model, Sr. No and other necessary details for all Material, test certificate, Manuals and Equipment installed.
(b) List of Local Agent / Supplier for all Materials and Equipment with Telephone, Fax and Email address.
(c) Detailed description of systems operation.
(d) Procedures for Preventive regular and the breakdown maintenance, with Manufacturer's Operation and Maintenance Catalog for all Systems / Equipments.
(e) Commissioning date for all Systems / Equipment.
(f) List of recommended spares.
(g) Trouble shooting – Cause / Remedy charts.
(h) Safety procedures.
(i) Startup / Shutdown interlock sequence.
(j) Emergency / Shutdown log sheet format.

Upon approval of the draft by the Consultant, submit 4 set of manuals to Consultants for onward submission to Client.

3.1.8 COOPERATION

Confer with all trades installing equipment, which may affect the work, and arrange equipment in proper relation with that equipment installed under all Divisions of the Contract.

Furnish all items to be built in by others, in time, complete with all pertinent information, commensurate with the progress of the work.

Store materials neatly and out of the way and clean up all refuse caused by the work daily, to ensure that it does not disturb or hamper the work of other agencies.
3.1.9 PROTECTION AND STORAGE

Protect the buildings and structures from damage due to carrying out of this work.

Protect all mechanical & electrical works from damage. Keep all equipment dry and clean at all times.

Cover all openings in equipment and materials. Cover all temporary openings in ducts and pipes with polyethylene sheets or caps until final connection is made.

Any damages to the equipment and material resulting from improper protection and storage arrangement made by contractor will have to be made good at his own cost, failing which the same be liable for rejection.

Due care must be exercised while installation/erection of equipment and material, to avoid damages to the equipment and material mentioned in this division and the work/material of other agencies.

Contractor to include for all necessary insurance coverages for their workers & material at site, copies of the same be produced prior to commencement of work.

3.1.10 EXISTING WORK AND EQUIPMENT

Before Contractor undertakes work in any area he must prepare a list of deficiencies in that area which affect his works, or which could possibly be construed as being caused by himself if not noted. In the event that such deficiency list is not prepared, then he shall be deemed responsible for such deficiencies. Any list shall be brought to the attention of the Consultant/Client forthwith.

3.1.11 SUPERVISION.

The contractor will maintain at site, as necessary for the performance of the Contract, qualified personnel and supporting staff, with proven experience in erecting, testing, and adjusting projects of comparable nature and complexity. Such staff will be fully dedicated to the project and be available at site for continuous supervision activities.

Before commencing work the Contractor will submit details of the proposed Engineers and Supervisors, including copies of their qualification and experience Certificates. If in the Consultant's/Client opinion the proposed Engineers or Supervisors are not adequately qualified or are otherwise unacceptable, the onus is on the Contractor to submit alternates until such approval is given.

Where the Contractor's staff becomes during the Contract deficient in performance, the Contractor is to remedy the situation by immediate and appropriate replacement, to Consultant's/Client approval.

Approval of the Contractor's Engineers or Staff shall in no way prevent the withdrawal of that approval at any time during the Contract should the Consultant /Client so desire. In the event of such disapproval, Contractor will be required to rectify the position as stated above.

In the event of any negligent or severely detrimental behavior the Consultant /Client has the right to order the removal from site of any Engineer, Supervisor, or worker on a “forthwith" basis.

3.1.12 WORKMANSHIP.

Good workmanship and neat appearance are the prerequisites for completion with the various sections of this specification. Work shall carried out in accordance with the statutory rules and conform to relevant rules and I.S Specifications.

Install equipment, ductwork, conduit and piping in a workmanlike manner to present a neat appearance and to function properly to the satisfaction of the Consultant/Client. Install ducts and pipes parallel and perpendicular to the building planes. Install all piping and ductwork concealed in chases, behind furring, or above ceiling, except in unfinished areas. Install all exposed systems neatly and group to present a neat appearance.

Install all gauges, thermometers, etc., to permit easy observance.
Install all equipment and apparatus which requires maintenance, adjustment, or eventual replacement with due allowance for this.

Install valves to guarantee proper sensing. Shield elements from direct radiation and avoid placing them behind obstructions.

Install all panels and boards, etc., to permit easy operation.

Include in the work all requirements of Manufacturers as shown on their drawings.

Replace all work unsatisfactory to the Consultant/Client without extra cost and to the standard required by the Consultant/Client. This applies to any item, which is found to be defective in service during the maintenance period, or extended maintenance period as appropriate.

If the contractor employs sub-contractors for works like equipment installation, ducting, piping, insulation etc., the same is to be communicated in advance to the consultant/Client with a detailed profile of the sub-contractor including their experience, skilled personnel and machine/tools availability for undertaking such works. The sub-contractor can start work only after acceptance / clearance issued by consultant/Client.

3.1.13 MATERIALS AND EQUIPMENT.

All materials used on the project shall be brand new and in compliance with the technical specification mentioned in the contract. Equipment/material Manufacturers mentioned in the list of makes alone will be accepted. Obtain approval of all manufacturers from the Consultant/Client. Contractor is advised not to submit any brand, which does not appear in the "List of approved makes".

"New" is defined as newly manufactured, and delivered to site as such. Any Equipment which in Consultants/Client opinion second hand or has been mishandled before delivery to site, shall be rejected.

All materials used on this project shall bear the third party quality assurance stamp like British Standard kitemark, UL, FM, and/or other quality assurance authority as appropriate, in the opinion of the Consultants.

Each equipment should be factory tested and certified all QA/QC test certificates to be submitted for review of consultant. If deemed necessary factory inspection may be undertaken by consultant /client.

Each equipment should be properly tagged, with name plates carrying all details relevant to the machine for ease of identity and reference.

3.1.14 CLEANING.

Each day as the work proceeds and on completion, clean up and remove from the premises all rubbish, surplus material, equipment, machinery, tools, scaffolds, and other items used in the performance of the work. Clean out dirt and debris and leave the buildings broom clean with no stains and in a condition acceptable to the Consultant/Client.

Where electrical items form part of the visible finish in the rooms, protect from over-painting, etc. and give all items a final cleaning before handing over of the project.

3.1.15 ACCESSIBILITY.

Each item of equipment shall be located so as to be accessible for maintenance or repair without removing adjacent structures, equipment, piping, ducts, or other materials. For the large Air Handling units the Contractor shall ensure that these can be built up on site from components, which can be taken into the area.

Any item of equipment needing maintenance shall be located so as to be accessible for maintenance or repair without removing adjacent structures, equipment, piping, ducts, or other materials.

3.1.16 CUTTING AND PATCHING.

Inform all other Divisions in time concerning required openings.
Obtain the approval of the Consultant/Client before doing any cutting. Supporting members of any floor, wall or the building structure shall only be cut and in such a manner as approved by the Consultant/Client. All reinstatement work must be done to the same standard as the original work.

3.1.17 INSERTS, SLEEVES AND CURBS.

Under this section supply necessary sleeves and other inserts to other trades.

Use only factory made, threaded or toggle type inserts as required for supports and anchors, properly sized for the load to be carried. Place inserts only in portions of the main structure and not in any finishing material.

Supply and locate all inserts, holes, anchor bolts, and sleeves in good time when walls, floors, and roof are erected.

Pass insulation unbroken where pipe or duct is insulated. Size sleeves to provide adequate clearance all around.

Use the following materials for pipe sleeves:

a) Through all interior walls above grade use PVC Class 150 pipes, machine cut, flush with finished structure.

b) Through all exterior walls above grade use PVC Class 150 pipes, machine cut, flush with finished structure inside and to suit flashing on outside.

c) Through all exterior walls below grade and all other waterproof walls use PVC Class 150 sleeves, machine cut. Check flashing specification for further details.

d) Through all waterproof floors, janitor's closets, mechanical rooms, kitchens, roofs, use PVC Class 150 sleeves, machine cut. Extend sleeves 100 mm above finished floor upwards and cut flush with underside of floor. Refer to flashing detail through waterproof floors.

e) Provide 100 mm high, 100 mm wide watertight concrete curbs with 20 mm chamfered edges around all pipes passing through waterproof floors except where furred in. Read Concrete specification before proceeding with curbs.

Pack all sleeves between the insulated pipe and the sleeve or where un-insulated between the pipe and the sleeve with loose fiberglass insulation. Seal the annular space as follows:

a) For all horizontal sleeves in exposed areas, use a seal equal or better fire rated than the wall to be sealed.

b) For all vertical sleeves through roofs, janitor's closets, equipment rooms, use permanently resilient silicone based sealing compound, non-inflammable and waterproof. Ensure that the seal is compatible with floor and ceiling finishes. Check the room finishing schedules for further details and clarify if necessary with the Consultant.

c) Through roofs, provide curbs and sleeves as shown on drawings and to suit flashing requirements.

Use the following sleeving for ducts:

For rectangular duct openings through walls and floors a removable hardwood box-out shall be provided of the required size. Soft wood or plywood will not be acceptable.

Wherever applicable, through fire walls, build fire dampers into wall, or make detailed fixing in accordance with Consultant's/Client instruction.

Through floors where ducts are not furred in or enclosed in a ductshaft, provide 100 mm high and 100 mm wide watertight concrete curbs, with 25 mm chamfered edges all around. Extend sleeves where used flush to top of curb. Read Concrete Specification before proceeding. Through floors where duct is enclosed in a duct shaft or furred in, provide the watertight curbs at the extreme top and bottom only.
After ducts are installed, pack the opening and seal the packing as follows:

a) Use fiberglass insulation for packing.

b) Seal the packing in openings through floors with permanently resilient silicone base non-inflammable waterproof compound. Press duct supports firmly down into caulkng before bolting it down to curb.

c) Through all vertical walls seal the fiberglass packing using permanently resilient silicone based sealant.

Brace duct sleeves and box-outs to retain their position and shape during the pouring of concrete and other work.

Provide bracing for each duct at every passage through structure to prevent sagging.

3.1.18 ACCESS PANELS AND DOORS.

Install all concealed mechanical equipment requiring adjustment or maintenance in locations easily accessible through access panels or doors. Install systems and components to result in a minimum number of access panels. Indicate access panels on as-built drawings.

Provide the respective Division of work with panels, doors or frames, complete with all pertinent information for installation.

Ensure that access doors are installed in a manner to match the building grids where applicable.

Prepare detail drawings showing location and type of all access doors in coordination with other trades before proceeding with installation and hand these to the Contractor to obtain approval.

Size all access doors to provide adequate access and commensurate with the type of structure and Architectural finish. Should it be necessary for persons to enter, provide a minimum opening of 600 x 450 mm.

Ensure proper fire rating of access doors in fire separations

Lay-in type ceiling tiles, if properly marked may serve as access panels.

3.1.19 GENERAL WELDING REQUIREMENTS.

All welding shall be generally in accordance with ANSI B31.

Tack welds shall be performed by fully qualified welders and all tack welds shall be of a length equal to twice the pipe thickness and shall fully penetrate the pipe walls wherever required.

Where welding is carried out in the proximity of inflammable materials special precautions shall be taken to prevent risk of fire or other damage to the building fabric.

Where oxyacetylene cutting equipment or any welding plant is being used by an operative for any of the works defined in the contract documents, then fire extinguishers shall be supplied and carried as part of the equipment. The operators of cutting and welding equipment shall be trained in the use of the fire extinguishers, which they carry and all extinguishers shall be fully charged and ready for use. In all cases, extinguishers shall be positioned immediately adjacent to the position where cutting and welding is being carried out and shall be readily accessible for use in the event of an emergency.

All accommodation, benches, tools, welding plant, acetylene, oxygen or electricity, filler rods and electrodes, which are necessary for installations where welding is required shall be provided as part of this contract.

Welding shall not be done at a temperature of 5 degrees Centigrade or below unless the parent metal is preheated by torches or other approved means until it is warm to the hand (about 27 degrees C) for about 150mm either side of the joint. No welding shall be done below minus 18 degrees C. After preheating, the heated portion including the welded joints shall be covered with muffs or suitable insulation materials to allow cooling free from draughts. Any open ends of the pipe or assembly shall be effectively sealed to prevent heat flow by convection.
All welded pipe assemblies shall be constructed so that individual welded joints do not affect each other. The distance between the centres of adjacent welds shall be not less than twice the bore diameter of the pipe.

No welded joints shall be left partially completed. Any joints tacked in position must be promptly finished within the working day. The Consultant/Client will reject all work not done in accordance with this instruction.

Where work is rejected, pipes must be machine cut at least 150 mm either side of rejected welds and proper weld preparation must be used on the shortened sector. Where shorter fill-in sections are required because of such rejection and reworking, then new full sized lengths must be supplied by the Contractor.

Where pipes with longitudinal seams are specified, pipe seams shall be arranged such that adjacent seams are opposed 45 deg. from each side of top dead centre and branches shall be made only with weldable fittings.

All filler metals which are coated shall be protected from excessive moisture changes. Filler materials or flexes which show any sign of deterioration shall not be used. If requested by the Consultant/Client samples of filler rods to be used shall be submitted to him for approval before any work is done on site.

3.1.20 TESTS FOR WELDER QUALIFICATION.

The purpose of the welder's qualification tests is to determine the ability of the welders to make sound and acceptable welds. Before any site welding on the contract is allowed, each proposed welder shall carry out the tests required in the presence of the Consultant/Client.

Any weld test specimens which have been suitably marked and approved shall be kept on site by a responsible person, so that they can be produced at any time, at the request of the Consultant/Client.

All accommodation, benches, tools, welding plant, acetylene, oxygen, electricity, test pieces, filler rods, electrodes, facilities for cutting and grinding, polishing, bending and examining, which are necessary for welders qualification tests shall be provided by the Contractor. In the absence of any items for inspecting the welds, the Consultant/Client may submit the finished samples to an independent laboratory for testing at the Contractor’s expense.

Under no circumstances shall a welder be employed on the contract, either on or off the site for welding operations other than those for which that welder is qualified.

Copies and records of all test reports shall be promptly given to and kept by the Consultant further submission to Client.

Even welders holding a certificate for welding are to be tested at this job site in full accordance with the specifications.

The Contractor shall be responsible for the quality of welding and brazing and shall provide the testing of the welders employed. Certificates of such proficiency test, together with stamped samples provided for Engineer's review before welding work is commenced.

Qualification tests certified by consultant will be made for butt and branch welds in pipes. One test piece per welder will be required for the qualification of welding of pipes exceeding 100m nominal diameter.

In addition, test pieces will be required for each position of a pipe. These positions will be horizontal and rotated while welding, horizontal and fixed while welding, vertical and fixed while welding for each range of nominal diameters specified.

3.1.21 PAINTING AND IDENTIFICATION.

All painting of plant, equipment, storage vessels, ducting, pipes, refrigerant piping, and the like shall be carried out by contractor.

Painting shall be applied to all exposed pipe work, ductwork and associated components, valves, fittings, etc., equipment, supports of any kind, insulation, plain mild steel, copper, or cast iron surfaces, refrigerant piping. Steel piping shall be painted even if to be insulated, before insulation is carried out.
All the refrigerant & water piping should be painted as per the standard colour code.

The following items do not require site painting:

(a) Insulation having any of the following finishes:
   (1) Aluminum foil.
   (2) Metalwork.
   (3) Polyisobutylene sheeting/ bitumen coating.
   (4) Vinyl-glass/ resin-aluminum foil laminate.

(b) Equipment or plant or supports or frames delivered to site with any of the following finishes:
   (1) Painted finish, other than primed only, provided that the finish is not damaged in any way.
   (2) Stainless steel or plastic coated steel.
   (3) Stoved enamel.

All surfaces to be painted shall be prepared by thoroughly cleaning and removing all rust, grease, oil, dirt and surface corrosion, using wire brush, emery paper and/ or degreasing medium as required. The paint shall be applied in accordance with the maker's instructions and the type of paint to be used shall be in accordance with the following:

For factory applied finishes, repainting or refinishing of any surfaces damaged during shipping, erection or construction shall be done using only factory-supplied materials.

After finished painting is completed, identify each piped and ducted service. Locate identification and flow arrows:

(a) Behind each access door.
(b) At each change of direction on all joining pipes and ducts.
(c) At not more than 10 meters apart in straight runs of exposed pipes and ducts, but on both sides of sleeves.
(d) At not more than 10 meters apart in straight runs of pipes and ducts behind removable enclosures such as lay-in ceiling but on both sides of sleeves.
(e) Above each floor or platform for vertical exposed pipes, preferably 1.5 meters above floor or platform level.

P.V.C. tape identifying bands may be used as an alternative.

Use stencils and stencil paint onto all piping and ductwork. After completion of the works provide to Owner usable stencils for each service. Use wording shown in the description section of the legend on the Mechanical Drawings, or as instructed in writing by the Consultant/Client.

Wherever insulation is to be painted, the paint used shall comply with all the fire resistance requirements for insulation finish, and shall be carried out by the insulation subcontractor.

In all cases the actual grade of paint to be used shall be suitable for the operating surface temperature and shall be approved by the maker for the application concerned. In certain cases the grade of finishing coat may not require the application of undercoats; in which case these may be omitted, provided that the Consultant's/Client approval in writing is obtained beforehand.

All insulated or un-insulated pipework in concealed positions shall be identified by means of 75 mm wide identification bands, painted neatly on, at right angles to the pipe axis at intervals not greater than 3 meters.
In addition the name of the service and pipe diameter shall be stenciled on in a visible position with an arrow indicating the direction of flow. Flow and returns shall have the letter "F" or "R" added to the identifying name. The identifying band colours and the finishing colour of the services to be painted shall be agreed with the Consultant/Client prior to application, but for tendering purposes shall be in accordance with the colours and procedures given in ASHRAE Guides.

<table>
<thead>
<tr>
<th>Conditioned Air Supply</th>
<th>Blue</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conditioned Air Return</td>
<td>Purple</td>
</tr>
<tr>
<td>Fresh Air</td>
<td>Green</td>
</tr>
<tr>
<td>Toilet Exhaust</td>
<td>Brown</td>
</tr>
<tr>
<td>Kitchen Exhaust, concealed,</td>
<td>Red</td>
</tr>
<tr>
<td>Condensate</td>
<td>White</td>
</tr>
</tbody>
</table>

Ductwork shall be identified in accordance with the procedures laid down in SMACNA.

All equipment located in concealed positions shall have a nameplate secured to the item giving the following information:

Equipment reference number (as indicated on the record drawings.)
System.
Room/Area served.
Duty/output information.

The nameplate shall be 100 x 100 mm approximately, of white plastic 3 mm thick with the above information engraved in black lettering and the plate shall be secured by screws, bolts, clips, etc., as appropriate to the item concerned.

This plate is in addition to any nameplate supplied by the manufacturer of the item giving detailed specification information for the equipment.

3.1.22 FLUSHING AND CLEANING.

Flush all fluid-carrying systems after completion as specified elsewhere. Discharge the flushing fluid through all strainers and out through line sized valves with hose ends. Clean all strainers. Repeat flushing operation to the approval of the Consultant/Client until the water is running clear, colorless and odourless.

3.1.23 INSPECTION, TESTING AND ADJUSTING.

All the works provided as part of this Contract shall be commissioned in accordance with all relevant Specifications and Codes of Practice (ASHRAE / CIBSE) and to the entire satisfaction of the Consultant/Client.

The Contractor shall employ the services of a specialist company approved by the Engineer regularly engaged in providing a testing balancing and commissioning service.

Carry out all tests specified. Carry out all tests required by Authorities having jurisdiction. Test equipment to the requirements of, and where necessary, in the presence of the Manufacturer.

Provide all equipment, labour, and instruments, loading devices, incidentals, and pay for all fuel, power and sundries required to carry out the tests.

All installations shall be inspected and tested in sections as the work proceeds and on completion as composite systems and it shall be noted that the Consultant/Client or any of the other relevant Authorities may require inspecting or testing any equipment during manufacture at the Manufacturer's works. All necessary arrangements shall be made as part of this Contract.

All tests shall be arranged in cooperation with the Consultant/Client and his Engineer and all other concerned parties and shall subject to time, location and nature of the test to be performed. No test shall be considered valid unless the Consultant/Client is present.
All necessary skilled and unskilled labour shall be provided for attendance during the tests (including pre- and post-test activities,) and the test media shall be provided and subsequently disposed of except where specifically stated otherwise.

The testing and adjusting is the contractual responsibility of the Contractor but actual performance of the tests is expected to be the sole responsibility of the Specialist Company.

Have all testing and balancing performed by only persons who are thoroughly versed in this type of testing and balancing and with proven ability. Submit names, complete with experience records, and references for approval of the Consultant/Client.

Any defects occurring at any time during the test duration shall be made good and a complete re-test shall be carried out, all at no cost to the Contract.

Where failure occurs during a test, inspection or commissioning procedure which results in damage to the building fabric and/or any services not provided as part of this Contract, or requires subsequent builder's work to be carried out, carry out all such repair work to the entire satisfaction of the Consultant/Client at no cost to Consultant/Client.

All test points shall be provided which are necessary to carry out the specified tests and commissioning procedures including facilities for measuring or monitoring temperature, pressure, pressure drop, volume flow, in-duct sound power or sound pressure, humidity, or other relevant conditions in both air side and water side systems. Such points shall be fitted with removable plugs, flanges, or other appropriate and approved devices.

Prepare test report forms for each test to be performed and submit these to the Consultant/Client at least two weeks prior to the commencement of any tests.

Test only after the system installation has been completed and the system has been put into continuous operation. Perform the testing, adjusting, and balancing when outside conditions are commensurate with the design conditions for the given system. Add dummy loads to the system if outside and inside conditions are less severe than the specified points.

Duplicate signed test certificates shall be provided after each test, which will be countersigned by the Consultant/Client who witnesses the test for further submission to Client. The test certificate shall give the following particulars: -

- Apparatus or section under test.
- Maker's number (if any).
- Nature, duration and conditions of test.
- Result of test.

No test shall be valid until the test certificate is provided.

Duplicate copies of test certificates carried out at Manufacture's works shall be forwarded to the Consultant/Client for approval prior to dispatch of the article to site.

No section of the works shall be insulated or in any other way concealed prior to testing and inspection and subsequent concealment where applicable shall only take place following written authority from the Consultant/Client.

All necessary facilities, measuring and recording instruments including test pumps and gauges for inspection, testing and commissioning requirements shall be provided and shall be checked or calibrated as necessary before use.

The Consultant/Client reserves the right to call for a demonstration of the accuracy of any instruments provided.

All representatives present during inspection, testing and commissioning shall be fully conversant with the system concerned and the method of system and instrument operation.
Manufacturer's or Specialist Subcontractors' representatives shall attend where specifically indicated elsewhere in the specification or where necessary to ensure full service and cooperation is available to the Consultant/Client to enable the works to be tested and commissioned in accordance with the requirements of the specification.

All necessary precautions shall be taken to safeguard against damage during inspection, testing or commissioning. Any damage so caused shall be made good at no cost to the contract.

All tests shall last for the minimum time period stated or longer if necessary to ensure all sections have been fully examined as required by the test.

3.1.24 INSPECTION OF THE WORK.

The representatives of the Client and the Consultant will make periodic visits to the site during construction to ascertain that the work is being executed in reasonable conformity with all plans and specifications, but will not execute quality control at all times. Contractor must maintain site order book and quality control as intended in the contract documents.

Correct all deficiencies immediately as noted during field inspections.

Request in writing that a final inspection of all services.

Do not issue this written request until:

All deficiencies noted during job inspections have been corrected.

All systems have been balanced and tested and are ready for operation.

All balancing reports have been submitted and reviewed.

All instruction manuals have been submitted and reviewed.

The cleaning up is finished in all respects.

All spare parts and replacement parts specified have been provided and receipt of the same acknowledged.

3.1.25 TESTING & COMMISSIONING OF SERVICES.

All checks and tests as per the manufacturer's drawing/manual, relevant code of installation and commissioning for various type of equipments shall be carried out by the contractor as part of installation work.

All piping systems shall be flushed, chemically cleaned and then filled with treated water, or appropriate fluid, vented as necessary, and brought to operating conditions and the flows then regulated to the design values.

All water circuits shall be balanced by means of the regulating valves provided and flow rates shall be determined on a temperature and pressure drop basis.

Flow through pumps shall be measured by relating the pressure drop across the pump to manufacturers test curves. A copy of the test curve indicating the final operating point shall be forwarded to the Consultant for further submission to Client.

All refrigerant systems shall be tested for leaks and vacuum shall be held for at least 24 hours before breaking with nitrogen gas and Vacuumed, purged and charged according to A.S.H.R.A.E. standard methods. All safety controls and interlocks will be tested as part of the commissioning procedures.

Flow through coils shall be adjusted to give the design temperature difference. In general water systems shall be balanced in accordance with the guidelines. Upon completion of balancing and testing operations for heating and cooling systems, temperature measurements shall be taken in all rooms and the readings tabulated in schedule form together with hourly ambient temperature readings taken over the measuring period. Two copies of the schedule shall be forwarded to the Consultant for submission to Client.
All ventilating systems shall be commissioned in accordance with the procedures recommended. Duplicate schedules of commissioning results shall be forwarded to the Consultant/Client and shall detail the recorded air volume and percentage deviation from design air volume, for each air input and extract terminal. Wet and dry bulb temperature measurements shall be taken in all rooms served by air supply systems and the results indicated on the schedule of commissioning results. Also ventilation fan shall be tested for the capacity, spray performance, static pressure of fans, power consumption, noise level and vibration isolation and result shall conform to the approved data furnished by the contractor.

These shall be recorded together with external ambient wet and dry bulb temperatures measured at hourly intervals over the measuring period.

Sound pressure levels (dBA) shall be measured in all rooms containing supply or extract terminals, all plant rooms, all rooms immediately adjacent to plant rooms and all rooms located above or below plant rooms. The Consultant/Client may at his discretion request a spectrum band analysis of sound pressure in any locations. All motors shall be meggared and a minimum IR value of 1 megon shall be obtained.

All automatic controls shall be commissioned by the controls supplier.

Fault conditions shall be simulated and all alarms and safety devices shall function correctly. Such proving tests shall be carried out in the presence of the Consultant/Client and certificates shall be provided specifically detailing all check procedures, which have been carried out.

The consultant/Client may ask for additional tests on site that are necessary to determine the works compliance with the specification, manufacturer’s guarantee/instructions or the applicable code of installation. The contractor shall carry out such additional test also.

3.1.26 SYSTEM ACCEPTANCE.

The ultimate condition for system acceptance is that the Consultant/Client have inspected the system and found it to be acceptable, and indicated this in writing.

Submit original copies of letters from manufacturers of all systems indicating that their technical representatives have inspected and tested the respective systems and are satisfied with the methods of installation, connections and operation.

Submit, "As built" drawings and operation and maintenance manuals.

Train HAL maintenance staff.

3.1.27 CORRECTION AFTER COMPLETION.

Remedy all work in accordance with the General Conditions of Contract during the Maintenance period.

Attend immediately to any and all the defects occurring during the period defined above and repair in a manner to prevent recurrence. This contractor is responsible for all work required by other trades necessary to repair the works of this section, or necessary to repair damage caused by the failure of any part of this section.

Instruct all Suppliers and Manufacturers that guarantees on equipment will commence when the completed work is accepted and not from the date the equipment is put into operation. In the event that this condition is omitted by the supplier, or if subsequent cost to the Client is involved, in such cases Contractor shall be liable for bearing such costs.

3.1.28 GUARANTEES

The Contractor will guarantee all material and workmanship for at least 12 months after successfully commissioning and take over by the Client. During which period any or all components found to be defective shall be replaced or repaired free of cost and any short coming found in the system as specified shall be removed at no extra cost. The contractor shall provide the necessary personnel and tools for fulfilling the above guarantee. If the defects are not removed within a reasonable time the owner may arrange to rectify the same at contractor risk and without prejudice to any other right.
Also party has to submit all guaranty and test certificates of the HVAC equipments.

All guarantees from equipment suppliers will be vested in the Client, regardless of whether the Contractor who supplied the equipment is still associated with the project or not.

Guarantees will be full guarantees and will include all overhead, profit, incidental charges and sundries.

Where damage is caused to any other item by any failure of the item guaranteed, then the guarantee shall also include the costs incurred in rectifying that damage.

3.1.29 MAINTENANCE.

Maintenance is defined as the Contractual Liability to maintain the equipment in working condition, PLUS the regular checks and servicing of equipment during the maintenance period, including all the consumables and spare parts to keep the equipment in best working order.

Regular maintenance shall be as necessary, but in any event not less frequently than monthly. Breakdown calls shall be attended immediately.

3.1.30 SAMPLES

The contractor should submit two set of samples of accessories or apparatus that are proposed to use for consultants/client for approval.

3.1.31 GENERAL TERMS AND CONDITIONS

(a) All tools and returnable items should be brought by the contractor within the premises of HAL on the contractor's delivery challan. It will be contractor's responsibility to take coordination from HAL security on the challan while bringing the items inside the premises of HAL. The contractor also required to preserve all the challan in separate files.

(b) The party /contractor may take his returnable material out of the HAL premises for repair or replacement or on permanent basis after completion of the work. Necessary Non-returnable gate pass will be issued by the concerned engineer-In charge of HAL on the basis of the material incoming delivery challan against which the material was brought inside the factory.

(c) The Contractor will be fully responsible for the quality of all material incorporated or brought for incorporation in the work.

(d) Contractor will be fully responsible for the safety of their personnel employed for execution of HVAC works.

(e) Contractor shall be fully responsible for the quality of all material incorporated or brought for incorporation in the work.

(f) Contractor should follow all relevant codes and IS standards for HVAC equipments.

(g) For the material supplied like HVAC equipment, contractor should supply test certificates, from the OEM and conformance to tenders specifications.

(h) In case of major items the contractor should offer the same for Pre dispatch Inspection. However the cost incurred on PDI in respect of the HAL team deputed for PDI shall be borne by HAL.

(i) The contractor should intimate in advance the readiness of the item for PDI along with following relevant details: a) Item to be inspected b) Place of Inspection. Subsequent on receipt of intimation of PDI, either the PDI will be carried out or based on the testing reports and standard document submitted before PDI, the same may be waived off. The decision of waive off PDI rests with HAL.

(j) The Delivery Challan of the supplied material with security clearance, test certificate & all the testing /commissioning report of the same should be persevered by the contractor in separate files. The same should be produced as and when required by the monitoring in charge during the execution of the work and finally submitted at the time of the project.

(k) The contractor has to supply various HVAC materials in suitable lots commensurate with the planned phase wise execution of the work so as to ensure optimum utilization of supplied material.

(l) Contractor has to co-ordinate with other division in advance for HVAC related civil & electrical works.

(m) The contractor shall also furnish all necessary consumables like anchor bolts and nut, crawl plugs, hookshop blades, taps, dies, files, wire brushes, necessary pipe scaffolding, ladders, wooden and consumable material like oxygen, greases, nitrogen, fasteners, gasket, refrigerant gas, supports, cotton
wast and other miscellaneous supplies of every kind required for carrying out the work under the contract.

(n) The contractor shall not dispose off transport or withdraw tools, tackles, equipment and material provided by him for the contract without taking prior written approval from consultant/Client. Consultant/Client at all times shall have right to refuse permission for disposal, transport or withdrawal of tools, tackles, equipment and material if in this opinion, the same will adversely affect the efficient and expeditious completion of the project.

(o) The contractor should furnish the details of all tools like welding & brazing equipments, testing equipments, test connection and kits etc, required for complete installation, testing and commissioning of the items included in the contract.

(p) The contractor should co-operate with other contractors at site in all matters of common interest through the consultant/Client/Engineer-in-charge, so that there should not be any obstruction to others and to ensure the safety of all personnel and works covered under this specification.

(q) The work should be carried out strictly as per the technical specification and execution drawing. In case of any doubt/misunderstanding as to correct interpretation of the drawing or specifications, necessary clarifications shall be obtained from consultant/Client. The contractor shall be made responsible for any damage to the equipment consequent to not following manufacturer's instructions correctly. All necessary drawing, manufacturer's manuals shall be furnished to Client and a copy to consultant.

(r) Any mis-handling or loosing of equipments/component parts, after taken over by the contractor from client/manufacture till the complete installation/inspection shall be contractor responsibly only.

(s) The contractor shall out touch-up painting on any equipment indicated by the client/consultant, if the finish paint on the equipment soiled or marred during installation or handling.

(t) The contractor should verify the exact quantities of materials/equipments required after site measurements as per execution drawings by the engineer before procuring the same.

Please note excess quantities of material supplied without prior approval from Consultant/Client are at contractor risk and Client will not be responsible for taking back material.

3.1.32 HANDLING OVER AND TAKING OVER OF WORK/EQUIPMENT/SYSTEM

The contractor should hand over the works/equipments/system covered under this contract only after they have been completely installed, tested and commissioned in all respect by the Contractor to the entire satisfaction of the Client/Consultant and all relevant test forms/certificate operation and maintenance manual’s as built drawing etc.should be forwarded to the consultant/Client. Any incomplete/partly commissioned works/equipments/system will not be taken over by the Client. In this regard, the decision of the consultant/Client will be final and binding on the contractor.

3.1.33 SAFE CUSTODY AND STORAGE

Safe custody of all equipment supplied by the Contractor shall be his own responsibility till the final taking over by the owner. He shall therefore, employ sufficient staff for watch and ward at his own expanse. The owner however, allows the contractor to use the plant room/weather maker room, etc for temporary storage of equipments if such space is ready and available.

3.1.34 REJECTION OF DEFECTIVE PLANT

If on test run or commissioning of any portion of the system, equipment or components are found to be defective or not fulfilling the intent or the meaning of specifications, the same shall be replaced or repaired to the entire satisfaction of Client.

In case the contractor fails to remove the defects, within a period considered reasonable, the owner reserve the right to take necessary remedial measures through other agencies and all expenses thus incurred would be recovered from Contractor.

3.1.35 Extra Item:

If any need arises for any additional item during the execution of work as per the site condition and not covered in the Bill of Quantities, the rate shall either be derived from the tenders items or substantiated by a rate analysis.
3.1.36 SCOPE OF WORK

Scope of work under this package covers the manufacture, inspection, supply, installation, testing, balancing, commissioning, handing over, testing (including performance testing at contractors works and/or his subcontractors works), delivery to site, storing and handling at site, carrying out acceptance test, completion of validation procedures as Installation Quality, Assurance (IQA) and Installation Quality Control (IQC) standards at site for the entire HVAC system as per BOQ and as described in the tender technical specifications to the complete satisfaction of the client.

It is not the intent to specify completely herein, all the details of design and construction of the equipment and system. However, the equipment and system shall conform, in all respects, to high standards of engineering, design and workmanship and be capable of performing in continuous commercial operation in a manner acceptable to the Project Consultant / Client, who will interpret the meaning of drawings and specifications, and shall have the power to reject any work or materials, which, in his judgment, are not in full accordance therewith.

Quantities, sizes and capacities of various equipment/material mentioned in this specification and enclosed drawings are for contractor’s guidance only. Contractor shall carefully check the above-mentioned details while selecting and offering the equipment, System components complete.

The extent of supply under this contract includes all items shown in the bid drawings, notwithstanding the fact that such items may have been omitted from the specification or schedules. Similarly, the extent of supply also includes all items mentioned in the specification or schedules, notwithstanding the fact such items may have been omitted in the drawings. Also such of those items not specifically included in the specifications and drawings, but which are required to complete the intent of the contract shall also be deemed to be within the scope of supply of the Contractor.

Such other works which are not included in the aforesaid Bill Of Quantities are generally intended to be executed through a separate agency. Notwithstanding the above, the clients reserve the right to order additional works under the same contract. The clients also reserve right to omit any item of work included in the aforesaid Bill of Quantities and award the same to any other contractor or not perform it at all at their discretion and the Contractor shall not have any claim because of the same. This specification covers only the broad outline of the HVAC facility, Electrical and Mechanical system to be provided. It is the contractor’s responsibility to check and satisfy himself that the requirements/capacities of the equipment/system wherever indicated in this specification are adequate to meet the stated design. The contractor for this work shall be required to work in co-operation with other agencies on site and give them all reasonable assistance and help for execution of the work in an efficient manner.

3.1.37 RATES

The rates quoted by the Contractor shall include for supplying materials and labour necessary for completing the work in the best and most workman like manner to the satisfaction of the Engineer-in-Charge/Consultant and which in the option of the Engineer-in-Charge cannot be made better. The rates shall be complete in all respects and shall include cost of materials with all the taxes, erection, fabrication, labour, supervision, testing, commissioning, tools/tackles, transport, ALL sales and other taxes, royalties, ALL duties on material contingencies, breakage, wastage, sundries, scaffolding, initial training of the Client representatives etc. The total price shall be in INR and at the project job site. Contractor should indicate separately the custom duties, excise duties, for each of the items, wherever applicable.

3.1.38 GENERAL

The general character and the scope of work to be carried out under this contract are illustrated in Drawings, Specifications and Bill of Quantities. The Contractor shall carry out and complete the said work under this contract in every respect in conformity with the contract documents and with the direction of and to the satisfaction of the Project Consultant/Client.

