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(Tender Specifications)

ENGINEERING PROJECTS (INDIA) LIMITED
(A GOVT. OF INDIA ENTERPRISE)

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STEEL STRUCTURES & AUXILIARY FACILITIES (CHAPTER-04)
GENERAL TECHNICAL SPECIFICATION
FOR
SUPPLY, FABRICATION, ERECTION
SHEETING & PAINTING OF
STEEL STRUCTURES
(GS – 04)
# CONTENTS

<table>
<thead>
<tr>
<th>Sl.No.</th>
<th>Description</th>
<th>Page No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Content sheet</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>Amendment sheet</td>
<td>2</td>
</tr>
<tr>
<td>3</td>
<td>General Description of Work</td>
<td>3,4</td>
</tr>
<tr>
<td>4</td>
<td>Scope of Work</td>
<td>4 to 6</td>
</tr>
<tr>
<td>5</td>
<td>Design of Building Structures</td>
<td>6 to 19</td>
</tr>
<tr>
<td>6</td>
<td>Design of Conveyor galleries &amp; Junction Houses</td>
<td>20 to 25</td>
</tr>
<tr>
<td>7</td>
<td>Pipe Line Supporting Structures</td>
<td>25,26</td>
</tr>
<tr>
<td>8</td>
<td>Steel Chimney</td>
<td>28</td>
</tr>
<tr>
<td>9</td>
<td>Standardisation and Uniformity</td>
<td>29</td>
</tr>
<tr>
<td>10</td>
<td>Fabrication of Steel Structures</td>
<td>30 to 42</td>
</tr>
<tr>
<td>11</td>
<td>Erection of Structures</td>
<td>42 to 50</td>
</tr>
<tr>
<td>12</td>
<td>Welding Specifications</td>
<td>50 to 56</td>
</tr>
<tr>
<td>13</td>
<td>Painting of Building Steel Structures</td>
<td>56 to 60</td>
</tr>
<tr>
<td>14</td>
<td>General Requirements</td>
<td>60 to 62</td>
</tr>
<tr>
<td>15</td>
<td>Inspection of Structures</td>
<td>62 to 64</td>
</tr>
<tr>
<td>16</td>
<td>Quality System and Third Party Inspection</td>
<td>64 to 71</td>
</tr>
<tr>
<td>17</td>
<td>Permissible Deviations in Assembly of Welded Joints</td>
<td>71,72</td>
</tr>
<tr>
<td>18</td>
<td>Permissible Deviations in Erection and Fabrication</td>
<td>72 to 83</td>
</tr>
<tr>
<td>Sl. No.</td>
<td>Description</td>
<td>Page No.</td>
</tr>
<tr>
<td>--------</td>
<td>-------------</td>
<td>---------</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
SECTION : 1

1.1 The general specifications for structural works furnished herein are intended as guidelines for execution of the works satisfying the Owner’s requirements as also complying with all technical norms in totality. This specification is to cover the design, preparation of design drawings and fabrication drawings, supply of all labour as well as materials and construction of all structural work on a turnkey basis for the Project / Works as described in the general conditions of contract.

1.2 Description of various items of work under this specification and nature of work in detail are given hereinafter. The complete work under this scope is referred to as STRUCTURAL WORKS. The detailed scope of works covered under Structural works is given in Section -2.

1.3 The work to be performed under this specification consists of design, engineering, supply, fabrication, erection and cladding, as well as providing all labour, materials, consumables, equipment, temporary works, temporary labour and staff colony, constructional plant, fuel supply, transportation and all incidental items not shown or specified but reasonably implied or necessary for the completion and proper functioning of the plant, all in strict accordance with the specifications, including revisions and amendments thereto as may be required during the execution of the work.

1.4 Supply of all materials including structural steel, roof cladding & side-cladding sheets, fasteners, paints, consumables like gas, electrodes etc. and all other materials as deemed necessary for proper completion of the work, are included in the scope of the Contractor.

1.5 The work shall be carried out according to the design/drawings to be developed by the Contractor and approved by the Owner/Consultant.
For all buildings and structures, necessary layout and details are to be developed by the Contractor keeping in view the statutory & functional requirements of the plant and facilities and providing enough space and access for operation, use and maintenance. Certain minimum requirements are indicated in this specification for guidance purpose only. However, the Contractor’s offer shall cover the complete requirements as per the best prevailing practices and to the complete satisfaction of the Owner.

1.6 Contractor shall inspect the site, examine and obtain all information required and satisfy himself regarding matters and things such as access to site, communications, transport, right of way, the type and number of equipment and facilities required for the work, availability of local labour, materials and their rates, local working conditions, weather, tidal / flood levels, subsoil conditions, natural drainage, etc. Ignorance of the site conditions shall not be accepted by the Owner as basis for any claim for compensation or extension of time. The submission of a bid by the Contractor will be construed as evidence that such an examination was made and any later claims / disputes in regard to price quoted shall not be entertained or considered by the Owner on account of ignorance of prevailing site conditions.

1.7. Contractor shall comply with all the applicable statutory rules pertaining to Factory act, Fire safety rule of Loss prevention association, Water act for Pollution control, Explosives act etc. Provisions of Safety, health and welfare according to Factories act shall also be complied with. Statutory clearances and norms of State Pollution Control Board shall be followed. Statutory body /Act requirements shall be fulfilled by the Contractor and in case any modifications /additions to the building /Structures are to be made as per the above, shall be carried out by the Contractor at no extra cost to the Owner.

SECTION - 2

SCOPE OF WORK
2.0. The scope of work shall cover, but shall not be exclusively limited to, the following:

- Collection of all site related data & conducting site investigations,
- Design, preparation of all design drawings, fabrication drawings,
- Obtaining Owner’s/Consultant’s approval on general arrangements and design of structures
- Dismantling, retrieval, sorting and storing of any existing structures as directed by the owner, if dismantling is a part of the total work
- Supply of all materials viz, raw steel, sheeting for roof and side cladding, and paints
- Supply of fasteners like bolts, nuts, washers etc
- Supply of consumables like electrodes for welding, gases for gas cutting etc
- Supply of plant & machinery, tools tackles, instruments for fabrication and erection
- Providing facilities for testing of materials and conducting NDT
- Providing facilities for transport and handling
- Deploying requisite skilled and unskilled manpower
- Making arrangements for all services like approach to site, electricity, water etc
- Fabrication of structures, their transport and proper storing at site
- Erection of structures, claddings, gutters, down pipes etc
- Application of paints at shop after fabrication and at site after erection
- Providing all reasonable facilities for inspection by Owner/Consultant
- Conducting NDT as stipulated by the Owner and making test results available to Owner / Consultant for evaluation
- compliance with primary acceptance tests / inspection, liquidation of defects; compliance with final acceptance tests / inspection, liquidation of defects;

- carrying out field-engineering decisions as desired by the Owner

- preparation of "As Built" drawings for all the structures and hand over to the Owner the completed structural work to the Owner's full satisfaction.

- supply of all loading data for RCC foundation, layout drawing, HD bolt insert details and all other necessary information for requirement of Foundation/ RCC work, where future expansion is envisaged, the successful contractor shall furnish load data separately for present and future construction.

- any other work deemed incidental for the completion of the overall work but not included in the above detailed scope.

SECTION – 3 DESIGN OF BUILDING STRUCTURES

3.0 General

This specification shall apply to steel work in building and general structural steel work. For technological structures, additional stipulations shall be considered as per technical requirements.

3.1 Design considerations

3.1.0 General

3.1.01 Structures shall be designed such that they are economical and safe and meet the functional and service requirement of the technological process for which
they are designed. The architectural planning of the building shall be based on technological requirements.

3.1.02 The structures shall be designed conforming to the relevant safety regulations, Factory Acts, Electricity Rules and stipulations of Statutory bodies as applicable to the project.

3.1.03 Natural ventilation shall be provided ensuring that it does not permit rain water entry into the building. Scope of natural lighting shall be used to the maximum possible extent.

3.1.04 Mild steel gutters and down-pipes with gutter outlets having grating cover shall be provided to carry rain water from roofs of buildings to the drainage system at ground level. All gutters shall be designed as walkable with 600 mm sole width.

3.1.05 Adequate facilities in the form of monorails, hoists, platforms etc. shall be provided to facilitate repair and maintenance of overhead cranes, equipment, etc. Access to these platforms shall be provided by stairs / ladders from the nearest accessible floor or platform.

3.1.06 Access to all floors, gangways and landings shall be by staircases. Access to platforms and landing of secondary importance or where such access is used only rarely, shall be by vertical ladders with safety hoops.

3.1.07 Roofs with access shall be provided with safety handrails along the periphery of the roof.

3.1.08 Edges of floors, gangways, stairs and landings shall be provided with safety hand railings.

3.1.09 At gable ends of buildings, platforms shall be provided connecting the walkways at crane gantry level.

3.1.10 Floors, gangways and landings shall be covered as follows:

   a) Gangways and landings shall have chequered plate with a minimum thickness of 6mm o/p suitably stiffened to meet design load requirements.

   b) Floors and operating platforms other than the above shall have chequered plate flooring or hot dip galvanised open gratings, or RCC slab resting on steel structural framework, to suit the technological requirements.
3.1.11 Protective metal heat shields shall be provided for steel structures exposed to continuous heat radiation of temperature exceeding 150 °C and also where hot metal splashing on structures is likely to occur.

3.1.12 All buildings and their foundations shall be designed so that it shall be possible to extend them in the longitudinal direction at a later date without further strengthening of gable structures. Provision for transverse extension, if any, shall also be made at the initial stage.

3.1.13 Sheeting on sides and gables shall generally terminate 3.0 m above ground floor level unless required to be otherwise. Sides below this level shall be generally screened by brick walls allowing sufficient air inlet to achieve natural ventilation, unless otherwise required from technological / ventilation requirements.

3.1.14 Connection by permanent bolts to structural elements subject to vibration shall be provided with lock nuts.

3.1.15 For Analysis/design of steel structural frame work STAAD PRO software shall be used. CD of input files shall be submitted to purchaser/consultant along with the hard copy of the document.

3.2 Elements of Structures

3.2.01 Columns

a) At the location of passage/opening through columns web shall be suitably strengthened by vierendeel panel or modified lattice system.

b) Shear force at the column base shall be resisted either by shear keys shop-welded to the underside of column base plates or by welding base plate to inserts provided in foundation.

c) The level of underside of column base shall be so chosen such that the complete anchor table lies below the finished floor level, thus keeping the shop floor free from projections of anchor tables.
3.2.02 Crane Girders

a) Crane girders shall generally be of simply supported design, unless continuous crane girders are specifically required.

b) Top flange plate shall be welded to web plate with full penetration butt weld with fully automatic submerged arc welding. Bottom flange plate shall be welded to web plate by continuous fillet welds with automatic/semi-automatic welding.

c) All intermediate stiffeners shall be fitted against top flange and welded to it by fillet welds/partial penetration butt welds. These stiffeners shall terminate short of bottom flange with at least 25 mm gap. The stiffeners shall be fillet welded to web plate and corners shall be cut suitably to clear thermally affected area of web to top flange connection.

d) End bearing stiffener plates of crane girder shall be capable of transmitting the maximum reactions to the columns. The bearing surface of the bearing plate shall be planed/machined to ensure full contact.

e) Tension flange of crane girders shall be stabilised by horizontal latticed bracings, where required in order to limit the slenderness ratio of the flange to 150.

f) Generally for girders having span 12m and above, vertical auxiliary girder and horizontal girder at crane girder bottom flange level shall be provided.

g) All crane girders shall be checked for fatigue as per IS: 1024 (latest).

h) i) At crane girder level, walkway shall be provided on both sides. Walkway at column location shall have minimum clear width of 500mm. Approach by staircase to this level shall be near the maintenance bay.

j) All crane girders and their supporting structures shall be designed for loading from loaded crane in worst position of crab and crane to create most unfavorable loading condition of the girders. For increase of load due to impact and crane load combination including lateral surge shall be taken as per provision of IS 875 (Part – 2) -1987.

k) Suitable approach to be provided for tightening of bolts of Crane Rail. Approach for Crane Rail fixing shall be properly planned for all types of sections of Crane Girders.

3.2.03 Surge Girder walkways and auxiliary beams.
General Technical Specification

a) Continuous maintenance walkways with safety hand-railing shall be provided along each column row adjacent to each crane gantry girder. These walkways shall be of non-slip plate construction connected to crane girder top flange by continuous fillet welds. Staircase at every 120m shall be provided from floor for access to this walkways so that stairs are available within 60m from any location.

b) Connections between surge girder and the main columns shall be designed to resist load due to lateral braking of crane trolley.

c) On the periphery of the building, full length handrails shall be provided along the edge of the maintenance walkway at crane girder level.

d) Handrail and its clearance from crane end carriage shall conform to provisions of relevant safety regulations.

3.2.04 Crane Stops

a) Crane stops shall be provided at the ends of each crane girder system, or as required to limit the movement of crane as per technological requirements.

b) Crane stops shall be bolted to crane gantry girder.

c) Only tested rail materials shall be used. Manufacturer’s test certificate, including chemical analysis shall be supplied.

d) Rails shall be free from twists, pitting, laminations and any other internal and external defects. The rail shall be straight and the deviation from the straightness shall not exceed + 1.5mm. If necessary the rail shall be cold straightened.

e) Unless otherwise specified, the crane rail joint shall be butt-jointed (either by Thermit or fusion welding) or by fishplates.

f) For Butt-welding the contractor shall take prior approval of the Purchaser regarding method of edge preparation, welding procedure and sequence of welding to be done. Edge preparation shall be done by oxyacetylene flame and shall be neatly finished by chipping and grinding.

g) All position low hydrogen electrodes conforming to IS 814-1991 shall be used for welding. The rail end shall be preheated to 250 deg. C before welding. The electrode shall be preheated as per manufacture’s instructions. The welded joint shall be allowed to cool slowly. It is recommended that the initial and intermediate layers of deposit may be by using ferron V, Superchord or equivalent. Top 3mm layer shall be deposited with Duroid 2A or equivalent, to obtain good wearing surface.
h) The joints shall be free from kinks, twists etc, and shall be grinded properly after welding to ensure smooth running of the crane.

i) Method of securing the crane rail to the crane gantry, alignment and expansion joints, if any, shall be subject to Purchaser’s approval. The crane rail clips shall be preferably forged or pressed from steel plates.

3.2.05 Roof Structures

a) The main supporting element for roof shall be roof trusses provided at uniform spacing to suit shop layout. Roof shall be provided with adequately sized roof monitor for natural ventilation, wherever required.

b) Roof shall have suitable slope to meet technological as well as rainwater drainage requirements. Hand railings at eaves level and gable ends of the roof of the building shall be provided.

c) System of bracings shall be provided in the roof top chord and bottom chord levels along with longitudinal ties to ensure stability and rigidity of the roof structures. Vertical bracings between trusses shall also be provided wherever required.

d) Galvanized wind tie (45x6 mm flat) shall be provided at the free edge of roof sheeting.

e) Suitable arrangement of anchors shall be provided at the ridge of roof sheeting for holding lanyards of safety belts.

3.2.06 Roof lighting walkways

a) Full length roof lighting walkways, generally 600 mm wide, shall be provided in each bay as required to match the number of rows of roof lights provided in the shop as per technological requirement.

b) These walkways shall span between roof truss members and will be decked with chequered plate floor. Walkways shall be provided with handrails on both sides.
3.2.07 Roof drainage system

a) Roof drainage system shall be designed for maximum precipitation for 5 minutes based on local meteorological data. A factor of safety of 1.3 shall be kept in the design.

b) All valley and eaves gutters shall be of pressed plate construction with a minimum sole width of 600 mm so as to function as walkways.

c) Eaves gutter shall be provided for eaves height ranging between 10 m to 25 m above apron/ground level.

d) The gutters shall be laid to slope towards down-pipes with welded outlets and having grills fitted flush with gutter sole. Slope of gutters and collector pipes shall not be flatter than the following limits:

   i) Longitudinal slope of gutter 1 : 500
   ii) Longitudinal slope of collector pipe 1 : 300

e) Poking holes with cover shall be provided in the down-pipes at suitable intervals as well as at accessible levels, to clean the down-pipes.

f) Collector pipes shall be provided with covered manholes at 6 m intervals.

g) Eaves gutter shall be provided with safety handrails.

h) When rain water falls from higher to lower roof, double layer of sheets shall be provided for the portion of roof sheeting on which rain water falls, provided the drop of roof is in the range of 3 m to 6 m. In case the drop is more than 6 m, independent gutter shall be provided.

i) Down pipes shall be spaced preferably at 24 m centres. The down-pipes shall be connected to the gutter with suitably designed hoppers with gratings at sole level of gutter, made of 8 mm dia rounds at 50 mm centers.

j) Joints of gutter and collector pipes shall be by welding in order to be leak-proof.
### 3.2.08 Wall Structures

a) Wall runners with necessary sag rod arrangements shall be provided to support wall and gable sheeting, including internal partition wall, wherever required.

b) Hanging wall posts shall generally terminate at 3.5 m above ground floor level unless required to be otherwise (Refer Clause 3.1.13).

c) Gables of buildings shall have wall post spaced at intervals to suit bay width.

d) Walls shall be provided with louvres and translucent sheeting at appropriate levels, to provide natural ventilation and lighting.

