

**Asian Development Bank (ADB) Assisted  
Delhi Water Supply Improvement Investment Program**

**BIDDING DOCUMENT  
For  
Procurement  
of**

**DWSIIP / 04: Transmission System Improvement and Construction of Clear Water  
Reservoirs & Pumping Stations for Wazirabad WTP Command area including  
SCADA & Instrumentation**

Under International Competitive Bidding

(Following ADB's single stage two envelope bidding procedure)

**Technical Bid - Volume 2**

**STANDARD SPECIFICATIONS**



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**6.2.1.1**  
**STANDARD SPECIFICATIONS**  
**(CIVIL WORKS)**



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## **1 GENERAL**

### **1.1 Preamble**

- 1.1.1. These Specifications cover the items of work in structural and non structural parts of the Works coming under purview of this document. All work shall be carried out in conformation with this. In general, provisions of CPWD specifications, Indian Standards, Indian Roads Congress Codes, Most Specifications and other national standards have been followed. These Specifications are not intended to cover the minute details. The work shall be executed in accordance with best modern practices. All codes and standards referred to in these Specifications shall be the latest revision thereof.

### **1.2 Inclusive Documents**

- 1.2.1. The provisions specified on the tender as well as execution Drawings and notes or other Specifications issued in writing by the Employer shall form part of these Specifications.

### **1.3 Order of Precedence, Clarifications and Interpretation**

- 1.3.1. When the various Specifications and codes referred to in preceding portion are at variance with these Specifications and with each other, the following order of precedence will generally be accepted. But in no case shall the materials, workmanship, design and construction fall short of the requirements of the mandatory provisions of the IS, IRC, MORTH, etc. codes and other stipulations and requirements of the NGT and other environment control bodies.

1. Written instructions of the Employer.
2. Particular (Civil) Specifications
3. Standard Specification, Item wise Technical Specifications, if provided, and Execution Drawings.
4. I.S. Codes.
5. IRC Codes, MoRTH., CPWD Specifications, etc.

- 1.3.2. The attention of the Contractor is drawn to those Clauses of IS codes which require either Specification by Employer or the mutual agreement between the supplier and purchaser. In such cases it is the responsibility of the Contractor to seek clarification on any uncertainty and obtain prior approval of the Employer before taking up the supply/construction.

### **1.4 Measurement and Payments-**

- 1.4.1. The methods of measurement and payment shall be as described under various items and in the bill of quantity. Where specific definitions are not given, the methods described in CPWD specifications and IS Codes will be followed. Should there be any detail of construction or materials which has not been referred to in these Specification or in the bill of quantities and Drawings but the necessity for which may be implied or inferred wherefrom, or which are usual or essential to the completion of the work in the trades, the same shall be deemed to

be included in the rates and prices quoted by the Contractor in the bill of quantities.

## **1.5 Unacceptable Work**

- 1.5.1. All defective Works are liable to be demolished, rebuilt and defective materials replaced by the Contractor at his own cost. In the event of such Works being accepted by carrying out repairs etc. as specified by the Employer, the cost of repairs will be borne by the Contractor.
- 1.5.2. In the event of the work being accepted by giving 'Design Concession', arising out of but not limited to under sizing, under strength, shift in location and alignment, etc. and accepting design stresses in members which are higher than those provided for in the original design or by accepting materials not fully meeting the Specifications, etc. the Contractor will be paid for the Works actually carried out by him at the suitable reduced rate of the tendered rates for the portion of the work thus accepted.

## **1.6 Water Supply and Sanitary Works**

- 1.6.1. All items covered under the above head shall conform to the detailed Specifications given for each of the items in addition to the by-laws of the local bodies within whose jurisdiction the Works are executed. The Works shall be carried out as per the relevant IS Codes and as per the instructions of the Employer.

## **1.7 Floor and Levels**

- 1.7.1. Building
  - 1.7.1.1 Floor I is the lowest floor above the ground level in the building unless otherwise specified in a particular case. The floors above Floor I shall be numbered in sequence as Floor 2, Floor 3 and so on. The number shall increase upwards.
  - 1.7.1.2 Floor level: For floor 1, top level of finished floor shall be the floor level and for all other floors above floor 1, top level of the structural slabs shall be the floor level.
  - 1.7.1.3 Plinth level: Floor 1 level or 1.2 m above the ground level whichever is lower shall be the plinth level.
- 1.7.2. Special Structures
  - 1.7.2.1 For structures like retaining walls, wing walls, chimneys, over head reservoirs/tanks and other elevated structures, where elevations/heights above a defined datum level have not been specified and identification of floors cannot be done as in case of buildings, levels at 1.2 m above the ground level shall be the floor level as well as plinth level. Level at a height of 3.5 m above floor 1 level will be reckoned as floor 2 levels and level at a height of 3.5 m above the floor 2 level will be floor 3 levels and so on. Where the total height above floor 1 level is

not a whole number multiple of 3.5 m, top most floor level shall be the next in sequence to the floor level below even if the difference in height between the two upper most floor levels is less than 3.5 m.

## **1.8 Foundation and Plinth**

1.8.1 The work in foundation and plinth shall include:

1. For buildings: All Works up to 1.2 m above ground level or up to floor 1 level whichever is lower;
2. For abutments, piers and well steining: All Works up to 1.2 m above the bed level;
3. For retaining walls, wing walls, compound walls, chimneys, overhead reservoirs/tanks and other elevated structures: All Works up to 1.2 m above the ground level;
4. For reservoirs/tanks (other than overhead reservoirs/tanks): All Works up to 1.2 m above the ground level
5. For basements: All Works up to 1.2 m above ground level or up to floor 1 level whichever is lower.

## **1.9 Maintaining Utility Service and Traffic**

1.9.1 Public Utilities

- 1.9.1.1. Drawings scheduling the affected services like water pipes, sewers, oil pipelines, cables, gas ducts etc. owned by various authorities including Public Undertakings and Local Authorities included in the Contract Documents shall be verified by the Contractor for the accuracy of the information prior to the commencement of any work.
- 1.9.1.2. Notwithstanding the fact that the information on affected services may not be exhaustive, the final position of these services within the Works shall be supposed to have been indicated based on the information furnished by different bodies and to the extent the bodies are familiar with the final proposals. The intermediate stages of the Works are, however, unknown at the design stage, these being dictated by the Contractor's methods of working. Accordingly, the Contractor's programme must take into account the period of notice and duration of diversionary Works of each body as given on the Drawings and the Contractor must also allow for any effect of these services and alterations upon the Works and for arranging regular meetings with the various bodies at the commencement of the Contract and throughout the period of the Works in order to maintain the required co-ordination. During the period of Works, the Contractor shall have no objection if the public utility bodies vary their decisions in the execution of their proposals in terms of programme and construction, provided that, in the opinion of the Employer, the Contractor has received reasonable notice thereof before the relevant alterations are put in hand.
- 1.9.1.3. No clearance or alterations to the utility shall be carried out unless specially ordered by the Employer.

- 1.9.1.4. Any services affected by the Works must be temporarily supported by the Contractor who must also take all measures reasonably required by the various bodies to protect their services and property during the progress of the Works.
- 1.9.1.5. The Contractor may be required to carry out certain Works for and on behalf of the various bodies and he shall also provide, with the prior approval of the Employer, such assistance to the various bodies as may be authorised by the Employer.
- 1.9.1.6. The work of temporarily supporting and protecting the public utility services during execution of the Works shall be deemed to be part of the Contract and no extra payment shall be made for the same.
- 1.9.1.7. The Contractor may be required to carry out the removal or shifting of certain services/utilities on specific orders from the Employer for which payment shall be made to him. Such workers shall be taken up by the Contractor only after obtaining clearance from Employer and ensuring adequate safety measures.

#### 1.9.2 Arrangement for Traffic during Construction

##### 1.9.2.1 General

The Contractor shall at all time carry out work on the roads in a manner creating least interference to the flow of traffic while consistent with the satisfactory execution of the same. For all Works involving improvements to the existing roads, the Contractor shall, in accordance with the directives of Employer, provide and maintain, during execution of the work, a passage for traffic either along a part of the existing carriageway under improvement, or along a temporary diversion constructed close to the road. The Contractor shall take prior approval of Employer regarding traffic arrangements during construction.

##### 1.9.2.2 Passage of Traffic along a part of the Existing Carriageway under Improvement

1. For widening/strengthening existing carriageway where part width of the existing carriageway is proposed to be used for passage of traffic, treated shoulders shall be provided on the side on which work is not in progress. The treatment to the shoulder shall consist of providing at least 150 mm thick granular base course covered with bituminous surface dressing in a width of at least 1.5 m and the surface shall be maintained throughout the period during which traffic uses the same to the satisfaction of the Employer. The continuous length, in which such a work shall be carried out, would be limited normally to 500 m at a place. However, where work is allowed by Employer in longer stretches passing places at least 20 m long with additional paved width of 2.5 m shall be provided at every 0.5 km interval.
2. In case of widening existing two-lane to four-lane, the additional two lanes would be constructed first and the traffic diverted to it and only thereafter the required treatment to the existing carriageway would be carried out. However,

in case where on the request of the Contractor, work on existing two-lane carriageway is allowed by the Employer with traffic using part of the existing carriageway, stipulations as in para above shall apply.

3. After obtaining, permission of Employer, the treated shoulder shall be dismantled, the debris disposed off and the area cleared as per the direction of the Employer.

#### 1.9.2.3 Passage of Traffic along a Temporary Diversion

1. In stretches where it is not possible to pass the traffic on part width of the carriageway, a temporary diversion shall be constructed with 7 m carriageway and 2.5 m earthen shoulders on each side (total width of roadway 12 m) with the following provision for road crust in the 7 m width:
  - 200 mm (compacted) granular sub base;
  - 225 mm (compacted) granular base course; and
  - Premix carpet with Seal Coat/Mix Seal Surfacing.
2. The alignment and longitudinal section of diversion including junctions and temporary cross drainage provision shall be as approved by Employer.

#### 1.9.2.4 Traffic Safety and Control

1. The Contractor shall take all necessary measures for the safety of traffic during construction and provide, erect and maintain such barricades, including signs, markings, flags, lights and flagmen as may be required by the Employer for the information and protection of traffic approaching or passing through the section of the highway under improvement. Before taking up any construction, an agreed phased programme for the diversion of traffic on the highway shall be drawn up in consultation with the Employer.
2. The barricades erected on either side of the carriageway/portion of the carriageway closed to traffic, shall be of strong design to resist violation, and painted with alternate black and white stripes. Red lanterns or warning lights of similar type shall be mounted on the barricades at night and kept lit throughout from sunset to sunrise.
3. At the points where traffic is to deviate from its normal path (whether on temporary diversion or part width of the carriage way) the channel for traffic shall be clearly marked with the aid of pavement markings, painted drums or a similar device as per the directions of the Employer. At night, the passage shall be delineated with lanterns or other suitable light source.
4. One-way traffic operation shall be established whenever the traffic is to be passed over part of the carriageway inadequate for two-lane traffic. This shall be done with the help of temporary traffic signals or flagmen kept positioned on opposite sides during all hours. For regulation of traffic, the flagmen shall be equipped with red and green flags and lanterns/lights.

5. On both sides, suitable regulatory/warning signs as approved by the Employer shall be installed for the guidance of road users. On each approach, at least two signs shall be put up, one close to the point where transition of carriageway begins and the other 120 m away. The signs shall be of approved design and of reflectory type, if so directed by the Employer.

#### 1.9.2.5 Maintenance of Diversions and Traffic Control Devices

Signs, lights, barriers and other traffic control devices, as well as the riding surface of diversions shall be maintained in a satisfactory condition till such time they are required as directed by Employer. The temporary traveled way shall be kept free of dust by frequent applications of water, as directed by the Employer.

#### 1.9.2.6 Measurements for Payment and Rate

1. All arrangements for traffic during construction including provision of temporary cross drainage structures, if required, and treated shoulder as described in Clause 1.9.2.2 including their maintenance, dismantling and clearing debris, where necessary, shall be considered as incidental to the Works and shall be the Contractor's responsibility.
2. The construction of temporary diversion including temporary cross drainage structures as described structures as described in Clause 1.9.2.3, shall be measured and paid as per Bill of quantities in price offer and shall be inclusive of full compensation for construction (including supply of material, labour, tools, etc.) maintenance, final dismantling, and disposal.

### 1.10 Setting Out

The Contractor shall establish working Bench Marks tied with the Reference Bench Mark in the area soon after taking possession of the site. The Reference Bench Mark for the area shall be as indicated in the Contract Documents and the values of the same shall be obtained by the Contractor from the Employer. The working Bench Marks shall be at the rate of four per km and also at or near all drainage structures, over-bridges and underpasses. The working Bench Marks/levels shall be approved by the Employer. Checks must be made on these Bench Marks once every months and adjustments, if any, agreed with the Employer and recorded. An up-to-date record of all Bench marks including approved adjustments, if any, shall be maintained by the Contractor and also a copy supplied to the Employer for his record.

- 1.10.1. The lines and levels of formation, side slopes, drainage Works, carriage ways and shoulders shall be carefully set out and frequently checked, care being taken to ensure that correct gradients and cross-sections are obtained everywhere.
- 1.10.2. In order to facilitate the setting out of the Works, the centre line of the carriageway or highway must be accurately established by the Contractor and approved by the Employer. It must then be accurately referenced in a manner satisfactory to the Employer, every 50 m intervals in plain and rolling terrain and



20 m intervals in hilly terrain and at all curve points as directed by the Employer, with marker pegs and chainage boards set in or near the fence line, and a schedule of reference dimensions shall be prepared and supplied by the Contractor to the Employer. These markers shall be maintained until the Works reach finished formation level and are accepted by the Employer.

- 1.10.3. On construction reaching the formation level stage, the centre line shall again be set out by the Contractor and when approved by the Employer, shall be accurately referenced in a manner satisfactory to the Employer by marker pegs set at the outer limits of the formation.
- 1.10.4. No reference peg or marker shall be moved or withdrawn without the approval of the Employer and no earthwork or structural work shall be commenced until the centre line has been referenced.
- 1.10.5. The Contractor will be the sole responsible party for safeguarding all survey monuments, bench marks, beacons, etc. The Employer will provide the Contractor with the data necessary for setting out of the centre line. All dimensions and levels shown on the Drawings or mentioned in documents forming part of or issued under the Contract shall be verified by the Contractor on the site and he shall immediately inform the Employer of any apparent errors or discrepancies in such dimensions or levels. The Contractor shall, in connection with the staking out of the centre line, survey the terrain along the road and shall submit to the Employer for his approval, a profile along the road centre line and cross-sections at intervals as required by the Employer.
- 1.10.6. After obtaining approval of the Employer, work on earthwork can commence and the profile and cross sections shall form the basis for measurements and payment. The Contractor shall be responsible for ensuring that all the basic traverse points are in place at the commencement of the contract and if any are missing, or appear to have been disturbed, the Contractor shall make arrangements to re-establish these points. A "Survey File" containing the necessary data will be made available for this purpose. If in the opinion of the Employer, design modifications of the centre line or grade are advisable, the Employer will issue detailed instructions to the Contractor and the Contractor shall perform the modifications in the field, as required, and modify the ground levels on the cross-sections accordingly as many times as required. There will be no separate payment for any survey work performed by the Contractor. The cost of these services shall be considered as being included in the cost of the items of work in the Bill of Quantities.
- 1.10.7. The work of setting out shall be deemed to be a part of general Works preparatory to the execution of work and no separate payment shall be made for the same.
- 1.10.8. Precision automatic levels, having a standard deviation of  $\pm 2$  mm per km, and fitted with micrometer attachment shall be used for all double run leveling work. Setting out of the road alignment and measurement of angles shall be done by using theodolite with traversing target, having an accuracy of one second. Measurement of distances shall be done using precision instruments like Distomat or equivalent.

### **1.11 Methodology and Sequence of Work**

- 1.11.1. Prior to start of the construction activities at site, the Contractor shall, within 30 days after the date of the Letter of Acceptance, submit to the Employer for approval, the detailed construction methodology including mechanical equipment proposed to be used, sequence of various activities and schedule from start to end of the project. Programme relating to pavement and shoulder construction shall be an integrated activity to be done simultaneously in a coordinated manner. The methodology and the sequence shall be so planned as to provide proper safety, drainage and free flow of traffic.

### **1.12 Approval of Materials**

- 1.12.1 Approval of all sources of material for Works shall be obtained in writing from the Employer before their use on the project.
- 1.12.2 Where the terms crushed gravel/shingle, crushed stone, broken stone or stone aggregate appear in any part of the Tender Documents or Drawings issued for work, they refer to crushed gravel / crushed shingle / crushed stone aggregate obtained from an integrated crushing plant having appropriate primary crusher, secondary crusher and vibratory screen.
- 1.12.3 Raw and processed samples of the mineral aggregates from the approved quarry shall be submitted by the Contractor at no extra cost.

### **1.13 Access to Abutting Properties**

- 1.13.1 For the duration of the Works the Contractor shall at all times provide convenient access to paths, steps, bridges or drives for all entrances to property abutting the site and maintain them clear, tidy, and free from mud and objectionable matter.
- 1.13.2 In addition to the above, in order to ensure uninterrupted traffic flow in the cross roads, the Contractor has to provide and maintain suitable crossing arrangement for the existing traffic to move across the construction work for all categories of roads crossing the roads under construction/improvement during the entire period of construction or till such time that alternative arrangement for the traffic is made.

### **1.14 Use of Equipment on Works**

- 1.14.1 The following conditions regarding use of equipment's on works shall be followed:
1. The Contractor shall be required to give a trial run of the equipment(s) or establishing their capability to achieve the required Specifications and tolerance to the satisfaction of the Employer before commencement of the work.
  2. All equipment's provided shall be proven efficiency and shall be operated and maintained at all times in a manner acceptable to the Employer.

3. No equipment or personnel will be removed from site without permission of Employer.

#### **1.15 Quality Control on Works and Materials**

- 1.15.1 The Contractor shall be responsible for the quality of the work in the entire construction work within the contract. He shall, therefore, have his own independent and adequate set-up for ensuring the same.
- 1.15.2 The Employer shall inspect the work from time to time during and after construction and ascertain the quality of the work tested (by himself, by his Testing and Quality Control Units or by any other agency deemed fit by him) generally as per the requirements of the specifications of CPWD. Additional tests may also be conducted where, in the opinion of the Employer, need for such test exists. In the absence of clear indications and frequency of tests for any item in the above mentioned publication, procedures and tests as directed by the Employer shall be followed.
  - 1.15.2.1 The Contractor shall provide necessary cooperation and assistance in obtaining the samples for tests and carrying out the field tests as required by the Employer from time to time. This may include provision of labour, attendance, assistance in packing and dispatching and any other assistance considered necessary in connection with the tests.
- 1.15.3 For the work of embankment, subgrade and pavement, construction of subsequent layer of same or other material over the finished layer shall be done after obtaining permission from the Employer.
- 1.15.4 Similar permission from the Employer shall be obtained in respect of other items of work prior to proceeding with the next stage of construction.
- 1.15.5 The Contractor shall carry out modification in procedure of work, if any, as directed by the Employer during inspection.
- 1.15.6 Works falling short of quality as per tests indicated in **Clause 1.15.2** above shall be rectified/reconstructed by the Contractor as directed by the Employer at his own cost.
- 1.15.7 For testing of samples of soil, soil mix, granular material and mix, bituminous mix, aggregates, cores etc. Samples in the required quantity and form shall be supplied to the Employer by the Contractor at his own cost
- 1.15.8 For cement, bitumen and similar other materials where essential tests are to be carried out at the manufacturer's plants or at laboratories other than the site laboratory, the cost of samples, sampling, testing and furnishing of test certificates shall be borne by the Contractor. He shall also furnish the test certificates to the Employer.
- 1.15.9 For testing of cement concrete at site during construction arrangement for supply of samples, sampling, testing and supply of test results shall be made by the

Contractor as per the frequency and number of tests specified in relevant IS codes, CPWD specifications or relevant Clauses (1702, 1704, 1707, 1717 etc.,).