3.1.39 ASSOCIATED WORKS

CIVIL & ELECTRICAL WORKS

Civil works like plant room, foundation of HVAC equipments, false ceiling with opening for grills and diffusers along with wooden frame work, wall opening for intakes, supply & return air duct, dampers, fire dampers, pipes and cables and then making good these opening by sealing them and finishing the same
with P.O.P. HVAC contractor has to indicate in advance on civil contractor drawing before execution of works. Main incoming power cabling including earthing and termination to main panel of AHU, ventilation fan and split type A/c shall be done by electrical contractor. HVAC contractor has to indicate in advance on electrical contractor drawing before execution of works.

WATER CHILLERS

SECTION 2

1.0 SCOPE OF WORKS.

1.1 The works shall include design, manufacture, packing, forwarding, supply, installation, testing, commissioning, balancing, adjustment and setting to work of the Liquid Chillers as per the performance characteristics mentioned in this document at the site.

1.2 Manufacturer / Contractor is to assume full responsibility for the correct functioning of the Chillers / system and to carry any liability or other insurance or guarantee as may be necessary to protect all parties in this regard.

1.3 Manufacturer shall produce the relevant QA/QC certificates, factory run test reports, and certificate of origin at the time of delivery.

1.4 Manufacturer shall supply the chiller with all the associated items & accessories required shall be supplied delivered and installed.

1.5 Packing & forwarding of the Chillers shall be as applicable standard skid mounted or factory standard with necessary wooden frames, packing covers and other safety standards as applicable for shipping activities from the country of origin to the site. If it is observed during the physical inspection that the Chillers delivered are not meeting the performance ratings and technical standards/specifications of the tender, then the manufacturer/vendor at his own cost shall replace the same with the correct equipment. If it is observed during the physical inspection that the Chillers delivered are damaged, then the manufacturer/vendor at his own cost shall replace or make good the damages and ensure client satisfaction.

1.6 The Loading, unloading, shifting and installing of the Chillers at the designated place is the scope of the Supplier & Contractor.

1.7 Testing (factory and field), start-up supervision, training and providing necessary documentations and tools for operation

1.8 Carry out performance test run at site

2.0 DESIGN PARAMETERS

Design, in general, shall be based on ASHRAE/ARI recommendation with the following particular requirements:

2.1 DESIGN TEMPERATURE CONDITIONS

SITE : NASIK.

a) AMBIENT CONDITIONS : SUMMER : 42.2 ºC DB & 23.9ºC WB

b) Performance Base : NASIK - Elevation level conditions.

2.2 NOISE LEVELS

Noise level of the Air cooled Chiller machines shall be strictly in accordance with the Standards and ratings mentioned in the ASHRAE / ARI. Any deviation from the acceptable range will need a
rectification by the manufacturer.

2.4 DESIGN CRITERIA

2.4.1 Chilled Water:

Chilled water inlet temperature : 54 ºF
Chilled water outlet temperature : 44 ºF
Condenser water inlet temperature : 88 ºF
Condenser water outlet temperature : 96 ºF

Maximum velocity of water through pipework: 7 fps

Pipes to be sized for full flow rate of all cooling coils.

2.5 General:

Chiller Unit to be in accordance with the ARI 550/590 USA and should be IKW/TR as per ASHRAE 90.1.

Construction shall comply with ASHRAE 15 Safety codes, UL 1995, ETL, NEMA, ASTM 653 and ASME codes of USA.

The manufacturing facility shall be an ISO 9001:2000 certified with respect to manufacturing quality standards.

Unit shall be full load run tested and all necessary certificates and reports for the same to be produced prior to delivery for approval of the concerned.

The compressor motors conform to NEMA standards, MG-1 & MG-2.

10 WATER COOLED PACKAGED LIQUID CHILLERS – SCREW TYPE

SCOPE

3.10 The Screw water chilling units shall be factory assembled and tested complete in all respects and shall be complying with all relevant ASHRAE standards.

3.11 Manufacture and supply of screw chiller with associated motor, soft starter and accessories.

3.12 All associated items herein to be supplied delivered and installed.

3.13 Assembly of chiller components including connection of cooler, condenser, motor, compressor etc into complete refrigeration machine at factory.

3.14 Testing (factory and field), start-up supervision, training and providing necessary documentation and tools for operation.

3.15 Provide manufacturers factory representatives services, including coordination and start-up and testing supervision.

3.16 Carryout performance test run at site.

3.17 The Test Certificates shall be submitted along with the Machine.

3.18 Tests shall be carried out for all parameters as per ARI Standards at the Factory. Performance test at site are also mandatory.

3.19 All the selection ratings shall be submitted along with the Offer.

3.1 WATER CHILLING UNIT

The Machine shall be factory assembled, single-piece chassis, Water -cooled liquid chiller with microprocessor controller. Contained within a single cabinet the unit shall be with complete factory wiring,
piping, controls, refrigerant charge (R-134a) & oil, and special features required prior to field start-up, equal rated compressors with dual (2) independent refrigerant circuits and including the below:

The Machine shall have equal rating Compressors on it and shall be a single piece assembly complying with and comprising of the following:

(a) Unit to be rated in accordance with ARI 550/590-98 USA standards
(b) Minimum Two Semi Hermetic Screw type compressors with motor and speed increasing gear assembly.
(c) Unit construction shall comply with ASHRAE 15 Safety Code, NEC, and ASME applicable codes (U.S.A. codes).
(d) Unit shall be manufactured in an ISO 9001-2000 registered facility.
(e) Shell and Tube Condenser with accessories.
(f) Direct expansion/Flooded Shell and Tube Chiller with accessories.
(g) Steel structure for assembling/mounting the above.
(h) Control panel with automatic capacity control device and various safety gauges and devices.
(i) Inter connected refrigerant piping with all accessories.
(j) Full first charge of refrigerant R-134A gas & oil.
(k) Starter for motor with inrush current not exceeding 1.8 to 2 times operating current.
(l) Insulation of Shell and Tube Chiller with 32 mm thick nitrile rubber or equivalent material or Polypropylene.
(m) Microprocessor panel with all safety interlocks and communication ports.
(n) Unit mounted flow switches with necessary interlocks.
(o) The chiller should have very low power consumption at full load as well as part load condition.
(p) Chiller should be

3.2 COMPRESSOR

The Twin Screw type compressor shall be Semi hermetic in design with facility to field service in case of any maintenance. The compressor should have highly efficient and low noise levels. The compressor motor shall be direct drive, 3500 rpm, protected by motor temperature sensors and shall be suction gas cooled. The screw shall be horizontal / vertical design with a set of gears with unequal number of lobes for high compression. The rotor shall be of either 2/3 gears, which are statically and dynamically balanced reducing vibrations, increase life of equipment. The rotors shall be made of high strength alloy steel material to withstand high pressures and temperatures. They shall be machined to close tolerances for high efficiency and low energy consumption. The rotor should be designed to withstand liquid slugging in case of eventuality. The screw rotors shall be mounted on class 5 grade roller Element bearings and should be able to withstand thrust loads and dynamic loads on the gears. Each compressor should be designed to operate up to a capacity of 25% of its total output in step less or defined steps as is suitable. These compressors should also be provided with integral internal economizers where centrifugal force will separate the flash gas from liquid refrigerant entering into the evaporator. The compressor connection shall be provided with isolating refrigerant valves to ensure compressor removal without system pump down. The external oil separator to be provided to effectively separate oil from the refrigerant. The oil automatically returns back to the compressor through an oil level float valve. Each compressor shall be equipped with suction and discharge valves, internal muffler and check valves. The compressor housing shall be of high-grade cast iron, machined with precision to provide a very close tolerance to the rotor (s) and the housing. The compressor shall be interlocked with the differential pressure switch in the chilled line, differential pressure switch in the condenser line, anti-freeze therostate, condenser water pump, chilled water pump. The interlocks shall be provided with indicating lamps in the control panel in the refrigerant plant room.

CAPACITY CONTROL

The capacity control shall be carried out by the microprocessor panel with operation levels of minimum 15% to 100% of full load, in conjunction with a slider valve mechanism. The power consumption of this compressor should not be more than 0.75 KW/TR of refrigeration at all operating conditions. In case of multi-compressor lead/lag compressor shall be advocated. It shall require the system in order to operate the equipment at optimum operation at maximum energy efficiency range. It shall operate the lead compressor and shall allow the lag compressor to operate on demand increase being more than 75% of lead compressor allowing lead and lag compressors to operate at part loads for high energy efficient
operation. At part loads both compressors should load equally sharing the total capacity at maximum energy efficient operation in conjunction with Electronic Expansion valves.

3.3 MOTOR

The motor shall be of refrigerant cooled type squirrel cage induction type motor class F insulation suitable for operation at 415 V/3 PH / 50 HZ supply with motor able to withstand voltage fluctuation of 415V ± 15% - 15% and it should be energy efficient. The motor shall be refrigerant cooled with independent isolation of circuit in case of any maintenance to attend on motor within the hermetic casing. The motor/compressor assembly shall be statically and dynamically balanced for reducing vibration and noise. The motor shall be protected thermally and current as well. IKW/TR shall not exceed 0.71.

3.4 STARTER FOR COMPRESSOR MOTOR

The starter provided on the unit shall be such that it will ensure starting current not to exceed 2.0-2.5 times the rated current. It shall also include all necessary safety devices i.e., overload relays, under voltage release, single phase preventing device and phase unbalance or reversal. They shall be provided with over current and under current protection.

3.5 CONDENSER:

Water-cooled design to be tested in accordance with ASME codes for refrigerant working pressures of 1410 KPA, water side pressure rating shall be 2070 KPA. The unit shall be of horizontal shell and tube type mechanically cleanable water-cooled type multi-pass condenser. Design shall incorporate complete independent refrigerant circuits based on the number of compressors. It shall be either 1 pass or 3 pass type. The shell shall be of carbon steel plate with fusion welded seam it shall be fitted with machined steel tube sheets on either end. The condenser tube shall be at least 12 mm OD and 1 mm thick seamless copper with integral fins. The tubes shall be supported in the shell by baffle supporting plates to achieve minimum vibration and its ends shall be properly expanded in the tube sheets to prevent leakage of refrigerant. The condenser shall be provided with removal heads on either side made of cast iron or steel with neatly machined surface for effective jointing with the shell for accessibility for cleaning/replacement of tubes. Suitable baffles shall be incorporated to achieve the required number of passes. It shall be possible to descale the tubes without disconnecting the water line connections. In case of multi compressor machine the condenser shall have two independent circuits for ease in operation and circuit isolation. Fouling factor for Condenser - 0.00025 hr.sft.F/Btu. The condensers shall have water boxes designed for unlit pass flow. Tube may be provided with special tabulating arrangement to improve heat transfer. The condenser shall be complete with the following accessories.

| a. Support for mounting |
| b. Inlet and outlet connections of the Refrigerant. |
| c. Flanged Water in & out connection |
| d. Shut off and adjusting valve, auto air vent, test cocks (if any),, relief valve and purge valve. |
| e. Drain cocks and air vents |
| f. Dial type temperature gauge / pressure gauge to be provided at water inlet and outlet. |
| g. It should be fitted with a safety relief valve, liquefied shut of valves and a purge vale. |

3.6 REFRIGERANT COMPONENTS

Refrigerant circuit components shall include Oil separator, high and low side pressure relief valves, discharge and liquid line shut off valve, filter drier, sight glass, Electronic expansion valves, economizers & complete charge of R134a gas & oil with compatible and manufacturer recommended oil.

3.7 CHILLER – COOLER (EVAPORATOR)

The Chiller unit shall be direct expansion shell and tube construction. The shell shall be of carbon welded steel plate construction filled with machined steel tube sheets on either of the end. The evaporator shall have highly efficient integrally seamless hard drawn finned copper tubes of not less than 12 mm OD and 0.7 mm thickness. The tube shall be supported in the shell with suitable stiff support to achieve minimize vibration and noise level. The tube ends shall be mechanically bonded to the tube sheets to prevent leakage of refrigerant. The evaporator shall be provided with eliminator to prevent liquid carry over to the compressor. In case of multi compressor machine, the chiller shall have two independent circuits for ease in operation and circuit isolation. The evaporator shall be insulated with 32 / 50 mm thick insulation PVC.
foam (or closed-cell nitrile rubber) with a maximum K factor of 0.28. The evaporator shall be provided with liquid level sight glass and pressure relief device to prevent excess pressure in the heat exchanger. The evaporator shall be hydraulically tested with a pressure of 300PSIG on the shell and waterside. Fouling factor for Condenser - 0.0001 hr.sft.F/Btu. The evaporator shall be complete in all respect and provided with following accessories.

- Refrigerant inlet and outlet pressure gauges.
- Refrigerant inlet / outlet Flange connection.
- Water in/out flange connection with thermometer.
- Drain & vent connection with stop valves.
- Pressure gauges on water inlet and outlet connection.
- Decaling valves.
- Flow switches in water line.
- Liquid line solenoid valve as required.

3.8 ELECTRICAL / CONTROL PANEL

The control panel design to be equivalent to NEMA 4 (IP55) with hinged door for easy access ensuring dust, Vermin and weatherproof construction and suitable for operation in plant room Conditions without malfunctioning or damage of any type. Internal power and control wiring to be neatly routed, adequately anchored and all wires identified with cable markers as per NEC standards applicable to HVAC units.

The electrical controls used in the control panel to be UL approved with care reliable in operation at high ambient conditions for a long period.

The components of both the power and control shall be split into two sections of main panel accessed by individual key locked doors. The panel shall be manufactured to ensure protection in all weather conditions. The power panel shall be fitted with door interlocked mains isolator to prevent access while it is live. The power section shall include all the necessary contactor fuses for compressors. The control center shall house all the electrical safety features for system safety.

Electrical Requirements:
1. Unit primary electrical power supply shall enter the unit at a single location. Include separate the terminal blocks for the power and controls. Include necessary disconnect and isolator.
2. Unit shall operate on 3-phase power at the voltage shown in the equipment schedule.
3. Control voltage shall be 115-v (60 Hz) or 230-v (50 Hz), single-phase, separate power supply.
4. Unit shall be shipped with factory control and power wiring installed.

3.9 ELECTRONIC EXPANSION VALVE (EEV)

The unit shall be provided with electronic expansion valve one for each circuit/ compressor which works on electronic signal on system requirement and operate accordingly for precise control of refrigerant flow through the cooler and accurately maintain the desired liquid level. The electronic expansion valves shall act by themselves as liquid line solenoid stop valves along with expansion valve for proper shut down. All the valves for multi-compressors shall be interfaced with the microprocessor control system for optimum system utilization and operation. The electronic expansion valves should maximize operating efficiencies on part and full load operations. During part load operations, the EEV’s combined with microprocessor panel should provide stable operating conditions and maximize energy saving potential, using logic.

3.10 MICRO PROCESSOR CONTROL PANEL

A microprocessor based control panel shall be fully wired, tested and factory mounted on the chiller. This shall be a part of the factory assembled chiller which shall be installed in a separate vermin proof panel and unit mounted in a locked enclosure. It shall have non-volatile memory. The panel shall have a soft touch keypad which can be used for setting/altering illustrating the machines operating status, programmable parameters, temperatures and pressure of fluids, it shall have intelligent software for predictive logic to select the most energy efficient combination of compressor/cylinder and electronic expansion valves to maintain stable operating conditions and maximize energy efficiency. The panel should also have the feature of rotating the multiprocessors for equal hours. The microprocessor shall also have diagnostic memory of latest fault conditions together with record of when they occurred. It shall have a record of last six faults occurred. It should also have internal clock to programme the operating schedule of the chiller in order to meet specific building load profile precisely. The Microprocessor panel shall have a voltage stabilizer to take care of +5% to -15% variation in control supply voltage. It shall also have the record of
energy consumed every hour. The panel shall also have facility to, communicate with Computer Control center within the plant room by providing necessary interface port on each panel at a future date. It shall have minimum 3 level password protection for operation system and changing of set points. All machines shall be provided with record of energy consumed and capacity delivered as a part of the system microprocessor.

3.11 REFRIGERANT PIPING

The refrigerant piping interconnecting all the above equipment shall be Heavy duty Seamless copper with tube dia as required and having a wall thickness of minimum 2 mm and able to withstand pressure upto 500 PSI. Necessary gas mufflers, flexible connections on discharge and suction side shall be provided to reduce vibration/noise of refrigerant/compressor.

3.12 Controls, Safeties, and Diagnostics:

1. Controls:
   a. Unit controls shall include the following minimum components:
      1) Microprocessor with non-volatile memory. Battery backup system shall not be accepted.
      2) Power and control circuit terminal blocks.
      3) ON/OFF control switch.
      4) Replaceable solid-state relay panels.
      5) Pressure sensors for suction/discharge, oil, economizer pressures. Thermistor installed to measure saturated condensing temperature, cooler saturation temperature, compressor return gas temperature, and cooler/condenser entering and leaving fluid temperatures.
      6) Chilled/condenser fluid flow switch.
   b. Unit controls shall include the following functions as standard:
      1) Automatic circuit lead/lag.
      2) Capacity control based on leaving chilled fluid temperature and compensated by rate of change of return-fluid temperature with temperature set point accuracy to 0.1 °F (0.06°C).
      3) Limiting the chilled fluid temperature pull-down rate at start-up to an adjustable range of 0.2°F to 2°F (0.11°C to 1.1°C) per minute to prevent excessive demand spikes at start-up.
      4) Seven-day time schedule.
      5) Leaving chilled fluid temperature reset from return fluid, outdoor-air temperature, space temperature, or 4 to 20 mA input.
      6) Demand limit control with 2-stage control (0 to 100% each) or through 4 to 20 mA input (0 to 100%).
      7) Chilled water pump start/stop control.
      8) Dual chiller control for parallel flow applications use one additional sensor.
      9) Amperage readout per compressor with %MTA per compressor.

   c. The control panel shall include, as standard, a portable hand held display module with a minimum of 4 lines and 20 characters per line, of clear English language. Display menus shall provide clear language descriptions of all menu items, operating modes, configuration points and alarm diagnostics. Reference to factory codes shall not be accepted. An industrial grade coiled extension cord shall allow the display module to be moved around the chiller. Magnets shall hold the display module to any sheet metal panel to allow hands-free operation. Display module shall have NEMA 4x housing suitable for use in outdoor environments. Display shall have backlight and contrast adjustment for easy viewing in bright sunlight or night conditions. The display module shall have raised surface buttons with positive tactile response.

   d. The chiller controller shall include multiple connection ports for communicating with the local equipment network and the ability to access all chiller control functions from any point on the chiller.

   e. The control system shall allow software upgrade without the need for new hardware modules.

2. Safeties:
   Unit shall be equipped with thermistors and all necessary components in conjunction with the control system to provide the unit with the following protections:
   a. Loss of refrigerant charge.
   b. Reverse rotation.
   c. Low chilled fluid temperature.
   d. Low oil pressure (each compressor circuit).
   e. Voltage imbalance.
   f. Ground current fault.
   g. Thermal overload.
h. High pressure.
i. Electrical overload.
j. Loss of phase.
k. Current imbalance.
l. Loss of flow.
m. Low evaporator pressure.
3. Chilled or condenser water pump failure.
4. Starter fault.
5. Sensor failure, specific to sensor.
7. No evaporator or condenser water flow.

3. Diagnostics:

a. The control panel shall include, as standard, a display:
   1) Touch screen display consisting of ¼ VGA LCD (liquid crystal display) with adjustable contrast and backlighting.
   2) Display shall allow a user to navigate through menus, select desired options and modify data.
   3) Information included for display shall be a minimum of 12 parameters.

b. Features of the display shall include:
   1) Display shall be customizable and allow up to 72 data points.
   2) Display shall support both local equipment or network made for remote mount.
   3) Display shall allow access to configuration, maintenance, service, set point, time schedules, alarm history and status data.
   4) Display shall have one button for chiller on/off.
   5) Display shall include three levels of password protection against unauthorized access to configuration and maintenance information, and display set up parameters.
   6) Display shall allow for easy connection of a portable hand held technician tool to access information and upload/or download chiller settings.
   7) Display shall be compatible with the Network system and provide network alarm acknowledgement or indication and provide capability to fully monitor and control chiller.
   8) Display alarms and parameters shall be capable of being displayed in full text.
   9) Display shall be capable of displaying the last 50 alarms and will store a snapshot of a minimum of 20 status data parameters for each alarm.
   10) Compressor run hours.
   11) Compressor number of starts.
   12) Compressor current.
   13) Time of day:
      a) Display module, in conjunction with the microprocessor, must also be capable of displaying the output (results) of a service test. Service test shall verify operation of every switch, thermistor, fan, and compressor before chiller is started.
      b) Diagnostics shall include the ability to review a list of the 30 most recent alarms with clear language descriptions of the alarm event. Display of alarm codes without the ability for clear language descriptions shall be prohibited.
      c) An alarm history buffer shall allow the user to store no less than 30 alarm events with clear language descriptions, time and date stamp event entry.
      d) The chiller controller shall include multiple connection ports for communicating with the local equipment network system and the ability to access all chiller control functions from any point on the chiller.

The control system shall allow software upgrade without the need for new hardware modules.

14) The unit shall display entering & leaving chilled water temperature, entering & leaving condenser temperature, evaporator, suction, discharge, condenser water temperature, LP, HP & OP display, Motor amperes and amps as a percentage of rated load amps, hour of operational number of starts, time of last start & stop, chilled water set point and rest temperature set point.

The display module shall be capable of indicating the safety lockout condition by displaying the information in clear language at the display. Information included for display shall be:

1) Compressor lockout.
2) Loss of charge.
3) Low fluid flow.
4) Low oil pressure.
5) Cooler freeze protection.
6) High or low suction superheat.
7) Thermistor malfunction.
8) Entering and leaving-fluid temperature.
9) Evaporator and condenser pressure.
10) Electronic expansion valve positions.
11) All set points.
12) Time of day.

3.13 STEEL STRUCTURES

The total unit shall be assembled on formed steel sections heavily galvanized, (G-90) galvanized steel. The MS supporting frame shall be sturdy and heavy gauge construction to withstand physical and dynamic loads during Chiller operation. The quality conforming to ASTM codes and standards. Frame Design shall permit easy removal and maintenance of various components. The cabinet / frame shall be sturdy enough to withstand transport without getting distorted and when stationary handle the equipment load.

The compressor shall be mounted on structural frame with vibration isolation springs ensuring the compressor vibration not transferring into the steel structure. The units shall be mounted on vibration isolation spring with maximum deflection of spring not exceeding 5mm under operation. There should be proper encasing of unit from all sides to reduce noise levels of the equipment.

3.14 ACCESSORIES

In addition to the above each unit shall include the flowing.
(a) Water flow switches at the Inlet/ outlet of evaporator.
(b) Spring isolation pad of not less than 80% efficiency.
(c) Full charge of refrigerant gas and required quantity of lubrication oil.
(d) Temperature / Pressure gauge at inlet/outlet of the condenser and the evaporator complete with isolating gate valve.
(e) Valves for cleaning of condenser drain water and purging of air.
(f) The each unit shall be factory painted with minimum two coats of synthetic enamel paint.
(g) Chillers shall have a Field-installed sequencing Kit control to sequence between 2 and 8 chillers in parallel in a single system.

Over and above whether specifically mentioned in the schedule of equipment or not but are required to be provided to form a complete system, found necessary to fulfill the intent and meaning of the system requirements shall be provided without any extra cost implication.

3.15 PERFORMANCE

The complete water-chilling unit shall be mounted on RCC foundation using grouting bolts, nuts, channels, etc. On installation the refrigeration circuits and the connected equipments &n parts shall be thoroughly tested leakage.

The unit shall be selected for the lowest operating noise level capacity rating and power consumption with operating point clearly indicated shall be submitted and verified at the time of testing and commissioning of the installation. Capacity shall be ascertained by measurement of chilled water flow rate and temperature of chilled water in and out of the chilling unit.

The performance of the unit shall be proved at site at the time of installation and also the power consumption should not exceed the confirmed rating through out the period of service of the equipment. The company shall stand guarantee for the aforesaid condition and shall compensate the client in case the power consumption proved at site is more than the stipulated power. The rate of compensation shall be as indicated in penalty clause of the conditions of contract. The contractor shall submit along the tender the computer selection rating charts of the machines offered. This shall indicate the selection of model of Compressor, Condenser, Chiller along with it full load rating of capacity and Power consumption. The selection shall also indicate IPLV/NPLV values along with part load performance with ARI relief and also constant condenser water temperature inlet. The selection chart shall provide details of percentage
capacity, power consumed, rated amperage, locked rotor amps and also inrush currents of equipment at maximum ambient conditions.

(d) Testing

The unit shall be tested for establishing the capacity and power consumption. Test shall be carried out on:

- (c) The compressor drive motor side
- (d) Condenser Side
- (e) Chiller side

All meters, gauges, thermosyphons, wattmeters shall be duly calibrated standard type and all necessary distance pieces, etc required in the piping for insertion shall be provided at the time the piping is installed. All test reading shall be co-related with each other and the design parameters before submission for approval. At least four reading lasting over a period of three hours shall be recorded.

Note: Water chilling plant shall be inspected at the manufacturing site before dispatch.

3.17 Painting

Screw chilling machine shall be finished with durable enamel paint. 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 enamel paint to match the finish over the adjoining shop-painted surface.

21.9 SUBMISSIONS.

4.1 Complete selection sheets indicating the technical performance characteristics of the selected chillers. Supporting engineering catalogs with full technical details are to be submitted for approval. The vendor to confirm the compliance with proposed capacities without any dilution in the performance selection criteria at the bidding stage itself.

4.2 After final checking of sizing after award of contract, resubmission will be made with any changes specifically noted. The final submittal shall include the GA drawings, installation and execution data.

In the event that the Consultant/client requires further information on any of the proposed items the Contractor shall arrange visits to similar units, which he has installed. In any event, all equipment proposed for the project shall be currently installed and working satisfactorily locally. The Contractor must be able to provide references of at least three satisfied Owners and Consultant with equipment of the particular size and model proposed.

SECTION 3

WATER PUMPS & COOLING TOWERS

Scope of Work

Supply, Installation, testing, balancing and Commissioning of pumpset with motor and all the associated accessories for condenser and chilled water pumping conforming to these specifications and in accordance with requirements of schedule of quantities.

SYSTEM DESCRIPTION

Furnish and install a factory assembled Constant speed packaged pumping system equal to ITT BELL & GOSSETTE/ GRUNFOS /ARMSTRONG/ KIRLOSKAR/BEACONS Chilled & condenser Water pump. The
system shall require only suction and discharge pipe connections, Flexible connectors; electrical junction boxes with switch Gear components.

**SUBMITTALS**

A. Submit shop drawings and product data; the following information shall be minimum:
1. System design information sheet.
2. Description of system operation.
3. Packaged system dimension and general arrangement drawing.
4. Pump material and construction drawing.
5. Pump curve showing design point.
7. Catalog information on valves, strainers and control components.
8. Electrical power and control-wiring diagram.
9. Catalog data on Direct Digital Controller.

B. Submit manufacturer's installation instruction.

**OPERATION AND MAINTENANCE DATA**

Submit operation and maintenance data. The following information shall be minimum:

1. System design information sheet.
2. Description of system operation.
3. Packaged system dimension and general arrangement drawing.
4. Electrical power and control wiring diagram.
5. Bill of material.
6. Pump operation and maintenance instructions.
7. Special electrical component operation instructions.

**QUALITY ASSURANCE**

A. The manufacturer of the chilled water pump and control package must be listed by Underwriters Laboratories as an approved manufacturer of UL “Packaged Pumping Systems” and as a manufacturer of industrial control panels under UL Section 508. The manufacturer shall furnish proof of the two listings as part of the submittal data.

B. The packaged pumping system manufacturer shall provide published catalog data clearly indicating that HVAC Packaged Pumping Systems are one of their standard product lines.

C. The manufacturer of the packaged pumping system shall have in place an ISO 9001 compliant Quality Assurance Program to assure the quality of engineering design, components, materials and workmanship provided in the packaged pumping system. Upon request, this procedure shall be submitted to the engineer.

D. The manufacturer shall have a minimum of ten years manufacturing and application experience and shall be responsible for the proper pressure and flow in the entire packaged system.

**DELIVERY, STORAGE, AND HANDLING**

Safe delivery, storage and handling of the products shall be in line with the recommended practice of the manufacturer.

A. General:

The packaged system shall consist of a system base, pumps, motors, valves, intermediate piping, piping supports, controls and other components as listed in this specification for a complete system. Each pump shall be provided with a coupling guard, air vent cocks, suction and discharge gate valves, discharge non return valve and a pot strainer. The Secondary chilled water system shall be designed for a total system flow as indicated in the schedules and BOQ.
Pumps shall be End Suction Back pull out type unless indicated specifically. Pump set shall be factory aligned and installed on suitable concrete foundation block with vibration isolation mounts.

B. Components

All components shall be mounted on a structural steel base. The base shall be large enough to support the packaged pumping system's pumps, piping and control panel(s). Steel supports shall be welded to the base to support the piping and control panel(s). Both the base and supports shall consist of structural steel components, all welded per the AISC Manual of Steel Construction, part 4 "Welded Joints". The base depth shall be equal to 1/12 the longest span between spring isolators but not greater than 12". Minimum depth shall be 6". The mass of the base shall provide adequate natural inertia to eliminate the need for field poured concrete. Provide vibration isolation in form of inertia base, reflected in typical details drawings and meeting local codes and requirements.

Casing

Pumps shall have the casing divided either on the horizontal or vertical centerline. The casing halves shall be accurately machined bolted together. A non-asbestos type gasket material shall be furnished between the casing halves. The casing material shall be close grained cast iron with a minimum tensile strength of 2300 kg/cm². Removal of the upper casing half shall permit removal of the complete rotating assembly without disturbing piping connections.

Impeller

The bronze impeller shall be an enclosed type double suction design, hydraulically and dynamically balanced. The impeller is to be securely mounted on the stainless steel shaft, and attached with a stainless steel impeller key. The impeller shall be locked in position by threaded sleeves.

Bearings

The stainless steel pump shaft shall be adequately supported by the pump bearings to limit the shaft deflection to 0.05 mm.

Bearings shall be the ball type, grease lubricated and locked to the shaft with positive locks of ample size to withstand any axial thrust loads.

Shaft Seal

The pump manufacturer shall recommend the proper mechanical seal based on the pressure, temperature and liquid outlined on the equipment schedule.

Shaft / Sleeves

Shaft shall be suitable grade Stainless Steel. Bronze shaft sleeves shall be firmly attached to the pump shaft through threading and locking means. Shaft sleeve design shall prevent corrosion and wear to the shaft.

Base, Coupling and Guard

The pumps shall be mounted on a cast iron base and directly connected through a heavy duty flexible coupling to a horizontal motor. The base shall be provided with a drip rim. The pump manufacturer shall provide coupling guard, which shall be mounted between the pump and motor and attached firmly to the base.

Pump design shall be as indicated on the drawings, either frame mounted end suction or horizontal split case, flexible coupled, with cast iron casing, bronze impeller, shaft sleeve, stainless steel shaft, and mechanical seal(s). Each coupling shall include an approved coupling guard. Pumps shall be factory
aligned and mounted on structural steel base and shall be free of distortion caused by flexing of the system base or system piping.

a. Balance rotating parts, statically and dynamically.
b. Construct to permit servicing without breaking piping or motor connections.
c. Operate at 415 V, 3 Ph and 50 Hz, 1450 rpm unless specified otherwise.
d. Pump Connections:
   1. Flanged: 2 1/2" Suction and larger
   2. N.P.T. : 2" Suction and smaller

3. Motors shall be of the premium-efficiency EFF 2 type, TEFC with a 1.15 S.F. Motor manufacturer's stated efficiencies shall be derived from tests conducted in accordance with NEMA Standard MG1-12.53a which is based upon IEEE Standard 112, Method B.

   The motor shall be sized to operate continuously without exceeding the horsepower rating regardless of the flow and head throughout the entire range of operation. Motors shall be TEFC, 1450 RPM. Motors shall be selected for the pumps to operate at any point of the pump curve.

4. The pump and motor design conditions shall be as described on the pump schedule. Pumps shall not overload the above motor sizes at any point on the pump curves.

5. Flexible connectors shall be furnished for the suction and discharge system connections. The connectors shall be constructed with steel flanges and a neoprene and nylon body. Connectors shall have a working pressure from 16" HG to 225 PSIG.

Design range shall be 0 to 100 FT water. External zero and span adjustments over-pressure to 2,000 PSI, and no humidity effects.

Minimum accuracy shall be ± 0.15% of calibrated span. Includes combined effects of linearity, hysteresis and repeatability. Stability shall be ± 0.25% of upper range limit for six months. No internal mechanical linkages shall be used in the transmitter(s).

FABRICATION

The packaged pumping system manufacturer shall provide a completely assembled and working water circulating system, fabricated using all new components. Fabrication shall incorporate sound engineering design, proven manufacturing techniques, and the latest proven technology available.

FINISHING

A. The manufacturer shall operate and maintain a paint spraying facility that conforms to EPA, OSHA and local codes requirements.

B. All steel components shall be cleaned, degreased and painted with a rust preventive, self-etching primer.

C. The complete packaged pumping system shall be factory painted with lead free, high gloss synthetic enamel prior to shipment.

D. Nameplates for each major component including pumps, motors, variable frequency drives, and electrical control panels shall be masked prior to painting and all shall be clean and clearly legible prior to shipment.

SOURCE QUALITY CONTROL

A. TESTING FACILITY

The packaged pumping system manufacturer shall maintain an operating test facility at the point of manufacture and shall performance test each component and feature of the assembled water circulating system with its remote transmitters and controls. The facility shall include components for measuring various features of the system, which are traceable to the National Bureau of Standards.
B. FACTORY TESTS

1. After factory assembly, the packaged pumping system shall be hydrostatically tested at 50 PSIG over maximum system working pressure or to 150 PSIG (whichever is higher) for a minimum of one hour.

C. INSPECTIONS

The manufacturer shall provide access to fabrication facilities to the owner or his representative at any time during the construction of the packaged pumping system. All testing may be witnessed by a representative of the owner, contractor and/or consulting engineer.

D. VERIFICATION OF PERFORMANCE

A written report certified by an officer of manufacturing company shall be provided to the owner’s representative on request.

COOLING TOWER

SCOPE

The scope of this section comprises the supply, erection, testing and commissioning of cooling tower conforming to these specifications and in accordance with requirements of schedule of quantities.

The Cooling towers shall be meeting and rated in accordance with the international test standards CTI ATC 105 1990.

INDUCED DRAFT COOLING TOWER

To remove heat generated by the water chilling plant induced draft cooling towers are envisaged comprising of FRP casing. FRP water basin, Sprinkler section, Elimination, TEFC motors and induced draft axial fans.

Casing

The casing shall be of fiberglass reinforced plastic, which shall be non-corrosive, weather proof & light in weight. The casing shall be supported with galvanized iron structural for rigidity. Each cooling tower shall be in cylindrical/rectangular in form and shall be able to withstand wind velocities up to 50 KMPH.

Water Basin

The water basin shall be also of fiberglass reinforced plastic, which shall withstand high temperatures, with socket or flanged inlet/outlets/make up/overflow for piping connection. An auxiliary suction tank shall also be provided with piping flanges or sockets.

Sprinkler system

Automatic rotary sprinkler system with rotary head and standpipe should distribute the hot water over the entire surface of the in-fill. The sprinkler pipe shall be non-clogging and should require low pressure to operate and also to ensure uniform water flow with minimum operating pump head.

Eliminators

Proper eliminators should be provided for low pressure drop and drift losses of water.

Fans & Motor

The fan shall be of induced draft axial flow with adjustable pitch angles. The fan should be direct driven preferably of Aluminum alloy or FRP. The motor shall be of weatherproof TEFC construction and should be suitable for 415 10%, 50 Hz, 3 Phase, AC supply.

PERFORMANCE DATA
The cooling tower performance and power consumption shall be submitted along with the tender and verified at the time of testing and commissioning of the cooling tower.

**DETAILED SPECIFICATIONS**

**GENERAL:**

(i) Design to withstand 1436 Pa wind load equivalent to 110 mph wind.
(ii) Free water drift loss shall not be greater than five hundredths of one percent of the water circulated to tower.
(iii) Sound levels at 50 ft in any direction shall not exceed 72 dbA – top, 66 dbA end CTI specified norms.
(iv) Manufacturer shall certify that performance of cooling towers will meet contract requirements, stating entering air wet bulb temperature, entering and leaving condenser water temperatures, water flow rates, fan kW (horsepower), and pump head at base of tower.
(v) Cooling Tower Institute (CTI) Certified Towers: These towers shall have been tested, rated, and certified in accordance with Cooling Tower Institute (CTI) Standard 201, and shall bear the CTI certification label, and shall be listed in the CTI directory of certified cooling towers.
(vi) Non-CTI certified Cooling towers: If CTI certification is not available, manufacturer for towers of 700 kW (200 tons) or larger, shall submit curves showing predicted performance as required in ASME PTC-23, or CTI Bulletin ATC-105 for Water Cooling Towers, and CTI Bulletin ATC-105S for Closed Circuit Cooling Towers.
(vii) Fan, motor alignment, balancing shall be in accordance with the CTI specified norms.
(viii) Cooling tower shall be supplied with ladder.