### 3.2.09 Floor Frameworks

a) Floor beams supporting vibrating equipment shall be designed to avoid resonant frequencies. (Refer clause 3.3.01 (c))

b) Beams along-with framework, shall be provided with both horizontal and vertical bracing (wherever permissible) to achieve overall rigidity.

### 3.2.10 Vertical bracings

a) Vertical bracings shall be provided on all column rows for each expansion block.

b) Vertical bracings shall extend from ground level to roof level and shall be designed to transmit longitudinal forces i.e wind forces, crane tractive forces, seismic forces etc. to the foundation.

c) Below crane girder level, for two-legged columns, the bracings shall be of twin system in the plane of each column leg, suitably tied or laced together.

### 3.2.11 Access staircase, walkways, platforms and ladders.
a) Wherever possible, access shall be provided by means of stairs.

b) All walkways and stairs leading to working platforms shall have minimum 1000 mm width of walkways/flight of stair.

c) All other walkways and stairs leading to areas for maintenance purpose, or due to restriction of space, shall have a minimum width of 800 mm of walkway/flight of stair, unless required otherwise.

d) Staircases shall be generally designed with slope of approximate 37.5° with the horizontal. (in no case the slope shall exceed 40 ° with the horizontal). Intermediate landings shall be provided wherever required such that vertical rise of each flight does not exceed 3000 mm. Risers in one flight shall be equally spaced.

e) Walkway floors and stair treads shall be designed with chequered plate ( or non-slip type plates). Ribbed floor/treads may be provided wherever the possibility of accumulation of dust exists, taking care that such provisions do not create a nuisance to the operating personnel on the shop floor.

f) Rise of treads in staircases shall not exceed 200 mm.

g) A minimum headroom of 2200 mm shall be provided over operating platforms, visitor's galleries, or other areas with possibility of public gathering. In all other platforms, walkways and stairs, a minimum headroom of 2000 mm shall be provided. Only in special cases, local headroom of 1800 mm may be allowed (i.e at intersection with structural members etc.).

h) Cat ladders shall be provided for access, wherever provision of staircase is impractical due to limitations of space, or the access is required very infrequently.

i) Wherever the height of cat ladder exceeds 4.0 m, safety cage shall be provided. Intermediate landing shall be provided to cat ladders such that vertical height of single rise does not exceed 8.0 m.

j) Cat ladders shall be designed with following provisions:

   i) Width of rung = 500 mm
   ii) Minimum rise of rung = 250 mm
       Maximum rise of rung = 300 mm
   iii) Minimum clearance from rung of ladder to back of cage (in case of caged ladders) = 700 mm
iv) Minimum clearance from the centre of cage all round = 350 mm

v) Slope of cat-ladders :

   I. For normal cat-ladders, slope shall be within the range of 75°-90° with the horizontal.

   II. For ship-type ladde (i.e cat-ladders with short side handrails) the slope shall be within the range of 65°-75° with the horizontal.

k) All walkways, platforms and stairs shall be provided with safety handrails. All handrails shall be constructed with steel tubes / angles for posts, top and middle rail and plates/sheets for toe plates. In case of stairs, the toe guards need not be provided.

l) The vertical height of hand-railings on walkways and stairs shall be minimum 1000 mm above floor level.

m) Hand-railing along edge of roof and gutters shall have a minimum height of 600 mm over top edge of gutters/sheets. In such hand-railings toe guards need not be provided. (only top handrail and mid-rail shall be provided).

i) Access to roof of the building shall be provided by means of staircases at midway length of the building. Pair of staircases shall be provided with one at the near end and the other at far end length of building. Approach to monitor roof / high bay roof from the roof of the bay approachable by staircases at midway length of the building shall be by means of staircase ( if height of roof > 3m ) or cat-ladder. Approach shall be provided on the roof of the building along the cross-section of the building.

3.3 Design

3.3.01 Design of structures

a) Design of steel structures shall be done in accordance with IS:800-1984 or any equivalent international code of practice that may be applicable.

b) Structures subjected to fluctuating/reversal of stress (eg. Crane girders) shall be designed in accordance with IS:1024-1979.

c) Resonance in structures : Structures supporting vibratory/reciprocating equipments shall be designed so as to obviate occurrence of resonance. The ratio of applied frequency to natural frequency shall not lie within the range 0.7
For wind load calculation the following data may be considered:
- Basic wind speed \( (V_b) \) at 10 M ht = 39 m/sec.
- Risk co-efficient \( (K_1) \) = 1.0
- Terrain ht and Structure size factor \( (K_2) \) shall be calculated with Category 2.
- Topography co-efficient \( (K_3) \) = 1.0

Seismic load: Structure shall be designed as per IS-1893-(Part1) 2002.

### 3.3.02 Description of design loads

Loads considered in design shall allow fully for all aspects of:

i) Dead weight of structures, walls, floors, equipment, wiring, machinery, pipe-work, cabling and any item of a permanent nature.

ii) Superimposed loads for roofs and floors plus any temporary machinery not allowed within the general superimposed loads.

iii) Crane loading.

iv) Temperature loads from process requirements because of the position of the structure relative to the heat source or from support of mains, pipes etc. subject to heat.

v) Maximum range of temperature variation for climatic conditions = ± 45°C

vi) Dust load.

vii) Dynamic loads from screens and other such reciprocating machinery.

viii) Maintenance hoists on Runway beams.

ix) Wind Loads

x) Seismic loads

xi) From future extensions.

xii) Any special erection requirements.

xiii) Erection loads on floor and structures

### 3.3.03 Loading codes
a) All live loads shall be considered in accordance with IS:875(Part-2)-1987.
   (Also refer clause 3.3.04)

b) Wind loads shall be in accordance with IS:875(Part-3)-1987 and any other
   consideration specific to the site.

c) Seismic loads shall be in accordance with IS:1893-2002.

d) Crane loading to be considered in design shall be as follows:

I. As per relevant clause of IS:800-1983.

II. IS:875(Part-2)-1987 for conditions not covered in IS:800-1983.3. unless more
    severe loads have to be considered for technological/operational conditions.

e) Crane stopper shall be designed in accordance with clause 6.1.4 of IS:875

f) In absence of any suitable provision for design loads, any other recognised
   code of practice may be followed subject to prior approval of the Owner.

3.3.04 Additional Design Loads

Besides technological loads, all platforms, walkways, stairs etc. shall be designed
for the following live loads:

i) Walkways and Platforms    : 2 KN/m²

ii) Visitor’s galleries       : 4 KN/m²

iii) Maintenance platforms   : 4 KN/m²
    including crane level walkway.

iv) Staircase and treads      : 4 KN/m²

v) Monorail walkways         : 4 KN/m²

vi) Handrails                : 0.75 KN/m run
    (Horizontal)

vii) Ladder                   : 0.9 KN
    at middle of rung

viii) Dust loads (for buildings and structures located in dusty zone)
     : 0.5 KN/m²

ix) All structures supporting: Overloading vibrating equipment by 25 % on
    (motors, fans etc.) Static load unless specified otherwise of Equipment.
3.3.05 **Combination of loads**

Various design loads considered shall be combined in accordance with clause 8.0 of IS:875(Part-5)-1987 to give the most severe loading condition for design of structures.

3.3.06 **Stress Enhancements**

Permissible limits of stress may be increased wherever permissible, in accordance with IS:800-1983.

3.3.07 **Limiting deflection**

a) The deflection shall be limited in various elements of structures in accordance with IS:800-1984 (clause 3.13).

b) In addition, the following limitations in deflection shall be observed in design:

**Vertical Deflection**

i) Monorail track beams, main floor beams, equipment supporting beams & beams supporting brick walls

\[ \text{Span} / 400 \]

ii) Main roof trusses, roof girders, main floor beams in operating platforms

\[ \text{Span} / 400 \]

iii) Secondary floor beams

\[ \text{Span} / 325 \]

**Horizontal Deflection**

i) Crane girders due to surge force:

\[ \text{Span} / 2000 \]

(from one crane only).

ii) Main columns at crane rail level:

\[ \text{H} / 2500 \]

in transverse direction due to action of crane surge (for surge force consider one crane for single bay and one crane each on adjacent aisles for multi-bay buildings)

iii) Open gantry for condition as in: H/4000 (ii) above.
Where \( H \) = Height of Column from bottom of base plate to crane rail level.

c) All deflections shall be calculated without dynamic factor.

3.3.08 Camber

Wherever excessive deformation is likely to cause operational problem or is aesthetically not agreeable, camber shall be provided to neutralise the effect of deformation due to dead load plus 50% of imposed loads.

3.3.09 Expansion joints

a) Longitudinal and transverse expansion joints shall be provided in buildings and structures in accordance with IS:800-1984 (clause 3.14).

b) Expansion joints shall be formed by providing double rows of columns, with overhanging gantry girders, secondary roof and wall framing being detailed to allow the maximum calculated movement for the specified temperature variation.

3.3.10 Miscellaneous design requirements

a) The minimum thickness of structural steel elements shall be in accordance with IS:800-1984 (clause 3.8). Minimum size angle shall be ISA50x50x6.

b) The diameter of structural bolts shall not be less than 16 mm except for those securing roof and wall sheets, windows, doors and stitching of thin coverings. For bolted joints, at least two bolts per joint shall be provided.

c) The size of fillet welds shall not be less than 5 mm.

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

e) Field connection and splices shall be made as follows:

i) by welding
ii) by permanent bolts (for secondary members such as purlins, wall runners etc.)

iii) by High Strength Friction Grip bolts (HSFG)

3.4 DESIGN OF CONVEYOR GALLERIES AND JUNCTION HOUSES

3.4.0 Design Considerations

3.4.01 The general parameters for conveyor galleries shall conform to the provision of IPSS:2-03-001-81 (Interplant Standards : Steel Industry - Design parameters for galleries and tunnels for belt conveyors in steel plant), and provisions of IS : 11592-1985 unless specified otherwise in Technical Specifications. The structures shall be designed so as to meet functional requirements and shall provide space for operation, maintenance and removal of machinery and give the workers good and safe environment.

3.4.02 Gallery floors shall be of pre-cast R.C.C slabs / Chequered plates (as required ) supported on steel beams.

3.4.03 Steps shall be provided (rise not exceeding 130 mm) along the walkways if the gallery slope exceeds 12°. In case the slope of gallery is between 6° to 12°, suitable ribs shall be provided on floor (without any sharp edges) at 250 to 300 mm intervals.

3.4.04 Provisions shall be made for emergency exit from galleries to ground level and also for cross-over above conveyor at 100 m intervals (maximum). The width of cross over shall not be less than 600 mm.

3.4.05 Roof and side walls of conveyor galleries shall be covered with GCS/ Aluminium sheets. with a provision of gap of 300 mm below roof and 150 mm from top of floor level on the side wall for ventilation.

3.4.06 Adequate provision for natural light inside conveyor gallery shall be made through side walls by providing translucent sheets (FRP sheets as per IS: 12866-1989). Every sixth sheet on side wall shall be FRP sheet and shall be staggered on opposite wall.
3.4.07  Roof slopes of conveyor galleries shall be 1:5 (1 vertical, 5 Horizontal).

3.4.08  The level of underside of the base plate of gallery supporting trestles shall be 300 mm above the average ground level of the surrounding area.

3.4.09  Protective hand railing shall be provided along gallery walkways, open platform, stairways, landings, edges of walkways when the gallery is not enclosed, and around erection openings, if any, to ensure safety of operating personnel.

3.4.10  Conveyor galleries longer than 150 m shall be provided with expansion joints with twin trestles/supports. Each expansion block shall have fixed support/rigid trestle with adequate arrangement (provision of top chord and bottom chord bracing to gallery girder etc.) for transferring the transverse and longitudinal forces to the foundation.

3.4.11  Gallery girders near junction house shall be preferably supported on trestle located as close to the junction house as possible, with part of gallery girder between junction house and trestle cantilevered from the trestle. Supporting gallery girders on junction house shall be generally avoided.

3.4.12  The underside of the belt conveyor shall be fully covered with 3 mm sheet in case of conveyor is located within the boundaries of the plant. Wherever such covering is not provided (as in case of the mines area or cross country), the covering must be provided where the gallery crosses roads, railway lines or areas of public gatherings.

3.4.13  Conveyor gallery over hot metal track:

   When underside of gallery is at less than 12m height from track level, heat shield shall be provided below gallery as well as on sides for a width of track 8 m (i.e. 4 m on either side of center line of the track).

3.4.14  When conveyor gallery crosses above or below H.T cables, a minimum clear distance of 1.0 m between the structural elements/cladding and HT cables shall be maintained.

3.4.15  When the conveyor bridge passes over plant roads, clearance between the road surface and the lowest points of the bridges shall not be less than 4.5 m or the height needed for the passage of the largest individual components of the plant equipment, whichever is the larger.

3.4.16  The junction house shall be designed to suit the technological requirements. Number of floors, height of building etc. shall be decided accordingly.
3.4.17 In general the junction house shall be designed as framed structures on shorter span side and vertically braced on longer side to achieve stability.

3.4.18 Floor of junction houses shall be of RCC slab supported on steel beams, unless required otherwise from technological consideration. The RCC slab will be connected to steel beams through suitable lugs.

3.4.19 Roof and side covering of junction houses shall be with GCS/Aluminium sheets / troughed colour coated sheets as specified. Roof slope shall be 1 : 5 (1 Vertical : 5 Horizontal).

3.4.20 Suitable access staircase and safety hand railing shall be provided to all floors of junction houses.

3.4.21 When hydro-washing of floor of junction house is envisaged, the floor beam supporting RCC slab shall be laid to a suitable slope to achieve the same, wherever the same is not practicable to achieve through screed concrete. (Minimum slope of floor shall be 1.5%).

3.4.22 Wall sheeting shall generally start from the lowest working floor and extend up to roof level with louvres at each floor level to ensure adequate natural ventilation.

3.4.23 Monorails for maintenance hoists shall be provided for maintenance and repair of various equipments located on the floors.

Components of structures

3.4.24 Gallery Trusses and Roof
   a) Gallery truss shall be of latticed type construction and shall support roof (for covered galleries) as well as floor deck supporting conveyor system.
   b) The trusses shall be adequately braced at top and bottom chord level to transfer the horizontal wind forces to end portals.

3.4.25 Stringer Beam
   These beams shall be suitably spaced to support the conveyor stringer post and shall deliver load to gallery trusses. Walkways on either side of the conveyor shall also be supported on these stringer beams.
3.4.26 Supporting Trestles

Intermediate trestles shall be two legged and shall deliver loads from gallery trusses to the foundations. In addition, four legged trestles shall be provided which will act as fixed support to transmit all longitudinal forces between expansion block, in addition to other forces.

3.4.27 Junction Houses

a) Floors - Floor beam layout shall be arranged to suit equipment layout as well as equipment anchoring system.

b) Columns - In addition to loads from floor and roof, columns shall be designed to transmit horizontal load due to belt tension/snapping of belts to the foundation.

3.4.28 Belt Tensioning Device

Suitable structures shall be provided to accommodate belt-tensioning device which may be located either under the conveyor gallery or in the junction house itself.

3.4.29 Wall Structures

a) Wall runners with necessary sag rods shall be provided to support wall sheeting in conveyor galleries and junction houses.

b) Wall sheeting and louvres - refer clause 3.2.08

3.4.30 Access stairs, walkways, platforms, ladders, hand railing etc. - These shall be provided in accordance with clause 3.2.11 of this specification.

3.5 Design of Structures.

3.5.0 a) Design of steel structures shall be done in accordance with IS:800-1984.

b) In absence of specified dynamic factor to be considered for the load from the belt conveyor, a dynamic factor of not less than 1.3 shall be considered for the design of floor beams and gallery girders.
c) Gallery trusses and stringers as well as floor beams of junction house shall be checked for obviating occurrence of resonance and shall be designed in accordance with clause 3.3.01(c).

d) For wind load consideration the following may be considered:
- Basic wind speed (vb) at 10 M ht = 39 m/s.
- Risk co-efficient (K1) = 1.0
- Terrain ht and structure size factor (K2) shall be calculated with category 2.
- Topography co-efficient (K3) = 1.0

e) Seismic load – structure shall be designed as per IS 1893 (Part 1) 2002. site is located in zone II.