1.15.10 Where the Employer considers that in the interest of the control of the quality on materials or workmanship, modifications, if any, are necessary, such modifications shall be carried out by the Contractor at no extra cost.

1.15.11 The Contract rate quoted for various items of work in the Bill of Quantities shall be deemed to be inclusive of all costs of the provisions indicated in the above mentioned clauses.

#### **1.16 Surveying and Measuring Equipment's**

1.16.11 Equipment for surveying and measurement on the work shall be procured by the Contractor for his use. The same shall also be made available to the Employer at site for any work connected with the Contract without any additional charge.

#### **1.17 Completion Drawings**

1.17.11 The Contractor shall submit to the Employer within One month of actual completion, "Completion" Drawings as specified below and operation and maintenance instructions for the whole of the works. These Drawings shall be accurate and correct in all respects and shall be shown to and approved by the Employer.

1.17.1 Completion Drawings on six prints & two soft copies shall be supplied by the Contractor.

#### **1.18 Protection of Environment & Natural Habitat**

1.18.1 Site Environmental Plan (SEP)

1.18.2 The Contractor shall prepare a detailed Site Environmental Plan (SEP) for the work site, base camp, etc., showing arrangements for disposal of sanitary and other waste, location of fuel, oil and lubricant depots, sheds for equipment, labour and housing facilities, etc., prior to the construction for approval of the Employer.

1.18.3. Safety, Security and Protection of the Environment

The Contractor shall take all necessary precautions against pollution or interference with the supply or obstruction of the flow of, surface or underground water. These precautions shall include but not be limited to physical measures such as earth bunds of adequate capacity around fuel, oil and solvent storage tanks and stores, oil and grease traps in drainage systems from workshops, vehicle and plant washing facilities and service and fueling areas and kitchens, the establishment of sanitary solid and liquid waste disposal systems, the maintenance in effective condition of these measures, the establishment of emergency response procedures for pollution events, and dust suppression, all in accordance with normal good practice and to the satisfaction of the Employer. Should any pollution arise from the Contractor's activities he shall clean up the

affected area immediately at his own cost and to the satisfaction of the Employer, and shall pay full compensation to any affected parties.

1.18.4 Protection of Trees and Vegetation

The Contractor shall ensure that no trees or shrubs or waterside vegetation are felled or harmed except for those required to be cleared for execution of the Works. The Contractor shall protect trees and vegetation from damage to the satisfaction of the Employer. No tree shall be removed without the prior approval of the Employer and any competent authorities. Should the Contractor become aware during the period of the Contract that any tree or trees designated for clearance have cultural or religious significance he shall immediately inform the Employer and await his instructions before proceeding with clearance. In the event that trees or other vegetation not designated for clearance are damaged or destroyed, they shall be repaired or replaced to the satisfaction of the Employer, who shall also impose a penalty to twice the commercial value of any timber affected, as assessed by the Employer.

1.18.5 Use of Wood as Fuel

The Contractor shall not use wood as a fuel for the execution of any part of the Works, including but not limited to the heating of bitumen and bitumen mixtures and the manufacture of bricks for use in the Works, and to the extent practicable shall ensure that fuels other than wood are used for cooking, and water heating in all his camps and living accommodations.

1.18.7 Power Supply

The Contractor shall make his own arrangements at his own expense for power supply for construction and other purposes. Only power from authorized connections or from well operational generator sets shall be used. In case of work in night shifts the Employer shall be informed well in advance and all arrangements should be get approved by the Employer.

1.18.8 Hot Mix Plants

The Contractor shall not locate any hot-mix or similar potentially polluting plant closer than 500 m to any settlement. Any such plant shall be fitted with dust suppression equipment and shall be operated and maintained at all times in conformity with the manufacturer's specifications instructions and manuals.

1.18.9 Relations with Local Communities and Authorities

In sitting and operating his plant and facilities and in executing the Works the Contractor shall at all time bear in mind and to the extent practicable minimize the impact of his activities on existing communities. Where communities are likely to be affected by major activities such as road widening or the establishment of a camp, large borrow pit or haul road, he shall liaise closely with the concerned communities and their representatives and if so directed, shall

attend meetings arranged by the Employer or Employer to resolve issues and minimize impacts on local communities.

#### 1.18.10 Fire Prevention

The Contractor shall take all precautions necessary ensure that no vegetation along the line of the road outside the area of the permanent works is affected by fires arising from the execution of the Works. The Contractor shall obtain and follow any instructions of the competent authorities with respect to fire hazard when working in the vicinity of gas installations. Should a fire occur in the natural vegetation or plantations adjacent to the road for any reason the Contractor shall immediately suppress it. In the event of any other fire emergency in the vicinity of the Works the Contractor shall render assistance to the civil authorities to the best of his ability. Areas of forest, scrub or plantation damaged by fire considered by the Employer to have been initiated by the Contractor's staff or labour shall be replanted and otherwise restored to the satisfaction of the Employer at the Contractor's expense.

### 1.19 Responsibilities & Facilities to be provided by the Contractor for its Labour / Staff

#### 1.19.1 Fair wages

- a. The Contractor shall pay not less than fair wage/minimum wages to labourers engaged by him on the work as revised from time to time by the Government of India & Government of Delhi, but the Government shall not be liable to pay any thing extra for it except as stipulated in price adjustment clause (Clause 41) of the Contract.

(Explanation: "Fair wage" means minimum wages for time or piece work, fixed or revised, as established by the State Government under the Minimum Wages Act, 1948.)

- b. The Contractor shall, notwithstanding the provisions of any Contract to the contrary, cause to be paid fair wages to labourers indirectly engaged on the work, including any labour engaged by his sub-Contractors in connection with the said work, as if the labourers have been immediately or directly employed by him.
- c. In respect of all labourers, immediately or directly employed on the work, for the purpose of the Contractor's part of this agreement, the Contractor shall comply with or cause to be complied with, the Public Works Department Contract Labour Regulations' made, or that may be made, by the Government, from time to time, in regard to payment of wages, wage period, deductions from wages, recovery of wages not paid, and unauthorized deductions, maintenance of wages register, wage card, publication of scale of wages and other terms of employment, inspection and submission of periodical returns, and all other matters of a like nature.
- d. The Employer shall have the right to deduct, from the money due to the Contractor, any sum required or estimated to be required for making good the loss suffered by a worker or workers by reasons of non-fulfillment of the conditions of

the Contract for the benefit of the worker or workers, non-payment of wages or of deductions made there from, which are not justified by the terms of the Contract or as a result of non-observance of the aforesaid regulations.

- f. The regulations, aforesaid, shall be deemed to be part of this Contract and any breach thereof, shall be deemed to be breach of the Contract.

#### 1.19.2 Housing for labour

The Contractor at his own expense shall provide and maintain, in a clean and sanitary condition, living accommodations for those employed by him on the project. Each building for living accommodation shall be provided with lights, water supply, and sanitary facilities and be properly furnished.

#### 1.19.3 Safety and accident prevention officer

Due precautions shall be taken by the Contractor, at his own cost, to ensure the safety and protection against accidents of all staff and labour engaged on the Works, local residents in the vicinity of the Works, and the public travelling through the Works. The Contractor shall have on his staff on Site a designated officer qualified to promote and maintain safe working practices. This officer shall have authority to issue instructions and shall take protective measures to prevent accidents, including but not limited to the establishment of safe working practices and the training of staff and labour in their implementation.

#### 1.19.4 Protective clothing and footwear

The Contractor shall, at his own expense, provide protective clothing and equipment to all staff and labour engaged on the Works to the satisfaction of the Employer, and on his failure to do so the Employer shall be entitled to provide the same and recover the cost from the Contractor. Such clothing and equipment shall include, at a minimum, protective footwear for workmen undertaking concrete mixing work, protective footwear and gloves for any workmen performing bituminous paving works, protective footwear, clothing, cream, gauntlet-type gloves, hats, safety glasses or goggles and filter masks for workmen undertaking lime stabilisation works, hard hats for workmen engaged on bridge construction, and otherwise as appropriate to the job in hand and to the Employer's satisfaction.

#### 1.19.5 First-aid services

The Contractor shall, at his own expense, provide first aid equipment at all camps and work sites to the satisfaction of the Employer, and shall ensure that at all work sites where 40 or more persons are engaged on the Works there shall at all times be a person qualified in first-aid with access to appropriate first-aid equipment. A first-aid post shall be established at each base camp comprising a suitable room with two beds, washing and examination facilities, appropriate medical supplies, and staffed on a full-time basis by a qualified paramedical attendant.

#### 1.19.6 Health and pests

The Contractor shall at his own expense and throughout the period of the Contract ensure that suitable arrangements are made for the prevention of epidemics and for all necessary welfare and hygiene requirements for his staff and labour, and shall comply with all the regulations and requirements of the local health authorities with respect to disease prevention and control. He shall warn his staff and labour of the dangers of communicable diseases including those transmitted by insects, water, faecal/oral contact and sexual activity. The Contractor shall take the precautions necessary to protect all staff and labour employed on the Site from insect nuisance, rats and other pests and minimise the dangers to health and the general nuisance caused by the same. Should malaria or other insect-borne diseases be prevalent in the area, he shall provide his staff and labour with suitable prophylactics, equip living accommodation with screens and bed-nets, and carry out spraying with approved insecticides, as appropriate and to the Employer's satisfaction.

**1.19.7 Supply of drinking water, sanitation**

The Contractor shall so far as is reasonable, having regard to local conditions, provide on the Site and at his expense an adequate supply of drinking water for the use of Contractor's staff and work people, together with sanitary facilities (portable toilets or latrines), to the satisfaction of the Employer.

**1.19.8 Festivals and religious customs**

The Contractor shall in all dealings with labour in his employment have due regard to all recognised festivals, days of rest and religious or other customs.

**1.19.9 Disorderly Conduct**

The Contractor shall at all time take reasonable precautions to prevent any unlawful, riotous or disorderly conduct by or amongst his employees and for the preservation of peace and protection of persons and property in the neighbourhood of the Works against the same. "Disorderly conduct" shall include but not be limited to harvesting of natural resources such as firewood or fish by the Contractor's labour when this is done to the detriment of pre-existing local interests.

**1.19.10 Records of labour and accidents**

The Contractor shall maintain full records of numbers, working hours and wages of labour, safety, health and welfare of persons, accidents, and damage to property and make such reports on these matters to the Employer as he may from time to time prescribe.

## **2 SITE CLEARANCE (CLEARING AND GRUBBING)**

### **2.1 Scope**

- 2.1.1 This work shall consist of cutting, removing and disposing of all materials such as trees, bushes, shrubs, stumps, roots, grass, weeds, top organic soil not exceeding 150 mm in thickness, rubbish etc., from the area of Works which in the opinion of the Employer are unsuitable for incorporation in the Works, and such other areas as



may be specified on the Drawings or by the Employer. It shall include necessary excavation, backfilling of pits resulting from uprooting of trees and stumps to required compaction, handling, salvaging, and disposal of cleared materials. Clearing and grubbing shall be performed in advance of earthwork operations and in accordance with the requirements of these Specifications.

## **2.2 Preservation of Property/Amenities**

- 2.2.1 Trees, shrubs, any other plants, pole lines, fences, signs, monuments, buildings, pipelines, sewers and all facilities within or adjacent to the site which are not to be disturbed shall be protected from injury or damage. The Contractor shall provide and install at his own expense, suitable safeguards approved by the Employer for this purpose.
- 2.2.2 During clearing and grubbing, the Contractor shall take all adequate precautions against soil erosion, water pollution, etc., and where required, undertake additional Works to that effect vide relevant Clauses.. Before start of operations, the Contractor shall submit to the Employer for approval, his work plan including the procedure to be followed for disposal of waste materials, etc., and the schedules for carrying out temporary and permanent erosion control Works as stipulated elsewhere in the document.

## **2.3 Methods, Tools and Equipment**

- 2.3.1 Only such methods, tools and equipment as are approved by the Employer and which will not affect the property to be preserved shall be adopted for the Work. If the area has thick vegetation / roots / trees, a crawler or pneumatic tyred dozer of adequate capacity may be used for clearance purposes. The dozer shall have ripper attachments for removal of tree stumps. All trees, stumps, etc., falling within excavation and fill lines shall be cut to such depth below ground level that in no case these fall within 500 mm of the subgrade / foundation / bed level. Also, all vegetation such as roots, under-growths, grass and other deleterious matter unsuitable for incorporation in the Work shall be removed between fill lines to the satisfaction of the Employer. On the areas beyond these limits, trees and stumps required to be removed as directed by the Employer shall be cut down to 1 m below ground level so that these do not present any unsightly appearance.
- 2.3.2 All branches of trees extending above the roadway shall be trimmed as directed by the Employer.
- 2.3.3 All excavations below the general ground level arising out of the removal of trees, stumps, etc., shall be filled with suitable material and compacted thoroughly so as to make the surface as these points conform to the surrounding area.
- 2.3.4 Ant-hills both above and below the ground, as are liable to collapse and obstruct free subsoil water flow shall be removed and their workings, which may extend to several meters, shall be suitably treated.

## **2.4 Disposal of Materials**

- 2.4.1 All materials arising from clearing and grubbing operations shall be the property of Employer and shall be disposed of by the Contractor as hereinafter provided or directed by the Employer.
- 2.4.2 Trunks and stumps of trees shall be cleaned of limbs and roots and stacked. Also boulders, stones and other materials usable in construction shall be neatly stacked as directed by the Employer. Stacking stumps, boulders, stones etc., shall be done at specified spots with all lifts and lead.
- 2.4.3 All products of clearing and grubbing which, in the opinion of the Employer, cannot be used or auctioned shall be cleared away from the site in a manner as directed by the Employer. Care shall be taken to see that unsuitable waste materials are disposed off in such a manner that there is no likelihood of these getting mixed up with the materials meant for construction.

## **2.5 Measurements for Payment**

- 2.5.1 Clearing and grubbing shall be measured on area basis. Clearing and grubbing of borrow areas shall be deemed to be a part of Works. Cutting of trees up to 300 mm in girth including removal of stumps and roots, and trimming of branches of trees extending above the roadway shall be considered incidental to the clearing and grubbing operations. Removal of stumps left over after trees have been cut by any other agency shall also be considered incidental to the clearing and grubbing operations.
- 2.5.2 Cutting, including removal of stumps and roots of trees of girth above 300 mm and backfilling to required compaction shall be measured in terms of number according to the sizes given below:
  - 1. Above 300 mm to 600 mm;
  - 2. Above 600 mm to 900 mm;
  - 3. Above 900 mm to 1800 mm; and
  - 4. Above 1800 mm.
- 2.5.3 For this purpose, the girth shall be measured at a height of 1 m above ground or at the top of the stump if the height of the stump is less than 1 m from the ground.

## **2.6 Rates**

- 2.6.1 The Contract unit rates for the various items of clearing and grubbing shall be payment in full for carrying out the required operations including full compensation for all labour, materials, tools, equipment and incidentals necessary to complete the work. These will also include removal of stumps of trees less than 300 mm in girth as well as stumps left over after cutting of trees carried out by another agency, excavation and back-filling to required density, where necessary, and handling, salvaging, piling and disposing of the cleared materials with all lifts and leads.
- 2.6.2 The Contract unit rates for cutting (including removal of stumps and roots) of trees of girth above 300 mm shall include excavation and back-filling to required

compaction, handling, salvaging, piling and disposing of the cleared materials with all lifts and lead.

### 3 DISMANTLING AND DEMOLITION

#### 3.1 Scope

- 3.1.1 This work shall consist of removing, as hereinafter set forth, existing buildings, roofs, ceiling, flooring and paving, concrete and brick roofs and suspended floors, walls and columns, reinforced concrete and brick work, partitions, wood work, steel and iron work, doors and windows, pipes and sewer lines, posts or struts, fencing wire mesh, glazing, culverts, bridges, pavements, kerbs and other structures like guard-rails, utility services, catch basins, inlets, etc., which are in place but interfere with the new construction or are not suitable to remain in place, and of salvaging and disposing of the resulting materials and back filling the resulting trenches and pits.
- 3.1.2 Existing culverts, bridges, pavements and other structures which are within the highway and which are designated for removal, shall be removed up to the limits and extent specified in the Drawings or as indicated by the Employer.
- 3.1.3 Dismantling and removal operations shall be carried out with such equipment and in such a manner as to leave undisturbed, adjacent pavement, structures and any other work to be left in place.
- 3.1.4 All operations necessary for the removal of any existing structure which might endanger new construction shall be completed prior to the start of new work.

#### 3.2 Applicable Codes

IS: 1200-1974 (Part: XVIII)	Method of Measurements of Building and Civil Employering Works. Demolition and Dismantling (Reaffirmed 1992) (3rd Revision).
IS: 4130-1991	Demolition of Buildings - Code of Safety (2nd Revision).

#### 3.3 Terminology

- 3.3.1 The term '**Dismantling**' implies carefully separating the parts without damage and removing. This may consist of dismantling one or more parts of the structure as specified or shown on the Drawings.
- 3.3.2 The term '**Demolition**' implies breaking up. This shall consist of demolishing whole or part of work including all relevant items as specified or shown on the Drawings.

#### 3.4 Buildings

### 3.4.1 Precautions

- 3.4.1.1 All materials obtained from dismantling or demolition shall be the property of the Employer unless otherwise specified and shall be kept in safe custody until they are handed over to the Employer.
- 3.4.1.2 The demolition shall always be well planned before hand and shall generally be done in reverse order of the one in which the structure was constructed. The operations shall be got approved from the Employer before starting the work.
- 3.4.1.3 Due care shall be taken to maintain the safety measures prescribed in IS: 4130.
- 3.4.1.4 Necessary propping, shoring and or under pinning shall be provided to ensure the safety of the adjoining work or property before dismantling and demolishing is taken up and the work shall be carried out in such a way that no damage is caused to the adjoining work or property. Wherever specified, temporary enclosures or partitions shall also be provided, as directed by the Employer.
- 3.4.1.5 Necessary precautions shall be taken to keep down the dust nuisance to the minimum.
- 3.4.1.6 Dismantling shall be done in a systemic manner. All materials which are likely to be damaged by dropping from a height or by demolishing roofs, masonry etc. shall be carefully removed first. The dismantled articles shall be removed manually or otherwise, lowered to the ground (and not thrown) and then properly stacked as directed by the Employer.
- 3.4.1.7 Where existing fixing is done by nails, screws, bolts, rivets, etc., dismantling shall be done by taking out the fixing with proper tools and not by tearing or ripping off.
- 3.4.1.8 Any serviceable material, obtained during dismantling or demolition, shall be separated out and stacked properly as directed by the Employer within a lead of 50 m. All unserviceable materials rubbish etc. shall be disposed off as directed by the Employer.
- 3.4.1.9 The Contractor shall maintain / disconnect existing services, whether temporary or permanent, where required by the Employer.