**Shop Drawings :**

1. Sufficient information, clearly presented, shall be included to determine compliance with drawings and specifications.
2. Include rated capacities, pressure drop, fan performance and rating curves, dimensions, weights, mounting details, front view, side view, equipment and device arrangement.
3. Include electrical rating, detail wiring for power, signals and controls.
4. Sound curves and characteristics of sound attenuators if required to meet the noise criteria.

**Certification:**

1. Submit four copies of performance curves, for CTI certified cooling towers, showing compliance with actual conditions specified, to the Resident Engineer two weeks prior to delivery of the equipment.
2. Two weeks prior to final inspection, submit four copies of the following to the Resident Engineer. Certification by the manufacturer that the cooling towers conform to the requirements of the drawings and specifications.
   c. Certification by the Contractor that the cooling towers have been properly installed, adjusted, and tested.
PRODUCTS

INDUCED DRAFT - COOLING TOWER:


Framing:
1. Rolled structural steel shapes, hot-dip galvanized after fabrication or structural shapes cold formed from galvanized steel sheets or plates, complying with ASTM A653/A653M, and having G235 (Z700) coating.

Louvers:
1. Minimum splash out type. Material for the louvers shall be similar to the casing or may be PVC if formed integral with the fill material.

Fill:
1. PVC resistant to rot, decay and biological attack; with a maximum flame spread rating of five per ASTM E84 and fabricated, formed and installed by manufacturer to ensure that water breaks up into droplets.

Drift Eliminators: Same as fill material. Eliminators shall ensure a maximum drift rate of 0.002 percent of recirculated water.

Collecting Basin: Material same as the unit casing in accordance with manufacturer's standard details. Outlet pump may also be of heavy glass-reinforced polyester (GRP) for depressed side outlet type. Provide a bronze make-up water float valve, overflow, drain not less than 50-mm (2 inches) suction connections, and outlet sump of size and depth to prevent cavitation and air entrainment in pump. Provide the following accessories:
1. Manufacturer’s standard bronze make up water float valve with an adjustable linkage.
2. Removable basin strainer, constructed of 304 stainless steel, shall have openings smaller than nozzle orifices.
3. Make-up water, overflow and drain connections.
4. Equalizer connection (multiple cooling tower systems).
5. Flume plate between adjacent cells (multi-cell units only).

Fans: Centrifugal or propeller type constructed of hot-dip galvanized steel, cast aluminum or aluminum alloy, glass fiber reinforced polyester or glass reinforced epoxy, statically and dynamically balanced at factory for quiet, and efficient operation. Forced-draft towers shall be centrifugal type only. Fans for induced-draft towers of 350 kW (100 tons) and less, and for forced-draft towers shall be belt driven.
1. For induced draft towers larger than 350 kW (100 tons), fan shall be driven through a gear reducer, or driven by a special V belt.
2. Gear reducer drive: Specially designed for cooling tower operation, with dynamically balanced drive shaft assembly or shock absorbent flexible coupling requiring no lubrication, cast iron case with readily accessible oil drum and fill, and self-contained oil reservoir sealed against water entrance.
3. Fan shall be driven by a one-piece, multi-groove, neoprene/polyester belt, where this is the manufacturer’s standard.

4. The alignment and balancing of the fans, motors and drive shaft as installed shall operate within the vibration tolerance specified as per CTI.

5. Motors and Motor Controllers, the following shall apply:
   a. Motors: Totally enclosed, epoxy encapsulated or totally enclosed fan cooled (TEFC) conforming to NEMA 250.
   b. Lubrication fittings shall be readily accessible outside the wet air stream. Provide access doors for inspection and cleaning.
   c. Fans over 1500 mm (60 inches) in diameter include a vibration cutout switch located in a protected position to effectively monitor fan vibration. Vibration switch shall be solid-state with adjustable time delay in NEMA 250, Type 4 enclosure. It shall stop fan motor under excessive fan vibration.

   Safety: Provide fan guards, ladders, handrails and platform in conformance with the ANSI A10.18 as follows:
   1. Fan Guard: Removable fan discharge with a rigid framed screen guard, installed over the fan cylinder.
   2. Ladders: Vertical hot-dip galvanized steel or aluminum ladder for each tower located outdoors. Ladders higher than 3.6 meters (12 feet) shall have safety cage. Ladders shall extend to within 300 mm (one foot) of the grade or the roof deck surface.
   3. Hand Railings: Steel or aluminum hand railings not less than 1070 mm (42 inches) high around perimeter of each fan-deck, or working surface 3.6 meters (12 feet) or more above ground, roof or other supporting construction. Handrails shall meet OSHA Standards.

EXECUTION

INSTALLATION

A. Install cooling tower according to equipment manufacturer’s written instruction.

B. Install cooling towers plumb, level and anchored on structure provided. Coordinate steel structure with cooling tower mounting requirements. If installed on concrete base follow manufacturers installation requirements and recommendations.

C. Install vibration controls according to manufacturer’s recommendations.

D. Maintain recommended clearances for service and maintenance.

E. Piping:
   1. Install piping, including flanges or union adjacent to cooling towers to allow for service and maintenance.
   2. Install flexible pipe connectors at connections to cooling towers mounted on vibration isolators.
   3. Install shutoff/balancing valves at cooling tower inlet connections.
   4. Connect overflow drain and blow down lines to sanitary sewage system.

G. Electrical Wiring: Install electrical devices, components and accessories furnished loose by manufacturer, including remote flow switches and variable frequency drives.
Field Quality Control
A. Provide the services of an independent testing and inspection agency to perform the field tests and inspections of non-CTI certified cooling towers.
B. If the cooling tower does not meet the specified performance, the Contractor shall make the tower corrections necessary to bring the tower into compliance with the specified performance including replacing the tower if necessary. Additional tests will be required until the tower meets the specified performance. Costs for the tower corrections or replacement, and tests shall be borne by the Contractor/manufacturer.

STARTUP AND TESTING
A. Provide the services of a factory-authorized and qualified representative to perform start up service.
B. Inspect field-assembled components and equipment installation, including piping and electrical connections.
C. Obtain and review performance curves and tables.
D. Perform startup checks, according to manufacturer's written instructions, and as noted below:
   1. Check clearances for airflow and tower servicing.
   2. Check for vibration isolation and structural support.
   4. Adjust belts to proper alignment and tension.
   5. Lubricate rotating parts.
   6. Operate equipment controls and safeties.
   7. Verify that tower discharge is high enough and it does not recirculate into air intake. Recommend corrective action.
E. Adjust water level for proper operating level and balance condenser water flow to each tower inlet.
F. Check water treatment water system, including blow down for proper operation of the tower.
G. Start cooling tower, including condenser water pumps and verify the tower operation.
H. Prepare and submit a written report of startup and inspection service to the Resident Engineer.

Training:
A. Furnish the services of a competent, factory-trained engineer or technician for a 2-hour period for instructing VA personnel in operation and maintenance of the equipment, including review of the operation and maintenance manual, on a date requested by the Resident Engineer. Coordinate this training with that of the chiller, if furnished together.

SECTION 4

HVAC EQUIPMENT

1.0 SCOPE OF WORKS.

1.1 The Scope of this section comprises supply, erection, testing, commissioning, balancing adjustment and setting to work of the following systems conforming of these specification and accordance with drawing and of the schedule of quantities:

- Central & Split type air-conditioning system
- Ventilation system.

1.2 Contractor is to assume full responsibility for the correct functioning of the system and to carry any liability or other insurance or guarantee as may be necessary to protect all parties in this regard.
1.3 Contractor shall be responsible for coordination with other trades and services and shall provide all materials, labour and supervision, equipment, tools, appliances, services, etc. for carrying out the following items of work:

- Supply and install of air conditioning and ventilation plant and equipment.
- Insulated ductwork complete with air terminals, dampers, supports, etc.
- Insulated chilled water pipework complete with valves, fittings, supports and its accessories etc.
- Electrical Controls and control panels.
- Motor control centres and starter panels complete with cabling and earthing from the panels to the respective equipment. Power supply upto the panel shall be the responsibility of the electrical contractor.
- Power supply to fan coil units, air handling units, ventilation fans etc. Electrical power supply terminating in an isolating switch within 2 metres of the equipment shall be the responsibility of the electrical contractor.
- Insulated drain piping from each air handling unit/fan coil unit to the nearest drain point. The drainage contractor shall be responsible for provision of a floor drain in each mechanical room.

1.4 The contractor shall also include all overheads at office and site, labour, sundries, plant, appliances and consumable both for the works and for balancing, testing & commissioning, and during the maintenance period.

2.0 DESIGN PARAMETERS

Design, in general, shall be based on ASHRAE recommendation with the following particular requirements:

2.1 DESIGN TEMPERATURE CONDITIONS

a) External
   Summer - 108 °F DB & 75 °F WB.
   Monsoon - 101 °F DB & 83 °F WB.
   Winter - 50 °F DB & 43 °F WB
b) Internal - 72+/− 2 deg F & 60 % RH
c) Performance Base: - Nasik - Elevation level conditions.

2.2 VENTILATION REQUIREMENTS

As shown on ventilation plans.

2.3 NOISE LEVELS – As per ASHRAE stds for various applications

2.4 DESIGN CRITERIA

2.4.1 Chilled Water to Cooling Coils

Chilled water inlet temperature : 44 °F
Chilled water outlet temperature : 55 °F

Maximum velocity of water through pipework: 2.0 (m/s)

Pipes to be sized for full flow rate of all cooling coils.
2.4.2 Air Distribution

Duct Velocity, supply : 1250 – 1400 FPM
Duct velocity, return : 1100 – 1250 FPM

2.6 PRESSURIZATION PHILOSOPHY

Fresh air requirements to each zone shall be generally determined by the level of dirty extract to that same zone, or to a value as required for the levels of occupancy in each zone.

Areas requiring no dirty extract shall be positively pressurized or maintained neutral as recommended by ASHRAE.

Areas requiring dirty extract shall be pressurized delta negative.

The whole building is positively pressurized to avoid any hot air infiltration.

2.7 FIRE PHILOSOPHY AND SMOKE MANAGEMENT

Also, fire dampers shall be positioned in all air ductwork crossing fire walls/slabs as shown in the drawings. They shall be triggered from a fusible link connection sited in the damper.

2.8 AIR INTAKE SYSTEM

Galvanised sheet steel Fresh air intake louvers with bird screens, filters and damper shall be provided in the clear openings in masonry wall is thru infiltration and Fresh air package wherever specified on the drawings. Air intake louvers shall in general be located as far away as possible from extract louvers and drainage vent stacks to avoid short circuiting of dirty air.

3.0 AIR HANDLING UNITS – FLOOR MOUNTED TYPE

Medium Pressure Cabinet Type All Sheet Metal Air Handling Units with static Pressure capability of 1000 Pa WC & above have been specified.

The Air Handling Units shall consist of the following sections:

13.23 Mixing Box with dampered inlet for return air.
13.24 Pre Filter Section (with Rough Filter & 30% efficiency (EU-4) Pocket Filter)
13.25 Face and bypass section with motorized dampers
13.26 Chilled Water Cooling Coil Section with SS-304 drain pan.
13.27 Fan section with drive package
13.28 Fine Filter Section (EU 9 - 95% efficiency down to 5 micron)
13.29 HEPA EU 14 filter section 99.5 % efficiency down to 0.5 micron
13.30 Plenum section with flexible connectors
13.31 Each AHU is supplied with a factory fitted GI powder coated, opposed blade volume control damper to facilitate air balancing.

The unit casing shall have a perimeter frame with a wholly modular system based on custom-made panels and reinforced vertical sections. The panels shall be fixed to the perimeter frame from outside the unit and screw heads shall be covered with nylon sleeves and caps, yielding of clear external surfaces free from bolt and bolt-head projections.

The entire unit shall be of sturdy construction to ensure freedom from vibration & noise during running.

The Panel shall be of double-skinned construction made of pre-coated GSS on outside and 0.6 mm galvanised sheet inside. They shall incorporate 25 mm thick sandwich for medium pressure AHU and for high pressure AHU it should be 40 mm thick injected HFC – Filler PUF Insulation material sandwiched between the external and internal sheets. The panels shall be coated with factory
applied heat-hardened polyester based powder paint. All internal corners to be with covering sections of extruded aluminum. The AHU is constructed on a thick fabricated GSS channel.

The entire framework shall be mounted on heavy gauge aluminum alloy channel base. The panels shall be sealed to the framework by heavy-duty ‘O’ ring gaskets held captive in framed extrusion. All panels shall be hinged. Hinges shall be made die cast aluminum with stainless steel pivots. Units supplied with various sections shall be suitable for on site assembly with continuous foam gasket. All fixtures and gaskets shall be concealed. The fan section is provided with suitable airtight tight access door for ease in serviceability of and motor. User-friendly nylon handles can be operated from both inside and outside the casing.

Internal surface shall be smooth & shall be cleanable without any projection.

All AHU shall incorporate thermal breaks.

**Centrifugal Fans:**

The fan shall be of DIDW Centrifugal type with backward inclined airfoil blades designs suitable for belt drive. The fan shall be imported, factory tested and assembled by original manufacturer. The blades shall be of mild steel backward curved airfoil blades with polyester powder coating finish.

The fan assembly shall be statically and dynamically balanced to ISO 194 & AMCA 204/3 – G 4.0 std certified. The fan shall be suitable for operating & deliver 15% excess of design airflow. Fans are selected based on higher efficiency and lower noise level.

Fans, as shown on the Drawings and having the capacities, characteristics and starting equipment shown on the schedule, shall be belt driven and of the centrifugal type, especially selected for AC & ventilating work. The wheel & housing shall be fabricated from heavy gauge galvanized steel. Fan shall run in perfect balance at all speeds, up to a 15% increase above the speeds indicated on the schedule, without noise or vibration in any fan or motor. Blades shall be die-formed, true to shape and held in place by rivets or welds. Fan shaft shall not reduce in diameter at the outboard bearing (opposite of drive end).

Fans shall be provided with anti friction bearing of the types specified herein. The fan bearings shall be mounted on the fan wheel and not on the panels of the casing. The fan – motor unit shall be totally isolated from the casing using cushy foot or equivalent vibration isolators beneath the structural frame. The bearing life shall be 200,000 hrs and they shall be self lubricating. Shafts shall be made of the best quality steel, turned and ground to close tolerance and shall run true and in perfect balance. All fans shall be furnished with variable inlet vanes.

All v-belt drives shall be designed for a minimum of 50% overload. Where more than one belt is required, matched sets shall be used. All belt drives shall be furnished with belt guards.

The impeller and shaft of the fan shall be both statically and dynamically balanced. Similarly, the fan as well as the motor shall also be dynamically balanced. The successful contractor shall furnish certificates to the effect that such dynamic balancing has been carried out. The results of balancing so carried out shall also be furnished in the certificates. Fan and motor is mounted on a fabricated slide rail. A specially designed motor mounting base plate allows adjustment of the belt tension without disturbing motor alignment. Flexible fire retardant canvas connection is provided at the fan outlet.

The fan housing with motor shall be mounted on a common extruded aluminum base mounted inside the air handling unit on anti-vibration mounts.

The fan outlet shall be connected to casing with the help of fire retardant fabric, mounted on aluminum extruded channels, acting as a flexible connection for anti-vibration.

All sections shall incorporate access panels with quick release latches for maintenance.

More generally, it is recommended at the following features incorporated in the medium pressure units.

- There will be only one impeller
The fan and motor shall be assembled together on a common base frame, which shall be mounted within fan section/casing on cushy foot or equivalent vibration isolators (springs).

- Bearings for the fan shaft shall be installed on a fan scroll and not on the casing of the unit.
- Flexible connections shall be provided between the fan outlet and the unit casing.
- Access doors of ample size with hinges and handles shall be provided to facilitate the entry of service personnel into the casing of the unit.
- All doors shall be provided with limit switches to interlock with fan motor.
- Fan chamber shall be provided with incandescent lamp protected with wire guard, which will come on when the door is opened.
- View port is provided on the fan door panel, which helps to monitor the fan and motor status. Marine lamp provided easy visibility.

Product Data: Submittal data for approval for all fans of every description furnished under this section of these Specifications driven by 5 (five) HP and larger motors shall include the following:

1. Fan curves with specified operating point clearly plotted. The recommended range of operation shall be stable.

2. Data to substantiate that fans on duct systems will operate in a stable range at 1/2" (one-half inch) S.P. above scheduled static pressure with motors sized accordingly.

3. Fans shall be capable of operating stably at reduced loads imposed by means of variable speed drives.

4. Data on sound power levels for both fan inlet and outlet at rated capacity.

5. Electrical characteristics and connection requirements.

6. All data on fan accessories.

Performance Ratings:

A. Conform to AMCA 210 and bear the AMCA Certified Rating Seal.

B. Sound Ratings: AMCA 301, tested to AMCA 300, and bear AMCA Certified Sound Rating Seal.

C. Fabrication: Conform to AMCA 99.

D. Performance Base: 500m above Sea level conditions.

E. Temperature Limit: Maximum 300 degrees F.

F. Static and Dynamic Balance: Eliminate vibration or noise transmission to occupied areas.

CHILLED WATER COILS:

A. Water coil capacities, pressure drops, capacity ratings and selection procedures shall be in accordance with ARI Standard 410-87. Necessary factory test certificates to be produced by the manufacturer/contractor.

B. Chilled water coils shall be of the extended surface type meeting all conditions and having the minimum face area and pressure drops scheduled on the Drawings, and shall have same end supply and return connections unless otherwise indicated. Coils shall be constructed of copper tubes 1/2" O.D. with .035" thick minimum wall thickness and Aluminum fins permanently bonded to the tubes by mechanical expansion. Coils shall have a maximum of 12 fins per inch, and a maximum of 6 rows. If additional cooling capacity is necessary, the additional capacity shall be provided by an additional coil, with an additional access section between the coils, and the coils shall be piped in series, counterflow to the direction of airflow. Aluminum fins on plate coils shall be .006" thick.

C. All coil headers and connections shall be of heavy gauge seamless hard drawn copper tubing with penetrations for connection of core tubing by die-formed intrusion process with resulting contact
depth between the header wall and core tubing of not less than .090". Joints between core tubing and header shall be of recess swage design to allow a large mating area for build up of brazing materials to give increased strength to the joint. Supply and return connection of brass or copper shall be terminated with National Pipe Threads with wrench flats.

**D. Coils**

Coils shall be designed and certified by the manufacturer to operate to scheduled face velocity plus 10% without moisture carry over. Each cooling coil section shall be provided with a Steel frame/casing, including tube sheets, no lighter than 16 gauge. Frame members shall extend over the ends and edges of the coils and shall be constructed with formed holes for tubes, permitting free expansion and contraction of coil sections while supported by an extended surface of the frame. Intermediate tube support sheets of 316-L stainless steel shall be provided in all coils having tube lengths in excess of 48": on long coil sections the spacing of coil supports shall not exceed 48". All intermediate supports shall be welded to coil frame members and fabricated with formed tube holes to support the penetrating tubes. Heating coil construction shall be similar, except casting frame and intermediate supports may be G90 galvanized material.

**E. Condensate**

Condensate from chilled water coils shall be piped to the nearest convenient floor drain. The pipe size shall be 1" minimum diameter, insulated as specified for chilled water piping. A trap of a minimum depth of 6 inches shall be provided in this drain line to prevent the escape or entry of air through the drain piping.

**F. Pressure test**

Pressure test all coils to 350 psi under water.

Drain trays shall be provided for all cooling coil, sections as well as dummy sections and fan casing complete with drain connection for proper drainage of water. Drain trays shall be of 18 G Stainless Steel, Slopes shall be provided from all sides to the drain point; 100% drainability shall be ensured.

Filter Section shall incorporate pre filters and bag filters.

1. **Pre Filter Efficiency** of not less than 30% by ASHRAE standard 52.1 – 1992 corresponding to Eurovent standard EU-4. Filter capacity shall be not less than 5000 cmh at a pressure drop not exceeding 9mm when filter is clean.

2. **Fine Filter Efficiency** of not less than 95% by ASHRAE standard 52.1 – 1992 corresponding to Eurovent standard EU-7. Filter capacity shall be not less than 5000 cmh at a pressure drop not exceeding 15mm when filter is clean.

3. **HEPA filter Efficiency** of not less than 99.5% by ASHRAE standard 52.1 – 1992 corresponding to Eurovent standard EU-14. Filter capacity shall be not less than 5000 cmh at a pressure drop not exceeding 35-40 mm when filter is clean.

Necessary pressure connections to be provided between the filter sections to measure differential pressure across the filter.

All access doors, coil connections etc., shall be provided on one side of the unit. In other words, access to the other side of the unit should not be necessary for any purpose whatever.

Special care shall be taken to ensure that doors, handles, hinges etc. shall be robust enough to withstand heavy industrial usage.

Silicone sealants shall be applied to all joints – both on the inside of the AHU.

The vibration of the AHU fans (as measured on the bearing block after assembly) shall not exceed a peak to peak displacement of 100 microns.

The computerized section and test certificate for the cooling coil shall be submitted by the supplier.

**Motors:** Three phase squirrel cage motors suitable for 415/3/50 power.

Enclosures shall be of the squirrel cage induction motor of TEFC type with a service factor of 1.15 and Class F insulation of IP55 protection and suitable for 65 deg C. Motor shall be especially designed
for quiet operation and motor speed shall not exceed 1500 RPM at maximum air flow. In general, all motors 3/4 horsepower and larger, unless smaller motors are indicated to be supplied as 3-phase, shall be 3-phase and shall be squirrel cage high efficiency induction type with standard NEMA frame sizes. Motors 1 HP and larger shall have integral frames. Starting Torque shall be between one and one and one-half times full load torque. Starting Current shall be Six times full load current. Power Output, Locked Rotor Torque, Breakdown or Pullout Torque: NEMA Design B characteristics. Design, Construction, Testing, and Performance: Conform to ANSI / NEMA MG 1 for Design B motors. Insulation System: NEMA Class F. Motor Frames: NEMA standard T-frames of steel, aluminum, or cast iron with end brackets of cast iron or Aluminum with steel inserts. Thermostat System (Motor Frame Sizes 254T and Larger): Three PTC thermistors imbedded in motor windings and epoxy encapsulated solid state control relay for wiring into motor starter; refer to Section 26 24 19.UT - Motor Control Centers.

Bearsin 9g: Ball or roller type, double shielded with continuous grease relief to accommodate excessive pressure caused by thermal expansion or over lubrication. All motor bearings shall be factory prepacked with a no detergent lubricant, and shall be provided with lubrication fitting arranged to provide easy access when installed on the driven apparatus except as noted hereinafter. Permanently lubricated factory-sealed motors may be provided in fractional HP sizes only where they are an integral part of a piece of approved apparatus. All bearings shall be designed for B-10, 200,000 hour minimum life hours of continuous service. Calculate bearing load with NEMA minimum V-belt pulley with belt center line at end of NEMA standard shaft extension. Stamp bearing sizes on nameplate.

The tenderers shall describe the tests that will be conducted at their manufacturers works on the Air Handling Units. They shall furnish a test certificate to the effect that such tests have been duly performed on the AHUs. Test certificate shall be furnished for all bought out items like filters, motor, manometer, etc.,

Tests shall be conducted on all AHUs at the factory for measurement of delivery vs. static pressure, total pressure, BKW, efficiency & noise level at 100%, 80%, 60%, 50% & 40% speeds. Owners / consultants will witness the testing of 1 or 2 AHUs of each specified type at the factory. The contractors shall intimate in advance the date of the tests, which they will witness at their option.

Further, all AHUs shall be leak-tested at 150 mm static pressure using an external testing rig. The test shall be conducted to Class ‘D’ level applicable for ducting as per STD DW 141/142. The test rig shall include an external fan with arrangements for varying the airflow instruments for measuring static pressure, airflow etc.,

The tenderers shall afford every facility for the accepting officer or his authorized representative to witness the tests if they so desire.

The Accessories shall include the Outlet plenum, flanges, flexible connections at supply and discharge, marine lamps, sight glass, belt guard, limit switch, Differential pressure switches & gauges for each filters, air flow switch across the fan section.

CABINET TYPE AIR HANDLING UNITS CEILING / VERTICAL TYPE

Cabinet Type Air Handling Units shall consists of the following sections:

9.1 Filter section with Panel type Rough Filter
9.2 Bag filter or Microvee filter 10 micron filter
9.3 Cooling Coil Section with cooling coil and bypass damper
9.4 SS Drain Pan
9.5 Fan Section with Fan
9.6 Supply air plenum with dampered openings.

Vertical Air Handling units are designed to occupy lesser floor space than the horizontal unit. The unit casing shall have a perimeter frame with a widely modular system based on custom-made panels and reinforced vertical sections. The panels shall be fixed to the perimeter frame from outside the unit and screw heads shall be covered with nylon sleeves and caps, yielding of clear external surfaces free from bolt and bolt-head projections. The entire unit shall be of sturdy construction to ensure freedom from vibration during running.
The panels shall be of double-skinned construction with both skins being of GI. They shall incorporate 25 mm thick injected HFC – Filter PUF insulation material sandwiched between the external and internal sheets. The panels shall be coated with factory applied heat-hardened polyester based powder paint. All internal corners to be with covering sections of extruded aluminum. Internal surface shall be smooth and shall be cleanable without any projection. All sections shall incorporate access panels with quick release latches for maintenance.

The filter section shall consist of two-stage filtration. First stage shall be Panel type Prefilters. The Prefilters shall have an efficiency of 90% down to 20 microns by Arrestance Test. The filter pressure drop shall not exceed 6 mmwg when clean and 12 mmwg when fully loaded. Second stage filters shall have an efficiency of 90% down to 10 microns by Arrestance Test. The filter pressure drop shall not exceed 12 mmwg when clean and 25 mm wg when fully loaded.

The fan shall be DIDW centrifugal type. Forward curved blades shall be of GSS while blades of other shape shall be of MS, treated and epoxy painted after manufacture (if of MS). The fan assembly shall be statically and dynamically balanced.

The fan bearings shall be mounted on the fan scroll and not on the panels of the casing. The fan-motor unit shall be totally isolated from the casing using spring steel mounted vibration isolators beneath the structural frame and by flexible connections between the fan mouth and the outlet connection on the fan section.

More generally, it is recommended at the following features incorporated in the medium Pressure units:
- There will be only one impeller.
- Impellers shall have forward curved blades of aerofoil design.
- The fan and motor shall be assembled together on a common MS frame, which shall be mounted within fan casing on cushion foot or equivalent vibration isolators.
- Bearings for the fan shaft shall be installed on a fan scroll and not on the casing of the unit.
- Flexible connections shall be provided between the fan outlet and the unit casing.
- Access doors of ample size with hinges and handles shall be provided to facilitate the entry of service personnel into the casing of the unit.
- All doors shall be provided with limit switches to interlock with fan motor.
- Fan chamber shall be provided with incandescent lamp protected with wireguard, which will come on when the door is opened.

Coils shall be of the fin and tube type having aluminum fins firmly bonded to copper tubes. All tubes shall be in staggered pattern. Headers shall be of MS and all tube connections to headers and return bends shall be brazed with silver brazing alloy.

Capacity of the coils shall be as shown in section III – Equipment Schedule.

The coil section shall be drained independently of the fan section.

Heating coil section shall incorporate heating coil made out of copper tubes with aluminum fins. All other constructional details shall be same as cooling coils.

Drain trays shall be provided for all cooling coil, sections as well as dummy sections and fan casing. Drain trays shall be of 18 G stainless steel. Slopes shall be provided from all sides to the drain point; 100% drainability shall be ensured.

Necessary pressure connections to be provided between the filter sections to measure differential pressure across the filter.

Where specified the high velocity filter section shall incorporate cleanable type (pre) filters. Face velocities up to 4.25 mps (850 fpm) are permissible. The filter media shall be extruded sections of high – density polyester or similar synthetic material, which shall be housed, in metallic frame with GI wire mesh support from both side. The efficiency of the filters shall be equivalent to or not less than 90% down to particle size of 20 microns. Only Flat Filter Sections suitable for accommodating filters of depth not
The filters and the filter section shall be so installed that filters can be readily removed for cleaning.

The empty section shall also be of double-skin construction & shall be provided wherever called for.

All access doors, coil connections etc. shall be provided on one side of the unit. In other words, access to the other side of the unit should not be necessary for any purpose what so ever.

Special care shall be taken to ensure that doors, handles, hinges, etc. shall be robust enough to withstand heavy industrial usage.

Silicone sealants shall be applied to all joints – both on the inside of the AHU.

The vibration of the AHU fans (as measured on the bearing block after assembly) shall not exceed a peak – to-peak displacement of 100 microns.

For all AHUs serrated rubber pads shall be provided for vibration isolation.

The tenderers shall describe the tests that will be conducted at their manufacturers works on the Air Handling Units. They shall furnish a test certificate to the effect that such tests have been duly performed on the AHUs. Test Certificate shall be furnished for all bought out items like filters, motor, manometer, tachometer, and static pressure tester etc.,

Tests shall be conducted on all AHUs at the factory for measurement of delivery vs. static Pressure, total pressure, BKW, efficiency & noise level at 100%, 80%, 60%, 50% & 40% speeds. Owners / Consultants will witness the testing of 1 or 2 AHUs of each specified type at the factory. The contractors shall intimate in advance the date of the tests, which they will witness at their option.

Further, all AHUs shall be leak-tested at 150 mm static pressure using an external testing rig. The test shall be conducted to Class ‘D’ level applicable for ducting as per STD DW 141 / 142. The test rig shall include an external fan with arrangements for varying the airflow instruments for measuring static pressure, airflow etc.,

The tenderer shall afford every facility for the accepting officer or his authorized representative to witness the tests if they so desire.

Vertical AHU’s – Shall be same constructional features as above, however the unit shall be suitable for Floor standing (mounted) application with a MS frame / pedestal.

FRESH AIR UNITS

Medium pressure cabinet type all sheet Metal Fresh Air Units with static pressure capability of upto 50 mm wg and above have been specified.

The VAU shall consist of the following sections for all VAUS:

(a) Air intake section
(b) Filter Section (with Rough Filter and 30% efficiency 9EU-3) pocket filter
(c) Fan Section

The unit casing shall have a perimeter frame with a wholly modular system based on standardized panels and reinforced vertical sections. The panels shall be fixed to the perimeter frame from inside the unit yielding clear external surfaces free from bolt and bolt head projections.

The entire unit shall be of sturdy construction to ensure freedom from vibration during running.

The panels shall be of double-skinned construction with both skins being of GI. They shall incorporate 25mm thick injected HFC Filler PUF insulation material sandwiched between the external and internal sheets. The panels shall be coated with factory
applied heat hardened polyester based powder paint. All internal corners to be with coving sections of extruded aluminum.

The fan shall be DIDW Forward curved centrifugal type. The blades shall be of mild steel Forward curved blades with polyester powder coating finish. The fan assembly shall be statically and dynamically balanced to ISO 1940 & AMCA 204/3 – G 4.0 std.

The fan bearings shall be mounted on the fan wheel and not on the panels of the casing. The fan-motor unit shall be totally isolated from the casing using cushion foot or equivalent vibration isolators beneath the structural frame and canvas connections between the fan mouth and the outlet connection on the fan section.

A single square flange outlet shall be provided for the fan.

The impeller and shaft of the fan shall be both statically and dynamically balanced. Similarly, the fan pulley as well as the motor pulleys shall also be dynamically balanced. Multiple speed pulleys to be provided to adjust the air flow rate required at site. The successful contractor shall furnish certificates to the effect that such dynamic balancing so carried out shall also be furnished in the certificates.

All sections shall incorporate access panels with quick release latches for maintenance.

More generally, it is recommended at the following features incorporated in the medium pressure units.

-There will be only one impeller.
-Impellers shall have forward curved blades
-The fan and motor shall be assembled together on a common GI frame, which shall be mounted within fan casing on cushion foot or equivalent vibration isolators.
-Flexible connections shall be provided between the fan outlet and the unit casing.
-Access doors of ample size with hinges and handles shall be provided to facilitate the entry of service personnel into the casing of the unit.
-All doors shall be provided with limit switches to interlock with fan motor.
-Fan chamber shall be provided with Compact Fluorescent (CF)-11 lamp protected with wireguard, which will come on when the door is opened.

Filter Section shall incorporate bag filters

-Efficiency of not less than 30% by ASHRAE standard 52.1 – 1992 corresponding to Eurovent standard EU-3. Filter capacity shall be not less than 5000 cmh at a pressure drop not exceeding 9mm when filter is clean.

Necessary pressure nozzles to be provided between the filter sections to measure differential pressure across the filters.

The filters and the filter section shall be so installed that filters can be readily removed for cleaning.

All access doors etc., shall be provided on one side of the unit. In other words, access to the other side of the unit should not be necessary for any purpose whatsoever.

Special care shall be taken to ensure that doors, handles, hinges, etc. shall be robust enough to withstand heavy industrial usage.

The vibration of the fans (as measured on the bearing block after assembly) shall not exceed a peak – to-peak displacement of 100 microns.

For all FAUs serrated rubber pads shall be provided for vibration isolation.

The tenderers shall describe the tests that will be conducted at their / manufacturers works on the ventilation Air Units. They shall furnish a test certificate /s to the effect that such tests have been duly performed on the FAUs. Test Certificate shall be furnished for all bought out items like filters, motor, manometer etc.,
Tests shall be conducted on all FAUs at the factory for measurement of delivery vs. static Pressure, total pressure, BKW, efficiency & noise level at 100%, 80%, 60%, 50% & 40% speeds. Owners / Consultants shall be intimated in advance the date of the tests, which they will witness at their option.

The tenderer shall afford every facility for the accepting officer or his authorized representative to witness the tests if they so desire.

Exhaust Air units:

The description shall be similar to the Fresh air units specs mentioned above. However the fan shall be SISW spark resistant fan.

APPLICATION
For supply or exhaust application in commercial and industrial buildings.

CONSTRUCTION
"Pittsburg lock" form housing manufactured in galvanized sheet steel for all sizes except 1250 and above, in mild steel finished with polyester powder coating. The wheel having forward curved blade is made of galvanized sheet steel.

TESTING
Both air and sound performance ratings are based on test to AMCA210 and AMCA300 Standards. All wheels are statically and dynamically balanced to ISO1940 and AMCA204 - G2.5 Standards.

4.0 FAN COIL UNITS & CASSETTES UNITS

FAN COIL UNITS:

4.1 Units shall be complete with chilled water coil(s), fan(s), motor(s), drain pan, and all required wiring, piping, controls and special features.

4.2 Horizontal Base Unit with Plenum for concealed installation shall have a factory installed, galvanized steel plenum section and throw away filter. The plenum shall be either bottom or rear return lined with 12mm thick glass fiber insulation and include a removable panel to provide a access to the fan/motor assembly.

4.3 Fans shall be direct driven, double width fan wheels shall have forward curved blades, and be statically and dynamically balanced.

4.4 Fan motors shall be 3-speed permanent split capacitor type with sleeve type bearings.

4.5 Standard base unit shall be equipped with a 3/4-row coil (minimum) for installation in a 2-pipe system. Coils shall have 12mm copper tubes, aluminum fins bonded to the tubes by mechanical expansion and have a working pressure of 16 bar. Each coil shall have a manual air vent and sweat connections for copper tubes.

4.6 The drain pan shall be constructed of galvanized steel extending the entire length and width of the coil(s) and pitched for drainage.

4.7 Insulation and adhesive shall meet NFPA-90A requirements for flame spread and smoke generation.

4.8 Units shall be provided with 25mm thick throw washable filters.
4.9 Control valves shall be modulating type three way for FCU’s capacity of 4.8KW and above and ON-OFF for capacity below 4.8KW.

4.10 Fan coil units shall be selected at high speed.

4.11 Fan coil unit for exposed application will be same construction features as listed above, However all the above components will be housed in a heavy gauge (18G) GI decorative cabinet finished with baked enamel powder coating of beige type. The Cabinet shall have a factory supplied double deflection discharge grill and louvered return air.

CASSETTE TYPE UNITS

The cassette type unit shall be a combination of the supply air slot, return air grille fan casing and cooling coil. No connection of ductwork is allowed

Each cassette type unit shall be provided with combined room temperature sensor

Complete with 3-speed controller

CHW Coils are of the corrugated fin-and-tube-type, constructed of seamless copper tubes of minimum thickness 0.014 inches (0.356 mm), mechanically bonded to aluminum fins. End plates and tube support sheets are 18 gauge galvanized steel formed to provide structural strength. Each coil to be pressure tested in the factory at not less than 300-psi (2070 kPa) air pressure. Coils conform to ARI 410.

Each cassette type unit shall be provided with stainless steel drain pan situated beneath the cooling coil and arranged so that all moisture will collect in and drain from the pan. Drain pans shall be insulated externally with 9 mm thick electrometric nitrile rubber insulation. Drain pan shall be fitted with a drainpipe, which shall be connected via suitable runs (correctly laid to fall) to the drainage system. Drain pans shall have copper male connectors for connection to the condensate drain. The connector shall be positioned to ensure rapid discharge of moisture from the pan.