3.5.1 Description of loads and loading codes

3.5.01 Unless specified otherwise hereinafter, all the live loads shall be considered in accordance with IS:875 (Part-2)-1987.

3.5.02 Wind loads shall be considered in accordance with IS:875 (Part-3)-1987.

3.5.03 Seismic loads shall be considered in accordance with IS:1893-1984.

3.5.04 Live loads from conveyor on the gallery floor shall be as per conveyor suppliers load data.

3.5.05 While designing the fixed support/rigid trestles in an expansion block of conveyor gallery the following loads (in addition to wind load) shall be considered.

a) Forces due to difference in frictional resistance of top and return idle rollers of conveyor.

b) Forces due to inertia of rollers at the time of starting of conveyor belt.

c) Break down load caused by snapping of belt (in case of multiple conveyors, snapping of one belt at a time) shall be considered.

d) Special loads if any

3.5.06 Gallery girders and floor shall be designed for the following live loads, inclusive of spillage loads on floors.

a) Walkway/Supporting beams for floor - 4.0 KN/m²

b) Under the conveyor belt - 0.75 KN/m²
c) Gallery girder, for floor load of - 3.0 KN/m²

3.5.07 Dust load on roof of junction house and conveyor galleries shall be considered as follows:

a) For building and structures located at a distance of 300 m from the dust producing units - 0.5 KN/m²

b) At a distance of 300 m to 800 m from the dust producing unit - 0.25 KN/m²

3.5.08 As per technological requirements, provision of supporting the following, and load arising thereof shall be considered in the design of conveyor gallery.

a) Ventilation duct.

b) Electrical cables/cable racks.

c) Fire Fighting equipment.

3.5.09 Junction house floors shall be designed for the following loads:

a) Live load on floor - 4.0 KN/m²

b) Tension from conveyor belt

c) Load due to equipment located on floor.

d) Load due to jamming of chutes.

e) Erection loads anywhere on the floor.

3.5.10 Combination of loads

The various loads specified shall be combined in accordance with clause 8.0 of IS:875 (Part-5)-1987 to give the most severe loading condition for design of structures.
3.5.11 Stress enhancements

Permissible limits of stress may be increased, wherever permissible, in accordance with IS:800-1984.

3.5.12 Limiting deflection

a) The deflection shall be limited in various elements of structures in accordance with clause 3.13 IS:800-1984.

b) In addition following limitation in deflection shall be observed in design:

   i) Gallery Trusses - Span / 400

   ii) Top of End portal of gallery truss - H / 325 where H = Height of portal above beams

   iii) Traverse deflection of top of supporting Trestle - H/1000 where H = Height of trestle above foundation.

3.6 PIPELINE SUPPORTING STRUCTURE

3.6.0 Design considerations

3.6.01 Bridges shall be provided to support pipelines of smaller diameters for which maximum permissible span is less than the distance between supporting trestles.

3.6.02 Trestles which are designed to transmit longitudinal loads (along the length of pipeline) to the foundation, shall be four legged construction. Other trestles which transmit only the vertical load to the foundation shall be two-legged construction.
3.6.03 Access stair and platforms shall be provided for maintenance of equipment installed in the pipeline (eg. valves etc.). Maintenance walkways with hand-railing shall also be provided along the pipeline, wherever required. Provision of access stairs, walkways platforms, hand-railing etc. shall conform to clause 3.2.11 of this specification.

3.7 Design of Structures

3.7.0 Design of steel structures shall be done in accordance with IS:800-1984.

3.7.01 Unless otherwise specified hereinafter, all live loads shall be considered in accordance with IS:875 (Part-2) 1987.

3.7.02 Wind load shall be considered in accordance with IS:875 (Part-3)-1987.

3.7.03 Seismic loads shall be considered in accordance with IS:1893-2002.

3.7.04 In addition, pipeline, bridge and supporting trestle shall be designed for the following loads:

   a) Weight of liquid or condensate, as is appropriate for pipeline.

   b) Weight of valves, compensators, fittings etc. in addition of self-weight of pipe.

   c) Load due to thermal expansion of pipeline

3.7.05 Maintenance platforms shall be designed for a service load of 4 kN/sq.m

3.7.06 Combination of loads

The various loads specified shall be combined in accordance with clause 8.0 of IS:875 (Part-5)-1987 to give the most severe loading condition for design of structures.

3.7.07 Stress enhancements

Permissible limits of stress may be increased, wherever permissible, in accordance with IS:800-1984.

3.7.08 Limiting deflection
a) Deflection of gallery bridge structure shall be limited to Span/400.

b) Traverse deformation of trestle shall be limited to H/1000 where H = Height of trestle above foundation level.

c) The deflection of other elements of structures shall be limited in accordance with clause 3.13 of IS:800-1984.

3.8 STEEL CHIMNEY

3.8.0 General
This specification shall apply to design of self supporting steel chimneys.

3.8.1 Design Consideration

a) Lining shall be provided in chimney shell as per technological requirements. In the case of lined chimneys, checking for stress and resonance due to wind shall be done for both the conditions i.e lined and unlined.

b) Annular platforms with minimum clear width of 1200mm shall be provided at locations of environment monitoring equipment, in addition to the stipulations of IS:6533 (Part-2)-1989. Landing/resting platforms to ladders shall be provided at intervals not exceeding 10.00 M where annular platforms are provided at intervals of height greater than 10.00 M.

c) Approach to platforms shall be with ladders with safety cages. (Refer Clause 3.2.11(j) of this specification.

d) Chimneys shall be provided with adequate number of Painter's trolleys for inspection and maintenance unless categorically agreed to otherwise with Owner. In case where Painter's trolley is not provided, suitable alternative facility shall be provided for inspection and maintenance.

e) Chimneys shall be fitted with helical strakes of three rail system, and shall be strong enough to withstand the additional wind load from the strakes.

3.8.2 Design

a) Steel chimneys shall be designed in accordance with IS:6533(Part-2)-1989.
3.8.3 Limiting Deflection

The maximum deflection at the top due to the action of wind, without considering the dynamic factor shall not be greater than \( h/200 \), where \( h \) is the unsupported height of the chimney.

3.9 STANDARISATION AND UNIFORMITY

3.9.0 General

Every endeavour shall be made to achieve standardisation and uniformity amongst the steel structures of different units of the plant.

3.9.1 The following items shall be kept in view in design of structures:

a) Uniform layout module shall be adopted to the extent possible consistent with economy. It is suggested to adopt a basic module of 3 m for building width and 6 m for column spacing along building length.

b) Uniform slopes of roofs matching with existing buildings unless specifically required otherwise for any particular unit.

c) Provision of expansion joints by using twin columns.

d) Uniform adoption of clearance between structures and moving parts of equipment.

e) Provision of adequate natural ventilation by using louvres (canopy like structures) at appropriate location and roof monitors/natural ventilation systems at roof.
4.0  FABRICATION OF STEEL STRUCTURES

4.1  Drawings

4.1.1  The Contractor shall prepare design drawings indicating general arrangement, members, sections and details of important joints, fabrication drawings, erection drawings, bill of materials, drawing office despatch lists / shipping documents, schedule of bolts and nuts and as built drawings. All drawing work shall be in metric system and all writing work shall be in English. Drawings shall be prepared using Autocad software.

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

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

4.1.4 Detailing of structural steel members subjected to dynamic loading shall be so as to keep the stress concentration to a minimum. Cross welding shall be avoided as far as practicable.

4.1.5 For bolted connections subjected to dynamic loading, lock nuts or spring washers shall be used in addition to plain washers.

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

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

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

4.1.9 All edge preparations for welding shall conform to IS:9595.

4.1.10 The contractor shall ensure correctness & completeness of fabrication drawings.

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

Unless otherwise specified in the drawings

a) All rolled sections and plates up to & including 20 mm thickness shall conform to Grade "A" as per IS : 2062.

b) Plates of thickness above 20 mm and Plated structures subjected to dynamic loading shall conform to Grade "B" as per IS: 2062.

c) For High Tensile steel requirements, material conforming to IS:8500 or SAIL- MA (HYA or HYB) shall be used.

4.2.2 Steel sheets shall conform to IS : 1079.

4.2.3 Steel tubes for structural purpose shall conform to IS : 1161 (of Grade Yst 240)

4.2.4 Corrugated Galvanised Sheets shall conform to IS:277 with appropriate Zinc coating for the selected thickness of sheet on roof and sides.

4.2.5 Aluminium industrial toughed sheets conforming to IS : 1254 shall be used as follows :

i) In roof - 0.91mm thick  
ii) In side walls - 0.71mm thick

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

4.2.7 Colour coated sheets shall be as per appropriate standard. All roof, monitor roof galvanised / zinc aluminium colour coated sheets of total coated thickness (TCT) of 0.65 mm with base metal yield strength of 240 MPa or alternately sheets having TCT of 0.5mm with base metal yield strength of 550 MPa.

All side sheets, monitor sides colour coated sheets of total thickness (TCT) of 0.6 mm with base metal yield strength of 240 MPa or alternately sheets having TCT of 0.5mm with base metal yield strength of 550 MPa. 

Ridging/ Flushing : colour coated sheets TCT of 0.8 mm with base metal yield strength of 240 MPa or alternately sheets having TCT of 0.5 mm with base metal yield strength of 550 MPa. For all above, minimum zinc deposition shall be 150 gms per sq.m.
4.2.8 Gutters shall be of copper bearing steel conforming to Grade "A" as per IS :2062

4.2.9 Crane Rails shall conform to IS : 3443.

4.2.10 All black bolts, nuts and locknuts shall conform to IS : 1363 and IS : 1364 (for precision and semi precision hexagonal bolts) of property class 6.4 unless otherwise specified. Washers shall conform to IS : 6610

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

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

4.2.13 Covered electrodes for arc welding shall conform to IS: 814. Coding of electrodes shall be as follows :
   a) ER421 ‘C’ X for mild steel of Grade ‘A’ and Grade ‘B’ as per IS : 2062
   b) EB 542 ‘C’ H3X for Mild steel of Grade ‘B’ as per IS 2062 for dynamically loaded structures (arising out of crane, vibratory screen, equipments etc.) ‘C’ is the value of the current as recommended by the electrode manufacturer.

4.2.14 Certified mill test reports of materials used in the work shall be made available for inspection by the Owner / Consultant upon request.

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

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

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

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

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

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

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

4.4 **Drilling and punching of holes**

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

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

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

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

4.5 **Assembly for fabrication**
4.5.1 Fabrication of all structural steelwork shall be in accordance with IS:800-1984 and in conformity with various clauses of this specification, unless otherwise specified in the drawings.

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

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

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

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

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

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

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

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

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

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

4.5.12 Where necessary, washers shall be tapered or otherwise suitably shaped to give the heads of nuts and bolts satisfactory bearing.

4.5.13 The threaded portion of each bolt shall project through the nut at least by one thread.
4.5.14 Tolerance of assembled components of structures are given in TABLE -

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

4.6 Method of Construction

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

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

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

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

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

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

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

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

4.7.2 For all full strength butt welding of plates and sections thicker than or equal to 10 mm, edge preparation shall be done and got approved by the Owner / Consultant.

4.7.3 Two numbers of washers shall be used for all bolted connections, one washer bearing against the head and other bearing against the nut.

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

4.7.5 If extra joints are to be provided in column, crane girder etc, prior approval on the same shall be obtained from the Owner / Consultant. However, as general guidance, the following is suggested:

- Splice joint on column and crane girder shall be of full strength butt weld, and, wherever possible, shall be located at the section of minimum or substantially lesser stress.
- Splice joints of web and flange should be sufficiently staggered in position.

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

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

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

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

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

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

4.8.6 All workmanship shall be in accordance with the best practice in modern structural shops. Greatest accuracy shall be achieved in the manufacture of every part of the work and all identical parts shall be strictly interchangeable.

4.8.7 Shearing or flame cutting may be used at the Contractor's option provided that a mechanically controlled cutting torch is used for flame cutting and that the resulting edges are clean and straight.

4.8.8 Unless clean square and true to shape all flame cut edges shall be planed/cleaned by chipping or grinding. Where machine flame cutting is permitted for high tensile steel, special care shall be taken to leave sufficient margin and all flame hardened material shall be removed by machining/edge grinding.
4.8.9 Wherever shearing is used for cutting to size, sheared members shall be free from distortions at sheared edge.

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

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

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

4.8.13 Holes for permanent black bolts shall not be more than 1.5 mm larger than the nominal diameter of the black bolts unless specified otherwise. All holes for turned and fitted bolts shall be sub punched or drilled and reamed at site under assembly of connected parts to a tolerance of +0.3 mm unless specified otherwise. Holes in purlins, side-sheeting runners, packing plates and lacing bars may be punched full size. Holes in light framing with the exception of joint holes, may be punched full size. All punching and sub-punching shall be clean and accurate and all drilling free from burrs. In block/batch drilling, parts shall be separated after drilling and the burrs removed. No hole shall be made by gas cutting process.

4.8.14 The component parts shall be so assembled that they are neither twisted nor otherwise damaged and specified cambers, if any, shall be provided. No drifting of hole shall be permitted except to draw the parts together. Drifts used shall not be larger than the nominal diameter of the bolt. Drifting done during assembling shall not distort the metal or enlarge the holes. Sufficient trial assembly shall be carried out in the fabrication works to prove the accuracy of workmanship of the and the number of such trials required shall be at inspector's discretion.
4.8.15 Where necessary, washers shall be tapered or otherwise suitably shaped to give the heads and nuts of bolts a satisfactory bearing. The threaded portion of each bolt shall project through the nut by at least one thread.

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

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

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

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

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

4.8.21 Fabrication of steel structures shall not be allowed inside the plant premises.

4.9 Wastage & Accountability
4.9.1 For the purpose of accounting of materials where the same is supplied by the Owner, free or on cost recoverable basis, the following wastage including rolling margin, invisible wastage and cut pieces of less than one metre length and plates with lesser dimension less than 300 mm shall be allowed.

a) Structural Steel : i) Sections - 5% on the quantity by weight computed, based on Fabrication drgs.

ii) Plates - 7.5% on the quantity by weight computed, based on Fabrication drawings.

b) Other materials : 5% on the quantity by weight computed, based on manufacturing drawings.

For all cut pieces (plates & sections) invisible wastage (cutting and burning losses) of maximum 0.5% will be admissible.

4.9.2 Owner reserves the right to take back such sections or quantity of steel issued in excess of quantity as per fabrication drawings plus permissible wastage where raw steel is issued free of cost by Owner. The contractor shall return to the Owner all such steel supplied in good and acceptable condition. In case of failure of the Contractor to return such surplus steel on demand by the Owner, Owner reserves the right to recover the cost of such steel at a penal rate of twice the SAIL- Stockyard rate of that particular section of steel as on the date of accountability.

4.9.3 If the Contractor fails to return scrap / wastage generated as per the percentage mentioned at 4.9.1, recovery on account of such scrap / wastage shall be made by the owner at prevailing rate of steel + 20 pc per tonne.

The charging of penal rate shall be without prejudice to any other remedies or action, available to the Owner, against the Contractor.

4.10 Despatch Instructions

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

4.10.2 "As built" drawing shall be prepared after fabrication is completed to indicate additions / alterations made during the process of fabrication.
4.10.3 Control assembly of important structures shall be done in the shop floor before despatch to avoid mismatching. For all such important structures, match marking shall be given at the control assembly stage in the shop floor and such match markings shall be made clearly visible while assembling the structures at site.

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

5. **ERECTION OF STEEL STRUCTURES**

5.1 **Scope**

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

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

b) Transportation at site of structures.

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

d) All minor rectification/modification such as:

   i) Removal of bends, kinks, twists, etc. for parts damaged during transportation and handling;

   ii) Cutting chipping, filing, grinding, etc., if required, for preparation and finishing of site connections;
iii) Reaming for use of next higher size bolt for holes which do not register or which are damaged.
iv) Welding of connections in place of bolting for which holes are either not drilled at all or wrongly drilled during fabrication.

e) Other rectification work such as

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

f) Fabrication of minor items/missing items or such important items as directed by the Owner Consultant.

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

h) Making arrangements for and providing all facilities for conducting ultrasonic X-ray or gamma ray tests on welds; getting the tests conducted by reputed testing laboratories, making available test films/ graphs, reports and interpretation.

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

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

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

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

m) Grouting of all column bases after proper alignment of columns and only after obtaining clearance from Owner / Consultant.

n) Supply of labour in sufficient numbers, where necessary, as directed by the Owner / Consultant.

o) Conducting preliminary acceptance and final acceptance tests.
p) Preparation of as built drawings, preparing of sketches/drawings to suit field engineering decisions, availability of material, convenience of fabrication, transportation and erection and changes during fabrication and erection.