### 3.4.2 Measurements

- 3.4.2.1 All work shall be measured net in the decimal system, as fixed in its place, subject to the following limits, unless otherwise stated hereinafter.
  - 1. Dimensions shall be measured correct to a cm.
  - 2. Areas shall be worked out in sq mt correct to two places of decimal.
  - 3. Cubical contents shall be worked out to the nearest 0.01 cum.
- 3.4.2.2 Parts of work required to be dismantled and those required to be demolished shall be measured separately.
- 3.4.2.3 Measurements of all works except hidden work shall be taken before demolition or dismantling and no allowance for increase in bulk shall be allowed.

3.4.2.4 Specifications for deduction for voids, openings etc. shall be on the same basis as that adopted for new construction of the work.

3.4.2.5 Work executed in the following conditions shall be measured separately:

1. Work in or under water and / or liquid mud;
2. Work in or under foul position.

#### **3.4.3 Rates**

3.4.3.1 The rate shall include the cost of all labour involved and tools used in demolishing and dismantling including scaffolding. The rate shall also include the charges for separating out and stacking the serviceable material properly and disposing off unserviceable material within a distance of 50 m.

3.4.3.2 The rate shall also include for temporary shoring for the safety of portions not required to be pulled down, or of adjoining property, and providing temporary enclosures or partitions, where considered necessary.

## **4 CARRIAGE OF MATERIALS**

### **4.1 Scope**

This Specification covers the general requirements for carriage of materials.

### **4.2 General**

The carriage and stacking of materials shall be done as directed by the Employer. Any tools and plants required for the work shall be arranged by the Contractor. The carriage of materials including loading within a lead of 50m, unloading and stacking within a lead of 50m.

### **4.3 Responsibility for Loss or Damage**

Loading, carriage, unloading and stacking shall be done carefully to avoid loss or damage to the materials. In case of any loss or damage, recovery shall be effected from the Contractor at twice the departmental issue rates of the materials. If the departmental issue rates of the materials are not available then the recovery shall be effected at twice the prevailing market rates as determined by the Employer.

### **4.4 Mode of Carriage**

Depending upon the feasibility and economy, the Employer shall determine the mode of carriage viz. whether by mechanical or animal transport or manual labour.

### **4.5 Lead**

- 4.5.1 All distances shall be measured over the shortest practical route and not necessarily the route actually taken.
- 4.5.2 Carriage by manual labour shall be reckoned in units of 50 m.
- 4.5.3 Carriage by animal and mechanical transport shall be reckoned in one km unit. Distances of 0.5 km or more shall be taken as 1 km and distance of less than 0.5 km shall be ignored. However, when the total lead is less than 0.5 km, it will not be ignored but paid for separately in successive stages of 50 m subject to the condition that the rate worked on this basis does not exceed the rate for initial lead of 1 km by mechanical / animal transport.

#### 4.6 Stacking, Covering and Protection

Material shall be stacked in such a manner as to ensure the preservation of their quality and fineness for the work. Different types of materials shall be stacked separately and in such a way that counting and measurements can be done without disturbing the stacks. Any material that is liable to be affected by rain or other adverse weather conditions shall be covered and protected against the same.

- 4.6.1 Earth, dismantled materials, malba and other similar materials shall be stacked as directed by the Employer.
- 4.6.2 Cement bags, steel bars, structural steel sections, bricks and timber and other similar materials shall be stacked in regular tiers.
- 4.6.3 Pipes of RCC, SW, GI, CI, etc. shall be stacked as per manufacturers/suppliers instructions or as directed by the Employer.
- 4.6.4 Lime, stone metal, sand and such similar materials shall be stacked as directed by the Employer.

#### 4.7 Measurements

Length, breadth and height of stacks shall be measured correct to a cm. The quantity shall be worked out in cubic metre correct to two places of decimal. The volume of stacks, shall be reduced by percentages as shown against each for looseness in stacking to arrive at the net quantity for payment. No reduction shall be made in respect of articles or materials for which mode of payment is by length or weight or number.

##### 4.7.1 Earth

In loose stacks such as cart loads, lorry loads, etc.	20 %
In fills consolidated by light mechanical machinery	10 %
In fills consolidated by heavy mechanical machinery but not under OMC	5 %
In fills consolidated by heavy mechanical machinery at OMC	Nil
Consolidated fills in confined situation such as under floors etc.	Nil

##### 4.7.2 Others

Manure or sludge	8 %
Moorum, building rubbish Lime and sand	Nil
Stone metal, 40 mm nominal size and above	7.5 %
Coarse aggregate/stone metal below 40 mm nominal size	Nil
Soling Stone / Boulder 100 mm and above	15 %
Excavated rocks	50 %

#### 4.8 Rate

4.8.1 The rate for carriage of materials is inclusive of all the operations described above.

### 5 EARTHWORK, EROSION CONTROL AND DRAINAGE

#### 5.1 Scope

5.1.1 This Specification covers the general requirements of earthwork in excavation in different materials necessary for the construction of the Works including structures, roadway, side drains, sewers and water supply lines in accordance with requirements of these Specifications and the lines, grades and cross-section shown in the Drawings or as indicated by the Employer. This Specification also includes site grading, filling in areas as shown in Drawing, filling back around foundations, plinths and approach ramps, conveyance and disposal of surplus spoils or stacking them properly as shown on the Drawings or as directed by the Employer and all operations covered within the intent and purpose of this Specification. It shall also include the hauling and stacking of or hauling to sites of embankment and subgrade construction, suitable cut materials as required, as also the disposal of unsuitable cut materials in specified manner, trimming and finishing of the road to specified dimensions or as directed by the Employer.

5.1.2 Excavation for structures shall consist of the removal of material for the construction of foundation for bridges, culverts, retaining walls, headwalls, cutoff walls, pipe culverts and other similar structures, in accordance with the requirements of these Specifications and the lines and dimensions shown on the Drawings or as indicated by the Employer. The work shall include construction of the necessary cofferdams and cribs and their subsequent removal; all necessary sheeting, shoring, bracing, draining and pumping; the removal of all logs, stumps, grubs and other deleterious matter and obstructions, necessary for placing the foundations; trimming bottoms of excavations; backfilling and clearing up the site and the disposal of all surplus material.

#### 5.2 Applicable Codes

The following Indian Standard Codes, unless otherwise specified herein, shall be applicable. In all cases, the latest revision of the codes shall be referred to.

1. IS: 783 Code of practice for laying of concrete pipes.
2. IS: 1200 Method of Measurement of Building Works (Part I).
3. IS: 3764 Safety code for excavation work.
4. IS: 3385 Code of practice for measurement of Civil Engineering Works.
5. IS: 2720 Method of test of soils (All parts)

6. IS: 1498 Classification and identification of soils for General Employering purposes
7. IS: 2809 Glossary of terms and symbols relating to Soil Employering
8. IS: 4081 Safety code for blasting and related drilling operations
9. IS: 4988 Glossary of terms and classifications of earth moving machinery (All Parts)

### 5.3 Drawings

Employer will furnish Drawings wherever, in his opinion, such Drawings are required to show areas to be excavated / filled, sequence of priorities etc. Contractor shall follow strictly such Drawings.

### 5.4 General

- 5.4.1 Contractor shall furnish all tools, plants, instruments, qualified supervisory personnel, labour, materials, any temporary work, consumable, any and everything necessary, whether or not such items are specifically stated herein for completion of the job in accordance with Specification requirements.
- 5.4.2 Contractor shall carry out the survey of the site before excavation and properly mark all lines and establish levels for various works such as earthwork in excavation for grading, basement, foundations, plinth filling, roads, drains, cable, trenches, pipelines etc. Such survey shall be carried out by taking accurate cross sections of the area perpendicular to established reference / grid lines at intervals as determined by Employer based on ground profile. These shall be checked by Employer and thereafter properly recorded.
- 5.4.3 The excavation shall be done to correct lines and levels. This shall also include, where required, proper shoring to maintain excavations and also the furnishing, erecting and maintaining of substantial barricades around excavated areas and warning lamps at night for ensuring safety.
- 5.4.4 The rates quoted shall also include the dumping of excavated materials in regular heaps, bunds, riprap with regular slopes as directed by Employer, within the lead specified and leveling the same as to provide natural drainage. Rock / soil excavated shall be stacked properly as directed by Employer. As a rule, all softer material shall be laid along the center of heaps, the harder and more weather resisting materials forming the casing on the sides and the top. Rock shall be stacked separately.
- 5.4.5 **Excavated materials**  
The Contractor shall not sell or otherwise dispose off, or remove, except for the purpose of this Contract, sand, stone, clay, ballast, earth, rock or any other substance or materials which may be obtained from any excavation made for the purpose of the Works, or any building or produce existing at the Site at the time of delivery of possession thereof. All such substances, materials, buildings and produce, shall be the property of the Employer; provided that the Contractor may with the permission of the Engineer-in-Charge use the same for the purpose of Works either free of cost or



on payment of cost, as provided for under the Special Conditions of the Contract or in the absence of such conditions, as per mutually accepted terms and conditions.

## **5.5 Clearing**

- 5.5.1 The area to be excavated / filled shall be cleared as described in Chapter 2.

## **5.6 Timber Shoring**

- 5.6.1 Close timbering shall be done by completely covering the sides of the trenches and pits generally with short, upright members called 'Polling Boards'. These shall be of minimum 25 cm X 4 cm sections or as directed by Employer. The boards shall generally be placed in position, vertically, side by side without any gap, on each side of the excavation and shall be secured by horizontal walling of strong wood at maximum 1.2 metres spacing, strutted with "Ballies" or as directed by Employer. The length of the "Ballie" struts shall depend on the width of the trench or pit. If the soil is very soft and loose, the boards shall be placed horizontally against each side of the excavation and supported by vertical walling, which in turn shall be taken into the ground and no portion of the vertical side of the trench or pit shall remain exposed, so as to render the earth liable to slip out.
- 5.6.2 Timber shoring shall be 'close' or 'open' type, depending on the nature of soil and the depth of pit or trench. The type of timbering shall be as approved by Employer. It shall be the responsibility of Contractor to take all necessary steps to prevent the sides of excavation, trenches, pits, etc., from collapsing.
- 5.6.3 Timber shoring may be required to keep the sides of excavations vertical to ensure safety of adjoining structures or to limit the slope of excavations, or due to space restrictions or for other reasons. Such shoring shall be carried out, except in an emergency, only on instructions from Employer.
- 5.6.4 The withdrawal of the timber shall be done very carefully, to prevent collapse, systematically from one end to the other end. Concrete or masonry shall not be damaged during the removal of the timber. No claim shall be entertained for any timber which cannot be withdrawn and is lost or buried.
- 5.6.5 In case of open timbering, the entire surface of the side of trench or pit is not required to be covered. The vertical boards of minimum 25 cm X 4 cm sections shall be spaced sufficiently apart to leave unsupported strips of maximum 50 cm average width. The detailed arrangement, sizes of the timber and the spacing shall be subject to the approval of Employer. In all other respects, Specification for close timbering shall apply to open timbering.
- 5.6.6 In case of large pits and open excavations, where shoring is required for securing safety of adjoining structures or for any other reasons and where the planking across sides of excavations / pits cannot be strutted against, suitable inclined struts supported on the excavated bed shall be provided. Load from such struts shall be suitably distributed on the bed to ensure no yielding of the strut. If, however, Employer directs any timbering to be left-in, keeping in mind the type of

construction or any other factor, Contractor shall be paid for, at the scheduled item rate, for such left-in timbering.

#### **5.6.7 Measurement**

5.6.7.1 The actual effective area of shored faces as approved by Employer shall be measured in sqm. The area of planking embedded in the bed / sides of excavation will not be considered, nor the area supporting inclined struts in case of large pits / open excavation. All planks, boards, walling, vertical, struts, props and all other materials required for shoring and subsequent safe dismantling and removal shall be included in the quoted unit rates.

5.6.7.2 Unless separately provided for in the schedule of quantities, shoring is deemed to have been included in the unit rates quoted for excavation.

### **5.7 Slips and Slides**

5.7.1 If slips, slides, over-breaks or subsidence occur in cuttings during the process of construction, they shall be removed at the cost of the Contractor as ordered by the Employer. Should slips occur, the slipped material shall be removed and the slope dressed to a modified stable slope. Removal of the slipped earth will not be paid for if the slips are due to the negligence of Contractor. Adequate precautions shall be taken to ensure that during construction, the slopes are not rendered unstable or give rise to recurrent slides after construction. If finished slopes slide into the roadway subsequently, such slides shall be removed and paid for at the Contract rate for the class of excavation involved, provided the slides are not due to any negligence on the part of the Contractor. The classification of the debris material from the slips, slides etc., shall conform to its condition at the time of removal and payment made accordingly regardless of its condition earlier.

### **5.8 Dewatering**

5.8.1 If water is met within the excavations due to springs, seepage, rain or other causes, it shall be removed by suitable diversions, pumping or bailing out and the excavation kept dry whenever so required or directed by the Employer. Care shall be taken to discharge the drained water into suitable outlet as not to cause damage to the works, crops or any other property. Due to any negligence on the part of the Contractor, if any such damage is caused, it shall be the sole responsibility of the Contractor to repair / restore to the original condition at his own cost or compensate for the damage. Sumps made for dewatering must be kept clear of the excavations / trenches required for further work. Method of pumping shall be approved by Employer; but in any case, the pumping arrangement shall be such that there shall be no movement of subsoil or blowing in due to differential head of water during pumping. Pumping arrangements shall be adequate to ensure no delays in construction.

5.8.2 All excavations shall be kept free of water. Grading in the vicinity of excavations shall be controlled to prevent surface water running into excavated areas.

- 5.8.3 When there is a continuous inflow of water and quantum of water to be handled is considered in the opinion of Employer, as large, 'Well Point System' - single stage or multistage, shall be adopted. Contractor shall submit to Employer his scheme of well point system including the stages, the spacing, number and diameter of well points, headers, etc. and the number, capacity and location of pumps for approval. Unless separately provided for in the schedule of prices, the cost of dewatering shall be included in the item rate for excavation.
- 5.8.4 Unless separately provided for in the schedule of quantities, dewatering is deemed to have been included in the unit rates quoted for excavation. If separately provided for, the unit of measurement shall be as indicated in the schedule of quantities.

## **5.9 Methods, Tools and Equipment**

- 5.9.1 Only such methods, tools and equipment as approved by the Employer shall be adopted / used in the work. If so desired by the Employer, the Contractor shall demonstrate the efficacy of the type of equipment to be used before the commencement of work.

## **5.10 Construction Operation for Structures**

### **5.10.1 Backfilling**

Backfilling shall be done with approved material after concrete or masonry is fully set and carried out in such a way as not to cause undue thrust on any part of the structure. All space between foundation masonry or concrete and the sides of excavation shall be refilled to the original surface in layers not exceeding 150 mm compacted thickness. The compaction shall be done with the help of suitable equipment such as mechanical tamper, rammer, plate vibrator etc., after necessary watering, so as to achieve a density not less than the field density before excavation.

### **5.10.2 Measurement for Payment**

- 5.10.2.1 Excavation for structures shall be measured in cum. for each class of material encountered, limited to the dimensions shown on the Drawings or as directed by the Employer. Excavation over increased width, cutting of slopes, shorting, shuttering and planking shall be deemed as convenience for the Contractor in executing the work and shall not be measured and paid for separately.
- 5.10.2.2 Preparation of rock foundation shall be measured in square metres. Foundation sealing, dewatering, including pumping shall be deemed to be incidental to the work unless separate provision is made for in the Contract. In the latter case, payment shall be on lump sum basis as provided in the Bill of Quantities.

### **5.10.3 Rates**

- 5.10.3.1 The Contract unit rate for the items of excavation for structures shall be payment in full for carrying out the required operations including full compensation for:
1. Setting out;
  2. Construction of necessary cofferdams, cribs, sheeting, shoring and bracing and their subsequent removal;
  3. Removal of all logs, stumps, grubs and other deleterious matter obstructions, for placing the foundations including trimming of bottoms of excavations;
  4. Foundation sealing, dewatering including pumping when no separate provision for it is made in the Contract;
  5. Backfilling, clearing up the site and disposal of all surplus material within all lifts and leads up to 1000 m or as otherwise specified; and
  6. All labour, material, tools, equipment, safety measures, diversion of traffic and incidentals necessary to complete the work to Specification.
- 5.10.3.2 The Contract unit rate for preparation of rock foundation shall be full compensation for cutting, trimming and cleaning the foundation surface and filling/sealing of all seams with cement grout or mortar including all materials, labour and incidents required for completing the work.
- 5.10.3.3 The Contract unit rate for transporting material from the excavation for structures shall be full compensation for all labour, equipment, tools and incidentals necessary on account of the additional haul of transportation involved beyond the initial lead of 1000 m.

## **5.11 Construction Operation for Water Supply Lines**

### **5.11.1 Excavation:**

- 5.11.1.1 All excavation work shall be carried out by mechanical equipment unless, in the opinion of Employer, the work involved and time schedule permit manual work.
- 5.11.1.2 Excavation for permanent work shall be taken out to such widths, lengths, depths and profiles as are shown on the Drawings or such other lines and grades as may be specified by Employer. Rough excavation shall be carried out to a depth 150 mm above the final level. The balance shall be excavated with special care. Soft pockets shall be removed even below the final level and extra excavation filled up as directed by Employer. The final excavation if so instructed by Employer should be carried out just prior to laying the mud-mat.
- 5.11.1.3 Contractor may, for facility of work or similar other reasons excavate, and also backfill later, if so approved by Employer, at his own cost, outside the lines shown on the Drawings or directed by Employer. Should any excavation be taken below the specified elevations. Contractor shall fill it up, with concrete of the same class as in the foundation resting thereon, up to the required elevation. No extra shall be claimed by Contractor on this account.
- 5.11.1.4 All excavations shall be done to the minimum dimension as required for safety and working facility. Prior approval of Employer shall be obtained by Contractor in each individual case, for the method he proposes to adopt for the excavation, including setting out, dimensions, side slopes, dewatering, disposal, etc. This approval,

however, shall not in any way relieve Contractor of his responsibility for any consequent loss or damage. The excavation must be carried out in the most expeditious and efficient manner. Side slopes shall be as steep as will stand and precaution shall be taken to prevent slips. Should slips occur, the slipped material shall be removed and the slope dressed to a modified stable slope. Removal of the slipped earth will not be paid for if the slips are due to the negligence of Contractor.