Built-in condensate pump shall be provided for the removal of condensate. A water sensing system with low, high and warning limits shall be provided which actuates the running of condensate pump at high water limit and trigger the alarm system at warning level. When water level reaches the warning limit, the sensing system shall cut off the unit operation. An alarm signal shall be given locally. The signal shall be connected to CCMS or remote indication system as specified. Condensate pump shall be designed to run continuously at some essential areas as specified. The power source for condensate pump and the associated control system shall be independent from that of cassette unit such that the pump can still be operated after the units has been switched off.

The filter media shall be of the washable type and shall be enclosed in a one piece formed stainless steel frame with covers flush mitered and reinforced by a die-formed inverse bead.

Automatic/manually adjustable louvers for directional airflow shall be provided for supply air slot in each unit. Options shall be given to choose from 2-way,3-way or 4-way supply air discharge

Fan motor shall be PSC squirrel cage, totally enclosed, fan cooled type. The motors insulation class and protection shall be acc. IEC-Standard. Motor shall be suitable for 3-speed operation.

After finalization of contract the successful bidder shall access the static pressure calculations and submit to consultant for approvals.

In the event that the Consultant requires further information on any of the proposed items the Contractor shall arrange visits to similar units, which he has installed. In any event, all equipment proposed for the project shall be currently installed and working satisfactorily locally. The Contractor must be able to provide references of at least three satisfied Owners and Consultant with equipment of the particular size and model proposed.

HI WALL MOUNTED SPLIT SYSTEM

4.12 GENERAL
Unit shall be air cooled, split type air conditioner consisting of one outdoor unit and a matching indoor unit, each having capability to cool independently for the requirements of the rooms.

Compressor shall be equipped with rotary type and mounted on rubber in shear foot mounts.

Outdoor unit shall be suitable for match connection to Wall mounted type models.

The maximum one run of refrigerant piping shall not exceed 35 feet, oil entrainment to be planned if required by the manufacturer/HVAC contractor.

4.13 OUTDOOR UNIT

The outdoor unit shall be a factory assembled unit housed in a sturdy weather proof casing constructed form rust-proofed mild steel panels coated with a baked enamel finish.

The outdoor unit shall have rotary scroll compressors and be able to operate in adverse conditions prevailing in the site without malfunctioning.

The noise level shall not be more than 59 dB(A) at normal operation measured horizontally 1m away and 1.5m above ground.

The outdoor unit shall have side discharge and should be allowed for side by side installation.

4.14 COMPRESSOR

The compressor shall be of highly efficient rotary scroll type and equipped with all necessary safety and standard controls necessary for proper and safe operation. These compressors have a self-regulating crankcase heater, improved internal pressure relief valve, which provides high pressure protection to the refrigerant system and rubber vibration isolators for quiet and efficient operation.

4.15 AIR COOLED CONDENSER

The condenser coil is of corrugated fin & tube type, constructed of seamless copper tubes with wall thickness of 0.014” (0.356mm), and mechanically bonded to aluminium fins. All copper tube return bends have 0.022” (0.56mm) wall thickness. Tube support sheets are of galvanized steel formed to provide structural strength. Tubes are circuited to ensure minimum pressure drop and maximum heat transfer. Each coil is completely dehydrated, charged and sealed at the factory upon completion of tests.

The fans are propeller type and direct-driven, front discharge and provided with fan guards. Units are equipped with totally enclosed fan motors for greater reliability and dependable performance for many years. Inherent thermal protection is automatic reset type.

SERVICE VALVES

Both suction and liquid service valves are brass, back seating type with flare connections. Valves are externally located so refrigerant tube connections can be made quickly and easily. Each valve has a gauge pressure port for ease of checking refrigerant operating pressures.

LOW PRESSURE SWITCH

Auto reset SPST switch activated by refrigerant pressure-locks out the compressor, if the refrigerant pressure falls below 25 PSIG. Also provides additional protection against evaporator freeze up due to loss of indoor airflow. Inverter control capable of changing the speed in accordance to the cooling load requirement.

4.16 HEAT EXCHANGER

As described above under Air cooled condenser.

4.17 REFRIGERANT CIRCUIT
The refrigerant circuit shall include an accumulator, liquid and gas shut off valves and a solenoid valves. All necessary safety devices shall be provided to ensure the safety operation of the system.

4.18 SAFETY DEVICES

The following safety devices shall be part of the outdoor unit:

High Pressure Switch, Low Pressure Switch, Fan Motor Safety Thermostat, Inverter Overload Protector, Over Current Relay, Fusible Plugs, Fuses.

4.19 OIL RECOVERY SYSTEM

Unit shall be equipped, with an oil recovery system to ensure stable operation with long refrigerant piping.

4.20 INDOOR UNIT

Each Indoor unit shall be as shown in the drawings and can be of the ceiling mounted cassette type (Double flow type), or ceiling mounted cassette type (Multi-flow type), or ceiling mounted built-in type, or ceiling mounted duct type, or ceiling suspended type, or floor standing type, or concealed floor mounted type, or Hi-Wall type, or ceiling mounted cassette corner type as specified in scope of work. It shall have electronic control valve which control refrigerant flow rate in respond to load variations of the room. The indoor unit should be equipped with LCD display type.

The fan shall be of the dual suction multi blade type and statically and dynamically balanced to ensure low noise and vibration free operation.

(q) The address of the indoor unit shall be set automatically in case of individual and group control.
(r) In case of centralized control, it shall be set by liquid crystal remote controller.

4.21 HI-WALL UNITS

The Hi-wall type unit shall be a combination of the supply air & return air grille, fan casing and cooling coil. No connection of ductwork is allowed.

Each Hi-wall unit shall be provided with combined room temperature sensor complete with 3-speed controller.

DX Coils are of the corrugated fin-and-tube-type, constructed of seamless copper tubes of minimum thickness 0.014 inches (0.356 mm), mechanically bonded to aluminum fins. End plates and tube support sheets are 18 gauge-galvanized steel formed to provide structural strength. Each coil to be pressure tested in the factory at not less than 300-psi (2070 kPa) air pressure. Coils conform to ARI 410.

The filter media shall be of the washable type and shall be enclosed in a one piece formed stainless steel frame with covers flush mitered and reinforced by a die-formed inverse bead.

Automatic/manually adjustable louvers for directional airflow shall be provided for supply air slot in each unit.

Fan motor shall be PSC squirrel cage, totally enclosed, fan cooled type. The motors insulation class and protection shall be acc. IEC-Standard. Motor shall be suitable for 3-speed operation.

4.22 CONTROL

Standard control as applicable for Hi wall splits shall be provided.

(i) Sleep Mode
(ii) Wireless controller with LCD
(iii) Quiet mode Operation
(iv) Auto Re-start Function
(v) Emergency Switch (ON/OFF Control)
(vi) Auto Vertical Air Sweep

5.0 Expansion Tank

Expansion Tank - Closed pre-charged pressure vessel designed to absorb expansion effects of Chilled water systems and maintain proper system pressurization. The tank shall take care of the expansion of water due to the temperature variation in the system shall be provided in the chilled water circuit. Shell construction of Carbon steel, bladder of butyl rubber to eliminate tank corrosion and water logging. Stds ASME, working pressures of 125 psig and 240°F. Expansion tank to take care of the expansion of water due to the temperature variation in the system shall be provided in the chilled water circuit. Tanks to be with all accessories & connections. The cost of Tank shall cover all valves, vents, gauges, fittings and required accessories

The tank shall be epoxy coating from inside and builtiminished coating from outside. The assembly shall also include monobock circulating pupms

The tank shall have a neoprene rubber diaphragm rated for continuous operation at 10 Bar NP with GI cladding.

The tank shall be complete with all tappings for inlet (which may also be the drain,) air recharge, and pressure relief.

6.0 Air Separator

An adequately sized centrifugal type Air separator to remove air from closed chilled water pipe circuit. The unit shall have inlet and outlet connections, tangential to the vessel shell. Vessel shall diameter to be three times the nominal inlet/outlet pipe diameter.

The unit shall have internal stainless steel air collector tube with 4 mm diameter perforations and 63% open area designed to direct accumulated air to the compression tank via an NPT connection at top of unit.

The unit shall have a removal galvanized steel system strainer with suitable diameter perforations and a free area of not less than five times the cross sectional area of connecting pipe. A blow down shall be provided to facilitate routine cleaning of the strainer.

7.0 FANS CENTRIFUGAL – CABINET TYPE UNITS

Cabinet type units casing shall be constructed as per the details mentioned in this section under article 3.0. The units shall be suitable for exhaust and fresh air handling. The AHU shall comprise of Fan and filter with related accessories.

Fans - Furnish, install and connect up complete, all supply, return, exhaust, transfer and exhaust fans. All fans shall be of the non-overloading centrifugal type.

Fans shall have direction of rotation, discharge direction indicated on the casing. Fan arrangement shall be selected to suit the space conditions.

Fan housing shall be rigidly built and braced. Where fan scroll is 480 mm or more in width provide access door with frame and gasket. All access doors shall be so fabricated that the inner surface is flush with the inside of the scroll. Raised frame doors of the pan type shall be provided on all fans where insulation is required. The doors shall be secured to the frame by hand-grip latches and shall be provided with lift handles. Bolted doors are not acceptable,

Fans shall not produce excessive noise as compared to units of like size and power when used in conjunction with the specified vibration isolation. Fan manufacturers shall furnish for approval for each fan certified sound power ratings with an octave band analysis and also the volume- horsepower-pressure characteristic curves from shut-off to free delivery. Wheels shall have ample strength and shall be statically and dynamically balanced to avoid vibration and shall have blades designed to ensure quiet efficient operation.

Fans, unless otherwise indicated, shall be belted to respective motors by "V" belt drives. Sheaves shall be cast steel. Drives requiring 2 grooves or more shall have variable pitch motor sheaves and
companion type fan sheaves. Belts shall have a rated capacity of not less than 150% of the motor horsepower. All "V" belt drives for integral horsepower motors shall have not less than two belts and shall have sufficient belt capacity to drive fans with one belt broken. Drives for fractional horsepower motors may have one belt rated at 200% of motor horsepower. If to balance an air system, a fan other than the one provided should be required, necessary changes shall be made in the "V" belt drive by the Contractor at his expense. Supply and install belt guards of perforated metal, or as approved for all sheaves and belts. Belt guards shall be grommeted at fan and motor shafts for ease in taking tachometer readings.

Each fan motor shall be sized to drive it's respective fan when fan is operating at a speed (due to pulley adjustment) of 10% in excess of that required to meet fan performance, and when the fan requires the maximum power at this speed.

All fans shall be factory coated with one coat of primer and one coat of machine enamel. The interior of all fans and all wheels shall be painted as per manufacturer's standard.

All fans discharging directly up through the roof shall be equipped with a 38 mm casing drain which shall be piped to the nearest floor drain.

All fans scheduled to be arranged as belted vent sets shall have overhung wheels and motors mounted on a common base with the bearings. All such belted vent sets shall be furnished with weatherproof motor housings where located outdoors.

All double width, double inlet fans shall be provided with galvanized steel inlet guard screens.

7.0 FANS, AXIAL.

Axial flow fans shall be capable of giving the design flow.

Each fan shall be supplied with a suitably rated contractor/ starter/ isolator of approved pattern.

Fan casings shall be constructed of mild steel plates with angle stiffeners, with the casing hot dip galvanized after manufacture. The inlets and outlets of the axial flow fans shall be flanged for connection to the system. A drain plug shall be fitted and the casing designed to permit removal of the impeller.

An access door is to be provided on the casings of all fans. Casings shall cover both impeller and motor so that fans can be removed without disturbing adjacent ductwork or other components of the system.

All lubrication points are to be extended to the outside of the casing and in a position that will permit access in relation to the adjacent plant, services or building structure.

Impellers shall be die cast in Aluminum alloy and X-rayed during manufacture. The impellers shall be capable of running continuously at 20% in excess of the rated speed. The impeller shall be keyed and locked onto the shaft, which shall be statically and dynamically balanced and tested at overspeed before dispatch from the Manufacturer's works.

Flexible connections shall be supplied and installed at both inlet and outlet of each fan.

The fan bearings shall be of the sleeve type wherever possible. The bearings are to be truly aligned and rigidly mounted on to the casing.

Graphs of the performance curve of each fan are to be forwarded to the Consultant/Client together with a test report on the sound level at three diameters in a free field condition prior to the order being confirmed.

Blade angle shall be adjustable over at least a 30-degree range, with markings at the root to indicate the blade angle.

Axial flow fans are to be driven by electric motors of commercially silent pattern carrying a Makers guarantee in this respect. The motors shall be totally enclosed, fan cooled.

All motors are to be positioned to permit effective ventilation of the motor and all component parts of the fan.
and motor are to be suitable to withstand the temperature conditions expected in the fan.

Electrical connections to the motors shall be in a totally enclosed terminal box secured to the exterior of the casing. Wiring within the axial flow fans shall be suitable for the conditions within the casings.

A suitable steel support is to be provided for each fan, and the frame is to be fabricated from rolled steel channel with adequate cross members for bolting the fan into position. The frame shall be of welded construction with anti-vibration mountings.

The anti-vibration mountings are to be rubber in shear pattern and of a type that are bolted to both the fan and the support.

8.0 PARTICULAR FAN

Inline Duct Mounted

Unit casing shall be manufactured in epoxy coated aluminium alloy and shall house twin fan assemblies, each comprising double inlet forward curved centrifugal impellers running in an individual scroll. Impellers may be either direct driven or belt driven depending upon the fan duty.

Units shall be supplied for either roof mounting or plant room use as indicated on the drawings.

9.0 ELECTRIC MOTORS

Unless otherwise specified in the equipment specifications, all motors supplied and installed as a part of mechanical works shall conform to the following requirements:

Motors shall be of high efficiency, and shall be constructed and type. These shall be of totally enclosed fan cooled (TEFC) type to IP54 either with foot-mounting or flange-mounting suitable for its application. Unless otherwise specified, motors shall be designed for continuous running duty type S1 for operation during 3 years without maintenance. They shall be of such size as to drive adequately their associated equipment under the range of operating conditions, without overloading.

Windings shall be insulated with Class F insulation material to BS. 2757, and temperature rise of windings shall be class B (I.E. maximum of 80 deg.C. as measured by resistance method).

Electric motors up to and including 0.37 Kw shall be suitable for operation at 240 volts single phase. Motors rated above 0.37 Kw shall be of the 3-phase squirrel cage induction type with drip proof housing. Motors located directly in air streams shall be totally enclosed, fan cooled.

All the motors shall be provided with a substantial earthing terminal tapped into the frame or clamping device located on the cable end box side of the motor.

Terminal connections shall be constructed in such a way that direct contact between screws, bolts or nuts and the conductor is avoided.

The terminal box shall be of sturdy construction with ample space for connecting cables. An earthing bolt of adequate size shall be provided inside the terminal box for connecting to the cable earthing. This will be in addition to the earthing bolt provided in the motor enclosure. The terminal box shall be adequately weather proofed with a suitable non sticking reusable non-hygroscopic gasket material. These terminal boxes also shall be provided with suitable cable sealing end boxes or cable glands.

In addition to these items the following information shall be indicated:

1. Type of enclosure

   b) Locked rotor torque on % of rated torque
   Locked rotor current in % of rated torque

   b) Allowable running-up time in seconds (ART) bearing type, size, fit, re-greasing period and type of grease.

   d) Net weight.
10. e) Purchase order number.

All motor shafts shall be provided with a key way unless the motor is of the flange mounted type in which case they shall be complete with adjustable rails.

The frame shall be painted in accordance with manufacturer's standards. However, the painting shall at least consist of one coat of primer and two coats of oil-resistant finishing paint.

10.0 MOTOR STARTERS, CONTROLS SWITCHGEAR

All starters and other control components shall be supplied and installed under this section but the contractor shall ensure that all components supplied shall comply with the requirements of the relevant sections of the electric specifications.

11.0 PANEL BOARDS AND MOTOR CONTROL CENTRE.

Construction of all panel board, motor control centres, control panels etc. shall comply with the relevant sections of the electrical specifications.

Air handling unit starter panels:

Each air-handling unit shall be supplied with a starter cubicle including the following:

a) A door interlocked isolator handle.
b) A three-position HAND/OFF/AUTO control switch.
c) A "motor run" lamp (green).
d) A "motor trip" lamp (red).
e) Motor speed selector switch
f) Motor starter assembly.
g) Control fuse.
h) Filter pressure drop (filter clog indication)
j) Inter-connection with fire alarm system and extract fans.
k) Power fuses with carriers and bases.
l) Moisture elimination heating coil.
m) Heating element contactors and controls.
n) Heating element 'energized' lamp (Green)
o) Heating element 'tripped' lamp (Red)

Note:
Control switch "Off" - Motor shall not run.
Control switch "Test" - Motor shall run except for local lock-off stop buttons.
Control switch "Auto" - Motor shall start and stop under dictation from remote control circuit.

Starter panels, where installed outdoor, shall be of the weatherproof type enclosure.

Fan Coil Unit Control Enclosure

Control components of each fan coil unit like contactors, transformers, controllers, etc. shall be
housed within an enclosure located besides the unit within the ceiling void.

Motor control centre shall be of the cubicle type, floor mounted and shall contain the following:

- Incoming as shown on the schematic diagram.
- Busbars for each phase, neutral and earth.
- Outgoing as shown on the schematic diagram.
- Starter as indicated on the schematic diagram.
- Pilot light for each phase.
- Pilot light for each motor in the plant room.
- On-off switch for each chiller control panel.
- Push button (start-stop) for each motor and plant room.
- One ammeter with selector switch for each motor in plant room.
- One ammeter for each phase for the incomer power supply.
- Voltmeter with selector switch.
- All required interlock wiring.
- Motor duty selector switch.
- Phase monitor relay for each motor.
- Low voltage protection device.
- Bank of capacitors for power factor improvement.
- Chiller sequence controls

Where motor control centres are installed outdoor, the panel shall be of the weatherproof type.

Motor control centre construction and components shall comply with the requirements as set out in the relevant sections of the electrical specifications.

12.0 SUBMISSIONS.

Initial technical submissions are to accompany the bid including full technical details of every item of equipment proposed for the project, with the appropriate figures and details highlighted in marker pen or similar in standard manufacturer's catalogues.

After final checking of sizing after award of contract, resubmission will be made with any changes specifically noted.

Technical submissions for the following are particularly required to be submitted.

Chillers
Air handling units.
Fan coil units.
Hi-Wall mounted A/c
Pressurization Unit
Motor Control Centre.
Fans.
Pumps
Chemical Treatment
Contractor has to conduct performance data & testing of unit computed at the site during commissioning & submit the same of all the unit

In the event that Consultant/Client requires further information on any of the proposed items the Contractor shall arrange visits to similar units, which he has installed. In any event, all equipment proposed for the project shall be currently installed and working satisfactorily locally. The Contractor must be able to provide references of at least three satisfied Owners and Consultant with equipment of the particular size and model proposed.

SECTION 5

DUCTWORK AND AIRSIDE EQUIPMENT

1.0 DUCTWORK MATERIAL.

1.1 Make all ductwork, unless specifically noted otherwise, of galvanized sheet steel conforming to ASTM A 525 or ASTM A 527, galvanized steel sheet, lock-forming quality, having zinc coating of 12.25 ounces per square foot for each side in conformance with ASTM A 90. The galvanizing shall be carefully done and the sheets shall be of such quality that they may be bent flat on themselves with no fracture to the coating or the base metal. All duct work, dampers and accessories shall be fabricated out of galvanized steel sheet manufactured to ISS: 277:2003. Duct shall be installed in a workman like manner, conforming to IS: 655-1963

All supports, stiffeners, flanges etc. used in ductwork construction and installation shall be hot dip galvanized. Ductwork guarantee shall cover workmanship, noise, chatter, whistling or vibration. Ductwork shall be free from pulsation under all conditions of operation.

2.0 DUCTWORK SPECIFICATION.

2.1 Ductwork fabrication / sheet metal ductwork material and installation shall comply with the latest edition of SMACNA Low Pressure Duct Construction Standards. Medium pressure round/oval double wall sheet metal ductwork shall comply with the latest edition of SMACNA High Pressure Duct Construction Standards. All air distribution devices (such as dampers) included in this specification shall comply with the latest applicable SMACNA manual and hanging methods shall be as described in the latest edition, and/or current edition of applicable manuals published by the Sheet Metal and Air Conditioning Contractors National Association Inc. (SMACNA), where methods described in these volumes are not at variance with the requirements of any authority having jurisdiction, or do not conflict with methods described hereafter.

2.2 DEFINITIONS

A. Duct Size. The ducts sizes shown are inside clear dimension and do not include proper allowances for 1-inch acoustical lining, if required, and/or unless otherwise indicated.

B. Low Pressure Systems. Less than 3-inches w.g. to +3-inches w.g. positive static pressure and velocity less than 2500 fpm.

C. Medium Pressure System. 3 inches through 6 inches w.g. positive static pressure and velocities greater than 2000 fpm. (10.2 m/sec).

3.0 DUCTWORK GENERAL.

1.30 All dimensions shall be checked on site before ductwork manufacture is commenced.

1.31 Submit ductwork shop drawings and product data. Indicate duct fittings, particulars such as gages, sizes, weld and configuration prior to start of work for low, medium and high pressure and exhaust systems.

1.32 Erect all ducts in the general locations shown on the drawing(s), but conform to all structural and finish conditions of the building. Before fabricating any ductwork, Contractor shall check the physical
conditions at the job site and make all necessary changes in cross sections, offsets and similar items, whether they are specifically indicated on drawings or not. Contractor to coordinate with all other services while installation of the ducting.

3.2. The whole of the ductwork installation shall be carried out by an approved specialist in ductwork manufacture and installation. No ductwork shall touch the building structure or building finishes direct, but shall be isolated with insulating spacer.

3.3. The fabrication shall be carried out in a neat and workmanlike manner with all ductwork true in size and cross-section, braced and stiffened as specified and with all internal and external surfaces free from projections and sharp edges.

3.4. At each main branch in ductwork and at each fan discharge and suction, provide sufficient number of Pitot tube test holes for balancing systems. Also provide test holes for traverse fan discharge and at all equipments. Test holes shall be located within easy reach of catwalks or ladder. Each test hole shall have 20 mm clear opening, provided with a metal ring plate with a threaded hole in the boss, and matching screwed head plug. Where these plugs are installed in insulated ductwork, provide an extension collar against which the insulation can be finished.

3.5. Ductwork shall be rigidly suspended or supported from building structure. Expansion type concrete inserts shall be placed so that the fastener is in shear rather than tension. Provide necessary steel angle iron required for bracing of ductwork or equipment, and for supporting ductwork from building structure. All supports shall be hot dip galvanized.

3.6. Increase in duct size shall be gradual. Where width or largest dimension of a duct is over 450 mm, duct shall be stiffened by bending in a break across corners in both directions. Ducts shall be self-supporting and complete in themselves. Visible internal portions of duct outlets to grilles and registers shall be painted in dull black.

3.7. All necessary allowances and provisions shall be made in the installation of the ducts for the structural framing of the building and when changes or offsets are necessary, the required cross-sectional areas shall be maintained. All of these changes however, shall be approved, and installed as directed at the time.

3.8. During installation the open ends of ducts shall be protected with blank, flanged sheet metal baffles, securely attached to prevent debris and dirt from entering.

3.9. Where ducts are shown connecting to masonry openings and/or along the edges of all plenums at floors, walls, etc., provide a continuous 30 x 30 x 4 mm galvanized angle iron which shall be bolted to the structure and made airtight to same by applying caulking compound on the angles before they are drawn down tight. The sheet metal at these locations shall be bolted to the angle iron framing.

3.10. All air ducts, casings, plenums etc., shall be constructed of lock forming quality prime galvanized steel sheets, which are free from blisters, slivers, pits, imperfectly coated spots etc. No second quality sheet metal allowed.

Where damage (or rusting) has occurred on galvanized duct work the affected section shall be made good by painting with two coats of zinc-rich paint and approved finishing paint, or where the damage in the Consultant's opinion cannot be made good, then a new section of ductwork shall be provided at no cost to the contract.

3.11. Duct shall be constructed using double or Pittsburgh lock corner seams. All seams shall be hammered down and made airtight by applying sealant before hammering down.

3.12. Support the vertical ducts installed in the various shafts at each floor level with galvanized supporting irons of approved size. Install these angles across the width of the shaft, with their ends attached to angle irons securely anchored into the masonry walls of the shaft, or attached to the framing of the floor openings. The ducts shall be bolted to these supporting angle irons.

3.13. Ensure that all openings required through floors, walls, partitions etc., for the duct system are provided in the exact location required.
3.14 Each piece of ductwork shall be wiped inside and out before installation and all open ends shall be capped and sealed to prevent entrance of dirt during construction. Ensure that ductwork systems are clean and free from dirt, dust, grime, debris etc., before initial operation of fans. Fans shall not be operated until the filters are installed and approval from the Consultant has been obtained.

3.15 All dusts shall be rigid and shall be adequately supported and braced where required with standing seams, tees or angles of ample size to keep the ducts true to shape and to prevent buckling, vibration or breathing.

4.0 LOW PRESSURE DUCTWORK.

4.1 This applies to ductwork with mean velocities less than 2,000 fpm (10 M/Sec) and static pressures of 2 inches water gauge, (500 pascals) or less.

4.2 Rectangular low-pressure ductwork shall be fabricated from prime quality, re-squared, tight coat galvanized steel sheets of the following gauges.

<table>
<thead>
<tr>
<th>Size of Duct (Milli metres)</th>
<th>Thickness GI Sheet Metal</th>
<th>Bracing</th>
</tr>
</thead>
<tbody>
<tr>
<td>400 mm less in width/depth</td>
<td>0.63 mm</td>
<td>None</td>
</tr>
<tr>
<td>400 to 750 mm width/depth</td>
<td>0.63 mm</td>
<td>25x25x3mm angles</td>
</tr>
<tr>
<td>751 to 904 mm width/depth</td>
<td>0.80 mm</td>
<td>25x25x3 &amp; 40x40x3mm</td>
</tr>
<tr>
<td>905 to 1525 mm width/depth</td>
<td>0.80 mm</td>
<td>38x38x3.2mm diagonal angles</td>
</tr>
<tr>
<td>1525 to 2250 mm</td>
<td>1.00 mm</td>
<td>38x38x3.2mm diagonal angles</td>
</tr>
<tr>
<td>2250 mm and over</td>
<td>1.25 mm</td>
<td>40x40x3mm diagonal angles</td>
</tr>
</tbody>
</table>

4.3 Low pressure suction and discharge plenum chambers shall be fabricated from 1.25 mm (18 gauge) galvanized steel with galvanized angle iron framework and bracing.

4.4 Construct tees, bends and elbows with radius of not less than 1-1/2 times the width of duct on centerline. Rectangular 90-degree elbows shall be constructed with double-wall, airfoil, and galvanized sheet metal turning vanes. The turning vanes shall be fabricated in accordance with SMACNA HVAC Duct Construction Standards. Same applies to square elbows. Vanes shall be tack welded to vane rail. For vane lengths over 1000 mm, tack焊 vanes to 10 mm tie-rod at mid-span.

4.4 Increase duct sizes gradually, not exceeding 15 degrees divergence wherever possible. Divergence upstream of equipment shall not exceed 30 degrees; convergence downstream shall not exceed 45 degrees.

5.0 ACCESS PANELS

1. Duct access panels shall be minimum 450 x 300 mm size. unless restricted by duct dimensions. All access panels shall be constructed from galvanized steel sheets, with necessary reinforcing inside for rigidity, with space filled with glass fiber insulation. Panels shall be made airtight with a continuous neoprene rubber gasket.

5.2 Apparatus access doors shall be minimum 600 x 1500 mm with angle or channel frame. Provide two 75 mm strap hinges with brass pins; and two handles minimum, operable from inside and outside. All access panels shall be constructed from double thickness 18 gauge (1.3 mm) galvanized steel, with 25 mm insulation between sides with necessary reinforcing for rigidity.

5.3 Provide access panels where shown, required and directed and in the following locations:
- Bottom of all duct risers.
- Next to outside air intakes and outlets.
- At each fire damper.
- Into apparatus casings to facilitate maintenance and cleaning of all components.

6.0 BALANCING DAMPERS. (VCD)

6.1 Install volume control dampers in accessible locations at all branch connections and wherever necessary to adjust the flow of air to secure correct distribution. Casing and blades shall be made of galvanized sheet metal, and shall be equipped with an approved device for fastening in any desired position. This device shall be such that the damper cannot move or rattle and pointer shall indicate the position of the damper from the outside of the finished duct insulation.

6.2 Volume control dampers of 1.2mm thick GSS blades, extended linkage rods for motorized operation, channels, flanges suitable for duct mounting and with a manual operating handle. Dampers shall be aerofoil multileaf opposed blade with blade height not more than 180 mm.

6.3 All blades shall be operated by a single operating with suitable link, livers and quadrant with gears and links as necessary. For their proper operating, control or setting devices shall be made robust, easy to operate and accessible.

6.4 The whole damper assembly shall be mounted in a galvanized frame with flanges.

6.5 Dampers shall be UL listed or certified by an equal regulatory authority.

7.0 VIBRATION ISOLATION (For all sections)

7.1 All plant and equipment shall be isolated from the building structure in such a manner that noise and vibration is not transmitted through the structure.

Anti-vibration equipment will be manufactured by a specialist company acceptable to the Consultant, and with standard ratings information available.

The following requirements are minimum requirements and must be confirmed by the specialist manufacturer's representative as being adequate for the particular equipment proposed by the Contractor.

7.2 In addition, Flexible connection shall be included at inlet and outlet to all items of equipment.

Flexible connections will be of full line size and will be flanged with gaskets and mating flanges.

Connectors shall be twin sphere manufactured with multiple ply's of nylon tire cord fabric and neoprene in hydraulic rubber presses and vulcanized.

8.0 DIFFUSERS AND REGISTERS

8.1 Supply and return air diffusers shall be shown on the drawing and indicated in schedule of quantities. Supply air Registers and diffusers to be of high quality Extruded Aluminum profiles, double deflection aerofoil blades with Aluminum profile with 20mm min spacing, nylon bushing and the damper frames and blades shall be high quality extruded Aluminum profile with natural aluminum finish. The supply air diffuser shall be provided with removal key operative volume control dampers. Diffusers, registers and grilles shall be arranged for flush mounting in lay-in type ceilings and over lap mounting in plaster, mineral tile and similar ceilings, with concealed fixings unless otherwise directed.

8.2 Grills shall be extruded aluminum construction. Grilles, register and diffuser locations shall be adjusted to suit reflected ceiling drawings, or Consultant's site instructions. All grilles, registers, diffusers, louvers shall be from one manufacturer.

8.3 Provide plaster frame for grilles, and diffusers installed in plaster ceilings.

8.4 All diffusers, grilles and registers shall be supplied completely factory powder coated. Finish colour shall be to the approval of the Architect. The interior of all grilles and diffusers is to be factory painted matt black.

8.5 All supply grilles and diffusers will have opposed blade-balancing dampers. All will have foam rubber sealing band around the edge to seal to the structure.
3.16 Unless otherwise specified basic grilles and diffuser materials shall be Aluminum extruded sections. Sections in the airstreams shall be carefully selected to minimize turbulence.

8.7 All grilles and diffusers supplied on this project shall be tested and rated in accordance with ASHRAE Standard 70-72, ADC Test Code 1062-GRD and ISO 3741.

8.8 Ceiling Diffusers shall be multicone giving 4 way horizontal discharge

The three centre cones of the diffuser shall be manufactured from pressed aluminum, with the remaining cones and the outer frame fabricated from extruded aluminum welded at the corners to give near invisible joints.

4 way pattern cores shall be used as indicated on schedules. All cores shall be interchangeable.

The core shall be removable without the use of special tools, but for safety, shall be fixed to the outer frame by a small length of chain.

The diffuser shall be complete with an opposed blade damper painted matt black.

Wherever the air volume of supply / return air diffuser is not in proportion with the Standard size of the diffuser the overall size shall remain suitable for the longer airflow rate during the fabrication of diffusers. For lesser flow rate internal core / cores shall be blocked to achieve the require airflow with adequate throw and specified noise levels.

All such alterations shall be carried out by the manufacturer in the factory in such a way that specified air volume is maintained all the time without effecting the required throw for that particular diffuser. Noise levels shall not exceed specified limits in any case.

In general, sizes and air volume of all diffusers as shown on design drawings shall be maintained by achieving required throw and specified noise levels without effecting uniform air diffusion pattern.

Where a 4-way throw diffusers are installed very close to wall or obstruction, the diffuser shall be 4 ways, but with internally blocked in the area of obstruction.

9.0 SAND TRAP LOUVER FOR AIR INTAKE

9.1 Sand trap louvers shall have a double deflection inlet passage to separate sand from incoming air by means of centrifugal forces.

9.2 Separation efficiency particle size 350-700 shall not be less than 90% at a face velocity of 1M/Sec and not less than 70% at a face velocity of 2M/sec.

9.3 Sand trap louver shall be of aluminum construction, self-cleaning and maintenance free. The base of the louver shall have self-emptying sand holes.

9.4 Pressure drop at 2 M/Sec average face velocity shall not exceed 120 pascals.

9.5 Insect mesh shall be included.

9.6 Sand louvres shall be provided with powder-coated finish to the approval of the Architect.

10.0 FILTERS

10.1 Pre filters

Filter Media shall be of the non-woven cotton fabric type. The filter media shall have an average efficiency of 25-30% on ASHRAE Test Standard 52-76. It shall have an average arrestance of 90-92% in accordance with that test standard.

Media support Grid shall be a welded wire grid with an effective open area of not less than 96%. The welded wire grid shall be bonded to the filter media to eliminate the possibility of media oscillation and
The media support grid shall be formed in such a manner that it affects a radial pleat design, allowing total use of filter media.

Enclosing frame shall be constructed of a rigid, heavy duty, high wet strength beverage board, with diagonal support members bonded to the air entering and air exiting side of each pleat, to ensure pleat stability. The inside periphery of the enclosing frame shall be bonded to the filter pack, thus, eliminating the possibility of air bypass.

11.0 SUBMISSIONS

11.1 Technical Submissions

For any minor revisions in architectural layouts, contractor shall be responsible to carry out part redesign for such area and submit necessary calculations for Engineer's approval before proceeding with the shop drawings.

11.2 The Contractor will prepare full shop drawings, including sections, of distribution systems and equipment.

11.3 Hardware Submissions.

The Contractor will submit catalogue information for all distribution equipment including, but not limited to:
- Ductwork - Low pressure.
- Flexible ductwork - Low pressure
- Flexible connections.
- Access panels.
- Balancing dampers.
- Vibration isolators.
- Diffusers, grilles and registers.
- Louvers, Sand louvers.
- Filters.

11.4 The Contractor will submit samples for any or all of the above as requested by the Consultant after receipt of the catalogues.

11.5 Samples will definitely be required of these items, which are exposed, such as diffusers, grilles and louvers. The samples must be of size, specification and finish to be relevant to the project.

9.7.2 Where a Country of Origin is given, this refers to the Head Office in the case of International Corporations. However, for each product not manufactured in that Country, separate approval must be obtained from the Consultant/Client.

12. EXECUTION

12.01 INSTALLATION - SHEET METAL DUCTWORK: Duct shall be installed generally as per the drawing and in strict accordance with approved shop drawings to be approved by the contractor.

A. Construction Standards. Use construction methods, which follow the requirements outlined in SMACNA Balancing and Adjusting publications, unless indicated otherwise in these specifications or accompanying drawings.

1. Reinforcement. Reinforce ducts having one side equal to 25 inches or more in accordance with recommended construction practice of SMACNA.

2. Plenum Construction. Construct single-wall and 2" (thick insulation double-wall) plenum chambers of 18G sheet metal reinforced with galvanized structural angles.
3. **Cross Breaking or Beading.** Cross break or bead sheet metal for rigidity, except ducts which are 12 inches or less in the longest dimension.

4. **Wall Penetrations.** Where ducts pass through walls in exposed areas, install suitable escutcheons made of sheet metal angles as closers. Support ducts where passing through floors with steel structural angles of adequate bearing surface, galvanized after fabrication and resting on top of the sleeve.

5. **Interior Painting.** Paint flat black, the interior of metal ductwork exposed to view through grilles, registers, and other openings. Do not install grilles, registers, or similar items until painting is complete.

6. **Ductwork Openings.** Provide openings in ductwork where required to accommodate thermometers and controllers. Provide pilot tube openings where required for testing of systems, complete with metal can with spring device or screw to ensure against air leakage. Where openings are provided in insulated ductwork, install insulation material inside a metal ring.

   (i) **Ductwork Location.** Locate ducts with sufficient space around equipment to allow normal operating and maintenance activities.