All such works are subject to approval by the Owner / Consultant.

5.2 **Erection Drawings**

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

5.3 **Storing and Handling**

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

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

5.3.3 Any material found damaged or defective shall be stacked separately and the damaged or defective portions shall be painted in distinct colour for identification. Such materials shall be dealt with as ordered by the Owner / Consultant.

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

5.4 **Defects in material & fabrication**
5.4.1 All materials shall be straight unless required to be of curvilinear form and shall be free from twist. All cold straightening shall be done by pressure only.

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

5.5 **Setting out**

5.5.1 The Contractor shall prepare geodetic survey scheme of all embedded parts and holding down bolts and submit the same to Owner / Consultant. The Contractor shall inform the Owner / Consultant about any discrepancy with approved design drawings well in advance of erection and if necessary shall make necessary adjustments at site or during fabrication of structures.

5.5.2 The Contractor shall assume, full responsibility for the free and correct setting out of all steel work and erection correctly in accordance with position, alignment, dimensions and levels shown on the approved drawings and plumbing vertical members. Particular care shall be taken to ensure free expansion and contraction wherever provided. Notwithstanding any assistance rendered to the Contractor by the Owner / Consultant, if at any time during the progress of the work, any error should appear or arise therein, on being required to do so, the Contractor at his own cost shall remove and amend the work to the satisfaction of the Owner / Consultant.

5.6 **Assembly and Erection**

5.6.1 Before starting erection, the Contractor shall submit to the Owner / Consultant for his approval the method he proposes to follow and the number of types of equipments and temporary, works he proposes to use for the erection.

5.6.2 The approval of drawings by the Owner / Consultant will not relieve the Contractor from the basic approach to design as regards the loads which the erection equipment and temporary work shall be called upon to carry and support. Adequate allowance and provision shall be made for lateral forces and wind loads.
5.6.3 If in the opinion of the Owner / Consultant, the tools, tackles plant and equipment instruments, apparatus, etc. arranged by the Contractor are not sufficient or are inadequate for the fulfilment of the contractual obligations of the Contractor within the stipulated period, the Owner / Consultant will have the right to order the Contractor and the Contractor shall comply with the order to bring/arrange such additional tools, tackles, plant and equipment instruments, apparatus, etc. to the site and employ the same to complete the work in time. All charges in connection thereof shall be borne by the Contractor.

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

i) Frame of building to be true and plumb.
ii) Temporary guying and bracing shall be used to align the framing during erection, if required.
iii) Temporary bracing may be required to sustain forces due to erection loads and equipments. Erected parts of the structures shall be made stable during all stages of erection. The stability of structures subjected to the action of wind, dead weight and erection forces shall be attained by observing specified sequence of erection of vertical and horizontal structural members and by installing permanent and temporary bracings.
iv) Erection members shall be held securely in place by bolts to take care of dead load, wind load and erection load.
v) Free expansion and contraction wherever provided.
vi) No final bolting or welding of joints shall be done until the structure has been properly aligned and consent obtained from Owner / Consultant.
vii) Erection tools and machinery shall be of suitable capacity for handling the materials furnished and must be in safe operating conditions at all times to avoid danger to materials and personnel.
viii) In positioning beams, columns or other steel members the use of steel sledges shall not be permitted.
ix) The Contractor shall report all failures of the fabricated Steel to fit together properly to the Owner / Consultant and shall obtain approval prior to taking corrective measures.

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

iii) All exposed bolt holes not required shall be plugged.

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

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

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

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

5.6.9 Instrumental checking for correctness of initial setting out of structures, and adjustment of alignment shall be carried out in sequence at different stages as determined by design as against checking and adjustment of alignment in one stage after completion of entire erection. The final levelling and alignment shall be carried out immediately after completion of each section of a building or when called for by the Owner / Consultant.

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

5.7 Field connections

5.7.1 The holes of erection joints required to be machine bolted shall be filled with temporary bolts and plugs after mounting the structures. The number of bolts and plugs shall be determined by design but it shall not be less than 50% of the total number of holes. In joints where the number of holes is equal to 5 or less, not less than 3 holes shall be filled. The number of plugs shall be about 20% of the holes filled.
5.7.2 The number of washers on permanent bolts shall not be more than two (and not less than one) for nut and one for the bolt head. Wooden rams or mallet shall be used in forcing members into position, in order to protect the metal from injury and shocks. Chipping of edges of plates shall be done without breaking parent metal. Chipped edges shall be finished with a file and all short corner and hammered rough faces shall be rounded off. Chipping with the use of sledge hammer shall only be permitted in exceptional cases and shall be done without resulting in fractured edges.

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

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

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

5.8 **Assembly by high strength friction grip bolts**

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

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

5.9 **Bedding and grouting**

5.9.1 Base plates shall be set to elevations shown in the drawings, supported and aligned using steel wedges and shims or any other approved method. The supply of wedges, shims and any other material for alignment shall be the responsibility of the Contractor as part of his work. Plates shall be levelled, properly positioned and the anchor bolts properly tightened. The bedding/grouting shall not be carried out until a sufficient number of columns have been properly aligned, levelled and plumbed, and sufficient girders, beams, trusses and bracings are in position to the satisfaction of the Owner / Consultant.

5.9.2 Grouting shall be done before casting of elevated RCC floors, if any, and before equipments contributing to the loading on columns are placed in position. No moving equipment shall be tested and no trial run of any equipment conducted, before grouting has been done and cured to the satisfaction of the Owner / Consultant.

5.9.3 Grouting shall be minimum M25 grade or one grade higher than the grade of base concrete with 10 mm and below graded coarse aggregate. Ready-mix, non-shrink, free-flow grout from recognised manufacturer as approved by the Owner / Consultant shall be used with pressure grouting technique to ensure proper filling-up of all void spaces underneath the base plate. Manufacturer’s recommendations / instructions shall be followed for proper application of grout material.

5.9.4 The Contractor shall inform the Owner / Consultant when the base plates are ready for grouting for their verification. The Contractor shall be responsible for final vertical and horizontal alignment of all the base plates.

5.10 **Painting after erection**

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

5.11 **ACCEPTANCE OF WORK**
5.11.1 Acceptance of erected steel structures shall be either after completion of erection of the whole building or in blocks. Intermediate acceptance certificates will be given in the following cases:

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

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

i) Documents showing approved deviations made during execution of erection work.
ii) Documents showing acceptance of embedded structural steelwork.
iii) Certificates/documents on control checking and test of materials (if any) and welds.
iv) Data and results of Geodetic measurements while checking the erection of structures.
v) Copies of "As Built Drawings" showing thereon all additions and alterations.

6.0 WELDING SPECIFICATIONS

6.1 General

6.1.1 The welding and welded work shall conform to IS:816 and other relevant codes unless otherwise specified. Electrodes shall conform to IS:814 and shall be approved by the Owner/consultant.

6.1.2 Welding shall be done by Electrical Arc Process. Automatic welding shall be employed for important structures as specified in the drawings. Generally, submersed arc, Automatic & Semi-automatic welding shall be
employed. Only where it is not practicable, Manual Arc welding may be
resorted to. In case of Manual Arc Welding, recommendations of
electrode manufacturer are to be strictly followed.

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

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

6.1.5 The layouts and sequence of operations shall be arranged so as to
eliminate distortion and shrinkage stress to the satisfaction of the
Inspector. Welding work shall be under constant supervision of
competent welding supervisor and shall be done in a properly organized
manner with the approved quality welding sets and with automatic
welding machines. Detailed welding procedure shall be submitted to
the Owner / Consultant and approval of the same shall be obtained
before fabrication is commenced.

6.2 **Welding Procedure**

6.2.1 Welding procedure to be prepared by the Contractor shall include the
following :

i) Type and size of electrodes.

ii) Current and arc voltage (for automatic welding)

iii) Length of run per electrode, or (for automatic welding) speed of
    travel.

iv) Number and arrangement of runs in multi-run welds.

v) Position of welding.

vi) Preparation and set-up of parts.

vii) Welding sequence.

viii) Pre or, post-heating.

ix) Specification and thickness of steel

x) Welding process ( manual arc / submerged arc welding )

xi) Thickness of components meeting at a joint

xii) Pre and post heating requirement

xiii) Weather condition – restrictions thereof
xiv) Use of jigs and fixtures
xv) Type of non-destructive testing to be carried out
xvi) Inspection procedure to be followed
xvii) Sequence and process to be followed in different multiple-pass butt welding for different plate thicknesses.

The welding procedure shall be subject to Owner's / Consultant's approval.

6.2.2 The welding procedure shall be arranged to suit the details of the joints as indicated in the drawings and the positions in which the welding is to be carried out. The welds shall meet the requirements of quality specified.

6.2.3 All electrodes for use in the work to which the specification relates shall be kept under dry conditions. Electrodes which are damaged by moisture shall not be used unless it is certified by the manufacturer that when it is properly dried there shall be no detrimental effect. Any electrode which has part of its flux coating broken away or is otherwise damaged shall be discarded.

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

6.2.5 Submerged arc welding of mild steel and low alloy steel shall be as per IS : 4353

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

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

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

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

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

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

6.2.12 Arc-strikes on parent surfaces of structures shall be strictly avoided.

6.3 Control in Welding

6.3.1 The extent of quality control in respect of welds for structural elements for both statically and dynamically loaded structures shall be as follows and shall be conducted by the contractor at his own cost:-

   a) **Visual Examination** - All welds shall be 100% visually inspected to check the following:

      i) Presence of undercut
General Technical Specification

ii) Visually identifiable surface cracks in both welds and base metals.
iii) Unfilled craters
iv) Improper weld profile and size
v) Excessive reinforcement in weld
vi) Surface porosity

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

b) **Dye Penetration Test (DPT)** - This shall be carried out for all important fillet welds and groove welds for both statically and dynamically loaded structures to check the following

i) Surface cracks
ii) Surface porosities

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

c) **Ultrasonic testing**: Ultrasonic test shall be conducted for all groove welds and heat affected zone in dynamically loaded structures and for other important load bearing butt welds in statically loaded structures as desired by Owner, to detect the following

i) Cracks
ii) Lack of fusion
iii) Slag inclusions
iv) Gas porosity

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

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

This test shall be limited to 2% of length of welds for welds made by manual or semi-automatic welding and 1% of length of weld if made by automatic welding machines. The location and extent of
General Technical Specification

Weld to be tested by this method will be decided by Owner to detect the following defects:

i) gas porosity
ii) slag inclusions
iii) lack of penetration
iv) lack of fusion
v) cracks

Radiographic testing shall be conducted in accordance with American National Standard ANSI/AWS D1.1-96. Any surface irregularity like undercuts, craters pits etc. shall be removed before conducting radiographic test. The length of weld to be tested shall not be more than 0.75 x focal distance. The width of the radiographic film shall be width of the welded joint plus 20 mm on either side of the weld.

6.3.2 The Contractor shall provide testing equipment for conducting non-destructive tests for confirming the integrity of welding wherever necessary as directed by the Owner / consultant.

6.4 Acceptable Limits of Defects of Weld

Limits of Acceptability of welding defects shall be as follows:

a) Visual inspection & Dye Penetration Test

The limits of acceptability of defects detected during visual inspection and Dye Penetration Test shall be in accordance with American National Standard ANSI/AWS D1.1-96.

b) Ultrasonic Testing - The limits of acceptability of defects detected during ultrasonic testing shall be in accordance with American National Standard ANSI/AWS D1.1-96.

c) Radiographic testing - The limits of acceptability of defects detected during Radiographic testing shall be in accordance with American National Standard ANSI/AWS D1.1-96.

General guidelines for permissible deviations in welding have been given in Section 11.0 of this document.
6.5 Rectification of Defects in Welds

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

i) All craters in the weld and breaks in the weld run shall be thoroughly filled with weld.

ii) Undercuts, beyond acceptable limits, shall be repaired with dressing so as to provide smooth transition of weld to parent metal.

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

7.0 PAINTING OF BUILDING STEEL STRUCTURES

All steel structural work shall be painted as follows unless otherwise stated in the drawing / Technical Specification. Relevant section of the GS shall be referred for further guidelines on painting.

7.1 Surface Preparation

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

Following are the type and standards of surface preparation to be followed based on the requirement of a particular painting system or as specified in the design drawings.

Manual / Power tool cleaning Manual/Power tool cleaning shall be done as per Grade St-2 or St-3 of Swedish Standard institution SIS 05 5900 or cl. 7.2.1.1 & 7.2.1.2 of IS : 1477 (Part - I).
**Grade St-2**: Thorough scraping and wire brushing, machine brushing, grinding, etc. This grade of preparation shall remove loose mill scale, rust and foreign matter. Finally the surface is to be cleaned with a vacuum cleaner or with clean compressed air or clean brush. After preparation, the surface should have a faint metallic sheen. The appearance shall correspond to the prints designated St-2.

**Grade St-3**: Very thorough scraping and wire brushing, machine brushing, grinding, etc. The surface preparation is same as for St-2 but to be done much more thoroughly. After preparing the surface, it should have a pronounced metallic sheen and correspond to the prints designated St-3.

**BLAST CLEANING** – Blast cleaning shall be done by shot blasting as per Grade SA-2 or SA-2 1/2 as specified in the drawings.

If no grade of surface preparation is specified, St-2 grade of preparation as per Swedish Standard shall be followed.

### 7.2 *Paints and painting*

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

#### 7.2.1

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

#### 7.2.2

In the event of conflict between this General Specification for painting and the paint manufacturer's specification, this conflict shall be immediately brought to the notice of the Owner / Consultant. Generally in cases of such conflicts, manufacturer's Specification/recommendation shall prevail.

#### 7.2.3

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

#### 7.2.4

Control areas shall serve as specimen of painted surfaces, for observing and recording quality and performance of paint.
7.2.5 In case of any doubts, the Contractor shall send samples of paint to recognized testing laboratories to establish quality of paint with respect to:
   i) Viscosity
   ii) Adhesion/bond of paint to steel surfaces
   iii) Adhesion/simulated salt spray test
   iv) Chemical analysis/percentage of solid by weight
   v) Normal wear resistance as encountered during handling and erection
   vi) Resistance against exposure to acid fumes, and such other tests as considered necessary by the Owner / Consultant.

Whole system of paint shall be obtained from the same manufacturer.

7.2.6 Guarantee period on paints and painting shall commence from the date of completion of finishing coat of paint on entire structures. The guarantee period shall be indicated depending on the type of surface preparation and system of painting. To fulfil this obligations, the Contractor may obtain from the painting manufacturer, guarantee for the performance of paint/painted surfaces.

7.2.7 The painting material as delivered to the Contractor/Applier, must be in the manufacturer's original containers bearing thereon manufacturer's name, brand and description. Paint/painting material in the containers without labels or with illegible labels shall be rejected, removed from the area and shall not be used. Thinners wherever used shall be those recommended by the paint manufacturer and shall be obtained in the containers with manufacturer's name and brand name of the thinner legibly printed, failing which the thinner is liable to be rejected and shall not be used.

7.2.8 Wherever shop primer painting is scratched, abraded or damaged, the surface shall be thoroughly cleaned using emery paper and power driven wire brush wherever warranted or as directed by the Owner / Consultant, and touched up with corresponding primer. Touching up paint shall be matched and blended to conspicuous marks. If more than 50% of the painting surface of an item requires repair, the entire item shall be mechanically cleaned and new primer coats followed by finishing coats shall be applied as per painting Specification.

7.2.9 All field welded areas on shop painted items shall be mechanically cleaned including the weld area proper, adjacent areas contaminated by
weld splatter or fumes & areas where existing primer / intermediate / finish paint is burnt. Subsequently, new primer and finishing coats of paint shall be applied as per painting Specification.

7.2.10 Application of paint shall be by spraying or brushing as per IS : 486 and IS . 487 and in uniform layers of 50% overlapping strokes by skilled painters. Painting shall not be done when the temperature is less than 5 degree C or more than 45 degree C and relative humidity is more than 85%; unless manufacturer's recommendations permit. Also painting shall not be done in foggy weather. During application, paint agitation must be provided where such agitation is recommended by the manufacturer.

7.2.11 Paint shall be applied at painting manufacturer's recommended rates. The number of coats shall be such that minimum dry film thickness specified is achieved. The dry film thickness (DFT) of painted surfaces shall be checked with ELCOMETER or measuring gauges to ensure specified DFT.