5.11.1.5 Excavation shall be carried out with such tools, tackles and equipment as described herein/before. Blasting or other methods may be resorted to in the case of hard rock; however not without the specific permission of Employer.

5.11.1.6 Employer may also direct that in some extreme case, the rock may be excavated by heating and sudden quenching for splitting the rock. Fire-wood shall be used for burning and payment shall be made for such work as called for in the schedule of quantities.

#### 5.11.2 Stripping loose rock:

5.11.2.1 All loose boulders, semi detached rocks (along with earthy stuff which might move therewith) not directly in the excavation but so close to the area to be excavated as to be liable, in the opinion of Employer, to fall or otherwise endanger the workmen, equipment, or the work, etc., shall be stripped off and removed away from the area of the excavation. The method used shall be such as not to shatter or render unstable or unsafe the portion which was originally sound and safe.

5.11.2.2 Any material not requiring removal as contemplated in the work, but which, in the opinion of Employer, is likely to become loose or unstable later, shall also be promptly and satisfactorily removed as directed by Employer. The cost of such stripping will be paid for at the unit rates accepted for the class of materials in question.

#### 5.11.3 Filling, Backfilling and Site Grading:

##### 5.11.3.1 General:

1. All fill material will be subject to Employer's approval. If any material is rejected by Employer, Contractor shall remove the same forthwith from the site at no extra cost to the Owner. Surplus fill material shall be deposited / disposed off as directed by Employer after the fill work is completed.
2. No earth fill shall commence until surface water discharges and streams have been properly intercepted or otherwise dealt with as directed by Employer.

##### 5.11.3.2 Material:

1. To the extent available, selected surplus spoils from excavated materials shall be used as backfill. Fill material shall be free from clods, salts, sulphates, organic or other foreign material. All clods of earth shall be broken or removed. Where excavated material is mostly rock, the boulders shall be broken into pieces not larger than 150 mm size, mixed with properly graded

fine material consisting of moorum or earth to fill up the voids and the mixture used for filling.

2. If any selected fill material is required to be borrowed, Contractor shall make arrangements for bringing such material from outside borrow pits. The material and source shall be subject to prior approval of Employer. The approved borrow pit area shall be cleared of all bushes, roots of trees, plants, rubbish etc. top soil containing salts / sulphate and other foreign material shall be removed. The materials so removed shall be burnt or disposed off as directed by Employer. Contractor shall make necessary access roads to borrow areas and maintain the same, if such access road does not exist, at his cost.

#### 5.11.3.3 Filling in pits and trenches around foundations of structures, walls etc.:

1. As soon as the work in foundations has been accepted and measured, the spaces around the foundations, structures, pits, trenches etc. shall be cleared of all debris, and filled with earth in layers not exceeding 15 cm., each layer being watered, rammed and properly consolidated, before the succeeding one is laid. Each layer shall be consolidated to the satisfaction of Employer. Earth shall be rammed with approved mechanical compaction machines. Usually no manual compaction shall be allowed unless Employer is satisfied that in some cases manual compaction by tampers cannot be avoided. The final backfill surface shall be trimmed and levelled to proper profile as directed by Employer or indicated on the Drawings.

#### 5.11.3.4 Plinth Filling:

1. Plinth filling shall be carried out with approved material as described hereinbefore in layers not exceeding 15 cm, watered and compacted with mechanical compaction machines. Employer may however permit manual compaction by hand tampers in case he is satisfied that mechanical compaction is not possible. When filling reaches the finished level, the surface shall be flooded with water, unless otherwise directed, for at least 2 hours, allowed to dry and then the surface again compacted as specified above to avoid settlements at a later stage. The finished level of the filling shall be trimmed to the level / slope specified.
2. Where specified in the schedule of works, compaction of the plinth fill shall be carried out by means of 12 tonne rollers smooth wheeled, sheep-foot or wobbly wheeled rollers. A smaller weight roller may be used only if permitted by Employer. As rolling proceeds water sprinkling shall be done to assist consolidation. Water shall not be sprinkled in case of sandy fill.
3. The thickness of each unconsolidated fill layer can in this case be up to a maximum of 300 mm. Employer will determine the thickness of the layers in which fill has to be consolidated depending on the fill material and equipment used.
4. Rolling shall commence from the outer edge and progress towards the centre and continue until compaction is to the satisfaction of Employer, but in no

case less than 10 passes of the roller will be accepted for each layer.

5. The compacted surface shall be properly shaped, trimmed and consolidated to an even and uniform gradient. All soft spots shall be excavated and filled and consolidated.
6. At some locations / areas it may not be possible to use rollers because of space restrictions etc. Contractor shall then be permitted to use pneumatic tampers, rammers etc. and he shall ensure proper compaction.

#### 5.11.3.5 Sand filling in plinth and other places:

1. At places backfilling shall be carried out with local sand if directed by Employer. The sand used shall be clean, medium grained and free from impurities. The filled-in-sand shall be kept flooded with water for 2 hours to ensure maximum consolidation. Any temporary work required to contain sand under flooded condition shall be to Contractor's account. The surface of the consolidated sand shall be dressed to required level or slope. Construction of floors or other structures on sand fill shall not be started until Employer has inspected and approved the fill.

#### 5.11.3.6 Filling in trenches:

1. Filling in trenches for pipes and drains shall be commenced as soon as the joints of pipe and drains have been tested and passed. The backfilling material shall be properly consolidated by watering and ramming, taking due care that no damage is caused to the pipes.
2. Where the trenches are excavated in soil, the filling from the bottom of the trench to the level of the centerline of the pipe shall be done by hand compaction with selected approved earth in layers not exceeding 8 cm; backfilling above the level of the centerline of the pipe shall be done with selected earth by hand compaction or other approved means in layers not exceeding 15 cm.
3. In case of excavation of trenches in rock, the filling up to a level 30 cm. above the top of the pipe shall be done with fine materials, such as earth, moorum etc. The filling up of the level of the centerline of the pipe shall be done by hand compaction in layers not exceeding 8 cm, whereas the filling above the centerline of the pipe shall be done by hand compaction or approved means in layers not exceeding 15 cm. The filling from a level 30 cm. above the top of the pipe to the top of the trench shall be done by hand or other approved mechanical methods with broken rock filling of size not exceeding 15 cm. mixed with fine material as available to fill up the voids.
4. Filling of the trenches shall be carried out simultaneously on both sides of the pipe to avoid unequal pressure on the pipe.

#### 5.11.4 General site grading:

1. Site grading shall be carried out as indicated in the Drawings and as directed by Employer. Excavation shall be carried out as specified in the Specification. Filling and compaction shall be carried out as specified under Clause 3.2.10 and elsewhere unless otherwise indicated below.
2. If no compaction is called for, the fill may be deposited to the full height in one operation and levelled. If the fill has to be compacted, it shall be placed in layers not exceeding 225 mm and levelled uniformly and compacted as indicated in Clause 5.15.4 before the next layer is deposited.
3. To ensure that the fill has been compacted as specified, field and laboratory tests shall be carried out by Contractor at his cost.
4. Field compaction test shall be carried out at different stages of filling and also after the fill to the entire height has been completed. This shall hold good for embankments as well.
5. Contractor shall protect the earth fill from being washed away by rain or damaged in any other way. Should any slip occur, Contractor shall remove the affected material and make good the slip at his cost.
6. The fill shall be carried out to such dimensions and levels as indicated on the Drawings after the stipulated compaction. The fill will be considered as incomplete if the desired compaction has not been obtained.
7. If specifically permitted by Employer, compaction can be obtained by allowing loaded trucks conveying fill or other material to ply over the fill area. Even if such a method is permitted, it will be for Contractor to demonstrate that the desired / specified compaction has been obtained. In order that the fill may be reasonably uniform throughout, the material should be dumped in place in approximately uniform layers. Traffic over the fill shall then be so routed to compact the area uniformly throughout.
8. If so specified, the rock as obtained from excavation may be used for filling and leveling to indicated grades without further breaking. In such an event, filling shall be done in layers not exceeding 50 cm, approximately. After rock filling to the approximate level, as indicated above has been carried out, the void in the rocks shall be filled with finer materials such as earth, broken stone, etc. and the area flooded so that the finer materials fill up the voids. Care shall be taken to ensure that the finer fill material does not get washed out. Over the layer so filled, a 100 mm thick mixed layer of broken material and earth shall be laid and consolidation carried out by a 12 tonne roller. No less than twelve passes of the roller shall be accepted before subsequent similar operations are taken up.

#### 5.11.5 Fill density:

- 5.11.5.1 The compaction, only where so called for, in the schedule of quantities / items shall comply with the specified (Proctor / Modified Proctor) density at moisture content differing not more than 4 percent from the optimum moisture content. Contractor shall demonstrate adequately at his cost, by field and laboratory tests that the



specified density has been obtained.

5.11.6 Lead:

- 5.11.6.1 Lead for deposition / disposal of excavated material, shall be as specified in the respective item of work. For the purpose of measurement of lead, the area to be excavated or filled or area on which excavated material is to be deposited / disposed off shall be divided into suitable blocks and for each of the blocks, the distance between centerlines shall be taken as the lead which shall be measured by the shortest straight line route on the plan and not the actual route taken by Contractor. No extra compensation is admissible on the grounds that the lead including that for borrowed material had to be transported over marshy or 'katcha' land / route.

5.11.7 Measurement and payment:

- 5.11.7.1 All excavation shall be measured net. Dimensions for purpose of payment shall be reckoned on the mean horizontal area of the excavation multiplied by the mean depth from the surface of the ground in accordance with the Drawings. Reasonable working space, beyond concrete dimensions and shuttering where considered necessary in the opinion of Employer will be allowed in excavation and considered for payment. However, if concreting is proposed on the excavated sides, no such over- excavation will be permitted. In such cases over- excavation shall be made good by Contractor with concrete of the same class as in the foundations at his cost.
- 5.11.7.2 Unless otherwise specified, the unit rates quoted for excavation in different types of material shall also account for a basic lead of 50 meters for disposal as specified or directed. Only leads beyond the basic lead of 50 meters will be considered as extra lead and paid for at the rates quoted in the schedules.
- 5.11.7.3 Backfilling as per Specification on the sides of foundations of columns, footings, structures, walls, tanks, rafts, trenches, etc. with excavated material will not be paid for separately. It shall be clearly understood that the quoted rates are for excavation / packing of selected stacked material, conveying it to the place of final backfill, compaction, etc. as specified. As a rule material to be backfilled shall be stacked temporarily within the basic lead of 50 meters unless otherwise directed by the Employer. If Employer directs / permits a lead of over 50 meters for such material, the conveyance of the material for the extra distance over the basic lead of 50 meters for backfilling will be paid for.
- 5.11.7.4 Payment for fill inside trenches, plinth or similar filling with selected excavated material will be made only for compaction as specified / directed. Cost of all other operations shall be deemed to have been covered in the rate quoted for excavation. Payment for this work will be made based on measurement of plinth / trench dimensions filled. The plinth group levels shall be surveyed beforehand for this purpose. If no compaction is specified / desired such filling will not be separately paid for. In such an event the fill shall be levelled finished to the profile as directed at no extra cost.
- 5.11.7.5 Backfilling, plinth filling, etc. with borrowed earth will be paid for at rates quoted. The quoted rate shall include all operations such as clearing, excavation, lead and

transport, fill, compaction, etc. as specified. Actual quantity of consolidated filling or actual quantity or excavation in the borrow pits (less such top soil which has been excavated and not used for filling) whichever is less shall be measured and paid for in cubic meters. The lead, lift etc. shall be as indicated in the schedule of quantities.

- 5.11.7.6 Actual quantity of consolidated sand filling shall be measured and paid in cubic meters.

## **5.12 Construction Operation for Surface/Sub-Surface Drains**

This work shall consist of constructing surface and/or sub-surface drains in accordance with the requirements of these Specifications and to the lines, grades, dimensions and other particulars shown on the Drawings or as directed by the Employer. Schedule of work shall be so arranged that the drains are completed in proper sequence with road works to ensure that no excavation of the completed road works is necessary subsequently or any damage is caused to these works due to lack of drainage.

### **5.12.1 Surface Drains**

- 5.12.1.1 The excavated material shall be removed from the area adjoining the drains and if found suitable, utilized in embankment / subgrade construction. All unsuitable material shall be disposed of as directed.
- 5.12.1.2 The excavated bed and sides of the drains shall be dressed to bring these in close conformity with the specified dimensions, levels and slopes.
- 5.12.1.3 Where so indicated, drains shall be lined or turfed with suitable materials in accordance with details shown on the Drawings.
- 5.12.1.4 All works on drain construction shall be planned and executed in proper sequence with other works as approved by the Employer, with a view to ensuring adequate drainage for the area and minimising erosion / sedimentation.

### **5.12.2 Sub-surface Drains**

Sub surface drains shall be of close joined perforated pipes, open jointed unperforated pipes, surrounded by granular material laid in a trench or aggregate drains to drain the pavement courses.

#### **5.12.2.1 Materials**

1. Pipe: Perforated pipes for the drains may be of metal / cement concrete / PVC, and unperforated pipes of vitrified clay / cement concrete. The type, size and grade of the pipe to be used shall be as specified in the Contract. In no case, however, shall the internal diameter of the pipe be less than 100 mm. Holes for perforated pipes shall be on one half of the circumference only and conform to the spacing indicated on the Drawings. Size of the holes shall not ordinarily be greater than half of D<sub>85</sub> size of the material surrounding the pipe, subject to being minimum 3 mm and maximum 6 mm. D<sub>85</sub> stands for the size of the

sieve that allows 85 per cent of the material to pass through it

2. Backfill material: Backfill material shall consist of sound, tough, hard, durable particles of free draining sand-gravel material or crushed stone and shall be free of organic material, clay balls or other deleterious matter. Unless the Contract specifies any particular gradings for the backfill material or requires these to be designed on inverted filter criteria for filtration and permeability to the approval of the Employer.

#### 5.12.2.2 Trench Excavation

Trench for sub-surface drain shall be excavated to the specified lines, grades and dimensions shown in the Drawings provided that width of trench at pipe level shall not be less than 450 mm. The excavation shall begin at the outlet end of the drain and proceed towards the upper end. Where unsuitable material is met with at the trench bed, the same shall be removed to such depth as directed by the Employer and backfilled with approved material which shall be thoroughly compacted to the specified degree.

#### 5.12.2.3 Laying of pipe and backfilling

1. Laying of pipe in the trench shall be started at the outlet end and proceed towards the upper end, true to the lines and grades specified. Unless otherwise provided, longitudinal gradient of the pipe shall not less than 1 in 100.
2. Before placing the pipe, backfill material of the required grading(s) shall be laid for full width of the trench bed and compacted to a minimum thickness of 150 mm or as shown on the Drawings. The pipe shall then be embedded firmly on the bed.
3. Perforated pipes, unless otherwise specified, shall be placed with their perforations down to minimise clogging. The pipe sections shall be jointed securely with appropriate coupling fittings or bands.
4. Non-perforated pipes shall be laid with joints as close as possible with the open joints wrapped with suitable pervious material (like double layer of hessian or some other material of not less than 150 mm width) to permit entry of water but prevent fines entering the pipes. In the case of non-perforated pipes with bell end, the bell shall face upgrade.
5. Upgrade end sections of the pipe installation shall be tightly closed by means of concrete plugs or plugs fabricated from the same material as the pipe and securely held in place to prevent entry of soil materials.
6. After the pipe installation has been completed and approved, backfill material of the required grading(s) (see Clause 5.16.2.1 para 2) shall be placed over the pipe to the required level in horizontal layers not exceeding 150 mm in thickness and thoroughly compacted. The minimum thickness of material above the top of the pipe shall be 300 mm.
7. Unless otherwise provided, sub-surface drains not located below the road

pavement shall be sealed at the top by means of 150 mm thick layer of compacted clay so as to prevent percolation of surface water.

#### 5.12.2.4 Drain outlet

The outlet for a sub-drain shall not be under water or plugged with debris but should be a free outlet discharging into a stream, culvert or open ditch. The bottom of the pipe shall be kept above high water in the ditch and the end protected with a grate or screen. For a length of 500 mm from the outlet end, the trench for pipe shall not be provided with granular material but backfilled with excavated soil and thoroughly compacted so as to stop water directly percolating from the backfill material around the pipe. The pipe in this section shall not have any perforations.

## **6 MATERIALS FOR STRUCTURES**

### **6.1 Scope**

- 6.1.1 Materials to be used in the work shall conform to the Specifications mentioned on the Drawings, the requirements laid down in this section and Specifications for relevant items of work covered under these Specifications.
- 6.1.2 If any material, not covered in these Specifications, is required to be used in the work, it shall conform to relevant Indian Standards, if there are any, or to the requirements specified by the Employer.

### **6.2 Sources of Material**

- 6.2.1 The Contractor shall notify the Employer of his proposed sources of materials prior to delivery. If it is found after trial that sources of supply previously approved do not produce uniform and satisfactory products, or if the product from any other source proves unacceptable at any time, the Contractor shall furnish acceptable material from other sources at his own expense.

### **6.3 Bricks**

- 6.3.1 Burnt clay bricks shall conform to the requirement of IS: 1077 and shall be hand moulded or machine moulded. They shall be free from cracks and flaws and nodules of free lime. The brick shall have smooth rectangular faces with sharp corners and emit a clear ringing sound when struck. The compressive strength of any individual brick tested shall not fall below the minimum average compressive strength specified for the corresponding class of brick by more than 20% .

### **6.4 Storage of Materials**

#### 6.4.1 General

- 6.4.1.1 All materials may be stored at proper places so as to prevent their deterioration or

intrusion by foreign matter and to ensure their satisfactory quality and fitness for the work. The storage space must also permit easy inspection, removal and restorage of the materials. All such materials even though stored in approved godowns/places, must be subjected to acceptance test prior to their immediate use.

#### 6.4.2 Brick

- 6.4.2.1 Bricks shall not be dumped at site. They shall be stacked in regular tiers as they are unloaded, to minimise breakage and defacement. The supply of bricks shall be available at site at any time. Bricks selected for use in different situations shall be stacked separately.

#### 6.4.3 Aggregates

- 6.4.3.1 Aggregate stockpiles may be made on ground that is denuded of vegetation, is hard and well drained. If necessary, the ground shall be covered with 50 mm plank.
- 6.4.3.2 Coarse aggregates, unless otherwise agreed by the Employer in writing, shall be delivered to the site in separate sizes (2 sizes when nominal size is 25 mm or less and 3 sizes when the nominal size is 32 mm or more). Aggregates placed directly on the ground shall not be removed from the stockpile within 30 cm of the ground until the final cleaning up of the work, and then only the clean aggregate will be permitted to be used.
- 6.4.3.3 In the case of fine aggregates, these shall be deposited at the mixing site not less than 8 hours before use and shall have been tested and approved by the Employer.
- 6.4.3.4 Broken Brick (Burnt Clay) Fine Aggregate (Surkhi) shall be stacked on a hard surface or platform so as to prevent the admixture of clay, dust, vegetation and other foreign matter. It shall be also protected from rain and dampness and kept under adequate covering.