   (ii) **Sealant.** The entire duct system shall be sealed. Nonhardening, water resistant, fire resistive, compatible with mating materials; liquid used along or with tape, or heavy mastic. Duct shall be thoroughly cleaned prior to application of sealant. All transverse joints, longitudinal seams and duct wall penetrations shall be sealed. All ductwork shall be sealed as per seal Class A irrespective of the duct pressure classifications.

   (iii) **Hangar Rod.** Galvanized steel, threaded continuously. (Refer Table)

   (iv) **Duct shall be straight be smooth on the inside neatly finished joints. All joints shall be made airtight.**

   (v) **Change in dimension and shape of ducts shall be gradual, cuved elbows, unless otherwise indicated, shall have a centerline radius equal to one and a half times the width of the duct. Air turns shall be installed in all vanes, arranges to permit the air to make the turn without appreciable turbulence. Suitable vanes shall be provided in duct collar to have uniform/proper air distribution.**

   (vi) **Duct shall be fabricated as per details shown on drawing. All ducts shall be rigid and shall be adequately supported and braced where required with standing seams, tees or angles of sample size to keep the ducts true shape and prevent hulking, vibration or breathing.**

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### 12.02 LOW PRESSURE DUCTWORK

1. **Construction.** Construct rectangular ducts in accordance with the SMACNA Duct Manual.

2. **Controls.** For control devices concealed by ceilings, furring, or in other inaccessible locations, furnish extension rods and appropriate recessed-type regulators, mounted on the surface of the ceiling or the furring, unless specified, or shown otherwise. For ducts which are not concealed, or ducts that are above lay-in ceiling but accessible, provide heavy-duty, quadrant-type, adjustable regulators having wing nuts for locking in position. Saw-mark the ends of all operating rods for dampers and air control devices to indicate damper position.

3. **Obstruction.** Install streamlines deflectors at any point where dividing a sheet metal duct around piping or where other such obstruction is permitted. Where such obstructions occur in insulated ducts, fill space inside streamliner and around obstructions with glass fiber insulation.

4. **Low Pressure Duct Supports.**

   Horizontal Ducts Up to 40 Inch. Support horizontal ducts up to and including 40 inches in their greater dimension by means of No. 18 U.S. gage band iron hangers attached to the ducts by means of screws, rivets or clamps, and fastened to inserts with toggle bolts, beam clamps or other approved means. Place supports on at least 8'-0" centers. Use clamps to fasten hangers to reinforcing on sealed ducts.

   Horizontal Ducts Larger Than 40 Inch. Support horizontal ducts larger than 40 inches in their greatest dimension by means of hanger rods bolted to angle iron trapeze hangers. Use double nuts and lock washers on threaded rod supports. Place supports on at least 8'-0" centers according to the following:
Angle Length | Angle | Rod Diameter
---|---|---
4'-0" | 1-1/2"x1-1/2"x1/8" | 1/4"
6'-0" | 1-1/2"x1-1/2"x1/8" | 1/4"
8'-0" | 2"x2"x3/16" | 5/16"
10'-0" | 2 1/2"x2 1/2"x 3/16" | 3/8"

Vertical Ducts. Support vertical ducts where they pass through the floor lines with 1-1/2" x 1-1/2" x 1/4" angles for ducts up to 60 inches. Above 60 inches, the angles must be increased in strength and sized on an individual basis considering space requirements.

7. MEDIUM PRESSURE DUCT SUPPORT SCHEDULE:

All horizontal rectangular ducts shall have duct hanger requirements as follows:

Minimum Hanger Size

Max. Duct Dimen. | Steel Rod | Galv. Steel Strap Width | Max. Spacing | Min.# Hngrs | Trapeze Size
---|---|---|---|---|---
0 thru 18" | -- | 1" x 16 ga. | 10’ | 2 | --
19" thru 36" | -- | 1" x 16 ga. | 10’ | 2 | --
37" thru 60" | 3/8" | 1" x 16 ga. | 8’ | 2 | 2" x 2" x 1/4"
61" thru 120" | 3/8" | 1-1/2" x 12 ga. | 8’ | 2 | 2" x 2" x 1/4"
121" thru 240" | 3/8" | 3/8"---4' | 3 | 2-1/2" x 2-1/2" x 3/16"

8. DUCT HANGERS - GENERAL NOTES (all pressures)

Hanger straps on duct width of 60 inches and under shall lap under the duct a minimum of 1 inch and have minimum of one fastening screw on the bottom and two on the side.

Hanger straps on duct widths over 60 inches shall be bolted to duct reinforcing with 3/8" bolts minimum.

Use 3/8" minimum bolts for securing duct hanger to band straps.

12.03 OPENING IN DUCTWORK

Provide opening in ductwork where required to accommodate thermometers and controllers. Provide pilot tube openings where required for testing of systems, complete with metal can with spring device or screw to ensure against air leakage. Where openings are provided in insulated ductwork, install insulation material inside a metal ring.

12.04 FLASHING

Where ducts pass through roofs or exterior walls, provide suitable flashing to prevent rain or air currents from entering the building. Provide flashing not less than No. 26 gage stainless steel or 16-ounce (450 g) copper.

12.05 DUCT LINING (LOW PRESSURE - RECTANGULAR)

Install glass fiber acoustical lining in all rectangular (except exhaust) ductwork shown on drawings. Provide Armaduct / Viodoflex / Phenotherm Eqvt acoustic lining inside the ducts upto the initial 3 – 5 m of the supply ducts for air conditioning applications. Secure to duct surfaces with Foster 85-22 adhesive and sheet metal fasteners on 12-inch centers. Omit lining as necessary to permit satisfactory operation of air control devices. Coat all exposed edges and leading edges of cross joints with adhesive. Insulation shall not breed or promote fungi or bacteria, shall resist mold growth, shall not rot or sustain vermin.
12.06 TESTS
Allowable Leakage. Test ductwork for leaks before concealing. Maximum allowable leakage is 5 percent of total flow.
Equipment. Provide equipment necessary for performing tests, including rotary blower, orifice section and U-tube gage board complete with cocks and rubber tubing.
Risers and Branch. Test duct riser or branch duct including flexible duct runouts in accordance with SMACNA manual.
Mains: Test mains after risers and branches are tied in and all equipment set. Close runout connections and place fan in operation. Provide pressure in mains above design pressure. Visually inspect joints. Repair leaks detected by sound or touch. Release mains for completion after joints are tight.

12.07 ADJUSTING AND CLEANING
Clean duct system and force air at high velocity through duct to remove accumulated dust. To obtain sufficient air, clean half the system at a time. Protect equipment which may be harmed by excessive dirt with temporary filters, or bypass during cleaning.

SECTION 6
FIRE DAMPER

A. Combination Fire/Smoke Dampers

1. Furnish and install where shown on the Drawings, or as required by the Specifications or BOQ combination fire/smoke dampers meeting the following requirements.

2. Each combination fire/smoke damper shall be 1 1/2 hour fire rated under UL Standard 555, 4th Edition, and shall be further classified by Underwriters Laboratories as a Leakage Rated Damper for use in smoke control systems under the latest version of ANS-UL 555. The damper manufacturer shall have tested as per UL, a complete range of damper sizes covering all dampers required by this Specification. The leakage rating under UL555S shall be no higher than Leakage Class I (4 cfm per square foot at one inch water gage pressure and 8 cfm per square foot at 4 inches water gage pressure). The maximum air pressure drop through each combination fire/smoke damper shall not exceed 0.10 inch water gage at the design air quantity. (Note that this may require a larger damper than the connected duct size.)

3. The damper frame shall be a minimum of 20 gauge galvanized steel formed into a structural hat channel shape with tabbed corners for reinforcement, as approved in testing by Underwriters Laboratories. Bearings shall be integral high surface area non electrolytic materials construction to incorporate a friction free frame blade lap seal, or molybdenum disulfide impregnated stainless steel or bronze oilite sleeve type turning in an extruded hole in the frame or an extruded frame raceway. The dampers may be either parallel or opposed blade type. The blades shall be constructed with a minimum of 14 gauge equivalent thicknesses. The blade edge seal material shall be able to withstand 450 degrees F. The jam seals shall be flexible stainless steel compression type or lap seal type.

4. In addition to the leakage ratings specified herein, the combination fire/smoke dampers and their operators shall be qualified under UL555S to an elevated temperature of 250 degrees F. Electric operators shall be installed by the damper manufacturer at the time of damper fabrication. The damper and operator shall be supplied as a single entity, which meets all applicable UL555 and UL555S qualifications for both dampers and operators. The manufacturer shall provide a factory assembled sleeve. The sleeve shall be a minimum of either 20 gauge for dampers where neither width nor height exceeds 48 inches or 16 gauge where either dimension equals or exceeds 48 inches.

5. As part of the UL qualification, dampers shall have demonstrated a capacity to operate (open and close) under HVAC system operation conditions, with pressures of at least 4 inches water gage in the closed position, and 2500 fpm air velocity in the open position.

6. Each combination fire/smoke damper shall be equipped with a UL Classified Firestat/releasing device. The firestat/releasing device shall electrically and mechanically lock the damper in a closed position when the duct temperatures exceed 165 degrees F and still allow the appropriate authority to operate the damper as may be required for smoke control functions. The damper must be operable while the temperature is above 250 degrees F. The actuator/operator package shall include two damper position indicator switches linked directly to damper blade to provide capability of remotely indicating damper position. One switch shall close when the damper is fully open, and the other switch shall close when the damper is fully closed. The Firestat/releasing device and position indicator switches shall be capable of interfacing electrically with the smoke detectors, building fire alarm systems, and remote indicating/control stations.
7. The damper releasing device shall be mounted within the airstream. The device shall be activated and the damper shall close and lock when subjected to duct temperatures in excess of approximately 285 degrees F.

8. Motors for operation of smoke dampers shall be smoke system fail safe, spring return normally open supplies and normally closed returns, or as indicated in the plans, and shall be furnished and installed by the damper manufacturer as required by the U.L. rating mentioned above. Motors shall be electric or pneumatic to match the type of temperature control system specified elsewhere in this specification. All required relays, EP switches, wiring piping and other labor and material necessary to completely interconnect the smoke detector system shall be furnished by the Contractor.

9. Each damper shall be furnished in a square or rectangular configuration. The Contractor shall furnish and install sleeves manufactured by the approved damper manufacturer for each damper. The sleeves shall be constructed with square or rectangular to square, rectangular, round, or oval adapters as required. Dampers shall be installed in the sleeves in accordance with manufacturers U.L. installation instructions. The entire assembly, following installation, shall be capable of withstanding 6” W.G. static pressure.

10. All combination fire/smoke dampers shall comply with the specification as written above and shall be of Caryaire / Air master / George Rao make.

C. Submittal and Installation

1. The air quantity and free area through each fire and combination fire and smoke damper has been noted on the drawing adjacent to the duct size or wall opening size where such damper is required.

2. Submittal(s) for fire and combination fire/smoke dampers shall include the following:
   a. Assign identification numbers for each damper with corresponding number noted on the drawings.
   b. Provide air quantity, size, free area of damper, pressure drop and proposed velocity through each damper.
   c. Provide manufacturer's data of damper and its accessories or options.

3. One sample 18” x 12” damper shall be furnished for the purpose of illustrating damper operation to the owner’s operating and maintenance personnel.

4. Access doors as specified elsewhere shall be provided to make all parts of the damper accessible. Doors shall open not less than 90 degrees following installation and shall be insulated type where installed in insulated ducts.

5. Contractor shall install each damper square and true to the building. The installation shall not place pressure on the damper frame, but shall enclose the damper as required by UL555.

6. After each combination fire and smoke damper has been installed and sealed in their prescribed openings and prior to the installation of the ceilings, the Contractor shall, as directed by the Construction Inspector, activate part or all the dampers as required to verify “first-time” closure. Activation of the damper shall be accomplished by manually operating the resettable link, disconnecting the linkage at the fusible link of the fire damper, and manually operating the fire/smoke damper through the pneumatic or electronic...
controls as appropriate. Failure of the damper to close properly and smoothly on the first attempt will be cause to replace the entire damper assembly.

SECTION 7

DUCT INSULATION

1.0 INSULATION GENERAL.

1.1 The whole of the insulation work shall be carried out by an approved specialist insulation Contractor.

1.2 All allowances shall be included for informing the specialist contractor of all details of the building structure, programme arrangements, and other relevant details at the time of tender and for all necessary visits to site by the contractor or his workers.

1.3 The insulation material shall be elastomeric closed cell self adhesive nitrile rubber insulation (ARMAFLEX / KFLEX/SUPREME) with the following properties:

12 Density – 40 Kg / cum
13 Temperature Range: – 60 deg C to 105 Deg C
14 Ozone friendly ; no cracking; ASTM D 1171
15 Color : Grey / Black
16 Reaction to fire: Self Extinguishing
18 Health Resistance: Dust and Fibre free
19 Thermal conductivity ( ) ASTM C 177
- Not greater than 0.036 W / mK at a mean temperature of 10º C
20 Vapour permeability
- 1.56 10-10 Kg/(m.hr.pa)
21 Fire rating
- Class 1 self extinguishing type

1.4 All material delivered to site shall be new and fully dried out and so maintained throughout the progress of the works.

All insulating materials shall be stored in storage sheds, and in accordance with the Manufacturer's recommendations.

1.5 In order to ensure that the insulation applied is in all respects in accordance with the specification, sections shall, as required by the Consultant, be cut from the finished insulation. If, however, defects are revealed, further sections shall be cut out for inspection, and all cutout sections shall be replaced at no cost to the Contract.

If further defects are revealed then the Consultant/Client shall have the right, when in his opinion it is necessary, to issue instructions for any part or the whole of the insulation to be removed and replaced. The replacement with new insulation shall be to the satisfaction of the Consultant and the cutting out and replacing shall be at no cost to the Contract.

1.6 Particular attention shall be paid to the finished appearance of all thermal insulation which must present a neat and symmetrical appearance running true in line with pipe layouts, etc.

1.7 Any rough, irregular and badly finished surfaces shall be stripped down and re-insulated to the Consultant's/Client satisfaction.

1.8 All systems are to have been tested and approved by the Consultant/Client prior to installation of
2.0 CONCEALED COLD AIR DUCTS.

2.1 Unless otherwise indicated insulate all ductwork (supply return, fresh air and extract) with 19mm thick elastomeric closed cell self-adhesive nitrile rubber insulation sheets. Cover the sections with vapour barrier of polythene sheet with minimum overlap of 75mm near the joints.

The insulation material to confirm to ASTM E 84.

3.0 EXPOSED COLD AIR DUCTS.

For ducts exposed in non air conditioned areas, insulate using the method described for concealed ducts, but using insulation with a minimum thickness of 40mm, elastomeric closed cell self adhesive nitrile rubber insulation Armaflex / Kflex . And the finishes to be as mentioned in clause 2.1. Finally cover with 24 guage aluminium sheet cladding.

Where ducts penetrate the building shell, the duct shall be flashed and waterproofed before any insulation is applied.

4.0 Condensate Drain Pipes and exposed cold water pipes on roof:

The pipework shall be insulated with 9mm thick elastomeric closed cell self-adhesive nitrile rubber.

5.0 LAGGING ADHESIVE

5.1 Adhesive shall be a flexible, fire resistive compound suitable for vapour sealing insulated ducts and pipes.

5.2 Adhesive shall be suitable for indoor and outdoor use and in high humidity environments.

6.0 ACOUSTIC INSULATION

6.1 All low-pressure ductwork shall be lined with acoustic insulation up to the first take off point, or 5 meters from the AHU outlet whichever is greater.

6.2 Duct acoustic lining shall be 9 mm thick, fiberglass, and 24 Kg/cum density with a thermal conductivity of 0.035 Watts/ M/ deg C with approved coating on inside.

6.3 Liner will be attached by a fire resistant adhesive such as Benjamin Foster 81-99, or equivalent. In addition mechanical fasteners shall be used on 400 mm centres on top and side sections. These fasteners must be spot-welded to the inside of the duct and must not perforate the duct. The insulation material shall be covered with 24 G perforated aluminium sheet.

7.0 ALUMINIUM CLADDING – FOR EXPOSED SURFACES

7.1 Aluminium cladding shall be provided to ducts with neat 90 degree joints and finish. Material shall be with stone finish.

7.2 In pipework the longitudinal joints shall be cleated or held in position with stainless steel bands and clips. Elbows and other fittings shall be made with mitred section and riveted. All valves strainers, flexible connection etc. shall have easy removable boxes with stainless steel aluminium toggle clips.

7.3 In ductwork the joints shall be riveted or banded with stainless steel band and clips to avoid sagging. Boxes to be made around duct traverse joints.

7.4 All gaps shall be to a minimum and shall be sealed with silicon mastic suitable for outdoor.

8.0 SAMPLES

8.1 Submit samples of all types of insulation for approval.
8.2 Submit with samples, the full technical brochures.

8.3 Where the specification calls for additional treatments, such as wrapping and waterproofing, submit also a completed sample of similar size.

1. All samples after approval are to be retained on site to be a reference for future work.

REFERENCES

A. ASTM B209 - Aluminum and Aluminum-Alloy Sheet and Plate.
C. ASTM C553 - Mineral Fiber Blanket and Felt Insulation.
D. ASTM C612 - Mineral Fiber Block and Board Thermal Insulation.
E. ASTM E84 - Surface Burning Characteristics of Building Materials.
H. SMACNA - HVAC Duct Construction Standards - Metal and Flexible.
I. UL 723 - Surface Burning Characteristics of Building Materials.

SUBMITTALS

A. Product Data: Provide product description, list of materials and thickness for each service, and locations.
C. Samples: Submit two samples of any representative size illustrating each insulation type.
D. Manufacturer's Installation Instructions: Indicate procedures, which ensure acceptable workmanship and installation standards will be achieved.

QUALITY ASSURANCE

A. Materials: Flame spread/smoke developed rating of 25/50 in accordance with NFPA 255.

QUALIFICATIONS

A. Applicator: Company specializing in performing the work of this section with minimum three years experience.

DELIVERY, STORAGE, AND HANDLING

A. Deliver, store, protect and handle products to site in proper conditions as stated in Section 1.
B. Deliver materials to site in original factory packaging, labeled with manufacturer's density and thickness.
C. Store insulation in original wrapping and protect from weather and construction traffic.
D. Protect insulation against dirt, water, chemical, and mechanical damage.

ENVIRONMENTAL REQUIREMENTS

A. Maintain ambient temperatures and conditions required by manufacturers of adhesives, mastics, and insulation cements.
B. Maintain temperature during and after installation for minimum period of 24 hours.

**EXECUTION:**

**EXAMINATION**

A. Verify that ductwork has been tested before applying insulation materials.

B. Verify that surfaces are clean, foreign material removed, and dry.

**INSTALLATION**

Install materials in accordance with manufacturer's instructions.

All insulation shall be applied by mechanics skilled in this particular work and regularly engaged in such occupation. All insulation shall be applied in strict accordance with these Specifications and with factory printed recommendations on items not herein mentioned. Unsightly, inadequate, or sloppy work will not be acceptable, and all such work shall be removed and replaced as many times as necessary to achieve an acceptable installation.

All insulation, jacket, adhesives, mastics, sealers, etc., utilized in the fabrication of these systems shall meet NFPA for fire resistant ratings (maximum of 25 flame spread and 50 smoke developed ratings) and shall be approved by the insulation manufacturer for guaranteed performances when incorporated into their insulation system, unless a specific product is specified for a specific application, and is stated as an exception to this requirement. Certificates to this effect shall be submitted along with Contractor's submittal data for this section of the Specifications. No material may be used that, when tested by the ASTM E84-89 test method, is found to melt, drip or delaminate to such a degree that the continuity of the flame front is destroyed, thereby resulting in an artificially low flame spread rating.

All surfaces to be insulated shall be clean and dry before applying the insulation. All sections of duct/pipe covering shall be firmly butted together. Where an insulation covering is applied, it shall lap the adjoining section of insulation by at least three inches (3"). Where insulation terminates, it shall be neatly beveled and finished. No insulation shall be applied until the pipe, duct, etc., have been pressure tested and found tight. Piping, flexible connections, flanges, valves, strainers, and unions shall be covered unless specifically noted otherwise. Flexible connections on duct shall not be covered. All materials used shall be fire retardant or nonflammable. Refer to Section 15A.

Extreme care shall be taken in covering high and medium pressure (high and medium pressure ductwork shall be all ductwork between the fan discharge and all mixing boxes) ductwork to insure the duct is not pierced with sheet metal screws or other fasteners. All high and medium pressure ducts in these specifications are classified as high velocity ductwork.

Where specified, aluminum bands shall be used on piping insulation. The bands shall be applied three (3) to a section of pipe. Fittings, valves, etc., shall have bands on each side.

For purpose of definition in this Specification: "concealed" areas are those areas which cannot be seen by the building occupants, and "exposed" areas are all areas which are exposed to view by the building occupants, including under counter and inside cabinet areas, plus all mechanical rooms.

The handling and installation of all insulation materials shall be performed in strict accordance with the manufacturer’s recommendations.

**TOLERANCE**

Substituted insulation materials shall provide thermal resistance within 5-10 percent at normal conditions, as materials indicated.

**SECTION 8**

**MEASUREMENTS**

The following procedure for measurement shall be followed for purpose of billing in case of items subject to variation in quantities.
1.0 Ducting:

13.2 Payment for ducting shall be on the basis of the external surface area of the ducting including all material and labour for installed duct.

13.3 The rate per square meter of the external surface shall include all wastage flanges, flanges, gaskets for joints, bolts and nuts, duct supports and hangers, vibration isolation pads or suspenders, flexible connections, inspection doors, dampers, turning vanes, straightening vanes, and any other item which will be required to complete the duct installation except external insulation and finish thereon.

13.3.1 The external area shall be calculated by measuring the over all width and depth (including the corner joints) in the center of the duct section and over-all length of each duct section from flange face to flange face in case of duct lengths with uniform cross section. Total area will be arrived at by adding up the areas of all duct sections.

13.3.2 In case of taper pieces average width and depth will be worked out as follows

\[
\begin{align*}
W_1 &= \text{Width of small cross section} \\
W_2 &= \text{Width of large cross section} \\
D_1 &= \text{Depth of small cross section} \\
D_2 &= \text{Depth of large cross section} \\
\text{Average Width} &= \frac{W_1 + W_2}{2} \\
\text{Average Depth} &= \frac{D_1 + D_2}{2}
\end{align*}
\]

Width and depth in the case of taper pieces shall be measured at the edge of the collar of the flange for duct / sections fitted with angle iron flanges; otherwise at the bottom of the flange where the flanges are of GSS. Face to face length for taper piece shall be the mean of the lengths measured face to face from the center of width and depth flanges.

1.3.3 For Circular pieces the diameter of the section midway between large and small diameter shall be measured and adopted as the mean diameter for circulating the surface area off the taper piece. Duct measurement for calculation of area shall be taken before application of insulation.

1.3.4 For special pieces like bends, branches, and tees, etc., the same principal of area measurement as for linear lengths shall be adopted, except for bends and elbows, the length of which shall be the average of the lengths of inner and outer periphery along the curvature of angle of the piece.

11 Grill/Diffuser:

Payment for grill/diffuser shall be on the basis of internal (effective) surface area of the grill/diffuser including all material and labour for installed grill/diffuser. The rate per Sq. meter of surface shall include all flanges, gaskets, bolts and nuts etc. The internal area shall be calculated by measuring the liner width and depth of the grill.

12 Piping

Piping shall be measured in unit of length along the center line of installed pipe including all pipe fitting, flanges (with gasket and nut and bolts for jointing), union bends, elbows, tees, concentric and eccentric reducers, inspection pieces expansion loop etc. The above accessories shall be measured as part of piping length along the center line of installed pipes and no special rates for these accessories shall be permitted. The quoted rates for center line liner measurements of piping shall include all wastage, allowance, pipe supports including hanger, MS channel, vibration isolators suspension where specified or required.

13 Piping Insulation

Piping insulation shall be measured in unit length along the centerline of the installed pipe, strictly on the same basis as the piping measurements described above. The linear measurement shall be taken before the application of the insulation.
14 Duct insulation/Accoustic lining

This item is provided separately for various thickness and shall be paid for on an area basis of un-insulated duct. The area of the duct to be insulated shall be measured before application of insulation.

The Owners/Consultants shall have the right to reject all supplies, which do not conform to the samples so approved.

2.0 The insulation shall be applied as under:

(i) Clean the duct surface to be insulated free from dust, grease & other dirt.
(ii) Measure the size of the duct and cut the insulation sheet to the required size with a sharp knife and straight edge. Remove the sheet from the role and fix it to the duct and apply slight pressure so that it bonds well. Ensure that sheet is in desired position before the adhesive of the sheet makes contact with the sheet metal duct.
(iii) Seat the joints using black adhesive tapes as per recommendations of the manufacturer.

SECTION 9

CHILLED / CONDENSER WATER PIPEWORK

1.0 PIPEWORK MATERIAL GENERAL

1.1 All pipework shall be free from surface or general corrosion and without any signs of scaling, pitting or excess weathering. Any pipework so affected shall be replaced at no cost to the contract.

Each length of pipework shall have at least one coloured identification band or identifying mark, when delivered. All pipework shall be supplied in the manufacturer's straight random lengths.

All plain mild steel pipework shall be supplied self-coloured and externally varnished.

1.2 Chilled Water/Condenser/Hot water Service Pipework.

1.3 All pipework and fitting shall be ERW of MS Class “C” (heavy class) confirming to BIS 1239 and 3589. All the joints in the piping system shall be done by welding.

1.4 Condensate Drain Pipework.

All condensate drain piping shall be GI with Insulation and HDPE as mentioned in schedules.

1.5 All pipework, pipework fittings, jointing materials and gaskets shall be stacked in storage sheds in accordance with the manufacturer’s recommendations and as required elsewhere in this specification. The ends of all pipework shall be protected during transit and storage.

1.6.1 Metal pipework may be stacked in the open, provided that such stacks are, in the Consultant's opinion, adequately protected from weathering. The pipework shall be located in steel pipe racks and clear of the floor; the floor being formed from either creosoted timber sleepers or paving slabs.

1.6.2 All piping shall be black steel unless otherwise stated. Pipes shall be given one primary coat of re-oxide paint before being installed. Pipes shall be sloping towards drain points.

1.6.3 Fittings shall be new, fitting used on welded piping shall be malleable casting of pressure rating for the piping system. Fitting used on welded piping shall be of the weldable type. Supply of flanges shall be include bolts, washer gasket, etc as required.

1.6.4 All equipment and valve connections shall be through flanges (welded or screwed) for galvanized steel.

1.6.5 Sufficient number of flanges and union shall be provided.

2.0 PIPE INSTALLATION GENERAL

2.1 All pipework shall be arranged to set round piers and other obstructions and minor modifications shall be made as required by the Consultant to circumvent site difficulties.
2.2 Pipe shall be arranged to follow the contour of walls or beams or other building structure lines and all vertical pipework shall be plumb, without offsets and set as close as possible to any local projections consistent with maintaining adequate clearances for installation of wall plates or insulation.

2.3 Pipework shall be installed so as to give the following minimum clearances between the pipe (or pipe insulation where specified) and adjacent surfaces as follows:

<table>
<thead>
<tr>
<th>Surface Description</th>
<th>Clearance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Walls</td>
<td>25 mm</td>
</tr>
<tr>
<td>Ceilings</td>
<td>50 mm</td>
</tr>
<tr>
<td>Finished floors; either: above top of skirting or (if greater)</td>
<td>50 mm</td>
</tr>
<tr>
<td>Adjacent pipes, both insulated</td>
<td>25 mm</td>
</tr>
<tr>
<td>Adjacent pipes in trench, both insulated</td>
<td>100 mm</td>
</tr>
<tr>
<td>Adjacent pipes, both uninsulated</td>
<td>150 mm</td>
</tr>
<tr>
<td>Adjacent pipes, one insulated</td>
<td>75 mm</td>
</tr>
<tr>
<td>Insulated pipes to adjacent conduit or trunking</td>
<td>100 mm</td>
</tr>
<tr>
<td>Not in conduit or trunking</td>
<td>150 mm</td>
</tr>
</tbody>
</table>

Not withstanding the above minimum clearances, sufficient space shall be allowed to facilitate easy application of insulating materials. Pipes shall not be enclosed in a common insulating covering.

2.4 Pipework shall be graded to ensure adequate draining and venting. Draining and venting facilities as detailed in the particular specification for individual services shall be fitted at all low and high points respectively and wherever else necessary to ensure that all sections and subsidiary sections can be drained and that no air locks can form.

2.5 The Consultant/Client may at his discretion ask for the removal of installed pipework for examination. No extra payment will be made when such removal is called for.

If the pipework is found to have been installed in an unsatisfactory manner, then the complete installation shall be thoroughly inspected and all unsatisfactory sections shall be removed and re-fixed in a proper manner.

2.6 During constructional work on all pipework services, care shall be taken to prevent any foreign matter entering the pipework. All open ends shall be capped with the appropriate pipework fittings. Wooden plugs and the like shall not be used. Valves fitted on the ends of pipework shall not be accepted as a means of preventing the ingress of foreign materials.

2.7 Failure to comply with these requirements shall mean that the Consultant/Client shall have the right to instruct that pipework so left uncovered to be dismantled for such lengths as the Consultant requests, and the pipework blown through and/or cleaned at no cost to the contract.

2.8 All pipework fittings shall be installed in such a manner to ensure that air cannot be trapped and that pipework can be drained.

2.9 Where fittings are connected to light or medium weight pipework they shall be 'medium' quality, and where connected to heavyweight pipework they shall be 'heavy' quality.

2.10 All fittings, valves, cocks etc., shall be manufactured from materials guaranteed proof against de-zincification unless specifically stated otherwise elsewhere.

2.11 Reducers on all vertical pipework shall be concentric. In all other positions eccentric reducers shall be fitted in a manner to maintain a level bottom and ensure that fluids are not collected at that point in the system. Where it is not possible to fit eccentric reducers the Consultant's approval shall be obtained before fitting concentric reducers. Reductions in all cases shall be made by the use of factory made fittings.

2.12 All branches shall be made by easy sweep tees, twin elbows. Bends shall be used wherever possible. All sweep fittings and all sweep bends shall be of the long radius pattern except where the use of these fittings would stand pipework too far from wall surfaces and make for unsightly appearance, in which
case short sweep tees and elbows may be used provided that the Consultant's written approval is obtained beforehand.

1. PIPEWORK INSTALLATION.

3.1 Welded Joints.

Welding shall generally be in accordance with the relevant Section of the General Specification.

All steel elbows shall be of long radius pattern except where space conditions do not permit. The substitutions of short radius elbows must be approved by the Consultant.

3.2 Welding Piping:

3.2.1 The ends of pipe lengths to be welded shall be cut square by saw or cutter and the edges beveled to form a "V" groove before welding. Under no circumstances, shall gas cutting form the edges.

3.2.2 Weld metal is to be thoroughly fused with base metal at all sections. Welds shall be of sound metal, free from laps, slag inclusion or other defects.

3.2.3 All welders shall be certified by the Consultant/Client for the service for which they are employed and on which they work.

3.2.4 Wherever welded piping connections to equipment, valves, or other units need maintenance, servicing, or require possible removal, the connection joint shall be flanged. Pressure rating of the pipe flanges shall match the pressure rating of the flanges on the equipment to which the piping connects.

4.0 PIPEWORK SUPPORTS

4.1 All pipework shall be adequately supported. All support installations shall be in accordance with relevant British Standard Specifications and Codes of Practice, except where modified or extended by the contract documents.

4.2 Supports shall allow free movement for expansion or contraction of pipework and shall be located to ensure that pipework branches or fittings are not fouled by the support during expansion or contraction of the pipework service.

4.3 Double banking of pipework from a single support position will be permitted, provided the normal operating temperature of the fluids in the two pipes do not differ by more than 30 degrees C., but only where space restrictions prohibit individual support. Triple banking will not be permitted.

4.4 Where double banking is necessary, the larger of the two pipes shall be uppermost, and where pipes are the same size but manufactured from different materials, then the pipe having the material with the lowest coefficient of expansion shall be uppermost. Support intervals for double-banked pipework of different sizes shall relate to the smaller size.

4.5 Vertical rising pipes shall be supported at the base and the support shall withstand the total weight of the pipe and fluid contained.

4.6 Supports shall not be permitted which clamp the pipe so that it is in contact with building fabric or structure.

4.7 All supports shall be specifically designed for the outside diameter of the pipe concerned (including specified packings). Oversized brackets will be rejected.

4.8 All pipework shall be supported in accordance with the following table:-
<table>
<thead>
<tr>
<th>Pipe Size (mm)</th>
<th>Horizontal Piping (Meters)</th>
<th>Vertical Piping (Meters)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Steel</td>
<td>Copper</td>
</tr>
<tr>
<td>15</td>
<td>2.1</td>
<td>1.5</td>
</tr>
<tr>
<td>20</td>
<td>2.1</td>
<td>1.5</td>
</tr>
<tr>
<td>25-32</td>
<td>2.4</td>
<td>1.8</td>
</tr>
<tr>
<td>40</td>
<td>2.7</td>
<td>2.4</td>
</tr>
<tr>
<td>50</td>
<td>3.0</td>
<td>2.4</td>
</tr>
<tr>
<td>65</td>
<td>3.3</td>
<td>2.7</td>
</tr>
<tr>
<td>80</td>
<td>3.7</td>
<td>3.0</td>
</tr>
<tr>
<td>100-125</td>
<td>4.0</td>
<td>3.7</td>
</tr>
<tr>
<td>150</td>
<td>5.2</td>
<td>4.0</td>
</tr>
<tr>
<td>200</td>
<td>5.5</td>
<td>5.0</td>
</tr>
<tr>
<td>250</td>
<td>6.0</td>
<td>5.5</td>
</tr>
<tr>
<td>300</td>
<td>7.0</td>
<td>6.0</td>
</tr>
<tr>
<td>350</td>
<td>7.5</td>
<td></td>
</tr>
<tr>
<td>400</td>
<td>8.0</td>
<td></td>
</tr>
<tr>
<td>450</td>
<td>8.5</td>
<td></td>
</tr>
<tr>
<td>500</td>
<td>9.0</td>
<td></td>
</tr>
</tbody>
</table>

a) Spacing does not apply where span calculations are made or where concentrated loads are placed between supports, such as flanges, valves, specialties, etc.

b) All spacing length are in metre.

4.9 Vertical steel pipework shall be provided with pipe alignment as recommended by supplier and with pipe anchors at locations as agreed with the Engineer.

4.10 All chilled water pipe supports shall be galvanized.

4.11 All chilled water pipework services shall be supported around the insulation and not directly around the pipework. Care shall be taken to ensure the integrity of vapour sealing is not damaged in any way.

4.12 It shall be noted that in certain cases it will be necessary to adopt a combination of the support methods indicated, and when supports are required to be detailed to suit special site conditions or requirements, then these details shall be submitted to the Consultant for approval. Anti-vibration supports shall be fitted at all locations where pipework vibration is likely to be a problem.

5.0 VALVES.

5.1 Valves shall be provided and installed where required for the purpose of circulation control and isolation. Valves shall be of full bore size to suit the mains into which they are installed.

5.2 All castings shall be clean close-grained metal, free from rough projections. Screwed valves shall have heavy hexagon reinforcement threads, ample length threads and heavy shoulder to prevent over entry of pipes. Flanged valves shall have the flanges flat faced and of thickness conforming to the
5.3 Valves shall have pressure rating as necessary for the service indicated on the drawing. Samples must be provided for inspection of the manufacturing methods.

5.4 Gate valves for sizes up to 50 mm, shall be bronze, on rising stem, screwed bonnet, one piece wedge. The stem shall have a lockshield to restrict unauthorized adjustment.

The casting shall have large hexagon section at all threads to permit gripping to prevent line distortion during installation.

Pressure rating shall be 16 bar.

5.5 Gate valves sizes 65mm dia and above shall be one piece butterfly valves, cast iron body, tapped, full lug body, 16 bar rated, 316 S / S shaft, aluminium bronze disc, EPDM seat extended onto flange face.

Valves on pipe connection to chiller condenser & pump shall be rated for 20 bar.

5.6 Globe valves size 50mm dia and below shall be bronze, rising stem, screwed bonnet and renewable dynamic disk.

5.7 Globe valves 65 mm and up shall be cast iron body valves rated for 16 bar, with outside screw and yoke, bolted bonnet, guide feature for disc seating.

5.8 Check valves up to size 50 mm shall be bronze, screwed ends, "Y" pattern with screwed access cap, regrindable seating, positive seating two piece swivel disc, rated at 16 bar.

5.9 Check valves size 65 mm to 100mm shall be cast iron body with bronze trim, 16 bar rated, rotating disc with flexible hinge assembly, bolted access.

Check valves above 100mm shall be cast iron body, silent check, globe style, spring actuated, renewable seats, stainless steel disc, rated for 16 bars.

Check valves on condenser pumps shall be rated for 20 bars.

5.10 Control Valves (double regulating) upto size 50mm dia shall be of bronze body/brass ball construction with glass and carbon filled TFE seat rings. Valves to have differential pressure readout ports across valve seat area. Read out ports to be fitted with internal EPT insert and check valve. Valve bodies to have 6MM NPT tapped drain/purge port. Valves to have memory stop feature to allow valve to be closed for service and then reopened to set point without disturbing balance position.