7.2.12 The inside surfaces of gutter which come in contact with rain water shall be provided with 2 finishing coats of water resistant, bitumastic paint of minimum DFT 75 microns, in addition to the primer coats of red oxide zinc phosphate in phenolic alkyde medium or 2 primer coats of epoxy based red oxide zinc chromate/epoxy based zinc phosphate of minimum DFT 25 microns per coat, as given in Specification and drawings. Other structures shall be painted as per painting system mentioned.

7.2.13 All structures shall receive one coat of primer paint at shop after fabrication before despatch after surface preparation has been done as per requirements. Unless otherwise specified all structures after erection shall be given one coat of primer and two coats of finishing paint of approved colour and quality. The under coat shall have different tint to distinguish the same from the finishing coat. Edges, corners, crevices, depressions, joints and welds shall receive special attention to ensure that they receive painting coats of required thickness.

7.2.14 Machine-finished surface shall be coated with white lead and tallow before shipment or before being put out into the open air. Part of steel structures to be embedded in concrete, shall be given a protective coat of Portland cement slurry immediately after fabrication after this part is thoroughly cleaned from grease, rust, mill scales etc. No paint shall be applied on such parts.
7.2.15 Zinc-rich primer paints, which have been exposed several months before finishing coat is applied, shall be washed down thoroughly to remove soluble zinc salt deposits. In similar circumstances, the surface of paint based on epoxy resin should be abraded or lightly blast cleaned to ensure adhesion of next coat.

7.2.16 Paints selection shall be based on Preferred make list of BSP. Type of paint (heat resistant/high corrosion resistant) required to be applied for a structure shall be approved by BSP and prior permission shall be taken before application of paint.

8.0 GENERAL REQUIREMENTS

8.1 Programme

The Contractor shall prepare a programme showing the date of supply of steel to his work, and the fabrication and erection of each section of the structure or structures. The erection dates shall be the dates for completion of all the follow-up work in addition to main erection keeping overall completion of project in view. The programme shall include quantum of different activities of work planned month wise to complete the work.

8.2 Drawings

8.2.1 The Contractor shall prepare steel structural arrangement drawings and design drawings along with analysis and design calculation of major elements and take their approval by Owner / Consultant within the time schedule as per contract. Necessary number of prints of drawings and documents; as per contract shall be submitted for approval. The Contractor shall prepare the fabrication drawings and bill of materials shall form part of the fabrication drawings which will be included in the body of the drawing or prepared separately.
8.2.2 Even if the drawings are Approved / Commented by the Owner / Consultant, the Contractor shall not be relieved of the responsibilities for the accuracy of the detailed dimensions shown in the drawings and the safety of all structural connections.

8.2.3 Notes on specifications shown on design drawings shall considered as superseding or overriding the specifications with which they conflict. On all drawings, dimensions shown in figures shall be acted on. Erection drawings in requisite number of sets shall be submitted to the Owner / Consultant showing thereon all authorized additions and alterations in the process of erection. These drawings shall show the "As-Built Installations".

8.2.4 Supply and distribution of fabrication drawings. and other documents like bolt list etc. for the contractors own use or for the use of his subcontractors shall be the responsibility of the Contractor.

8.2.5 The Contractor shall assume full responsibility for the correct setting out of all steel works and erecting correctly in accordance with alignment and levels shown on the approved drawings and plumbing of vertical members. Notwithstanding any assistance rendered to the Contractor by the Owner / Consultant, if at any time during the progress of the work, any error should appear or arise therein, on being required to do so, the Contractor at his own cost shall remove and amend the work to the satisfaction of the Owner/Consultant.

8.2.6 The Contractor shall provide his own measuring instruments for setting out, levelling and aligning work at his own expense.

8.3 **Co-ordination with other Contractors**

The structures shall have to be erected suitably detailed with erection of equipment or construction of civil works. The Contractor shall ensure spirit of co-operation with other contractors and strict adherence to the schedule so that erection schedules of the other parties are not affected.

8.4 **Staging**

Any staging necessary for the pre assembly work of structures shall be provided by the Contractor.
8.5 **Rules and regulations of safety, electricity boards, factory etc.**

The Contractor shall at all times comply with such rules and regulations as stipulated in relevant factory acts, electricity rules, safety regulations, etc.

8.6 **Deviations**

Should the contractor wish to deviate from any specifications or approved drawings and/or technical specifications, he shall obtain the Owner/Consultant’s written authority before proceeding with the deviations.

9. **INSPECTION OF STRUCTURES**

The Owner / Owner’s Inspector shall have free access at all times to those parts of Contractor’s or his Sub-Contractor’s works which are concerned with the fabrication of steel works and shall be afforded all reasonable facilities at all stages of preparation, fabrication and trial assemblies for satisfying himself that the fabrication is being undertaken in accordance with the provisions of relevant specification.

All gauges and templates, tools, apparatus, labour and assistance for checking shall be supplied by the contractor free of charge. The Owner / Inspector may at his discretion, check the test results obtained at the Contractor’s works, by independent test at the Government Test House or elsewhere, and should the material so tested be found to be unsatisfactory, the cost of such test shall be borne by the Contractor.

Contractor shall make all necessary arrangements for stage inspection by Owner/Inspector during the fabrication at shop and incorporate all on-the-spot instructions / changes conveyed in writing to the Contractor.
9.4 Material improperly detailed or wrongly fabricated shall be reported to the Owner/Inspector and shall be made good as directed. Minor misfits which can be remedied by moderate use of drift pins, and moderate amount of reaming and slight chipping may be corrected in that manner, if in the opinion of the Owner / Inspector the strength or appearance of the structure shall not be adversely affected. In the event the Owner / Inspector directs otherwise, the items shall be rejected and a completely new piece shall be fabricated. The cost of correcting errors shall be to the account of the Contractor.

9.5 The Owner / Owner’s Inspector shall have the power:

a) To declare, before any structure is submitted for inspection, that the same is not in accordance with the contract, owing to the adoption of any unsatisfactory method of fabrication and the same will be rejected.

b) To reject any structure as not being in accordance with specifications & drawings.

c) To insist that no structure or parts of the structure once rejected is resubmitted for inspection/test, except in cases where the Owner / Inspector authorised representative considers the defects as rectifiable.

9.5.1 If, on rejection of structure by the Owner/Inspector the Contractor fails to make satisfactory progress within the stipulated period, the Owner / Inspector shall be at liberty to cancel the contract and fabricate or authorise the fabrication of the structures at any other place he chooses, at the risk and cost of the Contractor, without prejudice to any action being taken in addition to terms of General Conditions of Contract.

9.5.2 The Owner / Inspector’s decision regarding rejection shall be final and binding on the Contractor.

9.5.3 The specifications prescribe various tests at specified intervals for ascertaining the quality of the work done. If the tests prove unsatisfactory, Owner/Inspector shall have liberty to order the Contractor to re-do the work, done in that period and/or to order such alterations and strengthening that may be necessary at the cost of the Contractor and the contractor shall be bound to carryout such orders failing which the rectification/redoing shall be done by the Owner through other agencies and the cost recovered from the Contractor.
9.5.4 Notwithstanding any inspection at the workshop the Owner/Inspector shall have the liberty to reject, without being liable for compensation any fabricated members or materials brought to site that do not conform to specifications / drawings.

9.5.5 All rejected materials shall be removed from the site of fabrication by the Contractor at his own cost and within the time stipulated by the Owner/Inspector.

10.0 QUALITY SYSTEM AND THIRD PARTY INSPECTION.

10.1 GENERAL

Inspection shall be carried out at the works of the Contractor during fabrication and on final product to ensure conformity of the same with the acceptable criteria of technical specifications, approved fabrication drawings and indicated standards.

10.1.1 This specification is in addition to the provisions laid down in Owner's General Condition of Contract (GCC) and special instructions to Contractor, if any.

10.2 QUALITY SYSTEM REQUIREMENTS.

The Contractor must recognise the importance of quality and follow the defined quality programme in all manufacturing and quality control activities of the product. The Contractor shall define and implement the tasks and controls that shall provide needed assurance in case manufacturing of product is sub-contracted either partly or fully and / or for the procured components of the product. All bought-out components, if any, shall be procured from approved list of vendors issued by the Project Authority.

Owner reserves the right to verify the quality programme and entire product characteristics to assure the intended and specified quality of the product.

10.3 QUALITY ASSURANCE PLAN (QAP)
10.3.1 The Contractor shall furnish the Quality Assurance Plan (QAP) for the respective structural unit / component after finalisation of billing schedule for Owner's approval at least two months prior to start of manufacturing.

10.3.2 The Contractor shall indicate the procurement source and furnish to Owner during discussions on QAP, copies of Owner Order, Sub-Owner Order, and data sheets as backup reference materials for scrutiny & finalisation of QAP.

10.3.3 QAP shall be prepared & furnished by the Contractor in the prescribed format (enclosed as Annexure- B) for structural components, in four sets.

10.3.4 Inspection and test requirements shall be decided with due consideration of factors like safety, duty cycle, operating conditions, equipment life, environmental conditions, place of installation and statutory regulations, as applicable, for a particular component. Any, additional type or special test or routine tests if found necessary to establish the intended quality, shall be incorporated in the QAP on mutual agreement without any commercial implication.

10.3.5 Detailed QAP shall be prepared by the Contractor based on the general plan given by Owner and shall be approved by Owner to avoid any complication later.

10.3.6 QAP shall clearly indicate the followings through use of codes in the appropriate columns:

   a) Range of inspection & tests to be done by the Contractor during fabrication of structures from raw materials to finishing stage.

   b) Suggestive check / hold points for Owner's inspection and witnessing of tests during the fabrication and final product inspection.

   c) Details of test certificates, internal inspection reports and calibration certificates to be furnished by the Contractor to Owner.

   d) Inspection documents to be furnished by the Contractor to Owner for reference during inspection.

10.3.7 Sampling method for lot inspection of similar bulk items, if any, shall be indicated under column 16 of QAP with linkage to applicable standard.

10.3.8 While submitting the QAP, the Contractor shall indicate the acceptance criteria under column 15 of QAP form regarding check parameters of each
component. Acceptance criteria shall have reference of documents viz. Owner Order, Sub-Owner Order, T.S., Approved fabrication drawings. Wherever the acceptance criterion is not available in above documents, the same shall be specified with traceability to national / international specifications.

10.4 **INDICATIVE SURVEILLANCE BY OWNER.**

10.4.1 Surveillance level of Owner may vary from component to component as per product characteristics.

Indicative extent of inspection for buildings and structures is furnished below for guidance of Contractors in developing QAP.

<table>
<thead>
<tr>
<th>Categories of Equipment</th>
<th>Extent of Inspection</th>
</tr>
</thead>
<tbody>
<tr>
<td>i) Manufactured items</td>
<td>Material &amp; manufacturer’s test certificate to be submitted by giving inspection call for the main equipment in the final stage.</td>
</tr>
<tr>
<td>(Structural fabricated and welded)</td>
<td></td>
</tr>
</tbody>
</table>

Scrutiny of welding procedure and welder’s qualification record shall be carried out if required as per governing code.

Following checks / tests shall be carried out in the final stage:
- Visual inspection
- Alignment and fitment checking
- Dimensional checking
- Weld inspection - visual and NDT as per design requirements. Radiographs are to be shown and reports to be submitted to Owner for review during inspection, if applicable.

10.5 **CALIBRATION OF MEASURING EQUIPMENT.**

10.5.1 All the measuring equipment used for inspection & testing shall be calibrated and appropriate accuracy class of measuring equipment shall be used. Calibration standards used for calibration of measuring
equipment shall be traceable to national standards of National Physical Laboratory (NPL), New Delhi with unbroken chains of comparison.

10.5.2 Calibration Certificate of All Measuring Equipments.

Valid calibration certificates for all measuring equipments used during inspection and testing with traceability to national standards of NPL / NPL accredited laboratories shall be furnished along with inspection call prior to undertaking inspection by Owner.

Calibration certificates shall also indicate reference number of calibration standards calibrated by NPL / NPL accredited laboratories and copies of such calibration certificates of calibration standards shall also be furnished when asked for.

10.6 **TEST CERTIFICATES AND DOCUMENTS.**

10.6.1 For each of the items being fabricated, the following test certificates and documents, as applicable, in requisite copies including original shall be submitted to Inspection Agency. All test certificates must be endorsed by the Contractor with linkage to project, purchase order and acceptance criteria.

i)  Raw materials identification & physical and chemical test certificates for all materials used in fabrication of the component (except IS 2062-1992).

ii)  WPS, PQR & WPQ Documents as per applicable code.

iii)  Details of stage-wise inspection & rectification records for fabricated items and machined articles.

iv)  Control dimension chart with records of alignment, trueness of shape, etc.

v)  Details of heat-treatment and stress relieving charts as per specification.

vi)  Non-Destructive Test reports as per respective code.

vii)  Hardness test certificate.

viii) Performance Test Certificates for all characteristics.
ix) Geometric accuracy and repeatability test reports of machine tools.

x) Surface preparation and painting certificates.

xi) Certificates from competent authority for the items coming under statutory regulations.

10.6.2 The Inspection Agency shall have the right to be present and witness all tests being carried out by the Contractor at their own laboratory or approved laboratories. Also, the Inspection Agency shall reserve the right to call for confirmatory test on samples, at his discretion.

10.7 MANUFACTURING AND INSPECTION SCHEDULE

The Contractor shall submit the schedule for fabrication and inspection indicating components/assembly/sub-assembly, date of approval of drawings/data sheets, address of Fabricator with contact person and scheduled date of inspection. Such reports shall be submitted to Owner with a copy to Inspection Coordinating Office once in a month. These monthly reports shall state the planning for next three months. Submission of first report must commence one month prior to commencement of fabrication activities of the component.

10.8 INTERNAL INSPECTION BY CONTRACTOR

10.8.1 The Contractor in accordance with approved drawings, T.S., Owner Order, and approved QAP shall carry out inspection and tests. The Contractor shall maintain records of each inspection and test carried out and signed documents shall be submitted to Owner for verification.

10.8.2 The Contractor shall carry out their internal inspection & obtain clearance from statutory bodies e.g. IBR, CCE, TAC, Weights & Measures, safety, IE rules etc. as and where applicable, prior to offering any component for Owner’s inspection in accordance with approved QAP.

10.8.3 The Contractor shall ensure use of appropriate calibrated measuring equipment during their internal inspection, as well as, make available the same during Owner’s inspection and tests. Also, they shall make necessary arrangement for access and use of Owner owned measuring equipment during inspection.

10.8.4 The Contractor shall identify all the inspected component / raw materials & shall maintain the record of status of inspection viz. inspected & found acceptable, require rectification / rework, rejected etc.
10.8.5 The Contractor shall establish and maintain procedures to ensure that product that does not conform to specified requirements, is prevented from inadvertent use or installation. The description of non-conformity that has been accepted subsequently by Owner by concession and / or of repairs shall be recorded.

Repaired and reworked product shall be offered for re-inspection to Owner along with records of corrective action taken.

10.8.6 The Contractor shall not despatch any equipment till receipt of despatch clearance from Owner.

10.9 METHOD OF UNDERTAKING INSPECTION & TESTING BY OWNER.

10.9.1 Agency Responsible:-

Inspection / Waiver of component shall be undertaken by various MECON Offices depending upon the location of manufacturers.

10.9.2 Method of Issuing Inspection Call to MECON:

(i) Inspection call shall be given only on readiness of the assembly / sub-assembly and approval of all relevant drawings and QAP. In case assembly sub - assembly offered for inspection are found not ready, all the cost of visit of Owner's personnel shall have to be borne by the Contractor. Also, if the assembly / sub-assembly after inspection found not acceptable, require rework and involve Owner's re-inspection, all the cost of such re-inspections shall also be borne by the Contractor.

(ii) Inspection call shall be floated to Owner with ten days clear margin, enclosing all documents like test Certificates, Internal Inspection Reports, Purchase Order, Sub-Purchase Order, T.S., Approved QAP, approved GA drawings/ data sheets and fabrication drawings with a copy of call letter to Inspection Co-ordinating Office. Inspection calls without above documents shall be ignored.

(iii) The supplier shall offer substantial quantities for economical inspection consistent with the size of order.

10.10 OBLIGATIONS OF CONTRACTOR.
10.10.1 The Contractor shall provide all facilities and ensure full and free access of the Inspection Engineer of Owner to the Contractor's or their Sub-Contractor's premises at any time during contract period, to facilitate him to carry out inspection & testing of the product during or after manufacture of the same.

10.10.2 The Contractor shall delegate a Representative / Co-ordinate to deal with Owner / Consultant on all inspection matters. Also, Contractor’s Representative shall be present during all inspection at Sub-Contractor's works.

10.10.3 The Contractor shall comply with instructions of the Inspection Engineer fully and with promptitude.

10.10.4 The Contractor / Sub-Contractor shall provide all instruments, tools, necessary testing & other inspection facilities to Inspection Engineer free of cost for carrying out inspection.