#### 6.4.4 Cement

- 6.4.4.1 Cement shall be transported, handled and stored on the site in such a manner as to avoid deterioration or contamination. Cement shall be stored above ground level in perfectly dry and water-tight sheds and shall be stacked not more than eight bags high. Wherever bulk storage containers are used their capacity should be sufficient to cater to the requirement at site and should be cleaned at least once every 3 to 4 months.
- 6.4.4.2 Each consignment shall be stored separately so that, it may be readily identified and inspected and cement shall be used in the sequence in which it is delivered at site. Any consignment or part of a consignment of cement which had deteriorated in any way, during storage, shall not be used in the works and shall be removed from the site by the Contractor without charge to the Employer.
- 6.4.4.3 The Contractor shall prepare and maintain proper records on site in respect of delivery, handling, storage and use of cement and these records shall be available for inspection by the Employer at all times.

6.4.4.4 The Contractor shall make a monthly return to the Employer on the date corresponding to the interim certificate date, showing the quantities of cement received and issued during the month and in stock at the end of the month.

#### 6.4.5 Lime

Lime shall be stored in water proof sheds. Hydrated lime shall be stored in the same manner as cement. Lime which has been damaged by moisture or air-slaking shall not be used. All damaged and rejected lime shall be removed from the site of work forthwith.

#### 6.4.6 Reinforcement / Untensioned Steel

6.4.6.1 The reinforcement bars, when delivered on the job, shall be stored above the surface of the ground upon platforms, skids, or other supports, and shall be protected from mechanical injury and from deterioration by exposure.

#### 6.4.7 Prestressing Materials

6.4.7.1 All prestressing steel, sheathing, anchorages and sleeves or coupling must be protected during transportation, handling and storage. The prestressing steel, sheathing and other accessories must be stored under cover from rain or damp ground and protected from the ambient atmosphere if its is likely to be aggressive. Storage at site must be kept to the absolute minimum.

1. Tendon: Wire, strand and bar from which tendons are to be fabricated shall be stored about 300 mm above the ground in a suitably covered and closed space so as to avoid direct climatic influences and to protect them from splashes from any other materials and from the cutting operation of any oxy-acetylene torch or arc welding process in the vicinity. Under no circumstances, tendon material shall be subjected to any welding operation or on site heat treatment or metallic coating such as galvanising. Storage facilities and the procedures for transporting material into or out of store shall be such that the material does not become kinked or notched. Wire or strand shall be stored in large diameter coils which enable the tendons to be laid out straight. As a guide, for wires above 5 mm dia, coils of about 2 m diameter without breaks or joints shall be obtained from manufacturer and stored. Protective wrapping for tendons shall be chemically neutral. All prestressing steel must be provided with temporary protection during storage.
2. Anchorage Components: The handling and storing procedures shall maintain the anchorage components in a condition in which they can subsequently perform their function to an adequate degree. Components shall be handled and stored so that mechanical damage and detrimental corrosion are prevented. The use of correctly formulated oils and greases or of other corrosion preventing materials is recommended where prolonged storage is required. Such protective material shall be guaranteed by the producer to be non-aggressive and non-degrading.

6.4.7.2 Prestressing steel shall be stored in a closed store having single door with double

locking arrangements and no windows. Also the air inside the store shall be kept dry as far as possible by using various means to the satisfaction of the Employer. Also instrument measuring the air humidity shall be installed inside the store. This is with a view to eliminating the possibility of initial rusting of prestressing steel during storage. The prestressing steel shall be coated with water solvable grease. The prestressing steel should be absolutely clean and without any signs of rust.

6.4.7.3 All prestressing steel shall be stored at least 30 cm above ground level and it shall be invariably wrapped by protective cover of tar paper or polythene or any other approved material.

6.4.7.4 The Contractor should see that prestressing steel shall be used within 3 months of its manufacture. He should chalk out his programme in this respect precisely, so as to avoid initial corrosion before placing in position.

#### 6.4.8 Water

6.4.8.1 Water shall be stored in containers / tanks covered at top and cleaned at regular intervals in order to prevent intrusion by foreign matter or growth of organic matter. Water from shallow, muddy or marshy surface shall not be permitted. The intake pipe shall be enclosed to exclude silt, mud, grass and other solid materials and there shall be a minimum depth of 0.60 m of water below the intake at all times.

### 6.5 Tests and Standard of Acceptance

6.5.1 All materials, even though stored in an approved manner shall be subjected to an acceptance test prior to their immediate use. Independent testing of cement for every consignment shall be done by the Contractor at site or in the laboratory approved by the Employer before use. Any cement with lower quality than those shown in manufacturer's certificate shall be debarred from use. In case of imported cement, the same series of tests shall be carried out before acceptance.

#### 6.5.2 Testing and Approval of Material

6.5.2.1 The Contractor shall furnish test certificates from the manufacturer/supplier of materials along with each batch of material(s) delivered to site.

6.5.2.2 The Contractor shall set up a field laboratory with necessary equipment for testing of all materials, finished products used in the construction as per requirements of conditions of contract and the relevant Specifications. The testing of all the materials shall be carried out by the Employer or his representative for which the Contractor shall make all the necessary arrangements and bear the entire cost.

6.5.2.3 Tests which cannot be carried out in the field laboratory have to be got done at the Contractor's cost at any recognised laboratory/testing establishments approved by the Employer.

#### 6.5.3 Sampling of Materials

6.5.3.1 Samples provided to the Employer or his representative for their retention are to be in labeled boxes suitable for storage.

6.5.3.2 Samples required for approval and testing must be supplied well in advance by at least 48 hours or minimum period required for carrying out relevant tests to allow for testing and approval. Delay to works arising from the late submission of samples will not be acceptable as a reason for delay in the completion of the works.

6.5.3.3 If materials are brought from abroad, the cost of sampling/testing whether in India or abroad shall be borne by the Contractor.

6.5.4 Rejection of Materials not Conforming to the Specifications

6.5.4.1 Any stack or batch of material(s) of which sample(s) does not conform to the prescribed tests and quality shall be rejected by the Employer or his representative and such materials shall be removed from site by the Contractor at his own cost. Such rejected materials shall not be made acceptable by any modifications.

6.5.5 Testing and Approval of Plant and Equipment

6.5.5.1 All Plants and equipment used for preparing, testing and production of materials for incorporation into the permanent works shall be in accordance with manufacturer's Specifications and shall be got approved by the Employer before use.



## 7 STRUCTURAL STEEL

### 7.1 Scope

These Specification cover the general requirements of furnishing, fabricating, transporting, erecting and painting structural steel, rivet steel, cast steel, steel forgings, cast iron and other incidental metal construction of the kind, size and quantity in conformity with the Drawings and as desired by the Employer.

### 7.2 Applicable Codes

- 7.2.1 The provisions of the latest Indian Standards listed below, but not restricted to, form part of these Specifications:

IS 226	Structural Steel (Standard Quality)
IS: 800	Code of Practice for Use of Structural Steel in General Building Construction
IS: 813	Scheme for Symbols for Welding.
IS: 814	Covered Electrodes for Metal Arc Welding of Structural Steel (Part I & II).
IS: 815	Classification and Coding of Covered Electrodes for Metal Arc Welding of Structural Steel.
IS: 816	Code of Practice for Use of Metal Arc Welding for General Construction in Mild Steel.
IS: 817	Code of Practice for Training and Testing of Metal Arc Welders.
IS: 822	Code of Procedures for Inspection of Welds.
IS: 823	Code of Procedure for Manual Metal Arc Welding of Mild Steel.
IS: 961	Structural Steel (High Tensile)
IS: 1024	Code of Practice for Use of Welding in Bridges.
IS: 1148	Hot Rolled Steel Rivet Bars (Upto 40 Mm Diameters) for Structural Purposes.
IS: 1387	General Requirements for The Supply of Metallurgical Material.
IS: 1477	Part I, Code of Practice for Painting of Ferrous Metals in Buildings - Pretreatment.
IS: 1599	Method for Bend Test for Steel Products Other Than Sheets, Strip., Wire and Tube.
IS: 1608	Method for Tensile Testing of Steel Products.
IS: 1731	Dimensions for Steel Flats for Structural and General Employing Purposes.
IS: 1852	Rolling and Cutting Tolerances for Hot-Rolled Steel Products.
IS: 1915	Code of Practice for Steel Bridges.
IS:	Allowable Deviations for Dimensions Without Specified Tolerances.

2101	
IS: 7318	Part I Fusion for Assembly of Structural Joints Using High Tensile Friction Grip Fasteners.
IS: 7318	Part I Fusion Welding of Steel.

7.2.2 Other I.S. Codes and I.R.C. codes pertaining to the items of structural steel not specifically listed shall also be deemed to come under the purview of this clause.

### 7.3 General

- 7.3.1 Finished rolled material shall be free from cracks, flaws, injurious seams, laps, blisters, ragged and imperfect edges and other defects. It shall have a smooth and uniform finish, and shall be straightened in the mill before shipment. They shall also be free from loose mill scale, rust, pits or other defects affecting its strength and durability.
- 7.3.2 The acceptance of any material on inspection at the mill i.e., rolling mills, foundry or fabricating plant where material for the work is manufactured, shall not be a bar to its subsequent rejection, if found defective.
- 7.3.3 Unless specified otherwise, high tensile steel rivet conforming to IS: 1149 shall be used for members of high tensile steel confirming to IS: 961 and shall not be used for mild steel members.
- 7.3.4 Unless specified otherwise, bolted connection of structural joints using high tensile friction grip bolts shall comply with requirements of IS: 4000.
- 7.3.5 Cast iron shall not be used in any portion of the bridge structure, except where it is subject to direct compression.

### 7.4 Materials

- 7.4.1 All materials conform to requirements are given below:
- 7.4.1.1 Mild steel for bolts and nuts shall conform to IS: 226 but have a minimum tensile strength of 44 kg/sq. mm. and minimum percentage elongation of 14. High tensile steel for bolts and nuts shall conform to IS: 961 but with a minimum tensile strength of 58 kg/sq. mm. High strength friction grip bolts shall be permitted for use only on satisfactory evidence of performance to the requirements (not covered by these Specifications) specified by the Employer or included in the special provisions.
- 7.4.1.2 For cast steel, the yield stress shall be determined and shall not be less than 50 percent of the minimum tensile strength.
- 7.4.1.3 Plain washers shall be of steel. Tapered or other specially shaped washers shall be of steel or malleable cast iron.
- 7.4.1.4 Parallel barrel drifts shall have a tensile strength not less than 55 kg/sq. mm. with elongation of not less than 20 percent measured on a gauge length of  $4\sqrt{S_0}$  ( $S_0 =$

Cross sectional area).

7.4.2 Materials for castings and forgings, fasteners and welding consumable shall be as under:

7.4.2.1 Castings and Forgings: Steel castings and forgings shall comply with requirements for the following Indian Standards, as appropriate:

IS: 1030	Carbon Steel Castings for General Employering Purposes
IS: 1875	Carbon Steel Billets, Blooms, Slabs, Bars for Forgings
IS: 2004	Carbon Steel Forgings for General Employering Purposes
IS: 2644	High Tensile Steel Castings
IS: 4367	Alloy & Tool Steel Forgings for General Industrial Use

7.4.2.2 Fasteners: Bolts, nuts, washers and rivets shall comply with following or relevant IS standards as appropriate:

IS: 1929	Hot Forges Steel Rivets for Hot Closing (12-36 mm Dia)
IS: 2155	Cold Forged Steel Rivets for Hot Closing (6-16 mm Dia)
IS: 1363	Hexagon Head Bolts, Screw and Nuts Product Grade C
IS: 1364	Hexagon Head Bolts, Screw & Nuts Product Grade A & B
IS: 1367	Technical Supply Conditions for Threaded Steel Fastener (Parts 1 To 18)
IS: 3640	Hexagon Fit Bolts
IS: 3757	High Tensile Friction Grip Bolts
IS: 6623	High Strength Structural Nuts
IS: 6639	Hexagon Bolts for Steel Structure
IS: 5624	Foundation Bolts
IS: 7002	Prevailing Torque Type Steel Hexagon Lock Nuts
IS: 5369	Plain Washers and Lock Washers - General Requirements
IS: 5370	Plain Washers with Outside Dia = 3 X Inside Dia
IS:	Taper Washers for Channels (ISMC)

5372	
IS: 5374	Taper Washers for I Beams (ISMB)
IS: 6610	Heavy Washers for Steel Structures
IS: 6649	Hardened and Tempered Washers for High Strength Structural Bolts and Nuts

#### 7.4.2.3 Welding consumable

Welding consumable shall comply with the following Indian Standards as appropriate:

IS: 814 (Part I)	Covered Electrodes for Metal Arc Welding of Structural (Part 1) Steel for Welding Other Than Sheets.
IS: 814 (Part II)	for Welding Sheets
IS: 1278	Filler Rods and Wires for Gas Welding
IS: 1395	Low and Medium Alloy Steel Covered Electrodes for Manual Metal Arc Welding
IS: 3613	Acceptance Test for Wire Flux Combinations for Submerged Arc Welding of Structural Steel
IS: 7280	Bare Wire Electrodes for Gas Shielded Arc Welding of Structural Steel
IS: 6419	Welding Rods and Bare Electrodes for Gas Shielded Arc Welding of Structural Steel
IS: 6560	Molybdenum and Chromium-Molybdenum Low Alloy Steel Welding Rods and Bare Electrodes for Gas Shielded Arc Welding

7.4.3 In aggressive environment, corrosion resistant steel can be used. These are low-alloyed steels containing a total of 1 per cent - 2 per cent alloys, in particular, copper, chromium, nickel and phosphorus.

#### 7.4.4 Paints

7.4.4.1 All materials for paints and enamels shall conform to the requirements specified on the Drawings or other special provisions laid down by the Employer.

7.4.4.2 The type of paints which can be used shall be as follows:

1. Ordinary i.e., paints based on drying oils, alkyd resin, modified alkyd resin, phenolic varnish epoxy.
2. Chemical Resistant - one pack type (ready for use) and two pack type (mixed before use.)
3. Vinyl
4. Chlorinated rubber
5. Bituminous

6. Epoxy
7. Polyurethane
8. Zinc rich

7.4.4.3 Unless otherwise specified, paints shall conform to the relevant IS Specifications. The paints which have been tested for the following qualities as per Specifications given in the relevant IS codes only shall be used:

1. Weight test (weight for 10 litre of paint, thoroughly mixed)
2. Drying time
3. Consistency
4. Dry thickness and rate of consumption

## **7.5 Fabrication**

### **7.5.1 General**

- 7.5.1.1 All work shall be in accordance with the Drawings and as per these Specifications with care being taken that all parts of an assembly fit accurately together. All members shall carry mark number and item number and, if required, serial number.
- 7.5.1.2 Unless specifically required under the contract, corresponding parts need not be interchangeable, but the parts shall be match marked as required under Clause 8.5.7.
- 7.5.1.3 Templates, jigs and other appliances used for ensuring the accuracy of the work shall be of mild steel; where specially required, these shall be bushed with hard steel. All measurements shall be made by means of steel tape or other device properly calibrated. Where bridge materials have been used as templates for drilling, these shall be inspected and passed by the Employer before they are used in the finished structure.
- 7.5.1.4 All structural steel members and parts shall have straight edges and blunt surfaces. If necessary, they shall be straightened or flattened by pressure unless they are required to be of curvilinear forms. They shall also be free from twist. Pressure applied for straightening or flattening shall be such as would not injure the materials. Hammering shall not be permitted. Adjacent surfaces or edges shall be in close contact or at uniform distance throughout.
- 7.5.1.5 The Contractor shall submit his programme of work to the Employer for his approval at least at least 15 days before the commencement of fabrication. This programme shall include the proposed system of identification and erection marks together with complete details of fabrication and welding procedures.
- 7.5.1.6 The Contractor shall prepare shop Drawings for fabricating any member and obtain approval of the Employer before the start of work. Complete information regarding the location, type, size and extent of all welds shall be clearly shown on the shop Drawings. These Drawings shall distinguish between shop and field welds.

### **7.5.2 Preparation of Edges and Ends**

- 7.5.2.1 All structural steel-parts, where required, shall be sheared, cropped, sawn or flame cut and ground accurately to the required dimension and shape.
- 7.5.2.2 End/edge planing and cutting shall be done by any one of the following prescribed methods or least as rolled:
1. Shearing, cropping, sawing, machining, machine flame cutting.
  2. Hand flame cutting with subsequent grinding to a smooth edge.
  3. Sheared edges of plate not more than 16 mm thick with subsequent grinding to smooth profile, which are for secondary use such as stiffeners and gussets.
- 7.5.2.3 If ends of stiffeners are required to be fitted, they shall be ground, so that the maximum gap over 60 per cent of the contact area does not exceed 0.25 mm.
- 7.5.2.4 Where flame cutting or shearing is used, at least one of the following requirements shall be satisfied.
1. The cut edge is not subjected to applied stress.
  2. The edge is incorporated in weld
  3. The hardness of cut edge does not exceed 350 HV 30
  4. The material is removed from edge to the extent of 2 mm or minimum necessary, so that the hardness is less than 350 HV 30.
  5. Edge is suitably heat treated by approved method to the satisfaction of the Employer and shown that cracks had not developed by dye penetrant or magnetic particle test.
  6. Thickness of plate is less than 40 mm for machine flame cutting for materials conforming to IS: 226 and IS: 2062. The requirement of hardness below 350 HV 30 of flame cut edges should be specified by the Employer.
- 7.5.2.5 Wherever specified by the Employer, the flame cut edges shall be ground or machined over and above the requirement (1) to (6)
- 7.5.2.6 Where machining for edge preparation in butt joint is specified, the ends shall be machined after the members have been fabricated.
- 7.5.2.7 Outside edges of plate and section, which are prone to corrosion shall be smoothed by grinding or filing.
- 7.5.2.8 In the case of high tensile steel at least 6 mm of the material from the flame cut edge shall be removed by machining.
- 7.5.2.9 Longitudinal edges of all plates and cover plates in plate girders and built-up members shall be machined except in the following cases:
1. Rolled edges of single universal plates or flats may not be machined.
  2. Covers to single flange plates may be left unmachined.
  3. Machine flame cutting instead of machining is acceptable for edges of single plates in compression and for edges of single plates, 25 mm or less thick, in tension

4. Edges of single shaped plates over 25 mm thick not capable of being machined by ordinary method may be machine flame cut and the end surface ground.
5. Edges of universal plates or flats of the same nominal width used in tiers may be left unmachined, if so authorised by the Employer.

7.5.2.10 All edges of splice and gusset plates 12 mm thick and over shall be machined and those less than 12 mm thick may be sheared and ground.

7.5.2.11 The ends of plates and sections forming the main components of plate girders or of build-up members shall be machined, machine flame cut, sawn or hand flame cut and ground.

7.5.2.12 Where ends of stiffeners are required to be fitted, they shall be machined, machine flame cut, sawn, sheared and ground, or hand flame cut and ground.