All valves to have calibrated nameplate to assure specific valve setting. Valves to be leak tight at full rated working pressure. All valves to be provided with moulded insulation to permit access for balance and read out.

5.11 Balancing valves (double regulating) size 65mm dia and above shall be of heavy duty cast iron flanged construction with 125psi ANSI flanged connections suitable up to 175 psi working pressure.

Valves on pipe connection to chiller condenser and condenser pumps shall be 20 bar rated.

Valves size 65 and 80mm dia shall have a brass ball with glass and carbon filled TFE seat rings. Valves size 100mm dia and above shall be fitted with a bronze seat, replaceable bronze disc with EPDM seal insert, and stainless steel stem. Valves to have memory stop feature to allow valve to be closed for service and then reopened to set point without disturbing balance position. All valves to have calibrated nameplate to assure specific valve setting. Valves to be leaktight at full rated working pressure. All valves to be provided with moulded insulation to permit access for balance and read out.

5.12 Balancing flow control valves (Motorised valve) – upto 300mm.


2. Valve size: shall be equal to full line size, as indicated on drawings.
3. Construction: Cast iron bodies, stainless steel stem and seat, enc plated plug.

4. 16 bar rated flanged.

5. All valves shall come with handwheel operator, calibrated flow setting scale, and pressure taps.

5.13 All valves shall be rated for a working pressure of 16 Bar, unless otherwise indicated.

5.14 In lieu of gate valves, butterfly valves may be used. Valves construction shall be ductile iron body, ductile iron disc, rubber encapsulated suited for the intended service. Valves shall be bubble tight, rated for 300 PSI with memory stop.

5.15 Certificate of Origin shall be provided for all valves.

6.0 STRAINERS.

Strainers shall be full line size located ahead of all pumps and in locations as indicated on drawings rated for 16 bar. Bodies shall be cast iron, screwed body," Y" type, up to 50 mm size with 37% open mesh bronze metal screen, and 3 mm diameter holes.

For sizes 65 MM and above, Iron body, flanged, "Y" type bolted cover flange, tapped blow-off outlet, 37% open mesh bronze metal screen, with 3 mm diameter holes.

Strainer on condenser pump suction shall be rated for 20 bar.

7.0 GAUGES AND ACCESSORIES.

7.1 Wet service thermometers shall be straight shank mercury fill insertion type. They shall have a stem length of 80 mm and a scale length of 225 mm, and the capability of adjusting the angle of the scale to the stem. Provide copper or brass separable wells for each thermometer.

7.2 Air service thermometers shall be straight shank mercury fill insertion type. They shall have a stem length of 150 mm and a scale length of 225 mm, and the capability of adjusting the angle of the scale to the stem.

7.3 Pressure gauges shall have 100 mm diameter cast Aluminium case, black figures, forged brass sockets with phosphor bronze bushed rotary type movement and Bourdon tube. Gauges shall be complete with impulse dampening insert and T-handle gauge cock.

7.4 Range of gauges shall be selected such that the operating point is almost midway of the selected range.

8.0 AIR VENTS

8.1 Provide air vents at all high points in supply and return piping.

8.2 Automatic air vents shall have gunmetal or brass bodies, non-ferrous or stainless steel floats and guides and non corrodirble valves and seats. Each automatic air vent shall be controlled by a lock shield valve. Air release pipes shall be run to discharge at the nearest visible point - to be agreed with the Engineer.

9.0 FLOW SWITCHES

9.1 Flow switches shall be provided at the outlet connection to each chiller.

9.2 Flow switches shall be paddle type with bronze construction for all parts in contact with water.

(k) FLOW MEASUREMENTS.
10.1 Provide in the main incoming supply line a feature to enable flow measurements to be made. Provide all equipment and, if indirect measurements are used, provide all calibration equipment, charts etc.

10.2 Provide water meter to monitor the quantity of water being added to the system by the make-up unit.

11.0 EXPANSION PROVISIONS AND ANCHOR POINTS.

11.1 All sections of pipework installations shall be installed in such a manner as to allow expansion and contraction for the pipework, without causing undue stress in any part of the installation.

11.2 Wherever possible expansion and contraction shall be absorbed by natural offsets and changes in direction of pipe runs. Provide anchors, pipe guides and expansion loops where shown or required, to the Consultant's approval. Do not use screwed fittings on expansion loops.

11.3 Connections to items of plant and equipment shall be made so that no stress is placed on the equipment or its connections. All expansion devices shall be carefully erected in full accordance with the manufacturer's recommendation and instructions, and be approved by the manufacturer for the particular application concerned.

11.4 No system of expansion control shall be accepted where the closure of movement exceeds the amount recommended by the manufacturer when operating from the cold to the upper limit working temperature. The minimum temperature difference for calculation purpose shall be 40 degrees C for interior pipes, and 50 degrees C for exposed or external runs.

11.5 All expansion devices shall be cold drawn by a distance equal to half the total expansion and all contraction devices shall be cold compressed by a distance equal to half the total contraction.

11.6 All anchor points shall be treated as main anchor points, the practice of utilizing a less substantial anchor for "intermediate positions" shall not be permitted.

11.7 Where the installation is required to be tested in sections, extra anchor points shall be installed where necessary, for the protection of the expansion devices.

12.0 WATER SYSTEM TREATMENT (CLEANING)

12.1 The chilled water system shall be prepared as detailed elsewhere herein. The system will then be further treated.

12.2 Prior to testing and commissioning, the consultant shall be provided with water conditioning programme, to control water quality. Cleaning shall be supervised, and programme of conditioning administered by the conditioning company.

12.3 For Precommission cleaning, the system shall be dosed with the prescribed amount of the non acid cleaning agent and a surfactant as advised by the chemical company.

12.4 Cleaner shall be run into the system and retained for a period of 72 hrs. or more as advised by the chemical company. At the end of this period the system shall be drained and flushed with clean water.

12.5 All strainers and trapping points shall be inspected, and any debris removed.

12.6 System shall be refilled with clean water, re-circulated or run through for a further four hours, and again drained and flushed. The flushing shall continue till the effluent is clear, colourless, odourless, free from suspended solids and such that the iron level is not more than 10 ppm.

12.7 Upon completion of flushing all strainers shall be inspected and any debris removed.

12.8 The system shall be refilled with clean water and a specified amount of inhibitor added.

12.9 The Chemical Company representative shall conduct an analysis of the system's water after the cleaning operation, and shall submit a report to the Consultant.
Note: The HVAC Contractor shall advise on the holding capacity of the systems to be cleaned to the Chemical Company, in order that the amount of cleaner required may be calculated.

13.0 START UP CHEMICALS.

13.1 The supply of all chemicals for system startup shall be the scope of this contract. Chemicals sufficient for contractual maintenance period shall be arranged by the Contractor.

14.0 VIBRATION ISOLATION.

See Ductwork Specification.

15.0 PRESSURE TESTS.

See relevant sections of the General requirements.

16.0 WELDING TESTS.

See relevant sections of the General requirements.

17.0 SUBMITTALS.

17.1 Technical submissions are to include the schematic for components actually to be installed showing flow rates, and accompanied by pressure drop calculation for the system.

17.2 Technical brochures and information on all components:-

Pipework, Pipe fittings, Pipe supports, Valves, Strainers, Gauges and accessories, Air vents, Flow measuring instruments, Expansion joints, Anchor points, Test forms, Insulation, Water treatment

17.3 In the event that the Consultant/Client requires further information on any item, samples must be provided as necessary.

SECTION 10

PIPING INSULATION

PART 1 GENERAL

1.01. SECTION INCLUDES

A. Piping insulation.
B. Jackets and accessories.

1.02. REFERENCES STANDARDS

ASTM.
NFPA
UL

1.03 SUBMITTALS

A. As mentioned in our general requirements

B. Product Data: Provide product description, list of materials ‘k’ value, ‘R’ value, mean temperature rating, and thickness for each service, and locations.
C. **Samples:** When requested, submit two samples of any representative size illustrating each insulation type.

D. **Manufacturer’s Installation Instructions:** Indicate procedures which ensure acceptable workmanship and installation standards will be achieved.

1.04. **QUALITY ASSURANCE**

A. All insulation, jacket, adhesives, mastics, sealers, etc., utilized in the fabrication of these systems shall meet NFPA for fire resistant ratings (maximum of 25 flame spread and 50 smoke developed ratings) and shall be approved by the insulation manufacturer for guaranteed performances when incorporated into their insulation system, unless a specific product is specified for a specific application, and is stated as an exception to this requirement. Certificates to this effect shall be submitted along with Contractor’s submittal data for this section of the Specifications. No material may be used that, when tested by the ASTM E84-89 test method, is found to melt, drip or delaminate to such a degree that the continuity of the flame front is destroyed, thereby resulting in an artificially low flame spread rating.

1. All surfaces to be insulated shall be clean and dry before applying the insulation. All sections of molded pipe covering shall be firmly butted together. Where an insulation covering is applied, it shall lap the adjoining section of insulation by at least three inches (3”). Where insulation terminates, it shall be neatly beveled and finished. No insulation shall be applied until the pipe, duct, etc., have been pressure tested and found tight. Piping, flexible connections, flanges, valves, strainers, and unions shall be covered unless specifically noted otherwise. Flexible connections on duct shall not be covered. All materials used shall be fire retardant or nonflammable.

C. All piping, equipment, ductwork, all plenums including metal and masonry construction, fans, etc., shall be insulated as indicated on the Drawings, as specified herein, and as required for a complete system. In each case, the insulation shall be equal to that specified and materials applied and finished as described in these Specifications.

D. To be considered, alternate materials shall have equivalent thermal and moisture resistance of the specified materials.

E. No insulation shall be applied on pipes until the pipes are satisfactorily tested.

1.05. **QUALIFICATIONS**

A. All insulation shall be applied by mechanics skilled in this particular work and regularly engaged in such occupation.

B. All insulation shall be applied in strict accordance with these Specifications and with factory printed recommendations on items not herein mentioned. Unsightly, inadequate, or sloppy work will not be acceptable, and all such work shall be removed and replaced as many times as necessary to achieve an acceptable installation. The company performing the work of this section shall have a minimum of three years experience specializing in the trade.

1.06. **DELIVERY, STORAGE, AND HANDLING**

A. Deliver, store, protect, and handle products to site as instructed in Section 1.

B. Deliver materials to site in original factory packaging, labeled with manufacturer’s identification, including product thermal ratings and thickness.

C. Store insulation in original wrapping and protect from weather and construction traffic. Protect insulation against dirt, water, chemical, and mechanical damage.

1.07. **ENVIRONMENTAL REQUIREMENTS**

A. Maintain ambient temperatures and conditions required by manufacturers of adhesives, mastics, and insulation cements.

B. Maintain temperature during and after installation for minimum period of 24 hours.
C. All insulation materials to be asbestos free.

PART 2 PRODUCTS

CHILLED WATER PIPING - TUNNELS AND BUILDINGS:

The Chilled water piping material shall be closed Cell Elastomeric Rubber Insulation with the following properties – Density of Material shall be between 40 to 60 Kg/m³; Thermal conductivity of elastomeric nitrile rubber shall not exceed 0.035 W/m K at an average temperature of 0°C; the insulation shall have fire performance such that it passes Class 1 as per BS476 Part 7 for surface spread of flame as per BS 476 and also pass Fire Propagation requirement as per BS476 Part 6 to meet the Class ‘O’ Fire category as per 1991 Building Regulations (England & Wales) and the Building Standards (Scotland) Regulations 1990; Water vapour permeability shall not exceed 0.017 Perm inch (2.48 x 10-14 Kg/m.s.Pa), i.e. Moisture Diffusion Resistance Factor or ‘µ’ value should be minimum 7000.

Thickness of the insulation shall be as specified herein: 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. Contractor to fulfill the requirements related to the painting if any. All MS pipes shall be provided with a coat of zinc chromate primer. Thermal insulation shall be applied as follows or as specified in drawings or schedule of quantity:

<table>
<thead>
<tr>
<th>Pipe nominal bore</th>
<th>Thk. For non-coastal places</th>
<th>Thk. For coastal places</th>
</tr>
</thead>
<tbody>
<tr>
<td>15mm - 25mm</td>
<td>19mm</td>
<td>25mm</td>
</tr>
<tr>
<td>32mm 80mm</td>
<td>25mm</td>
<td>32mm</td>
</tr>
<tr>
<td>100mm - 400mm</td>
<td>32mm</td>
<td>38mm</td>
</tr>
<tr>
<td>Above 400mm</td>
<td>45mm</td>
<td>45mm</td>
</tr>
</tbody>
</table>

Insulating material in tube form 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 centre. Wherever flat sheets shall be used it shall be cut out in correct dimension using correct tools. Scissors or Hacksaw-blade shall not be allowed. All longitudinal and transverse joints shall be sealed as per manufacturer recommendations. All longitudinal and transverse joints shall be sealed by providing 6 mm thick, 50 mm wide nitrile rubber tape. 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.

To provide mechanical strength and protection from damage all pipe / duct insulated with nitrile rubber as indicated in BOQ shall be covered with self-adhesive fiberglass fabric of weight 200 GSM (grams per mtr²) and thickness 7 mil. Insulated pipes & ducts exposed to UV rays shall be covered with self adhesive fiberglass fabric of weight 200 GSM. and thickness 7 mil. Application procedure: Spread the self adhesive fiberglass sheet (with minimum overlap of 1 inch at joints) on insulation. Taking due care so as not to form any wrinkles on the surface.

No chilled water pipe supporting structures shall pierce the insulation except as anchor points as shown on the Drawings. At these points, the anchor member shall occur on the bottom of the piping to allow condensation to drain.

CONDENSATE DRAIN AND WATER RECOVERY (Fin Water) PIPING:

Condensate drain piping from fan and coil units, coil banks, drinking fountain refrigeration units, and other items of piping or equipment subject to condensation forming on the surface shall be insulated with a closed cell elastomeric thermal insulation as detailed in “Piping insulation”. Drain piping from mechanical rooms, and other areas potentially receiving chilled water or condensate from air handlers, shall be similarly insulated for a minimum of 15 feet.

PROTECTIVE JACKETING – CHILLER PLANT ROOM
Aluminum 26 G Jacketing and fitting covers shall be 26G aluminum smooth and pleasing appearance. The jacket shall be pre-cut, pre-rolled, and lapped a minimum of two inches (2") in all directions to shed water. The metal shall be secured at each joint with a minimum of one each (1 ea.) ¾" wide .020 aluminum or stainless steel band and seal. The metal jacketing and fitting covers shall be fabricated of 0.016" aluminum or stainless steel with a smooth finish.

PUMPS:

The chilled water pump and hot water pumps shall not be insulated but the insulation of the connecting piping shall be continued up to the face of the flanges on the piping connection to the pump and any bare metal that projects over the bed plate of the pump and from which condensation might drip onto the floor.

Jacket material stapled in place and sealed with adhesive. Thickness shall be as scheduled.

ADHESIVE:

The Adhesive used for the piping, pumps and all other accessories shall be as recommended by manufacturer. The contractor shall NOT use adhesive without proper approval of the consultant/Client.

PART 3 EXECUTION

3.01 EXAMINATION

A. Verify that piping has been tested before applying insulation materials.
B. Verify that surfaces are clean, foreign material removed, and dry.

3.02 INSTALLATION

A. Install materials in accordance with manufacturer’s instructions in the absence of specific instruction herein.
B. On exposed piping, locate insulation and cover seams in least visible locations, but not higher than at the side of the pipe at the “90°” position, with the seam lapped such that the lap is directed down.
C. Insulated dual temperature pipes or cold pipes conveying fluids below ambient temperature: Vapor barriers are required. The vapor barrier shall be on the outside. Extreme care shall be taken that the vapor barrier is unbroken. Joints, etc., shall be sealed. Where insulation with a vapor barrier terminates, it shall be sealed off with the vapor barrier being continuous to the surface being insulated. Ends shall not be left raw.
1. Provide vapor barrier jackets, factory applied or field applied.
2. Insulate fittings, joints, and valves with molded insulation of like material and thickness as adjacent pipe.
3. Finish with glass cloth and vapor barrier adhesive.
D. Continue insulation through walls, sleeves, pipe hangers, and other pipe penetrations.
E. For insulated pipes conveying fluids above ambient temperature:
   a) Provide standard jackets, with or without vapor barrier, factory applied or field applied.
   b) Insulate fittings, joints, and valves with insulation of like material and thickness as adjoining pipe.
F. If PVC fitting covers are used they shall have 25/50 rating.
G. For hot piping conveying fluids 140 F or less, do not insulate flanges and unions at equipment, but bevel and seal ends of insulation.

H. For hot piping conveying fluids over 140 F, insulate flanges and unions, including those at equipment, but label the insulation to indicate a concealed flange or union. See 2.04K.

3.03 INSERTS, SUPPORTS and SHIELDS:

A. Application: Piping 2 inches diameter or larger for all systems except direct buried.

B. Shields: Install between pipe hangers or pipe hanger rolls and inserts. Hangers shall be on the outside of the insulation and shall not be in contact with the pipe. Curved metal shields shall be used between the hangers or support points and the bottom of the insulated pipe for insulated pipes 2” and larger. Curved metal shields shall be designed to limit the bearing stress on the insulation to 35 psi and shall be curved to fit up to mid-perimeter of the insulated pipe. Shields shall be made of galvanized iron, or black iron painted on both sides with two coats of aluminum paint. Required metal shield sizes are as follows:

<table>
<thead>
<tr>
<th>Lengths</th>
<th>Nominal IPS</th>
<th>Metal Thickness of Shield</th>
</tr>
</thead>
<tbody>
<tr>
<td>up thru 2”</td>
<td>14 gauge</td>
<td>12”</td>
</tr>
<tr>
<td>thru 6”</td>
<td>12 gauge</td>
<td>16”</td>
</tr>
<tr>
<td>and above</td>
<td>10 gauge</td>
<td>20”</td>
</tr>
</tbody>
</table>

2 Insert Location: Between support shield and piping and under the finish jacket.

3 Insert Configuration: Minimum 2” inches longer than length of shield, of same thickness and contour as adjoining insulation; may be factory fabricated.

4 Insert Material: Heavy density insulating material suitable for the planned temperature range, and the weight of the pipe.

5 The shields at support points shall be secured with ½” x 0.016” stainless steel bands and seals.

6 Finish insulation at supports, protrusions, and interruptions.

7 The application of the protective shields at rack and guide points in tunnels and in central chilling stations shall be as detailed on the accompanying Drawings.

8 In lieu of the above the following system of support may be used:

(vii) At the pipe support positions, the insulation and vapor barrier shall be continuous and shall not be punctured by the support. The insulation at the support shall be the full circumference of 5lbs/ft³ Koolphen K Phenolic Foam material to withstand the bearing loads transmitted from the pipe to the support, it shall extend for at least 1” on either side of the support to allow sealing of the joints with the pipe insulation jacket.

(viii) The load bearing insulation at the support shall be capable of withstanding the maximum static compressive loads generated by pipe supported at the centers shown in Table 1.

Variations: Pipe loads greater than those generated at the support centers shown in Table 1 shall be referred to the manufacturer to establish the length and density of the insulated support block. The support centers are based on the weight of Sch 80 pipe filled with water and covered with 1” thickness of 2.2 lbs/ft³ standard insulation including FSK/ASJ vapor barrier.

Table 1 K Block Support Centers

<table>
<thead>
<tr>
<th>Nominal Pipe Size</th>
<th>3/4</th>
<th>1</th>
<th>1 1/4</th>
<th>2</th>
<th>2 1/2</th>
<th>3</th>
<th>4</th>
<th>6</th>
<th>8</th>
<th>10</th>
<th>12</th>
<th>14</th>
<th>16</th>
<th>18</th>
<th>20</th>
<th>24</th>
</tr>
</thead>
</table>

SIGNATURE OF TENDERER WITH SEAL

EMPLOYER

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Max support centers (feet) | 6.5 | 6.5 | 6.5 | 10 | 10 | 10 | 10 | 14 | 14 | 14 | 20 | 20 | 20 | 20 | 20 | 20 | 20 | 20 | 20 |
Sch 80 pipe filled with water covered with 1" of Standard Insulation | 6.5 | 6.5 | 6.5 | 10 | 10 | 10 | 10 | 14 | 14 | 14 | 20 | 20 | 20 | 20 | 20 | 20 | 20 | 20 | 20 |
Metal Saddle Gauge (Galvanized Steel) | 22 | 22 | 22 | 20 | 20 | 20 | 16 | 14 | 14 | 14 | 14 | 14 | 14 | 14 | 14 | 14 | 14 | 14 | 14 |
Length of K Block (inches) | 6 | 6 | 6 | 6 | 6 | 6 | 9 | 9 | 9 | 9 | 9 | 9 | 12 | 12 | 12 | 12 | 12 | 12 | 12 |

For purpose of definition in this Specification: “concealed” areas are those areas which cannot be seen by the building occupants, and “exposed” areas are all areas which are exposed to view by the building occupants, including under counter and inside cabinet areas, plus all mechanical rooms.

Self Sealing Lap and butt joints will not be acceptable as the only seal on piping insulation joints. Self Sealing Lap and butt joints may be utilized only if the joints are additionally secured with field applied vapor barrier adhesive (on piping Systems requiring vapor barriers) or staples and field applied adhesive (on piping system which do not require a vapor barrier jacket). Mechanical fasteners shall be used whenever possible to assure permanent installation.

Special Protection: All insulated piping in the mechanical rooms within 8’-0” of the floor shall be encased in a protective jacket, and where applicable, finish at top with nickel-plated brass flange plate with set screws or end joint sealing butt strips.

All exposed outdoor piping shall have metal jacket.

**Insulation ‘R’ Value Schedule**  \( (R = \text{thickness} / k) \) FPS

<table>
<thead>
<tr>
<th>Oper Service</th>
<th>‘k’ @ Mean Temp</th>
<th>Min. R value for each Pipe Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>F &amp; less</td>
<td>to 2“</td>
<td>1”</td>
</tr>
<tr>
<td>Cold(6) 40-55</td>
<td>.25 @ 75</td>
<td>2.0</td>
</tr>
<tr>
<td>Cold(7) below 40</td>
<td>.25 @ 75</td>
<td>4.0</td>
</tr>
</tbody>
</table>

(6) Ch. Wtr; Dom. cold wtr; Storm; Cold condensate
(7) Ch. Wtr; Brine; Refrig lines

Minimum ‘R’ does not consider water vapor transmission and condensation. Additional insulation and/or vapor retarders may be required to limit water vapor transmission and condensation under extreme conditions.

A minus 10 percent tolerance, on the insulation performance listed shall be permitted for manufacturers' standard insulation systems

**SECTION 11**

1. FLEXIBLE CONNECTORS

Rubber Expansion Joints – Flexible Rubber Expansion Joints TO I be suitable used on all equipments such as pumps and chillers at both suction and discharge outlets. Each connector should consist of a single unfilled arch along with integral rubber flanges and should be furnished with a set of galvanized split retaining rings. Materials of construction will include Neoprene tube reinforced with multiple plies of Nylon tire cord with a Neoprene Cover. There will be metal reinforcement rings.
in the connector to add support. The flexible rubber expansion joint shall be rated as follows should be rated for a working pressure of 7 bar and a test pressure of 10 bar. All connectors must have a burst pressure of at least 3:1 over the above rated pressure. Control Rod Assemblies must be used on all unanchored systems; all systems with pump mounted on rubber vibration pads or spring vibration mounts; all systems where pressures or movements may exceed the published limits of the connectors; When control rods are used, they must be set so that axial extension movement of the connector shall not exceed the published limit of the connector; Rubber Expansion Joints shall be Easyflex Model 812, as manufactured by Kanwal Industrial Corporation.

2. FLEXIBLE DUCTS:

The Flexible duct shall be Mold and mildew resistant, UL181 listed and comply with NFPA Standards 90A and 90B, self-extinguishing, moisture resistant core, bi-directional reinforced metallized vapor barrier, acoustically rated, self-extinguishing chlorinated polyethylene (CPE) core permanently bonded to a coated spring steel wire helix that supports an ample blanket of fiberglass insulation, providing a double air seal.

Ducts shall be suitable for use in low and medium pressure heating and cooling systems, Temp. Range: -20F to 250F cont, R-Value: R-4.2, R-6.0, GREENGUARD Certified

The Flexible ducts to be in accordance with the guidelines issued by the Air Diffusion Council (ADC) and Underwriters Laboratories, Inc., (UL) to evaluate listed air ducts and air connectors for thermal resistance properties in accordance with the ADC Flexible Duct Performance & Installation Standard (1991, Revised 1996), using ASTM C-518 (1991) at installed wall thickness on flat insulation only.

SECTION 12
TESTING, ADJUSTING AND BALANCING (T A B)

1.01 SUMMARY

A. Perform all work required to prepare the building HVAC systems for testing, adjusting and balancing indicated by the Contract Documents as follows:

1. Responsibilities of project contractor.

2. Preparation for balancing of air systems.

B. The scope of the TAB work is responsibility of the HVAC Contractor to satisfactorily execute the TAB work as per ASHRAE SMCPNA. The Contractor in his original bid shall allow for the costs required to cover all work which may be required in the TAB phases as defined herein and as may be necessary for the completion of the TAB work as defined by the TAB firm.

1.02 SCOPE OF WORK

A. Testing, adjusting, and balancing (TAB) of the air conditioning and ventilation systems and related ancillary equipment will be performed.

B. As a part of this project Construction Contract, the Contractor shall make any changes or replacements to the sheaves, belts, dampers, valves, etc. required for correct balance as advised by the TAB firm, at no additional cost to the Owner.
C. The Contractor shall provide and coordinate the services of qualified, responsible Subcontractors, suppliers and personnel as required to correct, repair, and/or replace any and all deficient items or conditions found during the course of this project, including the testing, adjusting and balancing period.

D. In order that all systems may be properly tested, balanced, and adjusted as required herein by these Specifications, the Contractor shall operate said systems at his expense for the length of time necessary to properly verify their completion and readiness for TAB. This length of time shall be subject to the approval of the Construction Inspector.

E. Project Contract completion schedules shall allow for sufficient time to permit the completion of TAB services prior to Owner occupancy. The Contractor shall allow adequate time for the testing and balancing activities of the owner provided services, during the construction period, and prior to Substantial Completion as defined in the Uniform General Conditions of this Construction Document.

F. The Drawings and Specifications indicate valves, dampers and miscellaneous adjustment devices for the purpose of adjustment to obtain optimum operating conditions, and it will be the responsibility of the Contractor to install these devices in a manner that will leave them accessible and readily adjustable. Should any such device not be readily accessible, the Contractor shall provide access as requested by the TAB firm. Also, any malfunction encountered by TAB personnel and reported to the Contractor or the Construction Inspector shall be corrected by the Contractor immediately so that the balancing work can proceed with the minimum of delays.

1.03 RESPONSIBILITIES OF THE PROJECT CONTRACTOR:

A. The Contractor shall:

1. Have the HVAC systems in complete operational readiness for TAB work to begin.

2. Complete operational readiness of the air conditioning systems also requires that the following be accomplished:

   Air Distribution Systems:

   a. Verify installation for conformity to design. All supply, return and exhaust ducts terminated and pressure tested for leakage as required by the Specification.

   b. All volume, smoke and fire/smoke dampers are properly located and functional. Dampers serving requirements of minimum and maximum outside, return and relief air shall provide tight closure and full opening, smooth and free operation.

   c. All supply, return, exhaust and transfer grilles, registers, diffusers and terminal devices installed.

   d. Air handling systems, units and associated apparatus, such as heating and cooling coils, filter sections, access doors, etc., shall be blanked and/or sealed to eliminate excessive bypass or leakage of air.

   e. All fans (supply, return and exhaust) operating and verified for freedom from vibration, proper fan rotation and belt tension; heater elements in motor starters to be of proper size and rating; record motor amperage and voltage on each phase at start-up and running, and verify they do not exceed nameplate ratings.

3. Water Circulating Systems:

   a. Check and verify pump alignment and rotation.

   b. Open all valves to their full open position, close bypass stop valves. Set mixing valves to full-flow through systems components. After the system is flushed and checked for proper operation, remove and clean all strainers. The Contractor shall repeat the operation until circulating water is clean.

   c. Record each pump motor amperage on each phase and voltage after reaching rated speed. Readings shall not exceed nameplate rating.
d. Verify that the electrical heater elements are of the proper size and rating.

e. In preparation of TAB all water circulating systems shall be full and free of air, expansion tanks shall be set for proper water level, and all air vents shall be installed at high points of systems and operating freely. Systems shall be cleaned and flushed. Chemicals shall be added to closed systems to treat piping and inhibit corrosion.

f. Check and set operating parameters of the heat exchangers and control devices to the design requirements.

4. Automatic Controls:

a. The Contractor shall establish the requirements and present the control scheme and check sequences of operation for correctness.

b. Verify that all control components are installed in accordance with project requirements and are functional, including all electrical interlocks, dampers sequences, air and water resets, fire and freeze stats, high and low temperature thermostats, safeties, etc.

c. Verify that all controlling instruments are calibrated and set for design operating conditions with the exception of room thermostats or sensors, which shall be calibrated at the completion of TAB services with cooperation between the TAB firm and Control Contractor.

5. Tabulated Data: The motor amperages, voltages shall be recorded showing "actual" and "nameplate" voltage and amperage and submitted and actual RPM. This applies to each piece of electrically driven air conditioning equipment in the system including supply and exhaust fans, fans of fractional horsepower, pumps, etc.

D. Notification of System Readiness:

1. After completion of the work, the Contractor shall notify the Owner in writing, certifying that the work has been accomplished and that the building HVAC systems are in operational readiness. A copy of the tabulated report data to be submitted to Owner.

SECTION- 13
ELECTRICAL WORKS

1.0 SCOPE

The scope of this section comprises of supply, erection, testing and commissioning of complete power distribution covering power distribution cum Motor Control Centre (MCC), Power cabling and earthing etc for HVAC system.

2.0 GENERAL

Work shall be carried out in accordance with the accompanying specifications and shall comply with the latest relevant Indian Standards and Electricity Rules and Regulations.

CPRI type tested design shall be adopted for the motor control centers. All equipments shall be suitable for operation on 3 phase/single phase 415/230 volts, 50 cycles power supply system with solidly earthed neutral.

3.0 CONSTRUCTIONAL FEATURES

The Motor Control Centre (MCC) cum power distribution board shall be fully compartmentalised fabricated out of CRCA sheet steel. Wherever specified the same shall be suitable for outdoor installation, dead front, floor mounting/wall mounting type. The control panel shall be totally enclosed, completely dust and vermin proof and shall have hinged doors with Neoprene gasket.
Control panel shall be suitable for the climatic conditions as specified in Specifications. Steel sheets used in the construction of Control panel shall be 2 mm thick and shall be folded and braced as necessary to provide a rigid support for all components. Joints of any kind in sheet metal shall be seam welded, all welding, slag shall be rounded off and welding pits wiped smooth with plumber metal. The general construction shall confirm to relevant Codes, approved standards.

All panels and covers shall be properly fitted and square with the frame, and holes in the panel correctly positioned. Fixing screws shall enter into holes tapped into an adequate thickness of metal or provided with wing nuts. Self threading screws shall not be used in the construction of Control panels. A base channel of 75 mm x 75 mm x 5 mm thick shall be provided at the bottom for floor-mounted panels. Minimum clearance of 400 mm shall be provided between the floor of control panel and the lowest unit.

The panel shall be of adequate size with a provision of 25% spare space to accommodate possible future breakers. Breakers shall be arranged in multi-tier arrangement. Knockout holes of appropriate size and number shall be provided in the Motor Control Centre in conformity with the location of cable/conduit connections. Removable sheet steel plates shall be provided at the top to make holes for additional cable entry at site if required. Every cabinet shall be provided with Trifoliate or engraved metal name plates. All panels shall be provided with circuit diagram mounted on inside of door shutter protected with Hylam sheet. All live accessible connections shall be shrouded and minimum clearance between phase and earth shall be 20 mm and phase-to-phase shall be 25 mm.

4.0 WIRING SYSTEM

All L T power cabling between MCC and motors shall be carried out with 1100 volts grade PVC insulated, overall PVC sheathed aluminium / copper conductor armoured cables, Cables shall be sized by applying proper derating factor. All control wiring shall be carried out by using PVC insulated copper conductor wires in conduits. Minimum size of control wiring shall be 1.5 sq mm of Stranded copper conductor. Minimum size of conductor for power wiring shall be of 4 sq. mm in case of Aluminium Conductor & 2.5 sqmm in case of Copper conductor.

5.0 CIRCUIT COMPARTMENT

Each circuit breaker, contactor and relay shall be housed in a separate compartment and shall have steel sheets on top and bottom of compartment. Sheet steel hinged lockable door shall be duly interlocked with the breaker-opening handle in the “ON” position. Safety interlocks shall be provided to prevent the breaker from being drawn-out when the breaker is in ‘ON’ position. The door shall not form an integral part of the draw-out portion of the panel. Sheet steel barriers shall be provided between the tiers in a vertical section.

6.0 INSTRUMENT ACCOMMODATION

Adequate space shall be provided for accommodating instruments, indicating lamps, control contactors and control MCBs. These shall be accessible for testing and maintenance without any danger of accidental contact with live parts of the circuit breaker and bus bar ‘ON’ lamps shall be provided on all outgoing feeders.

7.0 BUS BAR CONNECTIONS

Bus bar and interconnections shall be of high conductivity electrolytic copper or Aluminium as per specifications and of rectangular cross section suitable for carrying the rated full load current and short circuit current without overheating of phase and neutral bus bar and shall be extendable on either side. Bus bar and interconnections shall be insulated with heat shrinkable sleeve and shall be colour coded and shall be supported on glass fiber reinforced thermosetting plastic / DMC / SMC insulated supports at regular intervals to withstand the force arising from in case of short circuit in the system. All bus bar shall be provided in a separate chamber and all connections shall be done by bolting. Additional cross sectional area shall be added to the bus bar to compensate for the holes. All connections between bus bar and breaker shall be through solid copper strips of proper size to carry full rated current as per approved for construction shop drawing and insulated with insulating sleeves. Bus bar shall be rated for current density of 1.00-amps/mm$^2$ cross-section area.
8.0 TEMPERATURE - RISE LIMIT

Unless otherwise specified, in the case of external surface of enclosures of bus bar trunking system which shall be accessible but do not need to be touched during normal operation, an increase in the temperature rise limits of 25° C above ambient temperature shall be permissible for metal surface and of 15° C above ambient temperature for insulating surfaces as per relevant Codes, and approved standards.

9.0 CABLE COMPARTMENTS

Cable compartment of adequate size shall be provided in the panel for easy clamping of all incoming and outgoing cables entering from the top/bottom. Adequate supports shall be provided in cable compartment to support cables as per approved for construction shop drawing.

10.0 AIR CIRCUIT BREAKERS (ACB)

Air Circuit Breakers shall be sheet metal enclosed flush front, draw out type and shall be provided with a trip free manual operating mechanism or as indicated in drawings and bill of quantities with mechanical “ON” “OFF” “TRIP” indications.

The ACB shall be 3 pole with modular construction, drawout, manually operated and shall be capable of providing short circuit, overload and earth fault protection through micro processor based control unit sensing the true RMS value to ensure accurate measurement meeting the EMI/EMC requirement as per standard.

The circuit breakers shall be for continuous rating and service short Circuit Breaking capacity shall be as specified on the single line diagram and shall be equal to the short circuit withstand values.

Circuit breakers shall be designed to `close' and `trip' without opening the circuit breaker compartment door. The operating handle and the mechanical trip push button shall be at the front of the breakers panel and integral with the breaker.

The ACB shall be provided with a door interlock. The contacts shall be of silver plated copper with a feature of contact wear inspection, indicating the life of the contacts. The ACB shall have double insulation (Class-II) with moving and fixed contacts totally enclosed for enhanced safety and inaccessibility to live parts.

11.0 CRADLE

The cradle shall be so designed and constructed as to permit smooth withdrawal and insertion of the breaker into it. The movements shall be free from jerks, easy to operate and shall be on steel balls/rollers and not on flat surfaces.

There shall be 4 distinct and separate position of the circuit breaker on the cradle.

Service Position: Main Isolating contacts and control contacts of the breaker are engaged.

Test Position: Main Isolating contacts are isolated but control contacts are still engaged.

Isolated Position: Both main isolating and control contacts are isolated.

Maintenance: Circuit breaker fully outside the panel ready for maintenance after the cubicle door is opened.
There shall be provision for locking the breaker in any or all of the first three positions.

12.0 PROTECTIONS

a. The Microprocessor based release unit shall be provided on circuit breaker for short circuit, over current and earth fault protection with adjustable settings.

The release shall incorporate an 8-bit micro-computer to offer accurate and versatile protection with complete flexibility and shall offer complete overcorrect protection to the electrical system in the following four zones:

9 Overload or long time protection.
10 Short circuit or short time protection with intentional delay.
11 Instantaneous protection with no intentional delay.
12 Ground fault protection.
13 True RMS sensing.