10.10.5 The cost of testing welds by ultrasonic, radiographic and dye penetration tests etc. in the fabrication workshop shall be borne by the Contractor.

10.10.6 The Contractor shall ensure that the assembly / component of the plant and equipment required to be inspected, are not dismantled or despatched before inspection.

10.10.7 The Contractor shall not offer equipment for inspection in painted condition unless otherwise agreed in writing by Owner / Consultant.

10.10.8 The Contractor shall ensure that the equipment and materials once rejected by the Inspection Engineer are not re-used in the manufacture of the plant and equipment. Where parts rejected by the Inspection Engineer have been rectified, as per agreed procedures laid down in advance, such parts shall be segregated for separate inspection and approval, before being used in the work.

10.11 STAMPING AND ISSUE OF INSPECTION DOCUMENTS.

Inspection Memo: -

For stage inspection & for rejected items / items which do not conform to Technical Specification in one or more quality characteristics requiring rectification / rework, Inspection Memo shall be issued in
standard form indicating therein the details of observation & remarks. Fabricator shall indicate all the non-conformities with respect to specification of the product in the Inspection Memo for further control.

Inspection Certificate: -

On satisfactory completion of final inspection & testing by Owner / Third Party Inspector, all accepted plant & equipment shall be stamped suitably and the Inspection Engineer for the accepted items shall issue Inspection Certificate in standard form.

Inspection Waiver Certificate: -

For the waiver category of items identified in the approved QAP, Owner shall issue Inspection Waiver Certificate after scrutiny of Contractor's Internal Inspection Report, Test Certificates and other Documents as identified in QAP.

10.12. GENERAL CLAUSES

10.12.1 Inspection & tests carried out by Owner / Third Party Inspector shall not absolve the responsibility of the Contractor to provide acceptable product nor shall it preclude subsequent rejection.

10.12.2 Owner / Third Party Inspector reserves the right to inspect any product at any stage of manufacturing without prior notice to Contractor beyond pre-identified stages & hold points of approved QAP.

11. PERMISSIBLE DEVIATION IN ASSEMBLY OF WELDED JOINTS

A) SQUARE BUTT-JOINT

a) Gap between the ends of plates : + 1.0 mm
b) Stepping of one plate over the other : + 1.0 mm

B) SINGLE VEE-GROOVE JOINT

a) Bevel angle : + 5 deg
b) Gap between two plates : + 1.0 mm

c) Stepping of one plate over the other : + 2.0 mm

d) Root thickness : + 1.0 mm

C) LAP JOINT

a) Over lap : + 5.0 mm

b) Gap between the surfaces : + 1.0 mm

D) TEE FILLET JOINT

a) Gap between the edge of the web and the surface of the flange : + 2.0 mm

E) DOUBLE VEE-GROOVE JOINT

a) Stepping of plate over one another : + 2.0 mm

b) Deviation in value of root thickness : + 1.0 mm

c) Deviation in bevel angle : + 1.0 mm

d) Deviation in value of gap : + 1.0 mm

12. PERMISSIBLE DEVIATIONS IN FABRICATION & ERECTION

TABLE – 1

<table>
<thead>
<tr>
<th>Description</th>
<th>Tolerance in mm</th>
</tr>
</thead>
<tbody>
<tr>
<td>DUST CATCHER SHELL</td>
<td></td>
</tr>
</tbody>
</table>
### Ellipticity (max. difference between diameters) of a course.

- **Ellipticity** (max. difference between diameters) of the cylindrical and conical portions.
- **Deviation in mm**

0.005 of the theoretical diameter of the cylinder and conical portion.

### Stepping of the edges of plates in the vertical and circular weld joint.

- **Stepping of the edges** of plates in the vertical and circular weld joint.
- **Deviation in mm**

0.1 of shell thickness but not more than 3 mm.

### Local warping of shell along the generatrix and periphery as measured by gauge over the length of 1500 mm.

- **Local warping** of shell along the generatrix and periphery as measured by gauge over the length of 1500 mm.
- **Deviation in mm**

Not more than 15 mm.

---

**TABLE – 2**

**BLAST FURNACE SHELL**

<table>
<thead>
<tr>
<th>DESCRIPTION</th>
<th>DEVIATION IN mm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ellipticity (max. difference in diameters) of a course.</td>
<td>+ 0.002 of the theoretical diameter of the course.</td>
</tr>
<tr>
<td>Stepping of the edges of plates in the vertical and circular weld joint.</td>
<td>0.1 of shell thickness but not more than 3 mm.</td>
</tr>
<tr>
<td>Local warping of shell along the generatrix and periphery as measured by gauge over the length of 1500 mm.</td>
<td>Not more than 15 mm.</td>
</tr>
</tbody>
</table>
Caving in or bulging of joints measured by gauge over a length of 200 mm.

Note: H - height measured from the base of the point of alignment.

TABLE – 3

**COVERAGE OF NDT FOR WELDS**

<table>
<thead>
<tr>
<th>STRUCTURE</th>
<th>NORMS FOR CONTROLLING AS A % OF TOTAL LENGTH OF WELDING (NOT LESS THAN) FOR</th>
<th>PLACES TO BE SUBJECTED TO RADIOGRAPHIC TESTING COMPULSORILY</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>ULTRASONIC TESTING</td>
<td></td>
</tr>
<tr>
<td>BF Shell</td>
<td>100</td>
<td>3</td>
</tr>
<tr>
<td>Stoves, hot blast main &amp; bustle main</td>
<td>100</td>
<td>10</td>
</tr>
<tr>
<td>Dust catcher, Junction &amp; places of variable cross sections by the following norms without ultrasonic testing with ultrasonic testing</td>
<td>--</td>
<td>3</td>
</tr>
<tr>
<td>---</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>100</td>
<td>-</td>
<td>1</td>
</tr>
<tr>
<td>Portions of gas pipelines from BF to DC &amp; DC to GCP</td>
<td>--</td>
<td>1</td>
</tr>
</tbody>
</table>

**TABLE – 4**

**ERECTION TOLERANCES**
<table>
<thead>
<tr>
<th>DESCRIPTION</th>
<th>TOLERANCE (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>COLUMNS</strong></td>
<td></td>
</tr>
<tr>
<td>Deviation of column axes at foundation top level with respect to true axes</td>
<td>± 5</td>
</tr>
<tr>
<td>In longitudinal direction</td>
<td></td>
</tr>
<tr>
<td>In lateral direction</td>
<td>± 5</td>
</tr>
<tr>
<td>Deviation in the level bearing surface of columns at foundation top level with respect to true level.</td>
<td>± 5</td>
</tr>
<tr>
<td>Out-of-plumbness (verticality of column axis from true vertical axis, as measured at column top: For columns without any special requirements</td>
<td>± H/1000 or</td>
</tr>
<tr>
<td>Up to and including 30 M height</td>
<td>±25 mm whichever is less.</td>
</tr>
<tr>
<td>Over 30 M height</td>
<td>± H/1200 or</td>
</tr>
<tr>
<td>For columns with special requirement like cranes or such similar requirements. Upto and including 30 M height</td>
<td>±35 mm max.</td>
</tr>
<tr>
<td>Over 30 M height</td>
<td>± H/1000 or</td>
</tr>
<tr>
<td>Deviations in straightness in longitudinal and transverse plans of columns at any point along the height.</td>
<td>± H/1000 or</td>
</tr>
<tr>
<td></td>
<td>±10 mm whichever is less.</td>
</tr>
<tr>
<td>DESCRIPTION</td>
<td>TOLERANCES (mm)</td>
</tr>
<tr>
<td>---------------------------------------------------------------------------</td>
<td>-------------------------------------</td>
</tr>
<tr>
<td><strong>TRUSSES</strong></td>
<td></td>
</tr>
<tr>
<td>Shift, at the centre of span of top chord member with respect to the vertical plan passing through the centre of bottom chord.</td>
<td>± 1/250 of height of truss at centre of span or ± 15 mm whichever is less.</td>
</tr>
<tr>
<td>Lateral shift of top chord of truss at the centre of span from the vertical plan passing through the centre of supports of the truss.</td>
<td>± 1/1500 of height of truss at centre of span or</td>
</tr>
<tr>
<td>DESCRIPTION</td>
<td>TOLERANCES (mm)</td>
</tr>
<tr>
<td>-------------</td>
<td>----------------</td>
</tr>
<tr>
<td><strong>CRANE GIRDERS &amp; RAILS</strong></td>
<td></td>
</tr>
<tr>
<td>Shift in the centre line of crane rail with respect to centre line of web of crane girder.</td>
<td>± (web thickness + 2)/2</td>
</tr>
<tr>
<td>Shift in plan of alignment of crane rail with respect to true axis of crane rail at any point.</td>
<td>± 5</td>
</tr>
<tr>
<td>Deviations in crane track gauge with respect to true crane gauge. For track gauge up to and including 15 M. For track gauge more than 15 M.</td>
<td>± 5 (5 + 0.25(S-15)) subject to a max. of 10 mm, where S in</td>
</tr>
</tbody>
</table>

º 10 mm whichever is less.
<table>
<thead>
<tr>
<th>Description</th>
<th>Limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Deviations in crane rail level at any point from true level.</td>
<td>± 10</td>
</tr>
<tr>
<td>Difference in levels between crane track rails (across the bay) at:</td>
<td>± 15</td>
</tr>
<tr>
<td>Support of crane girder</td>
<td>± 20</td>
</tr>
<tr>
<td>Mid span of crane girders</td>
<td></td>
</tr>
<tr>
<td>Relative shift of crane rail surfaces at a joint in plan and elevations.</td>
<td>2 mm subject to grinding of surfaces for smooth transitions.</td>
</tr>
<tr>
<td>Relative shift in location of crane stops (end buggers) along the crane track gauge.</td>
<td>1/1000 of track gauge S in mm subject to max. of 20 mm</td>
</tr>
<tr>
<td>CHIMNEYS &amp; TOWERS</td>
<td></td>
</tr>
<tr>
<td>Out of plumbness (vertically from the true vertical axis).</td>
<td>1/1000 of the height of chimney or tower in mm.</td>
</tr>
<tr>
<td>BUNKERS</td>
<td></td>
</tr>
<tr>
<td>Deviation in length of bunker from the true length.</td>
<td>± 1/1000 of length in mm</td>
</tr>
<tr>
<td>Deviation in width of bunker from the true width.</td>
<td>± 1/1000 of width in mm</td>
</tr>
<tr>
<td>Deviation in height of bunker from the true height.</td>
<td>± 1/1000 of height in mm</td>
</tr>
<tr>
<td>Section</td>
<td>Description</td>
</tr>
<tr>
<td>-----------------------------</td>
<td>----------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>BF SHELL</td>
<td>Ellipticity (the maximum difference in diameter in diameter) of courses.</td>
</tr>
<tr>
<td>STOVE SHELL</td>
<td>The dome centre shift with respect to the bottom centre.</td>
</tr>
<tr>
<td></td>
<td>Ellipticity</td>
</tr>
<tr>
<td>TOP STRUCTURES</td>
<td>Shift of frame centre from the designed position.</td>
</tr>
<tr>
<td></td>
<td>Non horizontality of girders</td>
</tr>
<tr>
<td>DOWN COMERS</td>
<td>Erection and sag of down comers</td>
</tr>
<tr>
<td>GAS PIPELINE SUPPORTS</td>
<td></td>
</tr>
<tr>
<td><strong>GAS &amp; AIR</strong></td>
<td></td>
</tr>
<tr>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>Distortion of flange/surfaces (except for the furnace top one) with respect to the branch pipe/pipe socket axis.</td>
<td>2 mm per 1 m of flange diameter.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>DUST CATCHER</strong></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Ellipticity</td>
<td>0.003 of the nominal diameter of the course.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>BUSTLE PIPE</strong></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>The deviations of the bottom level (of the shell) of the ring pipe (measured along the axis of air tuyere) from the designed one.</td>
<td>± 10 mm</td>
</tr>
<tr>
<td>Ellipticity</td>
<td>0.003 of the theoretical diameter.</td>
</tr>
</tbody>
</table>
Note:

The tolerances given at Sections 11 and 12 above, are meant as general guidelines, mainly for technological structures, and for those not covered in IS Codes.

Tolerances for fabrication and erection in general, shall be as per stipulations of IS : 7215-1974, and IS : 12843 -1989.

In case of a conflict between the guidelines given in IS Codes and this Specification, those specified herein shall prevail.

ANNEXURE-A

Permissible deviations in pitch and gauge of holes for bolts of normal accuracy ( high strength bolts included )

<table>
<thead>
<tr>
<th>Hole diameter Permissible deviations in each group of holes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Description</td>
</tr>
<tr>
<td>---------------</td>
</tr>
<tr>
<td>In spacing</td>
</tr>
<tr>
<td>1</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>a) Deviation</th>
<th>Upto 17.0</th>
<th>Above 17.0</th>
</tr>
</thead>
<tbody>
<tr>
<td>in the hole</td>
<td>+1</td>
<td>+1.5</td>
</tr>
<tr>
<td>diameter</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>b) Ovality</th>
<th>Upto 17.0;</th>
</tr>
</thead>
<tbody>
<tr>
<td>(difference</td>
<td>+1</td>
</tr>
<tr>
<td>between the</td>
<td>Above 17.0;</td>
</tr>
<tr>
<td>biggest and</td>
<td>between the</td>
</tr>
<tr>
<td>the smallest</td>
<td>biggest and</td>
</tr>
<tr>
<td>diameter)</td>
<td>the smallest</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>c) Curves, exceeding 1mm and</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
</tbody>
</table>
cracks on the hole edges
d) (i) Non-coin- --
cidence of holes in separate details of the assembled unit, upto 1mm
(ii) Above 1 mm --
upto 1.5 mm
e) Slope of axis --

Upto 50% Upto 50%
Upto 10% Upto 10%
Upto 30% No limits No limits
PAINTING

(CHAPTER-09)
GENERAL SPECIFICATION FOR PAINTING (GS – 09)
## CONTENTS

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Description</th>
<th>Page No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>01</td>
<td>GENERAL</td>
<td>1</td>
</tr>
<tr>
<td>02</td>
<td>SURFACE PREPARATION</td>
<td>1</td>
</tr>
<tr>
<td>03</td>
<td>PAINT APPLICATION</td>
<td>3</td>
</tr>
<tr>
<td>04</td>
<td>PAINTING SCHEMES</td>
<td>6</td>
</tr>
<tr>
<td>05</td>
<td>GUARANTEE</td>
<td>7</td>
</tr>
<tr>
<td></td>
<td>ANNEXURE-01 – SURFACE PREPARATION GRADE</td>
<td>8</td>
</tr>
<tr>
<td></td>
<td>ANNEXURE-02 – PAINT MATERIALS</td>
<td>9</td>
</tr>
<tr>
<td></td>
<td>ANNEXURE-03 – PAINTING SCHEME</td>
<td>15</td>
</tr>
<tr>
<td></td>
<td>ANNEXURE-04 – COLOUR CODE</td>
<td>18</td>
</tr>
</tbody>
</table>
01  **GENERAL**

01.01 This specification covers the materials, tools, facilities and quality requirement for surface preparation and painting of steel structures, equipment, piping, ducts, chutes, wood work etc.

01.02 This is only a general guideline of the painting scheme to be followed by the Tenderer. However, in case a specific painting procedure is stipulated in any tendering specification, then this general guideline shall be superceded. Any special case which may arise from time to time shall be dealt with individually on the merit of each case.

01.03 The term “painting” referred herein covers rust preventive, fungus/insects preventive and decorative coating along with surface protection of the following area but not limited to the areas indicated below.

i) Structural steel works

ii) Mechanical equipment

iii) Electrical equipment

iv) Instrumentation and control equipment.

v) Pipe work

vi) Oxygen plant, etc.

01.04 Surfaces made of asbestos, aluminum, brass, bronze, galvanized steel, stainless steel, cast iron and other corrosion resistant alloys and rubber/synthetic polymer/fiber reinforcement plastic and buried pipe work are not required to be painted unless specified except for aesthetic purposes or for identification bands, wherever relevant.

01.05 The complete paint system for any item includes the following basic activities:

i) Proper surface preparation

ii) Application of primer coats

iii) Application of intermediate coats

iv) Application of finished coats

All the above coats shall be of quality paint products and of approved make. The scope of work shall also include supply of all paint materials as per specification described herein.

01.06 If the contractor desires to adopt alternative paint system for any specific item for an improvement or equivalent to the system specified here-in or as per recommendations of paint manufacturer, may do so subject to purchaser’s approval in advance.