7.5.2.13 The ends of lacing bar shall be rounded unless otherwise required.

7.5.2.14 Others edges and ends of mild steel parts may be sheared and any burrs at edges shall be removed.

### 7.5.3 Bolts, Nuts and Washers

#### 7.5.3.1 Black bolts (black all over)

Black bolts are forged bolts in which the shanks, heads and nuts do not receive any further treatment except cutting of screw threads. They shall be true to shape and size and shall have the standard dimensions as shown on the Drawings.

#### 7.5.3.2 Close tolerance bolts

Close tolerance bolts shall be faced under the head and turned on the shank.

#### 7.5.3.3 Turned barrel bolts

The diameter of the screwed portion of turned barrel bolts shall be 1.5 mm smaller than the diameter of the barrel unless otherwise specified by the Employer. The diameter of the bolts as given on the Drawing shall be the nominal diameter of the barrel. The length of the barrel shall be such that it bears fully on all the parts connected. The threaded portion of each bolt shall project through the nut by at least one thread. Faces of heads and nuts bearing on steel work shall be machined.

#### 7.5.3.4 High strength friction bolts and bolted connections

The general requirement shall be as per relevant IS Specifications mentioned in **Clause 5.3** of (Fasteners) of IRC:24. Unless otherwise specified by the Employer, bolted connections of structural joints using high tensile friction grip bolts shall comply with requirements mentioned in IS: 4000.

#### 7.5.3.5 Washers

1. In all cases where the full bearing area of the both is to be developed, the bolt shall be provided with a steel washer under the nut of sufficient thickness to avoid any threaded portion of the bolt being within the thickness of the parts bolted together and to prevent the nut when screwed up, from bearing on the bolt.
2. For close tolerance or turned barrel bolts, steel washers whose faces give a true bearing shall be provided under the nut. The washer shall have a hole diameter not less than 1.5 mm larger than the barrel and a thickness of not less than 6 mm so that the nut when screwed up, will not bear on the shoulder of the bolt.
3. Taper washers with correct angle of taper shall be provided under all heads and nuts bearing on bevelled surfaces.
4. Spring washers may be used under nuts to prevent slackening of the nuts when excessive vibrations occur.
5. Where the heads or nuts bear on timber, square washers having a length of each side not less than three times the diameter of bolts or round washers having a diameter of  $3\frac{1}{2}$  times the diameter of bolts and with a thickness not less than one quarter of diameter shall be provided.

#### 7.5.3.6 Studs

Ordinary studs may be used for holding parts together, the holes in one of the parts being tapped to take the thread of the stud. Counter-sunk may be used for making connections where the surfaces are required to be clear of all obstruction, such as protruding heads of bolts or rivets, studs may also be welded on the steel work in the positions required.

#### 7.5.3.7 Service bolts

Service bolts shall have the same clearance as black bolts and where it is required that there should be no movement prior to final riveting, sufficient drifts or close tolerance bolts shall be used to locate the work.

#### 7.5.3.8 Tightening bolts

1. Bolted connection joints with black bolts and high strength bolts shall be inspected for compliance of Codal requirements.
2. The Employer shall observe the installation and tightening of bolts to ensure that correct tightening procedure is used and shall determine that all bolts are tightened. Regardless of tightening method used, tightening of bolts in a joint should commence at the most rigidly fixed or stiffest point and progress towards the free edges, both in initial snugging and in final tightening.



3. The tightness of bolts in connection shall be checked by inspection wrench, which can be torque wrench, power wrench or calibrated wrench.
4. Tightness of 10 percent bolts, but not less than two bolts, selected at random in each connection shall be checked by applying inspection torque. If no nut or bolt head is turned by this application, connection can be accepted as properly tightened, but if any nut or head has turned all bolts shall be checked and, if necessary, re-tightened.

#### 7.5.3.9 Drifts

The barrel shall be drawn or machined to the required diameter for a length of not less than one diameter over the combined thickness of the metal through which the drifts have to pass. The diameter of the parallel barrel shall be equal to the nominal diameter of the hole subject to a tolerance of +0 mm and - 0.125 mm. Both ends of the drift for a length equal to 1 1/2 times the diameter of the parallel portion of the bar shall be turned down with a taper to a diameter at the end equal to one-half that of parallel portion.

#### 7.5.4 Pins and Pin Holes

##### 7.5.4.1 Pins

The pins shall be parallel throughout and shall have a smooth surface free from flaws. They shall be of sufficient length to ensure that all parts connected thereby shall have full bearing on them. Where the ends are threaded, they shall be turned to a smaller diameter at the ends for the thread and shall be provided with a pilot nut, where necessary, to protect the thread when being drawn to place. Pins more than 175 mm in length or diameter shall be forged and annealed.

##### 7.5.4.2 Pin holes

Pin holes shall be bored true to gauge, smooth, straight at right angles to the axis of the member and parallel with each other, unless otherwise required. The tolerance in the length of tension members from outside to outside of pin holes and of compression members from inside to inside pin holes shall be one millimetre. In build-up members, the boring shall be done after the members have been riveted or welded. The specified diameter of the pin hole shall be its minimum diameter. The resulting clearance between the pin and the hole shall not be less than 0.5 mm and not more than 1.0 mm.

#### 7.5.5 Shop erection and Match Marking

- 7.5.5.1 Before being dispatched, the steel work shall be temporarily erected in the fabrication shop for inspection by the Employer either wholly or in such portion as the Employer may require so that he may be satisfied both in respect of the alignment and fit of all connections. For this purpose, sufficient number of parallel drifts and service bolts tightly screwed up shall be employed. All parts shall fit accurately and be in accordance with Drawings and Specifications.

- 7.5.5.2 The steel work shall be temporarily assembled at place of fabrication. Assembly

shall be of full truss or girder, unless progressive truss or girder assembly, full chord assembly, progressive chord assembly or special complete structure assembly is specified by the Employer.

- 7.5.5.3 The field connections of main members of trusses, arches, continuous beams, spans, bends, plate girders and rigid frame assembled, aligned, accuracy of holes and camber shall be checked by Employer and then only reaming of sub-size holes to specified size shall be taken up.
- 7.5.5.4 After the work has been passed by the Employer and before it is dismantled., each part shall be carefully marked for re-erection with distinguishing marks and stamped with durable markings. Drawings showing these markings correctly shall be supplied to the Employer.
- 7.5.5.5 Unloading, handling and storage of steel work as per these Specifications shall be the responsibility of the Contractor. The cost of repairs or of rejected material, its removal and the cost of transporting replacement material to the site shall be borne by the Contractor.
- 7.5.5.6 Where close tolerance or turned barrel bolts are used for those cases where interchangeability is not insisted upon, each span shall be erected and members of each span marked distinctly.

#### 7.5.6 Welding

- 7.5.6.1 All welding shall be done with prior approval of the Employer and the workmanship shall conform to the Specifications of IS: 823 or other relevant Indian Standards as appropriate.
- 7.5.6.2 When material thickness is 20 mm or more, special precautions like preheating shall be taken as laid down in IS: 823. Surfaces and edges to be welded shall be smooth, uniform and free from fins, tears, cracks and other discontinuities. Surface shall also be free from loose or thick scale, slag rust, moisture, oil and other foreign materials. Surfaces within 50 mm of any weld location shall be free from any paint or other material that may prevent proper welding or cause objectionable fumes during welding.
- 7.5.6.3 The general welding procedures including particulars of the preparation of fusion faces for metal arc welding shall be carried out in accordance with IS: 9595.
- 7.5.6.4 The welding procedures for shop and site welds including edge preparation of fusion faces shall be submitted in writing in accordance with **Clause 22 of IS: 9595** for the approval of the Employer before commencing fabrication and shall also be as per details shown on the Drawings. Any deviation from above has to be approved by Employer. Preparation of edges shall, wherever practicable, be done by machine methods.
- 7.5.6.5 Machine flame cut edges shall be substantially as smooth and regular as those produced by edge planning and shall be left free of slag. Manual flame cutting shall be permitted by the Employer only where machine cutting is not practicable.

- 7.5.6.6 Electrodes to be used for metal arc welding shall comply with relevant IS Specifications mentioned in IRC:24. Procedure test shall be carried out as per IS: 8613 to find out suitable wire-flux combination for welded joint.
- 7.5.6.7 Assembly of parts for welding shall be in accordance with provisions of IS: 9595.
- 7.5.6.8 The welded temporary attachment should be avoided as far as possible, otherwise the method of making any temporary attachment shall be approved by the Employer. Any scars from temporary attachment shall be removed by cutting, chipping and surface shall be finished smooth by grinding to the satisfaction of the Employer.
- 7.5.6.9 Welding shall not be done when the air temperature is less than 10 degrees Celsius. Welding shall not be done when the surfaces are moist, during periods of strong winds or in snowy weather unless the work and the welding operators are adequately protected.
- 7.5.6.10 For welding of any particular type of joint, welders shall qualify to the satisfaction of the Employer in accordance with appropriate welders qualification test as prescribed in any of the Indian Standards IS: 817, IS: 1966, IS: 1393, IS: 7307 (part I), IS: 7310 (Part I) and IS: 7318 (part I) as relevant.
- 7.5.6.11 In assembling and joining parts of a structure or of built-up members, the procedure and sequence of welding shall be such as to avoid distortion and minimise shrinkage stress.
- 7.5.6.12 All requirements regarding pre-heating of parent material and interpass temperature shall be in accordance with provision of IS: 9595.
- 7.5.6.13 Peening of weld shall be carried out wherever specified by the Employer:
1. If specified, peening may be employed to be effective on each weld layer except first.
  2. The peening should carried out after weld has cooled by light blows from a power hammer using a round nose tool. Care shall be taken to prevent scaling or flaking of weld and base metal from over peening.
- 7.5.6.14 Where the Employer has specified the butt welds are to be ground flush, the loss of parent metal shall not be greater than that allowed for minor surface defects. The ends of butt joints shall be welded so as to provide full throat thickness. This may be done by use of extension pieces, cross runs or other means approved by the Employer. Extension piece shall be removed after the joint has cooled and the ends of the weld shall be finished smooth and flush with the faces of the abutting parts.
- 7.5.6.15 The joints and welds listed below are prohibited type, which do not perform well under cyclic loading.
1. Butt joints are fully welded throughout their cross-section.
  2. Groove welds made from one side only without any backing grip
  3. Intermittent groove welds

4. Intermittent fillet welds
5. Bevel-grooves and J-grooves in butt joints for other than horizontal position.
6. Plug and slot welds

7.5.6.16 The run-on and run-off plate extension shall be used providing full throat thickness at the end of butt welded joints. These plates shall comply with the following requirements.

1. One pair of “run-on” and one pair of “run-off” plates prepared from same thickness and profile as the parent metal shall be attached to start and finish of all butt welds preferably by clamps.
2. When “run-on” and “run-off” plates shall be removed by flame cutting, it should be cut at more than 3 mm from parent metal and remaining metal shall be removed by grinding or by any other method approved by the Employer.

7.5.6.17 Welding of stud shear connectors

1. The stud shear connectors shall be welded in accordance with the manufacturer’s instructions including preheating.
2. The stud and the surface to which studs are welded shall be free from scale, moisture, rust and other foreign material. The stud base shall not be painted, galvanised or cadmium plated prior to welding.
3. Welding shall not be carried out when temperature is below 10 degrees Celsius or surface is wet or during periods of strong winds unless the work and the welder is adequately protected.
4. The welds shall be visually free from cracks and shall be capable of developing at least the nominal ultimate strength of studs.
5. The procedural trial for welding the stud shall be carried out when specified by the Employer.

#### 7.5.7 Tolerances

7.5.7.1 Tolerances in dimensions of components of fabricated structural steel work shall be specified on the Drawings and shall be subject to the approval of the Employer before fabrication. Unless specified, all parts of an assembly shall fit together accurately within tolerances specified in Table 8-2.

7.5.7.2 A machined bearing surface, where specified by the Employer, shall be machined within a deviation of 0.25 mm for surfaces that can be inscribed within a square of side 0.5m.

**Table 8-2 Fabrication Tolerances**

Sr.	INDIVIDUAL COMPONENTS	TOLERANCE
1.	Length	
	a) Member with both ends finished for contact bearing	± 1 mm
	b) Individual components of members with end plate connection	+ 0 mm
	c) Other members	- 2 mm

Sr.	INDIVIDUAL COMPONENTS	TOLERANCE
	I. Upto and including 12 M II. Over 12 M	$\pm 2$ mm $\pm 3.5$ mm
2.	Width a) Width of built-up girders b) Deviation in the width of members required to be inserted in other members	$\pm 3$ mm $+ 0$ mm $- 3$ mm
3.	Depth Deviation in the depths of solid web and open web grinders	$+ 3$ mm $- 2$ mm
4.	Straightness a) Deviation from straightness of columns  I. In elevation  II. In plan	L/3000 subject to a maximum of 15 mm where L is length of member $+ 5$ mm $- 0$ mm L/1000 subject to a maximum of 10 mm
5.	Deviation of centre line of web from centre line of flanges in built-up members at contact surfaces	3 mm
6.	Deviation from flatness of plate of webs of build-up members in a length equal to the depth of the member	0.005d to a maximum of 2mm where d is depth of the member
7.	Tilt of flange of plate girders a) At splices and stiffeners, at supports, at the top flanges of plate girders and at bearings  b) at other places	0.005 b to a minimum of 2 mm where b is width of the member 0.015 b to a maximum of 4 mm where b is width of the member
8.	Deviation from squareness of flange to web of columns and box girders	L/1000, where L is nominal length of the diagonal
9.	Deviation from squareness of fixed base plate (not machined) to axis of column. This dimension shall be measured parallel to the longitudinal axis of the column at points where the outer surfaces of the column sections make contact with the base plate	D/500, where D is the distance from the column axis to the point under consideration on the base plate
10.	Deviation from squareness of machined ends to axes of columns	D/1000, where D is as defined in 9 above
11.	Deviation from squareness of machines ends to axes of beams or girder	D/1000, where D is as defined in 9 above
12.	Ends of members abutting at joints through cleats or end plates, permissible deviation from squareness of ends	1/600 of depth of member subject to a maximum of 1.5 mm

## **7.6 Erection**

### **7.6.1 General**

- 7.6.1.1 The provisions of this item shall apply to erection of steel bridge superstructures or main members of bridge superstructures, composed of steel, which span between supports.
- 7.6.1.2 If the sub-structure and the superstructure are built under separate contracts, the department will provide the substructure, constructed to correct lines, dimensions and elevations properly finished and will establish the lines and the elevation required for setting steel.
- 7.6.1.3 The Contractor shall erect the structural steel, remove the temporary construction, and do all the work required to complete the construction included in the contract in accordance with the Drawings and the Specifications and to the entire satisfaction of the Employer.

### **7.6.2 Organisation and Equipment**

- 7.6.2.1 The Contractor shall submit erection plans prepared by the fabricator, showing a method and procedure of erection, compatible with the details of fabrication.
- 7.6.2.2 A detailed scheme must be prepared showing stage-wise activities, with complete Drawings and working phase-wise instructions. This should be based on detailed stage-wise calculation and take into account Specifications and capacity of erection equipment machinery, tools, tackles to be used and temporary working loads as per Codal provisions.
- 7.6.2.3 The scheme should be based on site conditions e.g., hydrology, rainfall, flood timings and intensity, soil and sub-soil conditions in the river bed and banks, maximum water depth, temperature and climatic conditions and available working space, etc.
- 7.6.2.4 The scheme should indicate precisely the type of temporary fasteners to be used as also the minimum percentage of permanent fasteners to be fitted during the stage erection. The working Drawings should give clearly the temporary jigs, fixtures, clamps, spacer supports, etc.
- 7.6.2.5 Unless otherwise provided in the contract, the Contractor shall supply and erect all necessary false work and staging and shall supply all labour, tools, erection plant and other materials necessary to carry out the work complete in all respects.
- 7.6.2.6 The Contractor shall supply all rivets, bolts, nuts, washers, etc., required to complete erection at site with an allowance for wastage, etc., of 12½ percent of the net number of field rivets, bolts, washers required, or a minimum of five number of each item.
- 7.6.2.7 Service bolts and nuts, ordinary platters, washers and drifts for use in the erection of work shall be supplied at 60 percent (45 per cent bolts and 15 per cent drifts) of the

number of field rivets per span in each size (this includes wastage). A reduction in the quantities of service bolts, etc., may however, be specified by the Employer if more than one span of each type is ordered.

- 7.6.2.8 Prior to actual commencement of erection all equipment, machinery, tools, tackles, ropes, etc., need to be tested to ensure their efficient working. Frequent visual inspection is essential in vulnerable area to detect displacements, distress, drainages, etc.
- 7.6.2.9 Deflection and vibratory tests shall be conducted in respect of supporting structures, launching truss as also the structure under erection and unusual observations reviewed; looseness of fittings are to be noted.
- 7.6.2.10 For welded structures, welders' qualifications and skill are to be checked as per standard norms. Non-destructive tests of joints as per designer's directives are to be carried out.
- 7.6.2.11 Precision non-destructive testing instruments available in the market should be used for noting various important parameters of the structures frequently and systematic record is to be kept.
- 7.6.2.12 Safety requirements should conform to IS: 7205, IS: 7273 and IS: 7269 as applicable and should be a consideration of safety, economy and rapidity.
- 7.6.2.13 Erection work should start with complete resources mobilised as per latest approved Drawings and after a thorough survey of foundations and other related structural work. In case of work of magnitude, maximum mechanisation is to be adopted.
- 7.6.2.14 The structure should divided into erectable modules as per the scheme This should be pre-assembled in a suitable yard/platform and its matching with members of the adjacent module checked by trial assembly before erection.
- 7.6.2.15 The structure shall be set out to the required lines and levels. The stocks and masses are to be carefully preserved. The steelworks should be erected, adjusted and completed in the required position to the specified line and levels with sufficient drifts and bolts. Packing materials are to be available to maintain this condition. Organised "Quality Surveillance" checks need to be exercised frequently.
- 7.6.2.16 Before starting work, the Contractor shall obtain necessary approval of the Employer as to the method adopted for erection, the number and character of tools and plants. The approval of the Employer shall not relieve the Contractor of his responsibility for the safety of his method or equipment or from carrying out the work fully in accordance with the Drawings and Specifications.
- 7.6.2.17 During the progress of work, the Contractor shall have a competent Employer or foreman in charge of the work, who shall be adequately experienced in steel erection and acceptable to the Employer.

### 7.6.3 Handling and Storing of Materials

- 7.6.3.1 Suitable area for storage of structures and components shall be located near the site of work. The access road should be free from water logging during working period and the storage area should be on leveled and firm ground.
- 7.6.3.2 The store should be provided with adequate handling equipment e.g., road mobile crane, gantries, derricks, chain pulley blocks, winch of capacity as required. Stacking area should be planned and have racks, stands sleeper, access tracks, etc., and properly lighted.
- 7.6.3.3 Storage should be planned to suit erection work sequence and avoid damage or distortion. Excessively rusted, bent or damaged steel shall be rejected. Methods of storage and handling steel, whether fabricated or not shall be subject to the approval of the Employer.
- 7.6.3.4 Fabricated materials are to be stored with erection marks visible such as not to come into contact with earth surface or water and should be accessible to handling equipment.
- 7.6.3.5 Small fitting hand tools are to be kept in containers in covered stores.
- 7.6.3.6 All materials, consumable, including raw steel or fabricated material shall be stored Specification-wise and size-wise above the ground upon platforms, skids or other supports. It shall be kept free from dirt and other foreign matter and shall be protected as far as possible from corrosion and distortion. The electrodes shall be stored Specification-wise and shall be kept in dry warm condition in properly designed racks. The bolts, nuts, washers and other fasteners shall be stored on racks above the ground with protective oil coating in gunny bags. The paint shall be stored under cover in air-tight containers.
- 7.6.3.7 IS: 7293 and IS: 7969 dealing with handling of materials and equipment for safe working should be followed. Safety nuts and bolts as directed are to be used while working. The Contractor shall be held responsible for loss or damage to any material paid for by the Department while in his care or for any damage to such material resulting from his work.