The release shall sample the current at the rate of 16 times per cycle to monitor the actual load current waveform flowing in the system and shall monitor the true RMS value of the load current. It shall take into account the effect of harmonics also.

b. Thermal Memory

When the breaker shall reclose after tripping on overload, then the thermal stresses caused by the overload if not dissipated completely, shall get stored in the memory of the release and this thermal memory shall ensure reduced tripping time in case of subsequent overloads. Realistic Hot/Cold curves shall take into account the integrated heating effects to offer closer protection to the system.

c. Defined time-current characteristics:

A variety of pick-up and time delay settings shall be available to define the current thresholds and the delays to be set independently for different protection zones thereby achieving a close-to-ideal protection curve. Available pick-up and time delay settings shall have flexibility for over two million different I-t characteristics to suit different applications.

d. Trip Indication

Electromechanical fault status indicators shall be provided to display the type of fault that caused a trip, without any auxiliary supply or battery, resulting in faster fault diagnosis and reduced system down time.

e. Test Facility

Test facility to test the operation of the release in different protection zones by simulating CT inputs externally through a testing kit.

f. Self powered

The release shall draw its power from the main breaker CTs and shall require no external power supply for its operation.

g. Tripping of the breaker

The release shall trip the breaker through a flux shift device which shall directly act on the breaker trip rod.
h. Zone Selective Interlocking

The release shall be suitable for communication between breakers to enable zone selective interlocking. This feature shall be provided for both short circuit and ground fault protection zones to offer intelligent discrimination between breakers. This feature enables faster clearance of fault conditions, thereby reducing the thermal and dynamic stresses produced during fault conditions and thus minimises the damage to the system.

j. The setting range of release shall be as follows:

<table>
<thead>
<tr>
<th>Type of Protection</th>
<th>PICK-UP CURRENT</th>
<th>TIME DELAY</th>
</tr>
</thead>
<tbody>
<tr>
<td>Long Time</td>
<td>0.5 to 1.0 times I_n (I_l)</td>
<td>0.2 to 30 sec at 6 I_l, Steps: 0.2, 0.5, 1.5, 2, 3.5, 6, 12, 17 and 30 secs, Tolerance: Corresponding to ±10% of current.</td>
</tr>
<tr>
<td></td>
<td>Steps: 0.50, 0.60, 0.65, 0.70, 0.75, 0.80, 0.85, 0.90, 0.95, and 1.00. Operating Limit: 1.05 to 1.2 times I_l.</td>
<td></td>
</tr>
<tr>
<td>Short Time</td>
<td>2 to 10 times I_l</td>
<td>20 ms to 600 ms, Steps: 20, 60, 100, 160, 200, 260, 300, 400, 500 and 600 ms, Tolerance: ±10% or 20 ms, whichever is higher.</td>
</tr>
<tr>
<td></td>
<td>Steps: 2, 3, 4, 5, 6, 7, 8, 9, 10, 12, 14, 16, one position as infinity.</td>
<td></td>
</tr>
<tr>
<td>Instantaneous</td>
<td>2 to 16 times I_m</td>
<td>100 ms to 400 ms, Steps: 100, 200, 300, 400 ms &amp; Infinity, Tolerance: ±10% or 20 ms, whichever is higher.</td>
</tr>
<tr>
<td></td>
<td>Steps: 2, 3, 4, 6, 8, 10, 12, 14, 16</td>
<td></td>
</tr>
<tr>
<td>Ground Fault</td>
<td>0.2 to 0.6 time I_m</td>
<td>100 ms to 400 ms, Steps: 100, 200, 300, 400 ms &amp; Infinity, Tolerance: ±10% or 20 ms, whichever is higher.</td>
</tr>
<tr>
<td></td>
<td>Steps: 0.2, 0.3, 0.4, 0.5, 0.6</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Tolerance: ±15%</td>
<td></td>
</tr>
</tbody>
</table>

Settings shall be by rotary switches having red knob for pick-up currents and blue knobs for time delays.

Factory Settings:

The release shall be set at the following values at the time of shipping:

LTP=0.5, LTD=2s, STP=9, STD=100 ms, IP=Infi, GFP=0.3, GFD=100 ms, Memory=OFF

II. Under voltage relay for voltage is less than 90% of the rated voltage (415 V) shall be provided in the incomer breaker only.

III. Over voltage relay for voltage more than 110% of the rated voltage (415 V) shall be provided in the incomer breaker only.
k. Minimum 6 NO and 6 NC auxiliary contacts shall be provided on each breaker. The contacts shall be rated 5 amps.

l. Rated insulation voltage shall be 1000 volts AC.

The auxiliary contacts blocks shall be so located as to be accessible from the front. The auxiliary contacts in the trip circuits shall close before the main contacts have closed. All other contacts shall close simultaneously with the main contacts. The auxiliary contacts in the trip circuits shall open after the main contacts open.

All current carrying parts shall be silver-plated and suitable arcing contacts with proper arc chutes shall be provided to protect the main contacts. The heat generated in the contacts due to tripping under fault conditions shall be very nominal. All air circuit breakers shall be labelled.

13.0 SAFETY FEATURES

I. The safety shutter shall prevent inadvertent contact with isolating contacts when breaker is withdrawn from the Cradle.

II. It shall not be possible to interchange two circuit breakers of two different thermal ratings.

III. There shall be provision of positive earth connection between fixed and moving portion of the ACB either thru connector plug or sliding solid earth mechanism. Earthing bolts shall be provided on the cradle or body of fixed ACB.

IV. Arc Chute covers wherever necessary shall be provided.

V. The incoming panel accommodating ACB shall be provided with indicating lamps for ON-OFF positions, digital voltmeter and ammeter of size not less than 96 mm x 96 mm, selector switches, MCB for protection circuit and current transformers.

VI. It shall be possible to bolt the drawout frame not only in connected position but also in TEST and DISCONNECTED position to prevent dislocation due to vibration and shocks.

14.0 MOULDED CASE CIRCUIT BREAKER (MCCB)

All MCCB’s shall be motor duty and Current Limiting type, and comprise of Quick Make - break switching mechanism, preferably Double Break Contact system, arc extinguishing device and the tripping unit shall be contained in a compact, high strength, heat resistant, flame retardant, insulating moulded case with high withstand capability against thermal and mechanical stresses. All MCCB’s shall be capable of defined Variable overload adjustment. All MCCB’s rated 200 Amps and above shall have adjustable Magnetic short circuit pick up.

The trip command shall override all other commands. MCCB shall employ maintenance free double break contact system to minimize the let thru’ energies and capable of achieving discrimination upto full short circuit capacity of downstream MCCB. The manufacturer shall provide both discrimination tables and let thru energy curves.

The breaking capacity of MCCB’s shall be asked for in the schedule of quantities. The breaking capacities specified will be ICU=ICS i.e type-2. Co-ordination as per relevant BIS and IEC Codes.

The MCCB’s shall be provided with rotary handle operating mechanism. The handle position shall give positive indication of ‘ON’, ‘OFF’ or ‘Tripped’ thus qualifying to Disconnection as per the IS/IEC indicating the true position of all the contacts. In case of 4 poles MCCB the neutral shall be defined and capable of offering protection.

15.0 MINIATURE CIRCUIT BREAKER (MCB)
Miniature Circuit Breaker shall comply with relevant BIS Codes and shall be quick make and break type for 230/415 VAC 50 Hz applications 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 have type ‘C’ characteristic. The MCB shall have the minimum power loss (Watts) per pole defined as per the IS/IEC and the manufacturer shall publish the values.

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 and TPN miniature circuit breakers shall have a common trip bar independent to the external operating handle.

16.0 PAINTING

All sheet steel work shall undergo a process of degreasing, pickling in acid, cold rinsing, phosphating, passivating (seven tank processing) and then painted with electrostatic paint (Powder coating). The shade of colour of panel inside/outside shall be as per relevant BIS code.

17.0 LABELS

Engraved PVC labels shall be provided on all incoming and outgoing feeder. Circuit diagram showing the arrangements of the circuit inside the control panel shall be pasted on inside of the panel door and covered with transparent plastic sheet.

18.0 METERS

i. All voltmeters and indicating lamps shall be protected by MCB’s.

ii. Meters and indicating instruments shall be flush mounts type.

iii. CT ratio and burdens shall be as specified on the Single line diagram.

19.0 CURRENT TRANSFORMERS

Current transformers shall be provided for feeders rated 15 HP and above. All phase shall be provided with current transformers of suitable VA burden with 5 amps secondaries for operation of associated metering.

The CTs shall confirm to relevant Indian Standards. The design and construction shall be dry type, epoxy resin cast robust to withstand thermal and dynamic stresses during short circuits. Secondary terminals of CTs shall be brought out suitable to a terminal block, which shall be easily accessible for testing and terminal connections. The protection CTs shall be of accuracy class 5P10 and measurement CTs shall be of accuracy class I.

20.0 SELECTOR SWITCH

Selector switches where called for, selector switches of rated capacity shall be provided in control panels, to give the choice of operating equipment in selective mode.

21.0 STARTERS

Each motor shall be provided with a starter of suitable rating. Starters shall be in accordance with relevant IS Codes. All Star Delta and ATS Starters shall be fully automatic. Each starter shall be provided with Motor Protective Circuit Breaker (MPCB) to suite the connected motor.

22.0 CONTACTOR

Contactor shall be built into a high strength thermoplastic body and shall be provided with an arc shield for quick arc extinguishing. Silver alloy tips shall be provided to ensure a high degree of reliability and endurance under continuous operation. The magnet system shall consist of laminated yoke and armature to ensure clean operation without hum or chatter.
Starters contactors shall have 3 main and 2 Nos. NO / NC auxiliary contacts and shall be air break type suitable for making and breaking contact at minimum power factor of 0.35. For design consideration of contactors the starting current of connected motor shall be assumed to be 6 times the full load current of the motor in case of direct-on-line starters and 3 times the full load current of the motor in case of Star Delta and Reduced Voltage Starters. The insulation for contactor coils shall be of Class “E”.

Coil shall be tape wound vacuum impregnated and shall be housed in a thermostatic bobbin, suitable for tropical conditions and shall withstand voltage fluctuations. Coil shall be suitable for 220/415±10% volts AC, 50 cycles AC supply.

**THERMAL OVERLOAD RELAY**

Thermal overload relay shall have built in phase failure sensitive tripping mechanism to prevent against single phasing as well as on overloading. The relay shall operate on the differential system of protection to safeguard against three-phase overload, single phasing and unbalanced voltage conditions.

Auto-manual conversion facility shall be provided to convert from auto-reset mode to manual-reset mode and vice-versa at site. Ambient temperature compensation shall be provided for variation in ambient temperature from -5° C to +55°C.

All overload relays shall be of three element, positive acting ambient temperature compensated time lagged thermal overload relays with adjustable setting. Relays shall be directly connected for motors upto 30 HP capacity. C.T. Operated relays shall be provided for motors above 30 HP capacity. Heater circuit contactors may not be provided with overload relays.

**TIME DELAY RELAYS**

Time delay relays shall be adjustable type with time delay adjustment from 0-180 seconds and shall have one set of auxiliary contacts for indicating lamp connection.

**INDICATING LAMP AND METERING**

All meters and indicating lamps shall be in accordance with relevant BIS standards. The meters shall be flush mounted type. The indicating lamp shall be of LED type. Each MCC and control panel shall be provided with voltmeter 0-500 volts with three way and off selector switch, CT operated ammeter of suitable range with three nos. CTS of suitable ratio with three way and off selector switch, phase indicating lamps, and other indicating lamps as called for. All voltage circuits shall be protected by MCBs.

**TOGGLE SWITCH**

Toggle switches, where called for in Schedule of Quantities, shall be in conformity with relevant IS Codes and shall be of 5 amps rating.

**PUSH BUTTON STATIONS**

Push button stations shall be provided for manual starting and stopping of motors / equipment. Green and Red colour push buttons shall be provided for ‘Starting’ and ‘Stopping’ operations. ‘Start’ or ‘Stop’ indicating flaps shall be provided for push buttons. Push Buttons shall be suitable for panel mounting and accessible from front without opening door. Lock lever shall be provided for ‘Stop’ push buttons. The push button contacts shall be suitable for 6 amps current capacity.

**CONDUITS**

Conduits and Accessories shall conform to relevant Indian Standards. Wall thickness shall be 16-gauge upto 32 mm dia and 14 gauges above 32 mm dia conduit. Screwed G.I.conduits shall be used. Joints between conduits and accessories shall be securely made, to ensure earth continuity. All conduit accessories shall be threaded type only. All raw metal shall be painted with bitumastic paint.
Only approved make of conduits and accessories shall be used.

Conduits shall be delivered to the site of construction in original bundles and each length of conduit shall bear the label of the manufacturer.

Maximum permissible number of 650/1100 volt grade PVC insulated wires that may be drawn into rigid non metallic or MS Conduits are given below:

<table>
<thead>
<tr>
<th>Size of wires Nominal Cross section Area (Sq. mm.)</th>
<th>Maximum number of wires within conduit size(mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.5</td>
<td>5 10 14 -- --</td>
</tr>
<tr>
<td>2.5</td>
<td>5 8 12 -- --</td>
</tr>
<tr>
<td>4</td>
<td>3 7 10 -- --</td>
</tr>
<tr>
<td>6</td>
<td>2 5 8 -- --</td>
</tr>
<tr>
<td>10</td>
<td>-- 3 5 6</td>
</tr>
<tr>
<td>16</td>
<td>-- 2 3 6</td>
</tr>
<tr>
<td>25</td>
<td>-- -- 2 4 6</td>
</tr>
<tr>
<td>35</td>
<td>-- -- -- 3 5</td>
</tr>
</tbody>
</table>

29.0 CABLES

M.V. Cables shall be PVC insulated aluminium conductor and armoured cables conforming to IS Codes. Cables shall be armoured and suitable for lying in trenches, ducts, and on cable trays as required. M.V. Cables shall be termite resistant. Cable glands shall be double compression glands. Control cables and indicating panel cables shall be multi core PVC insulated copper conductor and armoured cables.

30.0 CABLE LAYING

Cable shall be laid in accordance with IS code of Practice. Cables shall be laid on 14 gage factory fabricated perforated galvanized sheet steel cable trays, and cable drops / risers shall be fixed to ladder type cable trays factory fabricated out of galvanized steel angle. Access to all cables shall be provided to allow cable withdrawal / replacement in the future. Where more than one cable is running on a cable tray, one dia spacing shall be provided between cables to minimize the loss in current carrying capacity. Cables shall be suitably supported with Galvanized saddles when run on walls / trays. When buried, they shall be laid in 350 mm wide and 750 mm deep trench and shall be covered with 250 mm thick layer of soft sifted sand & protected with bricks/tiles. Special care shall be taken to ensure that the cables are not damaged at bends. The radius of bend of the cables when installed shall not be less than 12 times the diameter of cable.

31.0 WIRE AND WIRE SIZES

1100 volts grade PVC insulated copper conductor wires in conduit shall be used. For all single phase/ 3 phase wiring, 1100 volts grade PVC insulated copper conductor wires shall be used. The equipment inside plant room and AHU room shall be connected to the control panel by means of insulated copper conductor wires of adequate size in exposed conduits. Final connections to the equipment shall be through wiring enclosed in galvanized flexible conduits rigidly clamped at both ends and at regular intervals. An isolator shall be provided near each motor/equipment wherever the motor/equipment is separated from the supply panel through a partition barrier or through ceiling construction. PVC insulated copper conductor wires shall be used inside the control panel for connecting different components and all the wires inside the control panel shall be neatly dressed and plastic beads shall be provided at both the ends for easy identification of control wiring.

The minimum size of control wiring shall be 1.5 sq. mm PVC insulated stranded soft drawn copper conductor wires drawn through conduit to be provided for connecting equipment and control panels.

Power wiring, cabling shall be of the following sizes:
i. Upto 5 HP motors/ 5 KW heaters  3 x 4 sq. mm copper conductor.

ii. From 6 HP to 10 HP motors  6 KW to 7.5 KW heaters  3 x 6 sq. mm copper conductor.

iii. From 12.5 HP to 15 HP motors with star delta starters  2 Nos. 3 x 6 sq. mm copper conductor.

iv. From 20 HP to 25 HP motors  With star delta starters  2 Nos. 3 x 10 sq. mm copper conductors

v. From 30 HP to 35 HP Motors with star delta starters  2 nos. 3 x 16 sq. mm copper conductor armoured cable.

vi. From 40 HP to 50 HP Motors with star delta starters  2 Nos. 3 x 25 sq. mm aluminium conductor Armoured cable.

vii. From 60 HP to 75 HP motors  With star delta starters  aluminium conductor armoured cable.

viii. 100 HP motors  With soft starters  1 No. 3 x 150 sq. mm. aluminium conductor armoured cable

ix. 150 HP motor  With soft starters  1 No. 3 x 240 sq. mm. aluminium conductor armoured cable.

x. 250 HP motor  With soft starters  2 Nos. 3 x 240 sq. mm. aluminium conductor armoured cable.

xi. 400 HP motor  With soft starters  3 Nos. 3 x 240 sq. mm. aluminium conductor armoured cable.

xii. 600 HP motor  With soft starters  3 Nos. 3 x 400 sq. mm. aluminium conductor armoured cable.

All the switches, contactors, push button stations, indicating lamps shall be distinctly marked with a small description of the service installed. The following capacity contactors and overload relays shall be provided for different capacity motors or as per manufacturer's recommendation.

<table>
<thead>
<tr>
<th>TYPE OF STARTER</th>
<th>CONTACTOR CURRENT</th>
<th>OVERLOAD RELAY RANGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>5 HP Motors</td>
<td>D O L</td>
<td>16 amps</td>
</tr>
<tr>
<td>7.5 HP motors</td>
<td>D O L</td>
<td>16 amps</td>
</tr>
<tr>
<td>10 HP Motors</td>
<td>D O L</td>
<td>25 amps</td>
</tr>
<tr>
<td>12.5 HP Motors</td>
<td>Star Delta</td>
<td>16 amps</td>
</tr>
<tr>
<td>15 HP Motors</td>
<td>Star Delta</td>
<td>25 amps</td>
</tr>
<tr>
<td>20 HP Motors</td>
<td>Star Delta</td>
<td>32 amps</td>
</tr>
<tr>
<td>25 HP Motors</td>
<td>Star Delta</td>
<td>32 amps</td>
</tr>
<tr>
<td>30 HP Motors</td>
<td>Star Delta</td>
<td>40 amps</td>
</tr>
<tr>
<td>35 HP Motors</td>
<td>Star Delta</td>
<td>40 amps</td>
</tr>
<tr>
<td>40 HP Motors</td>
<td>Star Delta</td>
<td>40 amps</td>
</tr>
<tr>
<td>50 HP Motors</td>
<td>Star Delta</td>
<td>70 amps</td>
</tr>
</tbody>
</table>
60 HP Motors            Star Delta      110 amps         30-50 amps
75 HP Motors            Star Delta      110 amps         90-150 amps
100 HP Motors           Soft Starter    200 amps         CT operated relay
125 HP Motors           Soft Starter    200 amps         CT operated relay
150 HP Motors           Soft Starter    200 amps         CT operated relay
150 HP Motors           Soft Starter    300 amps         CT operated Relay.
200 HP Motors           Soft Starter    300 amps         CT operated Relay.
250 HP Motors           Soft Starter    400 amps         CT operated Relay.
300 HP Motors           Soft Starter    400 amps         CT operated Relay.
400 HP Motors           Soft Starter    600 amps         CT operated Relay.
600 HP Motors           Soft Starter    900 amps         CT operated Relay.

Two speed motors when specified, shall be provided with DOL starter irrespective of it rating.

32.0 EARTHING

Earthing shall be provided in accordance with relevant BIS Codes and shall be copper strips/wires. The main panel shall be connected to main earthing system of the power supply. All single-phase metal clad switches and control panels shall be earthed with minimum 3 mm diameter copper conductor wire. All 3 phase motors and equipment shall be earthed with 2 numbers distinct and independent copper wires/tapes as follows:

i. Motor upto and including 10 HP rating. 2 Nos. mm dia copper wires.
ii. Motor 12.5 HP to 40 HP capacity. 2 Nos. 4 mm dia copper wires.
iii. Motor 50 to 75 HP capacity 2 Nos. 6 mm dia copper strip
iv. Motor above 75 HP. 2 Nos. 25 mm x 3 mm copper strips.

All switches shall be earthed with two numbers distinct and independent copper wires’ tapes as follows:

i. 3 phase switches and control panels upto 60 amps rating. 2 nos. 10 sq mm size copper conductors.
ii. 3 phase switches, and control panels 63 amps to 100 amps rating. 2 Nos. 16 sq mm size copper conductors.
iii. 3 phase switches and control panels 125 amps to 200 amps rating. 2 Nos. 25 x 6 mm GI strips
iv. 3 phase switches, control panels, bus ducts, above 200 amps rating. 2 Nos. 40 x 6 mm GI strips

The earthing connections shall be tapped off from the main earthing of electrical installation. The overlapping in earthing strips at joints where required shall be minimum 75 mm. These straight joints shall be welded/crimping type lugs of adequate capacity and size shall be used for all termination of wires. Lugs shall be bolted to the equipment body to be earthed after the metal body is cleaned of paint and other oily substance.

33.0 DRAWINGS
Shop drawings for control panels and for wiring of equipment showing the route of conduit & cable shall be submitted by the contractor for approval of Architect/Consultant before starting the fabrication of panel and starting the work. On completion, four sets of complete “As-installed” drawings incorporating all details like, conduits routes, number of wires in conduit, location of panels, switches, junction/pull boxes and cables route etc. shall be furnished by the Contractor.

34.0 TESTING

Before commissioning of the equipment, the entire electrical installation shall be tested in accordance with relevant BIS codes and test report furnished by a qualified and authorized person. The entire electrical installation shall be gotten approved by Electrical Inspector and a certificate from Electrical Inspector shall be submitted. All tests shall be carried out in the presence of Owner's site representative. Testing of the panels shall be as per relevant BIS Codes:

35.0 PAINTING

All sheet steel work shall undergo a process of degreasing, thorough cleaning, and painting with a high corrosion resistant primer. All panels shall then be baked in an oven. The finishing treatment shall be by application of powder coating of approved shade.

36.0 MEASUREMENT OF ELECTRICAL CONTROL PANELS

Panels shall be counted as number of units. Quoted rates shall include as lumpsum (NOT measurable lengths) for all internal wiring, power wiring and earthing connections from the control panel to the starter and to the motor, control wiring for interlocking, power and control wiring for automatic and safety controls, and control wiring for remote start/stop as well as indication as per the specifications. The quoted rate of panel shall also include all accessories, switchgear, contactors, indicating meters and lights as per the Specifications and Schedule of Quantities. The end terminations to be included in the cable rate.

37.0 RUBBER MAT

Rubber mat shall be provided in front to cover the full length of all panels. Where back space is provided for working from the rear of the panel, rubber mat shall also be provided to cover the full length of panel.

38.0 CABLE TRAYS

The cable tray shall be fabricated out of 2 mm thick pregalvanized sheet steel using proper jigs and fixtures.

All accessories such as bends, tees etc., shall also be manufactured at the tray manufacturer’s works. Maa Industries, (Profab) Mumbai make cable trays shall be preferred. These shall not be fabricated at site.

Perforated cable trays shall be of similar material with 1.6 mm thick G.I cover on top retained. In position by screws

Cable tray sections shall be joined by fishplates.

The accessories like bends, reducers, etc., of similar material with galvanized hardware shall be supplied.
SECTION 14

PROGRAMMABLE LOGICAL CONTROL SYSTEMS

14 GENERAL

SECTION INCLUDES

A. Control equipment.
B. Software.

REFERENCES

B. ASME MC85.1 - Terminology for Automatic Control.

DEFINITIONS

A. Ensure terminology used in submittals conforms to [ASHRAE 85.] [ASME MC85.1.] [NEMA EMC1.]

SYSTEM DESCRIPTION

A. Automatic temperature control field monitoring and control system using field programmable micro-processor based units, with communications to Building Management System.
B. Central and remote hardware, software, and interconnecting wire and conduit.
C. Air handling units, Pumps, valves, instruments, and Terminal unit controls for variable air volume terminals, fan coils, pneumatic or electric unless indicated otherwise.
D. Damper Motors and Valve Operators: [Pneumatic.] [Electronic.]

SUBMITTALS

A. Submit under provisions of Section 01
B. Shop Drawings:
   1. Trunk cable schematic showing programmable control unit locations, and trunk data conductors.
   2. List of connected data points, including connected control unit and input device.
   3. System graphics indicating monitored systems, data (connected and calculated) point addresses, and operator notations.
   4. System configuration with peripheral devices, batteries, power supplies, diagrams, modems, and interconnections.
   5. Descriptive data and sequence of operation of operating, user, and application software.
12 Product Data: Provide data for each system component and software module.

13 Manufacturer's Installation Instructions: Include for all manufactured components.

PROJECT RECORD DOCUMENTS
A. Submit under provisions of Section 01
B. Accurately record actual location of control components, including panels, thermostats, and sensors.
C. Revise shop drawings to reflect actual installation and operating sequences.
D. Include data specified in "Submittals" in final "Record Documents" form.

OPERATION AND MAINTENANCE DATA
A. Submit under provisions of Section 1
B. Include interconnection wiring diagrams complete field installed system with identified and numbered, system components and devices.
C. Include keyboard illustrations and step-by-step procedures indexed for each operator function.
D. Include inspection period, cleaning methods, cleaning materials recommended, and calibration tolerances.

QUALIFICATIONS
A. Manufacturer: Company specializing in manufacturing the products specified in this Section with minimum FIVE years proven experience.
B. Installer: Company specializing in applying the work of this Section with minimum five years experience

12 Design system software under direct supervision of a Professional Engineer experienced in design of this work and licensed at the place where the Project is located.

COORDINATION
A. Coordinate work under provisions of Section 1
B. Ensure installation of components is complementary to installation of similar components in other systems.
C. Coordinate installation of system components with installation of mechanical systems equipment such as air handling units and air terminal units.

13 Ensure system is completed and commissioned.

WARRANTY
A. Provide five-year warranty from the date of commissioning.
B. Warranty: Include coverage for field programmable micro-processor based units.

PROTECTION OF SOFTWARE RIGHTS
A. Prior to delivery of software, the Owner and the party providing the software will enter into software license agreement with provisions for the following:
1. Limiting use of software to equipment provided under these specifications.
2. Limiting copying.
3. Preserving confidentiality.
4. Prohibiting transfer to a third party.

### 3.10.2 PRODUCTS

#### MANUFACTURERS

(a) JOHNSONS  
(b) SAUTER  
(c) SEIMENS  
(d) HONEYWELL  
(e) ABB  
(f) MITSUBISHI

#### LOCAL OPERATOR ACCESS AND DISPLAY PANEL

A. Provide local display and adjustment panel. Panels shall be [portable] [or] [integral to] programmable control unit. Panel contains a six character digital display, and a numerical keyboard. Display and adjust:

1. Input/output point information.
2. Controller set points.
3. Controller tuning constants.
4. Program execution times.
5. High and low limit values.
7. Time, date, year.


C. Provide status lights to annunciate controller test, trouble, alarm, auto control, override, and auxiliary button operation.

#### OPERATOR STATION

A. Operator Input/Output Devices:

2. Interface with standard EIA (Electronic Industries Association) hardware through EIA RS-232-C communications port over telephone lines through a suitable modem interface, or via dial-up network with auto-answer modems.
3. System loading shall be through CD.[floppy disk.]
4. Communication between the central processing unit and programmable control units, and between programmable control units shall be normally 9600 baud, by block mode transmission with cyclical redundant error checking, supervised for system integrity and for monitoring field point status.
5. Station includes multiple input/output devices which can be used simultaneously, having on-line definable characteristics.

6. Provide Building Environmental Control Center consisting of video display terminal, hard copy printer, and audible alarm horn.

B. Printer:
   1. Wide carriage with output of ten OR twelve OR fifteen characters per inch and 132 characters per line of paper, capable of using fan-fold paper. Laser printer preferred.

C. Terminal:
   1. 300 mm diagonal display with adjustable tilt.
   2. 24 line, 80 character color screen.
   3. Automatic screen blanking after timed inactivity.
   4. Low profile, detachable, keyboard having standard typewriter layout plus a 10 key numeric keypad, dedicated function keys.

**CONTROL UNITS**

A. Units: Modular in design and consisting of processor board with programmable RAM memory, local operator access and display panel, and integral interface equipment.

B. Battery Backup: For minimum of 100 hours for complete system including RAM without interruption, with automatic battery charger.

C. Provide the following functions:
   1. Mathematical: Absolute value, calculate, square root, power, sign, average, totalize.
   2. Logic: OR, AND, compare negate.
   3. Fixed Formula: High and low select, span, rate, ramp, enthalpy, wet bulb, dew point, relative humidity, humidity ratio, and filter.
   5. Display Panel: Display adjust, override, time, day, date, year, alarm scan, override scan.
   6. Control Routines: Proportional, integral, lead lag, hysteresis correction and incremental control.
   7. Energy Management: Duty cycling, load shed, optimal run time, holiday and daylight savings time correction.

D. Provide self-test procedure for checking digital display and computer. Display advisories for maintenance, performance, or software problems. Identify variables as reliable or unreliable. Variables identified as unreliable will flash when displayed and calculation will use default.

E. Indicate alarms and deviations. Alarm scan shows alarms and identification. Continue alarm indication until acknowledged and alarm condition is corrected.

F. Provide two communication interface ports permitting communication between processor, process interface equipment, other processors, and central processing unit as specified.

**DATA INTERFACE UNITS**

A. Provide equipment required to connect all sensors, transducers and interface relays required to monitor and control equipment in sequence of operation.
B. Provide each data interface equipment module with minimum of binary and analog inputs, and binary and analog outputs.

**INPUT/OUTPUT SENSORS**

**A. Temperature:**

1. Resistance temperature detectors with resistance tolerance of plus or minus 0.1 percent at 21 degrees C, interchangeability less than plus or minus 0.2 percent C, time constant of 13 seconds maximum for fluids and 200 seconds maximum for air.

2. Measuring current maximum 5 MA with maximum self-heat of 0.017 degrees C/MW in fluids and 0.008 degrees C/MW in fluids and 0.008 degrees C/MW in air.

3. Provide 3 lead wires and shield for input bridge circuit.

4. Use insertion elements in ducts not affected by temperature stratification or smaller than one square meter. Use averaging elements where larger or prone to stratification sensor length 2.5 m or 5 m as required.

5. Insertion elements for liquids shall be with brass socket with minimum insertion length of 2-1/2 inches (60 mm).

6. Supply room sensors with locking cover.

7. Provide outside air sensors with watertight inlet fitting, shielded from direct rays of sun.

**B. Humidity Sensors:**

1. Elements: Accurate within 5 percent full range with linear output.

2. Room Sensors: With locking cover, span of [10 to 60 percent relative humidity.] [30 to 80 percent relative humidity.]

3. Duct and Outside Air Sensors: With element guard and mounting plate, range of 0 - 100 percent relative humidity.

**C. Static Pressure Sensors:**

1. Unidirectional with ranges not exceeding 150 percent of maximum expected input.

2. Temperature compensated with typical thermal error or 0.06 percent of full scale in temperature range of 40 to 100 degrees F (5 to 40 degrees C).

3. Accuracy: One percent of full scale with repeatability 0.3 percent.

4. Output: 0 - 5 vdc with power at 12 to 28 vdc.

**D. Equipment Operation Sensors:**

1. Status Inputs for Fans: Differential pressure switch with adjustable range of 0 to 5 inches wg (0 to 1250 Pa).

2. Status Inputs for Pumps: Differential pressure switch piped across pump with adjustable pressure differential range of 8 to 60 psi (50 to 400 kPa).


**E. Digital to Pneumatic Transducers:** Convert [plus or minus 12 vdc pulse width modulation outputs] [continuous proportional current or voltage] to 0 to 20 psi (0 to 138 kPa).
F. Damper Position Indication: Potentiometer mounted in handbox enclosure with adjustable crank arm assembly connected to damper to transmit 0 - 100 percent damper travel.

G. Carbon Monoxide Detectors:
   1. Single or multichannel dual level detectors, using solid state sensors with three year minimum life. Sensor replacement shall take maximum 15 minutes. Suitable over temperature range of 23 to 130 degrees F (-5 to 55 degrees C).
   2. Provide individual indicators and contactors for each level, initially calibrated for 50 ppm and 100 ppm.
   3. Maximum response time to 100 ppm CO calibration gas shall be two minutes.

OPERATING SYSTEM SOFTWARE

A. System Format:
   1. Divide points of control or monitoring by system.
   2. Identify points with unique, structured point identifier reflecting "specific area" or "specific system", and "specified point".

B. Input Process:
   1. Select, from menu, one of four general types of commands based upon password clearance, command points, information points, builds parameters, and modify parameters. Commands not available by password clearance shall be deleted from video display.
   2. Enter memory changes through keyboard.
   3. Select entry modes, Aid or Direct, based on operator's degree of capability and familiarity with system.
   4. Aid Mode shall prompt operator through each step indicating available options.
   5. Direct Mode shall allow experienced operator to input command string directly.
   6. Enter commands as alpha/numeric character strings. Where commands require data for limits, set point, and time, enter value in same engineering units as controlled variable.
   7. Operator input shall not inhibit alarm reporting. Echo input on associated output device, to either execute or abort.

C. Operator Access Control: Restrict any operator commands through use of software password.

D. Information Access: Obtain point status information from any designated output device with access command. Point status consists of point identification, numerical value (analog points) and associated engineering units, and individual function label indicating that point is on or off or in Alarm Normal condition. Output includes date and time of execution.

E. Point Display: Video display includes status of single point or group of points with high and low limits (if applicable). Refresh display at least every 20 seconds.

F. Alarm summary includes status of points in Alarm condition.

G. Off-normal summary includes status of points in Off-Normal condition.

H. Alarm Reporting:
1. Alarm outputs contain descriptor, point identification, point data, engineering units, and date and time.

2. Inhibit reporting of associated analog and binary alarms upon HVAC system shutdown. Upon restart, inhibit alarm reporting for operator pre-determined time.

5. Operator specifies if alarm required acknowledgement.

I. Advisories:

1. Lockout summary which contains status of points in locked out condition.

2. Continuously interrogate system hardware and programmable control units for failure or tampering and report if operational or not operational.

3. Power failure detection, time and date.

4. System communication failure with operator device, field interface unit, point, programmable control unit.

J. Data Base Save/Restore:

1. Provide program which allows saving or restoring of operating data.

2. [Cassette tape] or [Floppy disk] units shall save or restore system operating data.

3. Data includes:
   a. Analog limits and differentials
   b. Start-stop times
   c. Access/secure times
   d. Lockout/unlock times
   e. Set point values and adjustment times
   f. Limits and differential values
   g. Totalization points, limits, and current values
   h. Alarm messages and their assignments
   i. Load control program operational parameters
   j. HVAC control program operational parameters

K. Power Failure Motor Restart: Provide program to restore systems to normal operating conditions following power outage, and to enforce emergency operating conditions during power outage. Automatically restart loads to correct operating condition if normal or emergency power is available.

**BASIC OPERATING FEATURES**

A. Binary Capabilities:

1. Monitor binary sensors, continuously storing present contact condition in memory.

2. Indicate if point is off-normal, in alarm, or off-line.
3. Program output points for Open/Closed, Test/Reset, and Start/Stop.

4. Feedback Start/Stop points. Employ point unique, feedback delay timer to temporarily suppress alarm reporting after input to allow time for response.

5. Output advisory message if response is not as commanded.

6. Hold points in present operating condition if controls power failure occurs.

B. Analog Capabilities:

1. Measure, transducer, transmit and display analog values.

2. Express analog point values in proper engineering units, displaying with up to [seven] [six] significant digits.

3. Have sensor to readout accuracy of plus or minus [one degree F (0.56 degrees C.)] [0.5 degrees F (0.28 degrees C.).]

4. Use [English] [S.I. Metric] system of measurement.

5. Provide for operator-designated ranges either linear, series of linear approximations, split ranges, or square root extractions of exponential functions.

6. Compare analog read to high and low limits and annunciate Alarm or Off-Normal condition.

7. Output alarm, including point identification current value and associated engineering units, high or low value, and time and date.

8. Automatically disable alarm reporting upon associated system shutdown. Allow sufficient time to return to normal operating conditions before allowing alarm reporting.


C. Analog Point Adjust:

1. Remotely adjust controller set points or dampers. Automatically adjust points based upon preselected time or value.

2. Employ feedback so that if point fails to respond, responds with wrong value, or drifts from set point value by plus or minus 2 percent, output alarm message. Employ feedback delay timer to temporarily suppress alarm reporting after input to allow time for response.

3. Hold points in present operating condition if controls power failure occurs.

D. Automatic Alarm Lockout: Automatically inhibit alarm reporting of analog and binary points upon associated system shutdown. Inhibit reporting for operator predetermined time, upon restart of HVAC systems.