02  **SURFACE PREPARATION**

02.01 Surface preparation required for paint application, shall be such as to clean the surface thoroughly of any material which will be conducive to premature failure of the paint substrates.
02.02 All surfaces shall be cleaned of loose substances, and foreign materials, such as dirt, rust, scale, oil, grease, welding flux, etc. in order that the prime coat is rigidly anchored to the virgin metal surface. The surface preparation shall confirm to pictorial representation of surface quality grade of Swedish Standards Institution SIS – 055900 or equivalent standards such as SSPC – VIS – 1.67 or DIN 55928(Part 4) or BS 4232 or IS 1477 – 1971 (Part I)

02.03 The acceptable surface preparation quality / grade are described under each paint system. The procedures include solvent cleaning, hand tool cleaning, power tool cleaning, blast cleaning, wood surface cleaning, flame cleaning and pickling. This will ensure surface quality as required by the specific primer paint. For ready reference surface preparation quality grade to be adopted in respect of SIS 055900 and DIN 55928 (part-4) is given in Annexure-01.

02.03.01 Solvent Cleaning

The surface shall be cleaned by wiping, immersion, spraying or vapour contacting of a suitable solvent or washing with an emulsion or alkaline solution to remove oil, grease, dirt, old paint, etc. Solvent cleaning shall not remove rust, scales, mill scales or weld flux. Therefore, before application of paint, solvent cleaning shall be followed by other cleaning procedures as stated in subsequent clauses.

02.03.02 Hand Tool Cleaning

The surface shall be cleaned manually by vigorous wire brushing as per grade St-2 quality of Swedish Standard Institution SIS 055900 and DIN 555928. This method effectively removes loosely adherent materials, but would not affect residues of rust or mill scales that are intact are firmly adherent. Finally the surface is to be cleaned with a vacuum cleaner or with clean compressed air or with clean brush. After preparation the surface shall have a faint metallic shine. The appearance shall correspond to the prints designated St – 2.

02.03.03 Power Tool Cleaning

The surface shall be cleaned by electric or pneumatic tools, such as brushes, sanding machines, disc abrasive grinder, rotary disc scaler etc. to St – 3 quality. The tools shall be used carefully to prevent excessive roughening of surface and formation of ridges and burrs. This method will remove loosely adherent materials but would not affect residues of rust or mill scales that are firmly adherent and intact.

02.03.04 Blast Cleaning

The surface shall be cleaned by impingement of abrasive materials, such as graded sand at high velocity created by clean and dry compressed air blast as per the grade according to Swedish Standard Institution SIS 055900. This method will remove loosely adherent materials as well as adherent scales and mill scales. Prior to application of blast, heavy deposit of oil and grease are removed by solvent cleaning excessive
surface scales are removed by hand tools or power tool cleaning. The extent of removal of adherent scales is varied, depending on the application and are defined by the surface quality grades Sa1, Sa2, Sa2.5 and Sa3 in the order of increasing cleanliness. The blast cleaning is not recommended for sheet metal work.

02.03.05 Flame Cleaning

The surface is cleaned by rapid heating by means of oxyacetylene flame to loosen the adherent scales, followed immediately by wire brushing. This method will remove loosely adherent materials as well as most of the adherent scales and mill scales. In order to minimize or prevent distortion flame cutting shall not be used on members having thickness of 6 mm and lower.

02.03.06 Pickling

In this method the surface is cleaned of mill scales, rust or rust scales by chemical reaction or electrolysis or both.

03. PAINT APPLICATION

03.01 Paints

03.01.01 Paint shall be applied in accordance with paint manufacturer’s recommendations. The work shall generally follow IS 1477 – 1971 (Part II) for jobs carried out in India and SSPC-PA-1 or DIN 55928 or equivalent for jobs carried out outside India.

03.01.02 General compatibility between primer and finishing paints shall be established by the paint manufacturer supplying the paints.

03.01.03 In the event of conflict between this general procedure on painting and the paint manufacturer’s specification, the same shall be immediately brought to the notice of the Purchaser. Generally in cases of such conflicts, manufacturer’s specifications/recommendations shall prevail.

03.01.04 Before buying the paint in bulk, it is recommended to obtain sample of paint and establish “Control Area of Painting”. On Control Area, surface preparation and painting shall be carried out.

03.01.05 If required, samples of paint shall be tested in laboratories to establish quality of paint with respect to:

(i) Viscosity
(ii) Adhesion/Bond of paint in steel surfaces
(iii) Adhesion/Simulated salt spray test.
(iv) Chemical analysis (percentage of solids by weight)
(v) Normal wear resistance as encountered during handling & erection.
(vi) Resistance against exposure to acid fumes, etc.

03.01.06 Whole quantity of paint for a particular system of paint shall be obtained from the same manufacturer.
03.01.07 The main Contractor shall be responsible for supply of paints and this responsibility shall not be passed on to the sub-contractor.

03.01.08 The painting material as delivered to the Contractor, must be in the manufacturer’s original container bearing thereon manufacturer’s name brand and description. Paint/Painting material in containers without labels or with illegible labels shall be rejected, removed from the area and shall not be used.

03.01.09 Thinners wherever used shall be those recommended by the paint manufacturers and shall be obtained in containers with manufacturer’s name and brand name of thinner legibly printed, failing which the thinner is liable to be rejected and shall not be used.

03.01.10 All paint containers shall be clearly labeled to show the paint identification, date of manufacture, batch number, special instruction, shelf life etc. The container shall be opened only at the time of use.

03.01.11 All paints shall be stored in accordance with the requirements of laid down procedure by the paint manufacturer.

03.01.12 All ingredients in a paint container shall be thoroughly mixed to break-up lumps and disperse pigments before use and during application to maintain homogeneity.

03.01.13 The proposed make, quality and shade of the paint shall have the approval of the client.

03.01.14 The colour code of the finishing paint to be followed shall be intimated to the successful Tenderer after finalisation of order. The undercoat shall have different tint to distinguish the same from the finishing coat.

03.01.15 The Contractor shall furnish paint manufacturer’s test report or technical data sheet pertaining to the paint selected. The data sheet shall indicate among other things the relevant standards, if any, composition in weight percent of pigments, vehicles, additives, drying time, viscosity, spreading rate, flash point, method of application, quality of surface preparation required, corrosion resistance properties and colour shades available.

03.01.16 For details of paint materials refer Annexure - 02

03.02 General

03.02.01 Each coat of paint shall be continuous, free of pores and of even film thickness without thin spots.

03.02.02 Each coat of paint shall be sufficiently dry before application of next coat.

03.02.03 Paint shall be applied at manufacturer’s recommended rates. The number of coats shall be such that the minimum dry film thickness specified is achieved. The dry film thickness of painted surfaces shall be checked with ELMOMETER of measuring gauges to ensure application of specified DFT.
03.02.04 Zinc rich primer paints which have been exposed several months before finishing coat is applied shall be washed down thoroughly to remove soluble zinc salt deposits.

03.02.05 The machine finished surfaces shall be coated with white lead and tallow before shipment or before being put out into the open air.

03.02.06 Areas which become inaccessible after assembly shall be painted before assembly (after obtaining painting clearance from the inspecting authority) after requisite surface cleaning as specified.

03.02.07 Paint shall not be applied when the ambient temperature is 5 deg C and below or 45 deg C and above. Also paint shall not be applied in rain, wind, fog or at relative humidity of 80 % and above unless the manufacturer’s recommendations permit. Applications of paint shall be only by spraying or brushing as per IS 486 – 1983 and IS 487 – 1985.

03.02.08 Primer paint shall be applied not later than 2 – 3 hours after preparation of surface, unless specified otherwise.

03.02.09 Edges, corners, crevices, depressions, joints and welds shall receive special attention to ensure that they receive painting coats of the required thickness.

03.02.10 Surfaces which cannot be painted but require protection shall be given a coat of rust inhibitive grease according to IS 958 – 1975 or solvent deposited compound according to IS 1153 – 1975 or IS 1674 – 1960.

03.02.11 Surfaces in contact during shop assembly shall not be painted. Surfaces which will be inaccessible after assembly shall receive minimum two coats of specified primer.

03.02.12 Surfaces to be in contact with wood, brick or other masonry shall be given one shop-coat of the specified primer.

03.03 Site/Field Painting

03.03.01 Wherever shop primer painting is scratched, abraded or damaged, the surface shall be thoroughly cleaned using emery paper and power driven wire brush wherever warranted, and touched up with corresponding primer. Touching up paint shall be matched and blended to eliminate conspicuous marks.

03.03.02 If more than 50% of the painted surface of an item requires repair, the entire item shall be mechanically cleaned and new primer coats shall be applied followed by intermediate and finishing coats as per painting specification.

03.03.03 All field welded areas on shop painted items shall be mechanically cleaned (including the weld area proper, adjacent areas contaminated by weld spatter or fumes and areas where existing primer paint is burnt).
Subsequently, new primer and finishing coats of paint shall be applied as per painting specification.

03.03.04 The first coat of finish paint at site shall be applied preferable within three months of the shop paint.

03.04 Structural

03.04.01 All fabricated steel structure, fabricated steel pipes, etc. shall have a minimum of two coats of primer paint before dispatch to site.

03.04.02 Parts of steel structures embedded in concrete shall be given a protective coat of Portland cement slurry immediately after fabrication and after surfaces of this part is thoroughly cleaned from grease, rust, mill scales, etc. No paint shall be applied on this part.

03.04.03 All structures shall receive appropriate number of primer and finishing coats in order to achieve overall DFT as per design drawings/specification.

03.05 Hot Surfaces

03.05.01 Total DFT for heat resistant paints should not exceed 100 – 120 microns, otherwise flaking occurs (as per paint manufacturer’s recommendations).

03.05.02 Heat resistant paints should be applied by brush.

03.05.03 Primer coat should not be applied on the surfaces having temperature condition more that 120 deg C.

04 PAINTING SCHEMES

For a complete painting scheme of any item being printed, all types of paints are to be procured from the same manufacturer as approved by the purchaser.

04.01 Legend

SP - Surface preparation quality as per SIS standard
2P1 - Two (2) coats of Primer paint type P1
1I1 - One (1) coats of Intermediate paint type I1
2F1 - Two (2) coats of Finish paint type F1
DFT - Dry Film Thickness in microns developed
CRT - Clean and Retouch

Type of paint products like P1 to P9, I1 to I4 and F1 to F10 have been specified under Annexure-02.

04.02 The painting scheme to be followed for various structure/equipment exposed to different condition is briefly given in Annexure-03 for guidance to the tenderer.
04.03 The colour code for different applications are indicated in Annexure-04. Wherever colour codes are not specified, the same is to be mutually agreed between the Purchaser and Contractor.

05. GUARANTEE

05.01 The Contractor shall guarantee that the physical and chemical properties of the paint materials conform with the specification of paint products.

05.02 The Contractor shall submit internal test reports from paint manufacturers regarding the quality of paint whenever asked by the Purchaser/Consultant.

05.03 Guarantee period shall commence from the date of completion of finishing coat of paint. The guarantee period will be indicated depending on the type of surface preparation and system of painting. To fulfill this obligations the Contractor may obtain from the painting manufacturer, guarantee for the performance of paint/painted surfaces.
### Surface Preparation Grade

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Surface Preparation</th>
<th>Swedish Std SIS 055900</th>
<th>DIN Std. Din 55928 (Part 4)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Blast cleaning to white metal</td>
<td>Sa 3</td>
<td>Sa 3</td>
</tr>
<tr>
<td></td>
<td>Removal of all visible rusts, mill-scales, paint and foreign</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>matters.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Blast cleaning to near white metal:</td>
<td>Sa 2.5</td>
<td>Sa 2.5</td>
</tr>
<tr>
<td></td>
<td>95% of any section of surface area is free from all</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>rusts, mill-scales and visible residues.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Blast cleaning to commercial quality:</td>
<td>Sa 2</td>
<td>Sa 2</td>
</tr>
<tr>
<td></td>
<td>At least 2/3 of any section of the surface area is free</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>from all rusts, mill-scales and visible residues.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Brush-off blast cleaning:</td>
<td>Sa 1</td>
<td>Sa 1</td>
</tr>
<tr>
<td></td>
<td>Removal of all loose mill-scales, rust and foreign matters</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>etc.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Power tool cleaning:</td>
<td>St 3</td>
<td>St 3</td>
</tr>
<tr>
<td></td>
<td>Very thorough scrapping and wire brushing to remove</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>loose mill-scale, rust and foreign matters to have</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>pronounced metallic shine.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Hand tool cleaning:</td>
<td>St 2</td>
<td>St 2</td>
</tr>
<tr>
<td></td>
<td>Removal by hand brushing of loose mill-scale, loose</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>rust and foreign matters.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
PAINT MATERIALS

01. PRIMER PAINTS (P)

Primer paint products shall be applied only on dry and clean surfaces.

01.01 Primer Paint – P1 (Phenolic – Alkyd Based)

A single pack air drying phenolic modified alkyd composition with zinc phosphate as a primer paint conforming generally to IS : 2074.

- Air drying time
  - About 60 minutes (touch dry)
  - Overnight (hard dry)

- Dry film thickness (DFT)/Coat
  - 40 microns (min)

- Temperature resistance
  - Upto 100°C dry heat

01.02 Primer Paint – P2 (Chlororubber Based)

A single pack air drying high build chlorinated rubber based zinc phosphate primer.

- Percent chlororubber
  - 20 to 22 (% Chlorine above 65% in chlororubber)

- Air drying time
  - About 15 minutes (touch dry)
  - Overnight (hard dry)

- DFT/Coat
  - 50 microns (min)

- Temperature resistance
  - Up to 65°C dry heat

01.03 Primer Paint – P3 (PVC Copolymer Alkyd Based)

Polyvinyl chloride (PVC) Alkyd zinc phosphate – redoxide based primer

- Ratio PVC copolymer + alkyd resin (1:1)

- Pigments Zinc phosphate & Fillers

- Air drying time
  - 24 hours

- DFT/Coat
  - 80 microns

- Temperature resistance
  - Upto 80°C dry heat
01.04 **Primer Paint – P4 (Epoxy Based)**

A two pack air drying Epoxy polyamide resin based red oxide-zinc phosphate primer.

- Epoxy content (% wt.) - 15 to 18
- Air drying time - About 30 minutes (touch dry)
  - overnight (hard dry)
- DFT/Coat - 30 microns (min)
- Temperature resistance - Upto 120°C dry heat

01.05 **Primer Paint – P5 (Epoxy Based)**

A two pack air drying Epoxy polyamide with zinc dust of at least 92% zinc dust on the dry film.

- Epoxy content (% wt.) - 8 to 10
- Air drying time - Less than 10 minutes (touch dry)
  - Less than 2 hours (hard dry)
- DFT/Coat - 40 microns (min)
- Temperature resistance - Upto 300°C dry heat

01.06 **Primer Paint – P6 (Poly – Vinyl Butyral Resin Based)**

A two pack air drying polyvinyl butyral resin based wash primer with rust inhibitive pigments.

- Air drying time - 5 to 7 minutes (touch dry)
  - 2 hours (hard dry)
- DFT/Coat - 8 microns
- Temperature resistance - Upto 65°C dry heat
- Application for - Galvanised iron, aluminium, light alloys etc. on which the adhesion of conventional paints are poor.

01.07 **Primer Paint – P7 (Ethyl Zinc Silicate, EZS Based)**

A two pack heavy duty zinc dust rich silicate primer which protects the surface with just a single coat.

- Total solids (3 wt) - 84 +/- 2
- Density (g/cc) - 3.07 +/- 0.05
Air drying time - To top coat 16 hours
DFT / coat - 60 microns
Temperature resistance - Upto 450 deg C dry heat

01.08 **Primer Paint – P8 (High Build Coal Tar Epoxy)**

A two pack cold cured H.B. epoxy coal tar coating – no primer is required.

Mixing ratio - Base: Hardener (4:1 by vol.)
Air drying time - 48 hours (hard dry)
DFT / Coat - 100 microns

01.09 **Wood Varnish-P9**

Treated oil based primer pigmented with suitable pigments:

Air drying time - 16 hours for application of top coat.
Coverage - 10 to 14 sq. m/litre

02. **INTERMEDIATE PAINTS (I)**

These paints shall be applied over primer coats as an intermediate layer to provide weather proof seal of primer coats.

02.01 **Intermediate Paint-II (Phenolic alkyd based)**

A single pack high build phenolic based paint with micaceous iron oxide (M10).

Air Drying Time - 4 to 6 hours (touch dry) - 2 days (hard dry)
DFT / Coat - 75 microns (min)
Temperature resistance - Upto 100 deg C dry heat
Compatible with - Primer P1

02.02 **Intermediate Paint-I2 (Chlororubber based)**

A single pack air drying high build chloro based paint with MIO.