#### 7.6.4 Formwork

- 7.6.4.1 The formwork shall be properly designed, substantially built and maintained for all anticipated loads. The Contractor, if required, shall submit plans for approval to the Employer. Approval of the plans, however, shall not relieve the Contractor of his responsibility.

#### 7.6.5 Straightening Bent Material

- 7.6.5.1 The straightening of plates, angles and other shapes shall be done by methods not likely to produce fracture or any injury. The metal shall not be heated unless permitted by the Employer for special cases, when the heating shall not be to a temperature higher than that producing a dark “cherry red” colour, followed by as slow cooling as possible. Following the straightening of a bend or buckle the surface shall be carefully investigated for evidence of fracture. Sharp kinks and bends may



be the cause for rejection of material.

#### 7.6.6 Assembling Steel

- 7.6.6.1 The parts shall be accurately assembled as shown on the Drawings and match marks shall be followed. The material shall be carefully handled so that no parts will be bent, broken or otherwise damaged.
- 7.6.6.2 Hammering which will injure or distort the members shall not be done. Bearing surface or surfaces to be in permanent contact shall be cleaned, before the members are assembled. The truss spans shall be erected on blocking, so placed as to give the proper camber. The blocking shall be left in place until the tendon chord splices are fully riveted and all other truss connections pinned and bolted. Rivets in splices of butt joints of compression members and rivets in railings shall not be driven until the span has been swung.
- 7.6.6.3 All joint surface for bolted connections including bolts, nuts, washers shall be free from scale, dirt, burrs, other foreign materials and defects that would prevent solid seating of parts. The slope of surface of bolted parts in contact with bolt head and nut shall not exceed 1 in 20, plane normal to bolt axis, otherwise suitable tapered washer shall be used.
- 7.6.6.4 All fasteners shall have a washer under nut or bolt head whichever is turned in tightening.
- 7.6.6.5 Any connection to be riveted or bolted shall be secured in close contact with service bolts or with a sufficient number of permanent bolts before the rivets are driven or before the connections are finally bolted. Joints shall normally be made by filling not less than 50 per cent of holes with service bolts and barrel drifts in the ratio 4:1. The service bolts are to be fully tightened up as soon as the joint is assembled. Connections to be made by close tolerance or barrel bolts shall be completed as soon as practicable after assembly.
- 7.6.6.6 Any connection to be site welded shall be securely held in position by approved methods to ensure accurate alignment, camber and elevation before welding is commenced.
- 7.6.6.7 The field riveting, welding, bolted and pin connection shall conform to the requirements of **Clause 7.5** as appropriate.
- 7.6.6.8 The correction of minor misfits involving harmless amounts of reaming, cutting and chipping will be considered a legitimate part of erection. However, any error in the shop fabrication or deformation resulting from handling and transportation which prevents proper assembling and fitting up of parts by moderate use of drifts or by a moderate amount of reaming and slight chipping or cutting shall be reported immediately to the Employer and his approval of the method of correction obtained. The correction shall be made in the presence of the Employer.

#### 7.6.7 Field Inspection

#### 7.6.7.1 General

All materials, equipment and work of erection shall be subject to the inspection of the Employer who shall be provided with all facilities including labour and tools required at all reasonable times. Any work found defective is liable to be rejected.

7.6.7.2 No protective treatment shall be applied to the work until the appropriate inspection and testing has been carried out. The stage inspection shall be carried out for all operations so as to ensure the correctness of fabrication and good quality. Girder dimensions and camber shall not be finally checked until all welding and heating operations are completed and the member has cooled to a uniform temperature.

7.6.7.3 Testing of material: Structural steel shall be tested for mechanical and chemical properties as per various IS codes as may be applicable and shall conform to requirements specified in IS: 226, IS: 2062, IS: 11587, IS: 1977, IS: 8500 and IS: 961 etc.,

1. Rivets, bolts, nuts, washers, welding consumable, steel forging, casting and stainless steel shall be tested for mechanical and chemical properties in the appropriate IS Code.
2. Rolling and cutting tolerance shall be as per IS: 1852. The thickness tolerance check measurements for the plate and rolled sections shall be taken at not less than 15 mm from edge.
3. Laminations in plates shall be carried out by ultra-sonic testing or any other specified methods.
4. Steel work shall be inspected for surface defects and exposed edge laminations during fabrication and blast cleaning. Significant edge laminations found shall be reported to the Employer for his decision.
5. Chipping, grinding, machining or ultrasonic testing shall be used to determine depth of imperfection.

#### 7.6.7.4 Bolted connections

1. Bolts and bolted connection joints with high strength friction grip bolts shall be inspected and tested according to IS: 4000.
2. Rivets and riveted connection shall be inspected and tested for compliance of Codal requirements.
3. The firmness of joint shall be checked by 0.2 mm filler gauge, which shall not go inside under the rivet head by more than 3 mm. There shall not be any gap between members to be riveted.
4. Driven rivets shall be checked with rivet testing hammer. When struck sharply on head with rivet testing hammer, rivet shall be free from movement and vibration.
5. All loose rivets and rivets with cracks, badly formed or different heads or with heads which are eccentric with shanks, shall be cut out and replaced.
6. The alignment of plates at all bolted splice joints and welded butt joints shall be checked for compliance with Codal requirements.
7. Testing of flame cut and sheared edges is to be done, where the hardness criteria given in the code are adopted. Hardness testing shall be carried out on six specimens.

#### 7.6.7.5 Welding and welding consumable

1. Welding procedure, welded connection and testing shall be in compliance with Codal requirements.
2. All facilities necessary for stage inspection during welding and on completion shall be provided to the Employer or their inspecting Authority by manufacturer.
3. Adequate means of identification either by identification mark or other record shall be provided to enable each weld to be traced to the welder(s) by whom it was carried out.
4. All metal arc welding shall be in compliance with IS: 9595 provisions.
5. The method of inspection shall be in accordance with IS: 822 and extent of inspection and testing shall be in accordance with the relevant standards or in the absence of such a standards, as agreed with the Employer.
6. Procedure tests: The Destructive and Non-Destructive test of weld shall be carried out according to IS: 7307 (Part I).
7. The particular length of welds in webs to be tested shall be agreed with the Employer, in case of (2) or (3).
8. Where specified by the Employer, bearing stiffeners or bearing diaphragms adjacent to welds, flange plates adjacent to web/flange welds, plates at cruciform welds, plates in box girder construction adjacent to corner welds or other details shall be ultrasonically tested after fabrication.
9. Any lamination, lamellar tearing or other defect found shall be recorded and reported to Employer for his decision.
10. Testing or Welding for Cast Steel: The testing of weld for cast steel shall be carried out as may be agreed to by the Employer.
11. Stud Shear Connectors: Stud shear connectors shall be subjected to the following tests:
12. The fixing of studs after being welded in position shall be tested by striking the side of the head of the stud with a 2 kg hammer to the satisfaction of the Employer.
13. The selected stud head stroked with 6 kg hammer shall be capable of lateral displacement of approximately 0.25 the height of the stud from its original position. The stud weld shall not show any sign of crack or lack of fusion.
14. The studs whose welds have failed the tests given in (1) and (2) shall be replaced.

#### 7.6.7.6 Inspection requirement

1. The fabricated member/component made out of rolled and build-up section shall be checked for compliance of the tolerances given in Table 1900-2. Inspection of member/components for compliance with tolerances, and the check for deviations shall be made over the full length.
2. During checking, the inspection requirement shall be placed in such a manner that local surface irregularities do not influence the results.
3. For plate, out-of-plane deviation shall be checked at right angle to the surface over the full area of plate.

4. The relative cross-girder or cross frame deviation shall be checked over the middle third of length of the cross girder or frame between each pair of webs and for cantilever at the end of member.
5. The web of rolled beam or channel section shall be checked for out-of-plane deviation in longitudinal direction equal to the depth of the section.
6. During inspection, the component/member shall not have any load or external restraint.
7. Inspection Stages: The inspection to be carried out for compliance of tolerances shall include but not be limited to the following stages:
  - For completed parts, component/members on completion of fabrication and before any subsequent operation such as surface preparation, painting, transportation, erection.
  - For webs of plate and box girder, longitudinal compression flange stiffeners in box girders and orthotropic decks and all web stiffeners at site joints, on completion of site joint
  - For cross girders and frames, cantilevers in orthotropic decks and other parts in which deviations have apparently increased on completion of site assembly.
8. Where on checking member/component for the deviations in respect of out-of-plane or out-of-straightness at right angles to the plate surface, and any other instances, exceed tolerance, the maximum deviation shall be measured and recorded. The recorded measurements shall be submitted to the Employer who will determine whether the component/member may be accepted without rectification, with rectification or rejected.

## **8 STRUCTURAL COCRETE AND MORTAR**

### **8.1 Controlled Concrete**

- 8.1.1 All concrete in the works shall be "Controlled Concrete" as defined in IS: 456, unless it is a nominal mix concrete such as 1:3:6, 1:4:8 or 1:5:10. Whether reinforced or otherwise, all controlled concrete works to be carried out under this Specification shall be divided into the following classification:
- 8.1.2 Minimum compressive strength of 15 cm. Cubes at 7 and 28 days after mixing, conducted in accordance with BIS and CPWD specifications.
- 8.1.3 Minimum cement content, minimum water- cement ratio and minimum grade of concrete for different exposures with normal weight aggregates of 20 mm nominal maximum size shall be as per IS 456/ CPWD Specifications.

### **8.2 Mix Design**

- 8.2.1 This is to investigate the grading of aggregates, water cement ratio, workability and the quantity of cement required to give preliminary and works cubes of the minimum strength specified. The proportions of the mix shall be determined by weight. Adjustment of aggregate proportions due to moisture present in the aggregate shall be made. Mix proportioning shall be based on the principles given in IS: 456-2000 and SP: 23-1982 "Handbook for Design Mix Concrete."
- 8.2.2 Whenever there is a change either in required strength of concrete, or water-cement ratio or workability or the source of aggregates and / or cement, preliminary tests shall be repeated to determine the revised proportions of the mix to suit the altered conditions. While designing mix proportions, over-wet mixes shall always be avoided.
- 8.2.3 While fixing the value for water / cement ratio for preliminary mixes, assistance may be derived from the graph (Appendix A IS: 456) showing the relationship between the 28-day compressive strengths of concrete mixes with different water / cement ratios and the 7 day compressive strength of cement tested in accordance with IS: 269.
- 8.2.4 Preliminary tests
  - 8.2.4.1 Tests specimens shall be prepared with at least two different water / cement ratios for each class of concrete, consistent with workability required for the nature of the work. The materials and proportions used in making preliminary tests shall be similar in all respects to those, to be actually employed in the works as the object of these tests is to determine the proportions of cement, aggregates and water necessary to produce concrete of required consistency and to give the specified strength. It will be Contractor's sole responsibility to carry out statement of proportions proposed to be used for the various concrete mixes. For preliminary tests, the following procedure shall be followed:

- 8.2.4.2 Materials shall be brought to the room temperature and all materials shall be in a dry condition. The quantities of water, cement and aggregates for each batch shall be determined by weight to an accuracy of 1 part in 1000 parts.

#### 8.2.5 Mixing Concrete

- 8.2.5.1 For all works, concrete shall be mixed in a mechanical mixer which along with other accessories shall be kept in first class working condition and so maintained throughout the construction. Mixing shall be continued till materials are uniformly distributed and a uniform colour of entire mass is obtained and each individual particle of the coarse aggregate shows a complete coating of mortar containing its proportionate amount of cement. In no case, the mixing be done for a period of not less than two minutes after all ingredients have been put into the mixer. In case of hand mixing, quantity of cement shall be increased by 10% above that specified in Clause 8.6.1, the cost of increased cement quantity being borne by the Contractor. Hand mixing shall be permitted only under exceptional conditions and the Contractor must take the permission of the Employer in advance. Mixers which have been out of use for more than 30 minutes shall be thoroughly cleaned before putting a new batch. Unless otherwise agreed by the Employer, the first batch of concrete from the mixer shall contain only two thirds of the normal quantity of coarse aggregate. The mixing plant shall be thoroughly cleaned before changing from one type of cement to another.

#### 8.2.6 Consistency

- 8.2.6.1 The consistency of each batch of concrete shall be measured immediately after mixing, by the slump test, care should be taken to ensure that no water or other material is lost, the material used for the slump test may be remixed with the remainder of the concrete for making the specimen test cubes. the period of re-mixing shall be as short as possible yet sufficient to produce a homogeneous mass.

#### 8.2.7 Size of Test Cubes

- 8.2.7.1 Compression tests of concrete cubes shall be made as per IS: 516 on 15 cm cubes. Each mould shall be provided with a metal base plate having no leakage. The base plate shall be preferably attached to the mould when assembled and shall be positively and rigidly held together. Before placing concrete, the mould and base plate shall be cleaned and oiled. The dimensions and internal faces of the mould shall be accurate within the following limits:

1. Height and distance between the opposite faces of the mould shall be of specified size  $\pm 0.2$  mm. The angle between the adjacent internal faces and between internal faces and top and bottom planes of mould shall be  $90^\circ \pm 0.5^\circ$ . The interior faces of the mould shall be plane surfaces with a permissible variation of 0.03 mm.

#### 8.2.8 Compacting

- 8.2.8.1 Concrete tests cubes shall be moulded by placing fresh concrete in the mould and

compacted as specified in IS: 516.

#### 8.2.9 Curing

- 8.2.9.1 Curing shall be as specified in IS: 516. The cubes shall be kept in moist air of at least 90% relative humidity at a temperature of  $27^{\circ}\text{C} \pm 2^{\circ}\text{C}$  for 2 hours  $\pm$  1/2 hr. from the time of adding water to the dry ingredients. Thereafter in clean, fresh water and kept at  $27^{\circ} \pm 2^{\circ}\text{C}$  temperature until seven days. A record of maximum and minimum temperatures at the places of storage of the cubes shall be maintained during the period they remain in storage.

#### 8.2.10 Testing of Specimens

- 8.2.10.1 The strength shall be determined based on not less than five cube test specimens for each age and each water cement ratio. All these laboratory test results shall be tabulated and furnished to Employer. The test results shall be accepted by Employer if the average compressive strengths of the specimens tested is not less than the compressive strength specified for the age at which specimens are tested, subject to the condition that only one out of the five consecutive tests may give a value less than the specified strength for that age. Employer may direct Contractor to repeat the tests if the results are not satisfactory and also to make such changes as he considers necessary to meet the requirements specified. All these preliminary tests shall be conducted by Contractor at his own cost in an approved laboratory.

### 8.3 Proportioning, Consistency, Batching and Mixing of Concrete

#### 8.3.1 Proportioning

##### 8.3.1.1 Aggregate

The proportions which shall be decided by conducting preliminary tests shall be by weight. These proportions of cement, fine and coarse aggregates shall be maintained during subsequent concrete batching by means of weigh batchers conforming to IS: 2722 capable of controlling the weights within one percent of the desired value. Except where it can be shown to the satisfaction of Employer that supply of properly graded aggregate of uniform quality can be maintained over the period of work, the grading of aggregate shall be controlled by obtaining the coarse aggregate in different sizes and blending them in the right proportions. The different sizes shall be stocked in separate stock piles. The grading of coarse and fine aggregate shall be checked as frequently as possible, as determined by Employer, to ensure maintaining of grading in accordance with the sample used in preliminary mix design. The material shall be stock piled well in advance of use.

##### 8.3.1.2 Cement

The cement shall be measured by weight.

##### 8.3.1.3 Water

Only such quantity of water shall be added to the cement and aggregates in the

concrete mix as to ensure dense concrete, specified surface finish, satisfactory workability, consistent with the strength stipulated for each class of concrete. The water added to the mix shall be such as not to cause segregation of material or the collection of excessive free water on the surface of the concrete.

#### 8.3.1.4 Definition of Water / Cement Ratio.

The water cement (W/C) ratio is defined as the weight of water in the mix (including the surface moisture of the aggregates) divided by the weight of cement in the mix.

#### 8.3.1.5 Water / Cement Ratio

The actual water cement ratio to be adopted shall be determined in each instance by Contractor and approved by Employer.

#### 8.3.1.6 Proportioning by Water / Cement Ratio

The W/C ratio specified for use by Employer shall be maintained. Contractor shall determine the water content of the aggregates as frequently as directed by Employer In- Charge as the work progresses and as specified in IS: 2386 (part III) and the amount of mixing water added at the mixer shall be adjusted as directed by Employer so as to maintain the specified by W/C ratio. To allow for the variation in weight of aggregates due to variation in their moisture content, suitable adjustments in the weights of aggregates shall also be made.

### 8.3.2 Consistency and slump

- 8.3.2.1 Concrete shall be of a consistency and workability suitable for the condition of the job. After the amount of water required is determined, the consistency of the mix shall be maintained throughout the progress of the corresponding parts. Compacting factor tests, in accordance with IS: 1199, shall be conducted from time to time to ensure the maintenance of such consistency.

### 8.3.3 Batching and mixing of concrete

- 8.3.3.1 The materials and proportions of concrete materials as established by the preliminary tests for the mix design shall be rigidly followed for all concrete on the project and shall not be changed except when specifically permitted by Employer.
- 8.3.3.2 Concrete shall be produced only by weigh batching the ingredients. The mixer and weigh batchers shall be maintained in clean, serviceable condition. The accuracy of weigh batchers shall be periodically checked. They shall be set up level on a firm base and the hopper shall be loaded evenly. The needle shall be adjusted to zero when the hopper is empty. Fine and coarse aggregates shall be weighed separately. Volume batching will not be permitted. However, Employer In- Charge may permit volume batching by subsequent conversion of the weights of important pours involving concrete of not more than 0.25 cubic metres, on days when other pours involving weigh batching are not likely to be taken up. Concrete shall be of strength stipulated in the respective items. All concrete shall be mixed in mechanically operated batch mixers complying with IS: 1791 and of approved make with suitable



provision for correctly controlling the water delivered to the drum.

8.3.3.3 The quantity of water actually entering the drum shall be checked with the reading of the gauge or valve setting, when starting a job. The test should be made while the mixer is running. The volume of the mixed material shall not exceed the manufacturer's rated mixer capacity. The batch shall be charged into the mixer so that some water will enter the drum in advance of cement and aggregates. All water shall be in the drum by the end of the first 15 seconds of the specified mixing time. Each batch shall be mixed until the concrete is uniform in colour, for a minimum period of two minutes after all the materials and water are in the drum. The entire contents of the drum shall be discharged in one operation before the raw materials for the succeeding batches are fed into the drum.