LOAD CONTROL PROGRAMS

A. General:

1. Provide means to reduce electrical energy usage, using control algorithms designed for electrical energy control.

2. Apply algorithms to other energy sources, such as steam or natural gas.


B. Demand Limiting:
1. Monitor total power consumption per power meter and shed associated loads automatically to reduce power consumption to an operator-presettable maximum demand level.

2. Use floating window type demand determination to monitor demand and compare to target value.

3. Automatically shed loads throughout the demand interval selecting loads with independently adjustable on and off time of between one and 255 minutes.

4. Output advisory if loads are not available to satisfy required shed amount, advice shed requirements[,] and requiring operator acknowledgement.]

5. Operator commands:
   a. Add/delete demand meter point.
   b. Define load point.
   c. Define load priority target.
   d. Define control target.
   e. Begin new billing period.
   f. Lock/unlock program.
   g. Activate/inactivate/restore load.
   h. Request load control system control summary.
   i. Request load control system load summary.

6. Load control system summary:
   a. Demand interval
   b. Current kW power and measured demand.
   c. Projected load limit.
   d. Total energy available from HVAC system
   e. Maximum, average, and current expendable load.
   f. Maximum, average and current deferrable load.
   g. Demand limit status, target value, and recent control action.
   h. Duty cycle status, target value, and recent control action.
   i. Convergence time.
   j. Restore bandwidth.

7. Load summary:
   a. Load priority.
   b. Expendable/deferrable load type.
   c. Point type, ID, status.
d. Load rating.

e. Minimum off, maximum off, and minimum on times.

C. Duty Cycling:

1. Periodically turn selected loads off to evenly reduce power consumption to target value, selecting loads with independently adjustable on and off time of between one and 255 minutes.

2. Operator commands:
   a. Define load point.
   b. Define control target.
   c. Activate/inactivate/restore load.
   (i) Request load control system load summary.

HVAC CONTROL PROGRAMS

A. General:

1. Support [English] [S.I. Metric] units of measurement.

2. Identify each HVAC Control system.

B. Optimal Run Time:

1. start-up and shutdown times of HVAC equipment for both heating and cooling.

2. Base on occupancy schedules, outside air temperature, seasonal requirements, and interior room mass temperature.

3. Start-up systems by using outside air temperature, room mass temperatures, and adaptive model prediction for how long building takes to warm up or cool down under different conditions.

4. Use outside air temperature to determine early shut down with ventilation override.

5. Analyze multiple building mass sensors to determine seasonal mode and worse case condition for each day.

6. Operator commands:
   a. Define time schedule.
   b. Add/delete fan status point.
   c. Add/delete outside air temperature point.
   d. Add/delete mass temperature point.
   e. Define heating/cooling parameters.
   f. Define mass sensor heating/cooling parameters.
   g. Lock/unlock program.
h. Request optimal run time control summary.

i. Request optimal run time mass temperature summary.

j. Request HVAC point summary.

k. Request HVAC saving profile summary.

7. Control summary:
   a. HVAC Control system begin/end status.
   b. Optimal run time lock/unlock control status.
   b. Heating/cooling mode status.
   c. Optimal run time schedule.
   d. Start/stop times.
   e. Selected mass temperature point ID.
   f. Optimal run time system normal start times.
   g. Occupancy and vacancy times.
   h. Optimal run time system heating/cooling mode parameters.

8. Mass temperature summary:
   a. Mass temperature point type and ID.
   b. Desired and current mass temperature values.
   c. Calculated warm-up/cool-down time for each mass temperature.
   d. Heating/cooling season limits.
   e. Break point temperature for cooling mode analysis.
   f. Linear compensation factor for heating mode analysis.

9. HVAC point summary:
   a. Control system identifier and status.
   b. Fan status. point ID and status.
   c. Outside air temperature point ID and status.
   d. Mass temperature point ID and status.
   e. Calculated optimal start and stop times.
   a) Period start.

C. Supply Air Reset:

1. Monitor heating and cooling loads in building spaces, terminal reheat systems, both hot deck and cold deck temperatures on dual duct and multizone systems, single zone unit discharge temperatures.
2. Adjust discharge temperatures to most energy efficient levels satisfying measured load by:
   a. Raising cooling temperatures to highest possible value.
   b. Reducing heating temperatures to lowest possible level.

3. Operator commands:
   a. Add/delete fan status point.
   b. Lock/unlock program.
   c. Request HVAC point summary.
   d. Add/Delete discharge controller point.
   e. Define discharge controller parameters.
   f. Add/delete air flow rate.
   g. Define space load and load parameters.
   h. Request space load summary.

4. Control summary:
   a. HVAC control system status (begin/end).
   b. Supply air reset system status.
   c. Optimal run time system status.
   d. Heating and cooling loop.
   e. High/low limits.
   f. Dead band.
   g. Response timer.
   h. Reset times.

5. Space load summary:
   a. HVAC system status.
   b. Optimal run time status.
   b. Heating/cooling loop status.
   c. Space load point ID.
   d. Current space load point value.
   e. Control heat/cool limited.
   f. Gain factor.
   g. Calculated reset values.
   h. Fan status point ID and status.
D. Enthalpy Switchover:

1. Calculate outside and return air enthalpies using measured temperature and relative humidity; determine energy expended and control outside and return air dampers.

2. Operator commands:
   a. Add/delete fan status point.
   b. Add/delete outside air temperature point.
   c. Add/delete discharge controller point.
   d. Define discharge controller parameters.
   e. Add/delete return air temperature point.
   f. Add/delete outside air dew point/humidity point.
   g. Add/delete return air dew point/humidity point.
   h. Add/delete damper switch.
   i. Add/delete minimum outside air.
   j. Add/delete atmospheric pressure.
   k. Add/delete heating override switch.
   l. Add/delete evaporative cooling switch.
   m. Add/delete airflow rate.
   n. Define enthalpy deadband.
   o. Lock/unlock program.
   p. Request control summary.
   q. Request HVAC point summary.

3. Control summary:
   a. HVAC control system begin/end status.
   b. Enthalpy switchover optimal system status.
   c. Optimal return time system status.
   d. Current outside air enthalpy.
   e. Calculated mixed air enthalpy.
   f. Calculated cooling cool enthalpy using outside air.
g. Calculated cooling cool enthalpy using mixed air.

h. Calculated enthalpy difference.

i. Enthalpy switch over deadband.

j. Status of damper mode switch.

PROGRAMMING APPLICATION FEATURES

A. Trend Point:

1. Sample up to points, real or computed, with each point capable of collecting samples at intervals specified in minutes, hours, days, or month.

2. Output trend logs as line graphs or bar graphs. Output graphic on terminal, with each point for line and bar graphs designated with a unique [pattern] [color], vertical scale either actual values or percent of range, and horizontal scale time base. Print trend logs up to 12 columns of one point/column.

B. Alarm Messages:

1. Allow definition of minimum of messages, each having minimum length of characters for each individual message.

2. Assign alarm messages to system messages including point's alarm condition, point's off-normal condition, totalized point's warning limit, and hardware elements advisories.

3. Output assigned alarm with "message requiring acknowledgement".

4. Operator commands include define, modify, or delete; output summary listing current alarms and assignments; output summary defining assigned points.

C. Weekly Scheduling:

1. Automatically initiate equipment or system commands, based on preselected time schedule for points specified.

2. Provide program times for each day of week, per point, with [one] minute resolution.

3. Automatically generate alarm output for points not responding to command.


5. Operator commands:

   a. System logs and summaries.

   b. Start of stop point.

   c. Lock or unlock control or alarm input.

   d. Add, delete, or modify analog limits and differentials.

   e. Adjust point operating position.

   f. Change point operational mode.

   g. Open or close point.
Project: “Civil, Electrical and other utility services for package -Civil- II (Rotable complex)
VOLUME –II. TECHNICAL SPECIFICATIONS FOR TENDER NO.NK/FW/CAP-ROH-577/2010-11

h. Enable/disable, lock/unlock, or execute interlock sequence or computation profile.

i. Begin or end point totalization. - Modify totalization values and limits.

j. Access or secure point.

k. Begin or end HVAC or load control system.

l. Modify load parameter.

m. Modify demand limiting and duty cycle targets.

6. Output summary: Listing of programmed function points, associated program times, and respective day of week programmed points by software groups or time of day.

D. Interlocking:

1. Permit events to occur, based on changing condition of one or more associated master points.

2. Binary contact, high/low limit of analog point or computed point shall be capable of being utilized as master. Same master may monitor or command multiple slaves.

3. Operator commands:

   a. Define single master/multiple master interlock process.

   b. Define logic interlock process.

   c. Lock/unlock program.

   d. Enable/disable interlock process.

   e. Execute terminate interlock process.

   f. Request interlock type summary.

3.10.3 EXECUTION

INSTALLATION

11 Install in accordance with manufacturer’s instructions and standard electrical works recommended practice.

C. Provide with 120v AC, 15 amp dedicated emergency power circuit to each programmable control unit.

MANUFACTURER'S FIELD SERVICES

A. Preparing and start up of systems.

DEMONSTRATION

A. Demonstrate complete and operating system to Owner.

INPUT/OUTPUT SCHEDULE

<table>
<thead>
<tr>
<th>POINT DESCRIPTION</th>
<th>POINT</th>
<th>POINT</th>
<th>POINT</th>
<th>POINT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Digital Input</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Demand Meter (kw)
Auxiliary Contact
Switches
Switch Closing
Flow Switch
Optical
Current
Pressure
Digital Output
Control Relay
Solenoid
Contactor
Analog Input
Temperature Sensors
Outdoor Air Space
Pipe Supply
Pipe Return
Duct Supply
Duct Return
Duct Mixed Air
Stack Temperature
Humidity Sensors
Outdoor Space
Duct Pressure/Vacuum
Filter
Flow
Current
Liquid Level
Photocell
Alarm

**INPUT/OUTPUT SCHEDULE**

<table>
<thead>
<tr>
<th>POINT DESCRIPTION</th>
<th>POINT</th>
<th>POINT</th>
<th>POINT</th>
<th>POINT</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>POINT_TYPE</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Inputs**
- Temperature
  - Relative Humidity
  - Pressure
  - Flow
  - Level
  - Position
  - Energy
  - Power
  - Outputs
  - Status
  - Alarm
  - Pneumatic Position
  - Electronic Position
  - Set Point Adjust
  - Start/Stop
  - Off/Low/High
  - Software Features
  - PID Control (DDC)
  - High Limit
Low Limit  
Run Time Totalization  
Consumption Totalization  
Program Start/Stop  
Load Shed  
Duty Cycle  
Enthalpy Switchover  
Optimal Run Time  
Supply Air Reset  
O.A. Interlock  
O.A. Temp. Reset  
Free Cooling Mode  
Warm-up Mode  
Boiler Interlock  
Chiller Sequencing  
Energy Calculation  

ALARM SCHEDULE

<table>
<thead>
<tr>
<th>TYPE</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>A1</td>
<td>High Limit</td>
</tr>
<tr>
<td>A2</td>
<td>Low Limit</td>
</tr>
<tr>
<td>A3</td>
<td>Run Time</td>
</tr>
<tr>
<td>A4</td>
<td>Maintenance</td>
</tr>
<tr>
<td>A5</td>
<td>Status</td>
</tr>
<tr>
<td>A6</td>
<td>Override</td>
</tr>
<tr>
<td>A7</td>
<td>Freeze</td>
</tr>
<tr>
<td>A8</td>
<td>Low Pressure</td>
</tr>
</tbody>
</table>

SECTION: 15  
FIELD DEVICES

SPECIFICATION

DIFFERENTIAL PRESSURE SWITCH (AIR) WITH DISPLAY

<table>
<thead>
<tr>
<th>Sl No</th>
<th>Description</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Medium</td>
<td>Air and non-corrosive gases</td>
</tr>
<tr>
<td>2</td>
<td>Setting range</td>
<td>20 to 300 Pa</td>
</tr>
<tr>
<td></td>
<td></td>
<td>50 to 500 Pa</td>
</tr>
<tr>
<td></td>
<td></td>
<td>100 to 1000 Pa</td>
</tr>
<tr>
<td>3</td>
<td>Pressure</td>
<td>5000 Pa overpressure</td>
</tr>
<tr>
<td>4</td>
<td>Hysteresis</td>
<td>10 Pa (/300)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>15 Pa (/500)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>20 Pa (/1000)</td>
</tr>
<tr>
<td>5</td>
<td>Contact</td>
<td>Single pole changeover rated 250 Vac @ 5 A</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(resistive) or 30 Vdc @ 2A</td>
</tr>
<tr>
<td>6</td>
<td>Life:</td>
<td>10 6 switching cycles</td>
</tr>
<tr>
<td>7</td>
<td>Pressure</td>
<td>20 Pa</td>
</tr>
<tr>
<td>8</td>
<td>Repeatability</td>
<td>± 2.5 Pa (/300)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>± 5 Pa (/500 or /1000)</td>
</tr>
<tr>
<td>9</td>
<td>Materials</td>
<td>Fibre-glass reinforced plastic</td>
</tr>
<tr>
<td>9.1</td>
<td>Case</td>
<td>Plastic</td>
</tr>
<tr>
<td>9.2</td>
<td>Cover</td>
<td>Plastic</td>
</tr>
<tr>
<td>10</td>
<td>Diaphragm</td>
<td>Silicone LSR</td>
</tr>
</tbody>
</table>
11 Weight 144 g (including bracket)
12 Electrical
12.1 Connectors Screw terminals
12.2 Cable entry Gland with Pg 11 female thread with built-in strain relief
13 Pressure
13.1 Connectors 6.2 mm diameter push-on barbs
13.2 Connection Kit 2 m tubing, 2 off duct nipples, 4 self-tapping screws
13.3 Protection IP54
14 Dimensions
14.1 Sensor 103 x 90 x 88 (max)
14.1 Duct nipples 50 x 25 mm diameter
14.2 Standards
15 EU conformity Low voltage directive 72/23/ENG
15.1 Gas appliance directive 90/396/END,
15.2 CE 0085 A P0918
16 Ambient limits
16.1 Storage 40 °C to +85 °C
16.2 Medium and Ambient 30 °C to +85 °C

<table>
<thead>
<tr>
<th>Sl No</th>
<th>Description</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Setting range</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>DPSL/L</td>
<td>40 to 200 mbar</td>
</tr>
<tr>
<td>1</td>
<td>DPSL/H</td>
<td>150 to 1000 mbar</td>
</tr>
<tr>
<td>2</td>
<td>Maximum Operating Pressure</td>
<td></td>
</tr>
<tr>
<td>2.1</td>
<td>DPSL/L</td>
<td>10000 mbar</td>
</tr>
<tr>
<td>2.2</td>
<td>DPSL/H</td>
<td>20000 mbar</td>
</tr>
<tr>
<td>3</td>
<td>Cable gland</td>
<td>PG9 thread (female in body)</td>
</tr>
<tr>
<td>4</td>
<td>Contact</td>
<td>: Single pole changeover rated 250 Vac at 1 A (resistive) or 0.5 A (motor loading).</td>
</tr>
<tr>
<td>5</td>
<td>Life</td>
<td>&gt;10⁶ switching cycles.</td>
</tr>
<tr>
<td>6</td>
<td>Smallest switching</td>
<td>3 mbar</td>
</tr>
<tr>
<td>7</td>
<td>Difference</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Repeatability</td>
<td>± 5% of switching point (± 0.4 mbar minimum)</td>
</tr>
<tr>
<td>9</td>
<td>Materials</td>
<td></td>
</tr>
<tr>
<td>9.1</td>
<td>Case</td>
<td>Brass</td>
</tr>
<tr>
<td>9.2</td>
<td>Cover</td>
<td>Plastic</td>
</tr>
<tr>
<td>9.3</td>
<td>Diaphragm</td>
<td>EPDM</td>
</tr>
<tr>
<td>10</td>
<td>Weight</td>
<td>1000g</td>
</tr>
<tr>
<td>11</td>
<td>Electrical</td>
<td>Screw terminals</td>
</tr>
<tr>
<td>12</td>
<td>Pressure Connections</td>
<td>G1/8&quot; (DIN 259), 1/8&quot; BSP female thread;</td>
</tr>
<tr>
<td>13</td>
<td>Protection</td>
<td>IP54</td>
</tr>
<tr>
<td>14</td>
<td>Dimensions</td>
<td>118 x 65 x 65 mm</td>
</tr>
<tr>
<td>14.1</td>
<td></td>
<td>120 x 69 x 65 mm (inc bracket)</td>
</tr>
<tr>
<td>15</td>
<td>Temperature (ambient and medium)</td>
<td>10 to 80 °C</td>
</tr>
</tbody>
</table>

DIFFERENTIAL PRESSURE SWITCH (AIR) WITH DISPLAY

Thermistor Room Temperature Sensor with digital Display

<table>
<thead>
<tr>
<th>Sl No</th>
<th>Description</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Electrical</td>
<td></td>
</tr>
</tbody>
</table>
### 1.1 Connection
- 1 part screw terminals for 0.5 to 2.5 mm² cross-section area cable.
- 2 terminals for TE/TS, 3 for TE/TS/K, and 6 for all other options.

### 1.2 Thermistor
- 10 kΩ @ 25 °C

### 1.3 Temperature range
- 10 to +40 °C (recommended).

### 1.4 Temperature Accuracy
- Of sensor, ±0.5 °C (-10 to +40 °C)

### 1.5 Potentiometer
- 1 kΩ to 11 kΩ ±20 %.

### 2 Mechanical

#### 2.1 Flush fitting
- 85 mm x 85 mm x 25 mm.

#### 2.2 Surface fitting
- 65 mm x 65 mm x 34 mm.

#### 2.3 Enclosure Material
- Flame retardant (V0) ABS.

#### 2.4 Environmental
- -10 to +50 °C
- 0 to 90 %RH non-condensing.

### Technical Specification

#### Duct type Humidity & Temperature Sensor with display

<table>
<thead>
<tr>
<th>Sl No</th>
<th>Description</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.1</td>
<td>Humidity measurement range</td>
<td>0 to 95 %RH non-condensing</td>
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<tr>
<td>1.2</td>
<td>Temperature measurement range</td>
<td>-10 to +70 °C</td>
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<tr>
<td>1.3</td>
<td>Humidity element H/DT, H/DT/2CC</td>
<td>Resistance change through bulk polymer</td>
</tr>
<tr>
<td>1.4</td>
<td>H/DT/5%</td>
<td>Humidity accuracy of sensor (at 25 °C) including hysteresis, linearity, and repeatability.</td>
</tr>
<tr>
<td>1.5</td>
<td>H/DT</td>
<td>±3 %RH (20 to 90 %RH)</td>
</tr>
<tr>
<td>1.6</td>
<td>H/DT/2CC</td>
<td>±2 %RH (20 to 90 %RH)</td>
</tr>
<tr>
<td>1.7</td>
<td>H/DT/5%</td>
<td>±5 %RH (30 to 70 %RH)</td>
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<td>Temperature effect on RH</td>
<td>Less than 0.11% per °C</td>
</tr>
<tr>
<td>1.9</td>
<td>Sensitivity</td>
<td>0.1 %RH</td>
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<tr>
<td>1.10</td>
<td>Hysteresis</td>
<td>Less than 1 %</td>
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<td>1.11</td>
<td>Repeatability</td>
<td>0.5 %RH</td>
</tr>
<tr>
<td>1.12</td>
<td>H/DT, H/DT/5%</td>
<td>Thermistor 10 kΩ at 25 °C</td>
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<tr>
<td>1.13</td>
<td>H/DT/2CC</td>
<td>Platinum 100 Ω</td>
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<td>1.14</td>
<td>H/DT, H/DT/5%</td>
<td>±0.5 °C</td>
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<td>1.15</td>
<td>H/DT/2CC</td>
<td>±0.5 °C</td>
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<td>Humidity output signal</td>
<td>4 to 20 mA for 0 to 100 %RH</td>
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<td>H/DT, H/DT/5%</td>
<td>Thermostat 10 kΩ at 25 °C</td>
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<td>Supply Voltage</td>
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<td>1.22</td>
<td>H/DT/5%</td>
<td>15 to 36 Vdc</td>
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#### 2 Mechanical

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<td>Duct probe</td>
<td>310 x 19 mm</td>
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<td>2.2</td>
<td>Head</td>
<td>94 x 57 x 85 mm</td>
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<td>2.3</td>
<td>Fixing centres</td>
<td>85 mm</td>
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<tr>
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<td>H/DT/5%</td>
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</tr>
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</table>
2.4 Duct probe 320 x 19 mm
2.5 Head 116 x 57 x 90 mm
2.6 Fixing centres 92 mm
2.7 Cable entry M20
2.8 Material
2.8a Enclosure Enclosure : Impact resistant ABS
2.8b Duct probe Stainless Steel
2.9 Connectors
2.9a H/DT, H/DT/2CC 2 part screw terminals for 0.5 to 5 mm² cable.
2.9b H/DT/5% Single part terminals for 0.5 to 5 mm² cable.
2.10 Weight 286 gm

3 Environmental
3.1 Ambient limits
3.1a Temperature -10 to +70 °C
3.1b Humidity 0 to 95 %RH non-condensing
3.2 Protection IP67

Technical Specification
Out side type Humidity & Temperature Sensor with display

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<td>Humidity accuracy</td>
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<td>including hysteresis, linearity and</td>
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<td>Sensitivity</td>
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<td>Hysteresis</td>
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<td>1.8</td>
<td>Repeatability</td>
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<td>1.9</td>
<td>Long term stability</td>
<td>Less than 1 % drift per year</td>
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<td>Temperature element</td>
<td>Thermistor 10 kΩ at 25 °C</td>
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<td>Temperature accuracy of sensor</td>
<td>± 1 °C</td>
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<td>Humidity output signal</td>
<td>4 to 20 mA for 0 to 100 %RH</td>
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<td>Temperature output signal</td>
<td>Thermistor 10 kΩ at 25 °C</td>
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<td>Supply Voltage</td>
<td>12 to 36 Vdc</td>
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<tr>
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<td>H/OT/RS</td>
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<td>Mast diameter</td>
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<td>H/OT/RS</td>
<td>58 mm (square)</td>
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2.6 Cable entry M20
2.7 Material (H/OT) PVC
2.7a Cowling PVC
2.7b Housing Impact resistant ABS
2.8 Material (H/OT/RS)
2.8a Probe Stainless Steel
2.8b Housing Impact resistant ABS
2.9 Radiation Shield UV stabilised thermoplastic
2.10 Bracket Aluminium
2.11 Connectors 2 part screw terminals for 0.5 to 5 mm² cable
2.12 Weight
2.12a H/OT 180 gm
2.12b H/OT/RS 1065 gm

3 Environmental
3.1 Ambient limits
3.1a Temperature -40 to +70 °C
3.1b Humidity 0 to 99 %RH non-condensing
3.2 Protection IP67

<table>
<thead>
<tr>
<th>Technical Specification</th>
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<td>Space type Humidity &amp; Temperature Sensor with display</td>
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<th>Remarks</th>
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<td>1.1</td>
<td>Humidity measurement range</td>
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<td>1.2a</td>
<td>H/ST</td>
<td>-10 to +40 °C</td>
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<td>H/ST/2CC</td>
<td>0 to +40 °C</td>
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<td>Humidity element</td>
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<td>1.3a</td>
<td>H/ST, H/ST/2CC</td>
<td>Resistance change through bulk polymer</td>
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<td>1.3b</td>
<td>H/S/5%</td>
<td>Capacitance change across polymer</td>
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<td>Humidity accuracy including</td>
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<td>1.4a</td>
<td>hysteresis, linearity and</td>
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<td>repeatability.</td>
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<tr>
<td>1.4c</td>
<td>H/ST</td>
<td>±3 %RH (20 to 90 %RH)</td>
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<td>1.4d</td>
<td>H/ST/2CC</td>
<td>±2 %RH (20 to 90 %RH)</td>
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<td>1.4e</td>
<td>H/S/5%</td>
<td>±5 %RH (30 to 70 %RH)</td>
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<tr>
<td>1.5</td>
<td>Temperature effect on RH</td>
<td>Less than 0.11% per °C</td>
</tr>
<tr>
<td>1.6</td>
<td>Sensitivity</td>
<td>0.1 %RH</td>
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<tr>
<td>1.7</td>
<td>Hysteresis</td>
<td>Less than 1 %</td>
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<td>1.8</td>
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<td>H/ST</td>
<td>Thermistor 10 kΩ at 25 °C</td>
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<td>Platinum 100 Ω</td>
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<td>Temperature accuracy of sensor</td>
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<tr>
<td>1.11a</td>
<td>H/ST</td>
<td>±0.5 °C</td>
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### 1.11b

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<tr>
<th><strong>H/ST/2CC</strong></th>
<th>±0.5 °C</th>
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### 1.12

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<tr>
<th><strong>Humidity output signal</strong></th>
<th>4 to 20 mA for 0 to 100 %RH</th>
</tr>
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### 1.13

<table>
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<tr>
<th><strong>Temperature output signal</strong></th>
<th><strong>H/ST</strong></th>
<th>Thermistor 10 kΩ at 25 °C</th>
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</thead>
<tbody>
<tr>
<td><strong>H/ST/2CC</strong></td>
<td>4 to 20 mA for 0 to 40 °C</td>
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### 1.14

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<th><strong>Supply Voltage</strong></th>
<th><strong>H/ST, H/ST/2CC</strong></th>
<th>12 to 36 Vdc</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>H/S/5%</strong></td>
<td>15 to 36 Vdc</td>
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### Mechanical

<table>
<thead>
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<th><strong>Dimensions</strong></th>
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<tbody>
<tr>
<td><strong>H/ST, H/ST/2CC</strong></td>
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<tr>
<td><strong>H/S/5%</strong></td>
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<table>
<thead>
<tr>
<th><strong>Enclosure Material</strong></th>
<th>Flame retardant (VO) ABS</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th><strong>Connectors</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>H/ST, H/ST/2CC</strong></td>
</tr>
<tr>
<td><strong>H/S/5%</strong></td>
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<table>
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<tr>
<th><strong>Weight</strong></th>
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<tbody>
<tr>
<td><strong>H/ST, H/ST/2CC</strong></td>
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<td><strong>H/S/5%</strong></td>
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### Environmental

<table>
<thead>
<tr>
<th><strong>Ambient limits</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Temperature</strong></td>
</tr>
<tr>
<td><strong>Humidity</strong></td>
</tr>
</tbody>
</table>

### LIST OF MAKES

**SECTION 16**

**SCHEDULE OF MANUFACTURERS – HVAC WORKS**

All the materials supplied under this contract shall be from one of the manufacturers listed below. No alternate Makes shall be accepted unless all the listed Makes are unavailable. Materials proposed from listed Makes also must fully comply with Detailed Specifications.

1. CHILLERS - HVAC
   - BLUESTAR / CARRIER/ CLIVET
   - YORK / KIRLOSKAR /MCQUAY
   - HITACHI/VOLTAS-DUNHAMBUSH/ TRANE

   **CHILLER PACKAGE**
   - SNOWCOOL INDIA / BLUESTAR /
   - CARRIER / YORK / CARRIER/
   - HITACHI / VOLTAS DUNHAMBUSH / CLIVET

2. AIR HANDLING UNITS
   - BLUESTAR /BLUESTAR /CLIVET-VTS (FAN RUGER/COMEFRI/NICOTRA) VOLTAS /ZECO
   - VAYHAN / SUVIDHA SAVIER
   - ETA NOVAIR /
   - FLAKT/ LLYODS

3. FAN COIL UNITS
   - BLUESTAR /ZECO
   - ETA /TRANE
   - CARYAIRE - FLAKT
   - VOLTAS,
<p>| | |</p>
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<td>5. HI WALL MINISPLIT</td>
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<td>7. Fans (Centrifugal / Axial)</td>
<td>KRUGER / FLAKT / GREENHECK</td>
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<td>NICOTRA / NADI / SYSTEM AIR</td>
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<td>8. Air Distribution Devices</td>
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<td>CARRYAIRE</td>
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<td>AIRFLOW</td>
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<tr>
<td>10. Duct Supports</td>
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<td>14. Copper Pipes</td>
<td>RAJCO / MANDEV / TOTALINE</td>
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<td>Butterfly / Ball Valves</td>
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<td>Y Strainer</td>
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<td>22</td>
<td>ALL Instruments</td>
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<td>(Including Pressure &amp; Temp Gauges)</td>
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<tr>
<td>24</td>
<td>Inline / Propeller Fans</td>
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<tr>
<td>25</td>
<td>Air Cooled Condensing Units</td>
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<tr>
<td>26</td>
<td>Spring Isolators</td>
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<tr>
<td>27</td>
<td>Air Filters</td>
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<tr>
<td>29</td>
<td>Precision A/C</td>
</tr>
<tr>
<td>30</td>
<td>VAV Terminal Boxes</td>
</tr>
<tr>
<td>31</td>
<td>Cooling Towers</td>
</tr>
<tr>
<td>32</td>
<td>Balancing Valves</td>
</tr>
</tbody>
</table>
33. CLOSED EXPANSION TANK  ITT / AMTROL / ANERGY
34. AIR SEPARATOR  ITT – ROLAIRTROL/ ANERGY / AMTROL
35. 2 WAY VALVES MOTORISED  BELIMO / BONOMI / SAUTER JOHNSON HONEYWELL / SIEMENS
36. M S CONDUITS  BHARAT / GUPTA / GV
37. WELDING ELECTRODES  ADVANI / ESSAB
38. COMBINED SMOKE & FD  CARYAIR/ GREENHECK /AIRMASTER
39. FD ACTUATOR  BELIMO / JUVINTA
40. FACTORY DUCTS  ROLASTAR / ZECO/NUTECH
41. SPIRAL DUCTS  GP SPIRO / WESTERN DUCTS
42. FACTORY FABRICATED PLENUMS  AIRMASTER/ ROLASTAR/CARYAIRE
43. FLEXIBLE DUCTS  UPTWIGA/CARYAIRE/ SEVENSTAR/AIRMASTER NUTECH
44. OPTIC FIBRE CABLES  AVAYA / AMP / LAPP / BELDON
45. FIRE DAMPER  RAVISTAR / AIRMASTER
46. 3-WAY MIXING VALVE AND CONTROL  HONEYWELL/JOHNSON/DANFOSS
47. FLOW SWITCH  RAPID CONTROL /HONEYWELL/ JOHNSON

HVAC - ELECTRICALS

<table>
<thead>
<tr>
<th>Sl.No.</th>
<th>Items Descriptions</th>
<th>Make of Components</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>ACB</td>
<td>ABB / Schneider / Siemens/L&amp; T</td>
</tr>
<tr>
<td>2</td>
<td>MCCBs / MPCBs/DBs</td>
<td>ABB / Schneider / Siemens / Legrand / L&amp;T / Havells/Merlin Gerin</td>
</tr>
<tr>
<td>3</td>
<td>Contactors and O/L Relay</td>
<td>ABB / Schneider / Siemens</td>
</tr>
<tr>
<td></td>
<td>Description</td>
<td>Brands/Models</td>
</tr>
<tr>
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<td>-----------------------------------------</td>
</tr>
<tr>
<td>4</td>
<td>Load Monitors / Controller</td>
<td>Ducati / Electrex / Enercon</td>
</tr>
<tr>
<td>5</td>
<td>MCBs</td>
<td>ABB / Schneider / Siemens / Legrand / L&amp;T / Havells</td>
</tr>
<tr>
<td>6</td>
<td>Capacitor (Heavy duty MPP Gas filled)</td>
<td>Siemens (EPCOS)</td>
</tr>
<tr>
<td>7</td>
<td>CTs and PTs</td>
<td>Kappa / Siemens</td>
</tr>
<tr>
<td>8</td>
<td>Control Switches</td>
<td>Kaycee / Siemens / Salzer/L&amp;T</td>
</tr>
<tr>
<td>9</td>
<td>ELR / Earth Fault Relay</td>
<td>JVS / Alstom / Prok DVS</td>
</tr>
<tr>
<td>10</td>
<td>Protective Relays</td>
<td>JVS / Alstom / SEGC / Approved equivalent</td>
</tr>
<tr>
<td>11</td>
<td>Push Buttons</td>
<td>ABB/Siemens / Teknic / Schneider/GE</td>
</tr>
<tr>
<td>12</td>
<td>Indicating lamps (LED type)</td>
<td>Siemens / Teknic / Schneider/L&amp;T</td>
</tr>
<tr>
<td>13</td>
<td>Wires (FRLS)</td>
<td>Farcom / RR Kabel / Anchor</td>
</tr>
<tr>
<td>14</td>
<td>Lugs. Glands</td>
<td>Dowells / SMI / Comet/Lotus/Multi</td>
</tr>
<tr>
<td>15</td>
<td>Terminals</td>
<td>Elmex / Wago – Finger touch proof</td>
</tr>
<tr>
<td>16</td>
<td>Ferrules</td>
<td>Mayfair</td>
</tr>
<tr>
<td>17</td>
<td>Busbar supports</td>
<td>Powermat or approved equivalent</td>
</tr>
<tr>
<td>18</td>
<td>Energy Meter</td>
<td>Electrex / Enercon</td>
</tr>
<tr>
<td>19</td>
<td>Name plates</td>
<td>Screen printed acrylic</td>
</tr>
<tr>
<td>20</td>
<td>Switchboard manufacturer</td>
<td>CPRI APPROVED</td>
</tr>
<tr>
<td>21</td>
<td>Starter/Switches/Contractors</td>
<td>L &amp;T/Siemens/Crompton</td>
</tr>
<tr>
<td>22</td>
<td>Switch Board</td>
<td>Khokar/Seimens/GE power Control/Advance/Pragati</td>
</tr>
<tr>
<td>23</td>
<td>Time delay Relay/Limit Switch</td>
<td>L &amp;T/Siemens/Crompton</td>
</tr>
<tr>
<td>24</td>
<td>Single Phase Preventor</td>
<td>L &amp;T/Siemens/Crompton/GE</td>
</tr>
<tr>
<td>25</td>
<td>CABLE TRAYS</td>
<td>Profab/Patni/Elcon</td>
</tr>
</tbody>
</table>

25  Senser/Thermostate Siemens/Honeywell/Johnsons/Danfoss

Project: “Civil, Electrical and other utility services for package -Civil-II (Rotable complex)
VOLUME –II. TECHNICAL SPECIFICATIONS FOR TENDER NO.NK/FW/CAP-ROH-577/2010-11

SIGNATURE OF TENDERER WITH SEAL

EMPLOYER

Page 435 of 494
**Additional Technical Specification, hvc, Pkg-ii, HAL Project.**

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
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</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Consider CTI certified counter flow induced draft type FRP - for cooling tower.</td>
</tr>
<tr>
<td>2.</td>
<td>Consider 0.9 Ounces per Sq.ft (275 GSM) - for Zinc coating (for galvanizing of ducts).</td>
</tr>
</tbody>
</table>
| 3. | BOQ Item No. 1 in Part B –  
The chiller will be procured separately by HAL and shall be provided free of charges to contractor for installation by contractor. Only labour charges to be quoted. |
<p>| 4. | Consider Qty – 44 nos Disconnect switches for Part-B, Boq, Pkg II. |</p>
<table>
<thead>
<tr>
<th>Sr.No</th>
<th>EPIL Query</th>
<th>Reference</th>
<th>Semac Reply</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Pkg. - III - Specify the eco-friendy Refrigerant for ductable Units.</td>
<td>Pkg-III,BOQ-1 for Air cooled CEILING CONCEALED DUCTABLE SPLIT UNIT.</td>
<td>R410A / R407C / R32</td>
</tr>
<tr>
<td>2</td>
<td>Pkg - II - Whether Induced draft counter Flow Cooling Tower are acceptable.</td>
<td>Pkg-II,(Part -A, BOQ-4),(Part -B, BOQ-3) for COOLING TOWER.</td>
<td>ok noted</td>
</tr>
<tr>
<td>3</td>
<td>Pkg - II - As per manufactures recommendation the cooling tower shall be with sprinkler system. We seek your acceptance on the same.</td>
<td></td>
<td>Please consider CTI certified Counter flow induced draft type FRP Cooling Tower</td>
</tr>
<tr>
<td>4</td>
<td>Pkg. -II - Qty and unit of DISCONNECT SWITCHES are not mentioned in the Part -B, BOQ.</td>
<td>Part -B, DISCONNECT SWITCHES.</td>
<td>Please consider 44 disconnect switches</td>
</tr>
<tr>
<td>5</td>
<td>Pkg. - II &amp; III - IO summary for estimating the PLC Controller.</td>
<td></td>
<td>Provide me the reference of BOQ line item.</td>
</tr>
<tr>
<td>6</td>
<td>Pkg.-II &amp; III - The zinc coating indicated in Specification is of 12.25 ounces per square foot. but, It is not in manufacture range of suppliers. So, we propose zinc coating of grade G40 i.e 0.4 Ounces per Sq.ft for galvanizing of ducts. We seek your acceptance on the same.</td>
<td>Technical Specification of Pkg-III &amp; II.</td>
<td>Please consider 0.9 Ounces per Sq.ft (275 GSM).</td>
</tr>
</tbody>
</table>