Air Drying Time - 15 minutes (touch dry) - 24 hours (hard dry)
DFT / Coat - 70 microns (min)
Temperature resistance - Upto 65 deg C dry heat
Compatible with - Primer P2, P3 & P4

02.03 **Intermediate Paint-I3 (PVC – Alkyd Based)**

PVC Coploymer - Resin 1 : 1
Pigments - Micaceous iron oxide (MIO)
DFT / Coat - 80 microns (min)
02.04 **Intermediate paint-I4**

A two pack air drying high build epoxy resin based paint with MIO.

- **Air drying time**
  - 6 to 8 hours (touch dry)
  - 7 days (full cure)
- **DFT / coat**
  - 100 microns
- **Temperature resistance**
  - Up to 180°C dry heat
- **Compatible with**
  - Primer P4 & P5

03. **FINISH PAINTS (F)**

Finish paint costs shall be applied over primer coats and intermediate coats after proper cleaning and touch up of primed surface.

03.01 **Finish Paint – F1**

A single pack air drying high gloss phenolic alkyd modified synthetic enamel paint suitably pigmented.

- **Air drying time**
  - 3 to 4 hours (touch dry)
  - 24 hours (hard dry)
- **DFT / Coat**
  - 25 microns (min)
- **Temperature resistance**
  - Upto 100°C dry heat
- **Compatible with**
  - Primer P1
  - Intermediate I1
- **Colour**
  - Generally all shades

03.02 **Finish Paint – F2**

A single pack air drying polyurethane enamel of high gloss and hard finish suitably pigmented.

- **Air drying time**
  - 2 to 2 ½ hours (touch dry)
  - 6 hours (hard dry)
- **DFT / Coat**
  - 30 microns (min)
- **Temperature resistance**
  - Upto 100°C dry heat
- **Compatible with**
  - Primer P1 & P8 and Intermediate I1
- **Colour**
  - Generally all shades
03.03 **Finish Paint – F3**

A two pack air drying bituminous aluminum paint.

**Air drying time**
- 1 to 2 hours (touch dry)
- 21 hours (hard dry)

**DFT/Coat**
- 25 microns (min)

**Temperature resistance**
- Upto 100°C dry heat

**Compatible with**
- Primer P1 and Intermediate I1

**Colour**
- Bright metallic

03.04 **Finish Paint – F4**

A ready mixed oil-alkyd based synthetic enamel paint of high gloss and hard wearing properties.

**Air drying time**
- 6 to 8 hours

**Coverage**
- 14 to 16 Sq. m /litre

**Temperature resistance**
- Upto 60°C dry heat

**Compatible with**
- P8

**Colour**
- Generally all shades

03.05 **Finish Paint – F5**

A single pack air drying plasticized chlororubber paint suitably pigmented.

**Air drying time**
- 30 minutes (touch dry)
- 24 hours (hard dry)

**DFT/Coat**
- 35 microns (min)

**Temperature resistance**
- Upto 65°C dry heat

**Compatible with**
- Primer P2 & P3, Intermediate I2 & I3

**Colour**
- Nearly all shades except few.
03.06 **Finish Paint – F6**
A PVC – Copolymer alkyd based enamel.
- Density - 1.17 ± 0.05
- Total solids (1 wt) - 55 ± 2
- DFT/Coat - 40 microns
- Compatible with - P2 and P3

03.07 **Finish Paint – F7**
A two pack air drying epoxy polyamide enamel suitably pigmented.
- Air drying time - 2 to 3 hours (touch dry)
  - 7 days (full cure)
- DFT/Coat - 40 microns (min)
- Temperature resistance - Up to 130°C dry heat
- Compatible with - Primer P4 & P5, Intermediate I4
- Colour - Generally all shades.

03.08 **Finish Paint – F8**
A single pack synthetic rubber based aluminium paint.
- Air drying time - 2 hours (touch dry)
  - 24 hours (hard dry)
- DFT/Coat - 25 microns (min)
- Temperature resistance - Upto 200°C dry heat
- Compatible with - No Primer paint except primer P6 is applicable in case of non-ferrous substrate.
- Colour - Smooth aluminium.
### Painting Scheme

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Description</th>
<th>Painting Scheme</th>
<th>Total DFT</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>At Shop</td>
<td>At Site</td>
</tr>
<tr>
<td>1.0</td>
<td><strong>Steel Structures</strong> <em>(Temp. not exceeding 80°C)</em></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.1</td>
<td>Technological steel structures for plant and equipment</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Indoor</td>
<td>SP – Sa 2.5</td>
<td>CRT</td>
</tr>
<tr>
<td></td>
<td>Outdoor</td>
<td>SP – Sa 2.5</td>
<td>CRT</td>
</tr>
<tr>
<td>1.2</td>
<td>Fabricated steel structures at site for rung ladders, cat-ladders, gates, rolling shutters, etc. (Springs/rubbing surfaces excluded)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Indoor / Outdoor</td>
<td>SP – St-2 and/or St-3</td>
<td>CRT</td>
</tr>
<tr>
<td>1.3</td>
<td>Walkways, stairs, platforms etc. which are of wearing surface</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Indoor</td>
<td>SP – St-2 and/or St-3</td>
<td>CRT</td>
</tr>
<tr>
<td></td>
<td>Outdoor</td>
<td>SP- St2 and/or St-3</td>
<td>CRT</td>
</tr>
<tr>
<td>1.4</td>
<td>Steel doors and windows</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Indoor / Outdoor</td>
<td>SP–St-2 and/or St-3</td>
<td>CRT</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Description</th>
<th>Painting Scheme</th>
<th>Total DFT</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>At Shop</td>
<td>At Site</td>
</tr>
<tr>
<td>2.0</td>
<td><strong>MECHANICAL EQUIPMENT</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.1</td>
<td>Mechanical equipment <em>(Temp. not exceeding 80°C)</em></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.1.1</td>
<td>Static equipment like storage tanks, vessels, bins, bunkers, heat exchangers, coolers,</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
## 2.1.2 Rotary/moving equipment and machineries like crushers, mills, vibratory screens, bin activators, blowers, fan, air/gas compressors, pumps, gear boxes, machine housings etc.

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Description</th>
<th>Painting Scheme</th>
<th>Total DFT</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>At Shop</td>
<td>At Site</td>
</tr>
<tr>
<td></td>
<td>cyclones, scrubbers, etc.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Indoor</td>
<td></td>
<td>SP – Sa 2.5 2P2/2P3</td>
<td>CRT 2F5/2F6</td>
</tr>
<tr>
<td>- Outdoor</td>
<td></td>
<td>SP – Sa 2.5 2P2/2P3+1I2/1I3</td>
<td>CRT 2F5/2F6</td>
</tr>
</tbody>
</table>

## 3.0 Pipe / Duct work (Overground)

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Description</th>
<th>Painting Scheme</th>
<th>Total DFT</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>At Shop</td>
<td>At Site</td>
</tr>
<tr>
<td>3.1</td>
<td>Non – insulated (temperature up to 80°C)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Indoor</td>
<td></td>
<td>SP – St2 and or St3 2P1</td>
<td>CRT 2F1</td>
</tr>
<tr>
<td>- Outdoor</td>
<td></td>
<td>SP – St2 and / or St3 2P1 + 1I1</td>
<td>CRT 2F1</td>
</tr>
</tbody>
</table>

## 3.2 Insulated (hot)

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Description</th>
<th>Painting Scheme</th>
<th>Total DFT</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>At Shop</td>
<td>At Site</td>
</tr>
<tr>
<td>3.2</td>
<td>Insulated (hot)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Indoor/Outdoor</td>
<td></td>
<td>SP- St2 and/ or St3 1P1</td>
<td>Remove paint and insulate</td>
</tr>
</tbody>
</table>

## 4.0 Oxygen Plant

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Description</th>
<th>Painting Scheme</th>
<th>Total DFT</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.0</td>
<td>Oxygen Plant</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

## 4.1 Outdoor steel structures

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Description</th>
<th>Painting Scheme</th>
<th>Total DFT</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.1</td>
<td>Outdoor steel structures</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### Painting Scheme

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Description</th>
<th>Painting Scheme</th>
<th>Total DFT</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.2</td>
<td>Rotary equipment like air compressors</td>
<td>2P1 + 1I1 2F3</td>
<td>205</td>
</tr>
<tr>
<td>5.0</td>
<td><strong>Others</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5.1</td>
<td>Standard mobile equipment like chasis of trucks, dumpers, crawler cranes bulldozers, railway rakes, chasis of slag cars, ladle cars, etc.</td>
<td>As per manufacturer’s standards</td>
<td></td>
</tr>
<tr>
<td>5.2</td>
<td>Laboratory equipment like ovens, screens, magnetic stirrers, samplers, etc.</td>
<td>Stove enamelling CRT</td>
<td>110</td>
</tr>
<tr>
<td>5.3</td>
<td>Steel structures partly immersed in water</td>
<td>SP – Sa 2.5 2P8 CRT</td>
<td>200</td>
</tr>
</tbody>
</table>

**Notes:**

1. Painting scheme of all fabricated steel structures, fabricated pipe work, building structure, conveyor galleries, pipe trestles etc. is indicated in the Technical Specification of steel structures.

2. **Primer Paint**

   Primer coat shall be suitable for intended temperature applications as per manufacturer’s recommendation. The primer selection shall be generally in line with the specification laid down in Annexure-02.

3. **Finish Paint**

   In case of Aluminium cladding final painting will not be required.
### COLOUR CODE

The colour codes are mentioned for all the items including pipe work. Shades of finish coat of paint applied over respective item indicated below are tentative and subject to alteration as per Purchaser’s request or due to compatible paint system adopted. The service for which colour code/bands are not specified are to be mutually agreed for by the Purchaser & the Contractor.

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Items Painted</th>
<th>Colour</th>
<th>Colour No. of IS:5</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td><strong>Structures</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Building frames including bracings, side girder, louver etc.</td>
<td>Aircraft grey</td>
<td>693</td>
</tr>
<tr>
<td></td>
<td>Crane girders</td>
<td>Azure blue</td>
<td>104</td>
</tr>
<tr>
<td></td>
<td>Crane stops</td>
<td>Post office red</td>
<td>538</td>
</tr>
<tr>
<td></td>
<td>Gutters</td>
<td>Black bituminous aluminium</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Fire escape platforms ladders, etc.</td>
<td>Signal red</td>
<td>537</td>
</tr>
<tr>
<td></td>
<td>General hand railing, top runners</td>
<td>Lemon yellow</td>
<td>355</td>
</tr>
<tr>
<td></td>
<td>Rung ladders</td>
<td>Lemon yellow</td>
<td>355</td>
</tr>
<tr>
<td></td>
<td>All members blocking passages for movement</td>
<td>Lemon yellow</td>
<td>355</td>
</tr>
<tr>
<td></td>
<td>Trestles, towers and pipe bridges</td>
<td>Dark admiralty grey</td>
<td>632</td>
</tr>
<tr>
<td></td>
<td>Conveyor gallery structures</td>
<td>Aircraft grey</td>
<td>693</td>
</tr>
<tr>
<td></td>
<td>Steel chimneys</td>
<td>Aluminium</td>
<td>-</td>
</tr>
<tr>
<td>2.</td>
<td><strong>Equipment and Machinery</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>General indoor equipment</td>
<td>Light grey</td>
<td>631</td>
</tr>
<tr>
<td></td>
<td>General outdoor equipment</td>
<td>Dark admiralty grey</td>
<td>632</td>
</tr>
<tr>
<td></td>
<td>Crane bridges, trolleys, hooks etc. and other mobile equipment</td>
<td>Base: Lemon yellow</td>
<td>355</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Stripes: Black (100 mm wide)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Furnaces</td>
<td>Aluminium</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Tanks</td>
<td>Base: Same as for general equipment</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Strips: Same shade as for piping around the tnk at half the tank height</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Fire-fighting equipment</td>
<td>Signal red</td>
<td>537</td>
</tr>
<tr>
<td>3.</td>
<td><strong>Pipe work</strong></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Colours shall be as given below. The base colour shall be applied throughout entire length except on surfaces of materials such as asbestos, aluminium, brass, bronze, galvanized steel, stainless steel and other corrosion resistant alloys and rubber / synthetic polymers. In such cases identification colour bands of at least 500mm width shall be provided near each branch, valve and at distances not exceeding 10m either as local colour coatings or coloured adhesive type of suitable material or label attached to the pipe work. Additional identification bands superimposed over the base colour shall be provided near each branch, valve and at distance not exceeding 10m. The bands shall be atleast 25mm wide except in care of double bands where the first band shall be about 100mm wide. Direction of flow shall be clearly marked on the pipelines at intervals not exceeding 10m and all branches and change of directions.
<table>
<thead>
<tr>
<th>Service</th>
<th>Colour</th>
<th>Colour No. of IS:5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sea or river water (untreated)</td>
<td>Base – Sea green</td>
<td>217</td>
</tr>
<tr>
<td></td>
<td>Band - White</td>
<td></td>
</tr>
<tr>
<td>Cooling water</td>
<td>Base – Sea green</td>
<td>217</td>
</tr>
<tr>
<td></td>
<td>Band - White</td>
<td>166</td>
</tr>
<tr>
<td>Boiler feed water</td>
<td>Base – Sea green</td>
<td>217</td>
</tr>
<tr>
<td>Condensate</td>
<td>Base – Sea green</td>
<td>217</td>
</tr>
<tr>
<td></td>
<td>Band – Light brown</td>
<td>410</td>
</tr>
<tr>
<td>Drinking water</td>
<td>Base – Sea green</td>
<td>217</td>
</tr>
<tr>
<td></td>
<td>First band - French blue</td>
<td>166</td>
</tr>
<tr>
<td></td>
<td>Second band – Signal red</td>
<td>537</td>
</tr>
<tr>
<td>Industrial water</td>
<td>Base – Sea green</td>
<td>217</td>
</tr>
<tr>
<td></td>
<td>Band – Light orange</td>
<td>557</td>
</tr>
<tr>
<td>Compressed air</td>
<td>Base – Sky blue</td>
<td>101</td>
</tr>
<tr>
<td>Instrument air</td>
<td>Base – Sky blue</td>
<td>101</td>
</tr>
<tr>
<td></td>
<td>Band – Light brown</td>
<td>410</td>
</tr>
<tr>
<td>Drainage</td>
<td>Base – Black</td>
<td>-</td>
</tr>
<tr>
<td>Fuel oil</td>
<td>Base – Light brown</td>
<td>410</td>
</tr>
<tr>
<td></td>
<td>Band – Signal red</td>
<td>537</td>
</tr>
<tr>
<td>Coke oven/BF gas/other fuel gases</td>
<td>Base – Canary yellow</td>
<td>309</td>
</tr>
<tr>
<td></td>
<td>Band – Signal red</td>
<td>537</td>
</tr>
<tr>
<td>Argon</td>
<td>Base – Canary yellow</td>
<td>309</td>
</tr>
<tr>
<td></td>
<td>Band – French blue</td>
<td>166</td>
</tr>
<tr>
<td>Acetylene</td>
<td>Base – Canary yellow</td>
<td>309</td>
</tr>
<tr>
<td></td>
<td>Band – Dark violet</td>
<td>796</td>
</tr>
<tr>
<td>LP Gas (LPG)</td>
<td>Base – Canary yellow</td>
<td>309</td>
</tr>
<tr>
<td></td>
<td>First band – Signal red</td>
<td>537</td>
</tr>
<tr>
<td></td>
<td>Second band – Traffic green</td>
<td>267</td>
</tr>
<tr>
<td>Nitrogen</td>
<td>Base – Canary yellow</td>
<td>309</td>
</tr>
<tr>
<td></td>
<td>Band – Black</td>
<td>-</td>
</tr>
<tr>
<td>Oxygen</td>
<td>Base – Canary yellow</td>
<td>309</td>
</tr>
<tr>
<td></td>
<td>Band – White</td>
<td>-</td>
</tr>
<tr>
<td>Non-acidic slurries</td>
<td>Base – Sea green</td>
<td>217</td>
</tr>
<tr>
<td></td>
<td>Band – White</td>
<td>-</td>
</tr>
<tr>
<td>Fire-fighting system</td>
<td>Base – Signal red</td>
<td>537</td>
</tr>
<tr>
<td>Rain water down pipes</td>
<td>Base – Sea green</td>
<td>217</td>
</tr>
<tr>
<td></td>
<td>Band – Sky blue</td>
<td>101</td>
</tr>
<tr>
<td>Duct work</td>
<td>Base – Aluminium</td>
<td>-</td>
</tr>
</tbody>
</table>

**Note**: For these services, hazard marking as per fig. 4C of IS:2379 shall also be provided.