8.3.3.4 Each time the work stops, the mixer shall be cleaned out and when next commencing the mixing, the first batch shall have 10% additional cement to allow for sticking in the drum.

#### 8.3.4 Sampling and testing concrete in the field

##### 8.3.4.1 Consistency:

Slump tests shall be carried out as often as demanded by Employer and invariably from the same of concrete from which the test cubes are made. Slump tests shall be done immediately after sampling.

##### 8.3.5 Admixtures:

8.3.5.1 Admixtures may be used in concrete only with the approval of Employer based upon evidence that, with the passage of time, neither the compressive strength nor its durability will reduce. Calcium chloride shall not be used for accelerating set of the cement for any concrete containing reinforcement, or embedded steel parts. When calcium chloride is permitted to be used, such as in mass concrete works, it shall be dissolved in water and added to the mixing water in an amount not to exceed 1½ percent of the weight of the cement in each batch of concrete. When admixtures are used, the designed concrete mix shall be corrected accordingly. Admixtures shall be used as per manufacturer's instructions and in the manner and with the control specified by Employer.

##### 8.3.5.2 Air entraining agents:

Where specified and approved by Employer, neutralized vinsol resin or any other approved air entraining agent may be used to produce the specified amount of air in the concrete mix and these agents shall conform to the requirements of ASTM standard 6-260; Air Entraining Admixtures for Concrete. The recommended total air content of the concrete is 4% ± 1%. The method of measuring air content shall be as per IS: 1199.

##### 8.3.5.3 Water reducing admixtures:

Where specified and approved by Employer water reducing lignosulfonate mixture

shall be added in quantities specified by Employer. The admixtures shall be added in the form of a solution.

8.3.5.4 Retarding admixtures:

Where specified and approval by Employer, retarding agents shall be added to the concrete mix in quantities specified by Employer.

8.3.5.5 Water proofing agent:

Where specified and approved by Employer, water proofing agent conforming to IS: 2645, shall be added in quantities specified by Employer.

8.3.5.6 Other admixtures:

Employer may at his discretion instruct Contractor to use any other admixture in the concrete.

8.3.6 Optional Tests

8.3.6.1 Employer, if he so desires, may order tests to be carried out on cement, sand, coarse aggregate, water in accordance with the relevant Indian Standards.

8.3.6.2 Tests on cement shall include:

1. Fineness test
2. Test for normal consistency
3. Test for setting time
4. Test for soundness
5. Test for tensile strength
6. Test for compressive strength
7. Test for heat of hydration (by experiment and by calculations) in accordance with IS: 269.

8.3.6.3 Tests on sand shall include:

1. Sieve test
2. Test for organic impurities
3. Decantation test for determining clay and silt content
4. Specific gravity test
5. Test for unit weight and bulkage factor
6. Test for sieve analysis and fineness modulus.

8.3.6.4 Tests on coarse aggregate shall include

1. Sieve analysis
2. Specific gravity and unit weight of dry, loose and rodded aggregate
3. Soundness and alkali aggregate reactivity
4. Petrographic examination
5. Deleterious materials and organic impurities

6. Test for aggregate crushing value.

8.3.6.5 Any or all these tests would normally be ordered to be carried out only if Employer In- Charge feels the materials are not in accordance with the Specifications or if the specified concrete strengths are not obtained and shall be performed by Contractor at an approved test laboratory. If the tests are successful, owner shall pay for all such optional tests otherwise Contractor shall have to pay for them.

8.3.6.6 If the works cubes do not give the stipulated strengths, Employer reserves the right to ask Contractor to dismantle such portions of the work, which in his opinion are unacceptable and re-do the work to the standard stipulated, at Contractor's cost. The unit rate for concrete shall be all inclusive, including making preliminary mix design and test cubes, works, cubes, testing them as per Specification, slump tests, optional tests, etc. complete.

8.3.6.7 Load test on members or any other tests:

In the event of any work being suspected of faulty material or workmanship or both, Employer requiring its removal and reconstruction may order, or Contractor may request that it should be load tested in accordance with the following provisions:

1. The test load shall be 125 percent of the maximum super- imposed load for which the structure was designed. Such test load shall not be applied before 56 days after the effective hardening of concrete. During the test, struts strong enough to take the whole load shall be placed in position leaving a gap under the members. The test load shall be maintained for 2 hours before removal.
2. If within 24 hours of the removal of the load, the structure does not show a recovery of at least 75 percent of the maximum deflection shown during the 24 hours under load, the test loading shall be repeated after a lapse of at least 72 hours. The structure shall be considered to have failed to pass the test if the recovery after the second test is not at least 75 percent of the maximum deflection shown during the second test. If the structure is certified as failed by the Employer, the cost of the load test shall be borne by the Contractor.
3. Any other tests, e.g. taking out in an approved manner concrete cores, examination and tests on such cores removed from such parts of the structure as directed by Employer In- Charge, sonic testing etc. shall be carried out by Contractor if so directed.

Unsatisfactory tests:

1. Should the results of any test prove unsatisfactory, or the structure shows signs of weakness, undue deflection or faulty construction Contractor shall remove and rebuild the member or members involved or carry out such other remedial measures as may be required by Employer / Owner. Contractor shall bear the cost of so doing, unless the failure of the member or members to fulfill the test conditions is proved to be solely due to faulty design. The cost of load and other tests shall be borne by Contractor if the tests show unsatisfactory results; otherwise such costs will be borne by Owner.

### 8.3.7 Concrete in alkali soils and alkaline water:

- 8.3.7.1 Where concrete is liable to attack from alkali salts or alkaline water, special cements containing low amount of tricalcium aluminate shall be used, if so specified on the Drawings. Such concrete shall have a minimum 28 days compressive strength of 250 kg/cm<sup>2</sup> and shall contain not less than 370 Kg of cement per cubic metre of concrete. If specified, additional protection shall be obtained by the use of a chemically resistant stone facing or a layer of Plaster of Paris covered with suitable fabric, such as jute, thoroughly impregnated with tar.

### 8.3.8 Preparation prior to concrete placement, final inspection and approval

- 8.3.8.1 Before the concrete is actually placed in position, the insides of the formwork shall be inspected to see that they have been cleaned and oiled. Temporary openings shall be provided to facilitate inspection, especially at bottom of columns and wall forms, to permit removal of saw dust, wood shavings, binding wire, rubbish, dirt etc. Openings shall be placed or holes drilled so that these materials and water can be removed easily. Such openings / holes shall be later suitably plugged.
- 8.3.8.2 The various traders shall be permitted ample time to install drainage and plumbing lines, floor and trench drains, conduits, hangers, anchors, inserts, sleeves, bolts, frames and other miscellaneous embedments to be cast in the concrete as indicated on the Drawings or as is necessary for the proper execution of the work. Contractor shall cooperate fully with all such agencies, and shall permit the use of scaffolding, formwork etc. by other trades at no extra cost.
- 8.3.8.3 All embedded parts, inserts etc. supplied by Owner or Contractor shall be correctly positioned and securely held in the forms to prevent displacement during depositing and vibrating of concrete.
- 8.3.8.4 All anchor bolts shall be positioned and kept in place with the help of properly manufactured templates unless specifically waived in writing by Employer. The use of all such templates, fixtures etc. shall be deemed to be included in the rates. Slots, openings, holes, pockets etc. shall be provided in the concrete work in the positions indicated in the Drawings or as directed by Employer.
- 8.3.8.5 Reinforcement and other items to be cast in concrete shall have clean surfaces that will not impair bond.
- 8.3.8.6 Prior to concrete placement all work shall be inspected and approved by Employer and if found unsatisfactory, concrete shall not be poured until after all defects have been corrected at Contractor's cost.
- 8.3.8.7 Approval by Employer of any and all materials and work as required herein shall not relieve Contractor from his obligation to produce finished concrete in accordance with the Drawings and Specifications.

### 8.3.9 Rain or wash water:

8.3.9.1 No concrete shall be placed in wet weather or on a water covered surface. Any concrete that has been washed by heavy rains shall be entirely removed, if there is any sign of cement and sand having been washed away from the concrete mixture. To guard against damage which may be caused by rains, the works shall be covered with tarpaulins immediately after the concrete has been placed and compacted before leaving the work unattended. Any water accumulating on the surface of the newly placed concrete shall be removed by approved means and no further concrete shall be placed thereon until such water is removed. To avoid flow of water over / around freshly placed concrete, suitable drains & sumps shall be provided.

8.3.10 Bonding mortar:

8.3.10.1 Immediately before concrete placement begins, prepared surfaces except formwork, which will come in contact with the concrete to be placed, shall be covered with a bonding mortar.

8.3.11 Transportation:

8.3.11.1 All buckets, containers or conveyers used for transporting concrete shall be mortar-tight. Irrespective of the method of transportation adopted, concrete shall be delivered with the required consistency and plasticity without segregation or loss of slump. However, chutes shall not be used for transport of concrete without the written permission of Employer and concrete shall not be rehandled before placing.

8.3.12 Retempered or contaminated concrete:

8.3.12.1 Concrete must be placed in its final position before it becomes too stiff to work. On no account, water shall be added after the initial mixing. Concrete which has become stiff or has been contaminated with foreign materials shall be rejected and disposed off as directed by Employer.

8.3.12.2 Cleaning of equipment:

8.3.12.3 All equipment used for mixing, transporting and placing of concrete shall be maintained in clean condition. All pans, buckets, hoppers, chutes, pipelines and other equipment shall be thoroughly cleaned after each period of placement.

**8.4 Procedure for Placing of Concrete:**

8.4.1 Employer's approval of equipment & methods:

8.4.1.1 Before any concrete is placed, the entire placing programme, consisting of equipment, layout, proposed procedures and methods shall be submitted to Employer for approval if so demanded by Employer and no concrete shall be placed until Employer's approval has been received. Equipment for conveying concrete shall be of such size and design as to ensure a practically continuous flow of concrete during depositing, without segregation of materials, considering the size of the job and placement location.

#### 8.4.2 Time interval between mixing and placing

- 8.4.2.1 Concrete shall be placed in its final position before the cement reaches its initial set and concrete shall normally be compacted in its final position within thirty minutes of leaving the mixer, and once compacted it shall not be disturbed.

#### 8.4.3 Avoiding segregation

- 8.4.3.1 Concrete shall, in all cases, be deposited as nearly as practicable directly in its final position, and shall not be rehandled or caused to flow in a manner which will cause segregation, loss of materials, displacement of reinforcement, shuttering or embedded inserts or impair its strength. For locations where direct placement is not possible, and in narrow forms, Contractor shall provide suitable drop and "Elephant Trunks" to confine the movement of concrete.

- 8.4.3.2 Special care shall be taken when concrete is dropped from a height, especially if reinforcement is in the way, particularly in columns and thin walls.

#### 8.4.4 Placing by manual labour

- 8.4.4.1 Except when otherwise approved by Employer, concrete shall be placed in the shuttering by shovels or other approved implements and shall not be dropped from a height more than 1.0 M or handled in a manner which will cause segregation.

#### 8.4.5 Placing by mechanical equipment

- 8.4.5.1 The following Specification shall apply when placing of concrete by use of mechanical equipment is specifically called for while inviting bids or is warranted considering the nature of work involved.

- 8.4.5.2 The control of placing shall begin at the mixer discharge by a vertical drop into the middle of the bucket or hopper and this principle of a vertical discharge of concrete shall be adhered to throughout all stages of delivery until the concrete comes to rest in its final position.

#### 8.4.6 Type of Buckets.

- 8.4.6.1 Central-bottom-dump buckets of a type that provides for positive regulation of the amount and rate of deposition of concrete in all dumping position shall be employed.

#### 8.4.7 Operation of Bucket

- 8.4.7.1 Placing concrete in large open areas, the bucket shall be spotted directly over the position designated and then lowering for dumping. The open bucket shall clear the concrete already in place and the height of drop shall not exceed 1.00 M. The bucket shall be opened slowly to avoid high vertical bounce. Dumping of buckets on the swing or in any manner which results in separation of ingredients or disturbance of previously placed concrete will not be permitted.

#### 8.4.8 Placement in restricted forms

- 8.4.8.1 Concrete placed in restricted forms by barrows, buggies, short chutes and shoveling shall be subject to the requirement for vertical delivery of limited height to avoid segregation and shall be deposited as nearly as practicable in its final position.

#### 8.4.9 Chuting

- 8.4.9.1 Where it is necessary to use transfer chutes, specific approval of Employer must be obtained to type, length, slopes, baffles, vertical terminals and timing of operations. These shall be so arranged that an almost continuous flow of concrete is obtained at the discharge and without segregation. To allow for the loss of mortar against the sides of the chutes, the first mixes shall have less coarse aggregate. During cleaning of chutes, the waste water shall be kept clear of the forms. Concrete shall not be permitted to fall from the end of the chutes by more than 1.0 M. Chutes, when approved for use, shall have slopes not flatter than 1 vertical: 3 horizontal and not steeper than 1 vertical: 2 horizontal. Chutes shall be of metal or metal lined and of rounded cross section. The slopes of all chute sections shall be approximately the same. The discharge end of the chutes shall be maintained above the surface of the concrete in the forms.

#### 8.4.10 Placing by pumping / pneumatic placers

- 8.4.10.1 Concrete may be conveyed and placed by mechanically operated equipment e.g. pumps or pneumatic placers, only with the written permission necessary for conveying concrete by this method.
- 8.4.10.2 When pumping is adopted, before pumping of concrete is started, the pipeline shall be lubricated with one or two batches of mortar composed of one part cement and two parts sand. The concrete mix shall be specially designed to suit pumping. Care shall be taken to avoid stoppages in work once pumping has started.
- 8.4.10.3 When pneumatic placer is used, the manufacturer's advice on layout of pipeline shall be followed to avoid blockages and excessive wear. Restraint shall be provided at the discharge box to take care for the reaction at this end.
- 8.4.10.4 Manufacturer's advice shall be followed regarding concrete quality and all other related matters when pumping / pneumatic placing equipment are used.

#### 8.4.11 Concrete in layers

- 8.4.11.1 Concrete, once started, shall be continuous until the pour is completed. Concrete shall be placed in successive horizontal layers of uniform thickness ranging from 15 to 90 cm or as directed by Employer. These shall be placed as rapidly as practicable to prevent the formation of cold joints or planes of weakness between each succeeding layer within the pour. The thickness of each layer shall be such that it can be deposited before the previous layer has stiffened. The bucket loads or other units of deposit, shall be spotted progressively along the face of the layer with such overlap as will facilitate spreading the layer to uniform depth and texture with a minimum of shoveling. Any tendency to segregation shall be corrected by shoveling

stones. Such a condition shall be corrected by redesign of mix or other means, as directed by Employer.

#### 8.4.12 Bedding of layers

- 8.4.12.1 The top surface of each pour and Bedding planes shall be approximately horizontal unless otherwise instructed.

#### 8.4.13 Compaction

- 8.4.13.1 Concrete shall be compacted during placing, with approved vibrating equipment until the concrete has been consolidated to the maximum practicable density, is free of pockets of coarse aggregate fits tightly against all form surfaces, reinforcement and embedded fixtures. Particular care shall be taken to ensure that all concrete placed against the form faces and into corners of forms or against hardened concrete at joints is free from voids or cavities. The use of vibrators shall be consistent with the concrete mix and caution exercised not to over vibrate the concrete to the point that segregation results.

#### 8.4.14 Type of Vibrators

- 8.4.14.1 Vibrators shall conform to IS Specifications. Type of vibrator to be used shall depend on the structure where concrete is to be placed. Shutter vibrators to be effective, shall be firmly secured to the formwork which must be sufficiently rigid to the transmit the vibration and string enough not to be damaged by it. Immersion vibrators shall have "no load" frequency, on the size of the vibrator.
- 8.4.14.2 Immersion vibrators in sufficient numbers and each of adequate size shall be used to properly consolidate all concrete. Tapping or external vibrating of forms by hand tools or immersion vibrators will not be permitted.

#### 8.4.15 Use of Vibrators

- 8.4.15.1 The exact manner of application and the most suitable machines for the purpose must be carefully considered and operated by experienced men. Immersion vibrators shall be inserted vertically at points not more than 450 mm apart and withdrawn when air bubbles cease to come to the surface. Immersion vibrators shall be withdrawn very slowly. In no case shall immersion vibrators be used to transport concrete inside the forms. Particular attention shall be paid to vibration at the top of lift e.g. in a column or wall.

#### 8.4.16 Melding Successive Batches

- 8.4.16.1 When placing concrete in layers, which are advancing horizontally as the work progresses, great care shall be exercised to ensure adequate vibration, blending and melding of the concrete between the succeeding layers.

#### 8.4.17 Penetration of Vibrator

- 8.4.17.1 The immersion vibrator shall penetrate the layer being placed and also penetrate the



layer below while the underlayer is still plastic to ensure good bond and homogeneity between the two layers and prevent the formation of cold joints.

#### 8.4.18 Vibrating Against Reinforcement

- 8.4.18.1 Care shall be taken to prevent contact of immersion vibrators against reinforcement steel. Immersion vibrators shall not be allowed to come in contact with reinforcement steel after start of initial set. They shall also not be allowed to come in contact with forms or finished surfaces.

#### 8.4.19 Use of Form Attached Vibrators

- 8.4.19.1 Form attached vibrators shall be used only with specific authorization of Employer.

#### 8.4.20 Use of Surface Vibrators

- 8.4.20.1 The use of surface vibrators will not be permitted under normal conditions. However, for thin slabs, such as highways, runways and similar constructions, surface vibration by specially designed vibrators may be permitted, upon approval of Employer.

#### 8.4.21 Stone pockets and Mortar Pondages

- 8.4.21.1 The formation of stone pockets or mortar pondages in corners and against faces of forms shall not be permitted. Should these occur, they shall be dug out, reformed and refilled to sufficient depth and shape for through bonding, as directed by Employer.

#### 8.4.22 Placement interval

- 8.4.22.1 Except when placing with slip forms, each placement of concrete in multiple lift work, shall be allowed to set for atleast 24 hours after the final set of concrete and before the start of a subsequent placement.

#### 8.4.23 Special provision in placing

- 8.4.23.1 When placing concrete in walls with openings, in floors of integral slabs and beam construction and other similar conditions, the placing shall stop when the concrete reaches the top of the opening in walls or bottom horizontal surface of the slab, as the case may be. Placing shall be resumed before the concrete in place takes initial set, but not until it has had time to settle as determined by Employer In- Charge.

#### 8.4.24 Placing concrete through reinforcing steel

- 8.4.24.1 When placing concrete through reinforcing steel, care shall be taken to prevent segregation of the coarse aggregate. Where the congestion of steel makes placing difficult, it may be necessary to temporarily move the top aside to get proper placement and restore reinforcing steel to design position.

#### 8.4.25 Bleeding

- 8.4.25.1 Bleeding or free water on top of concrete being deposited into the forms, shall be a cause to stop the concrete pour and the conditions causing this defect corrected before any further concreting is resumed.

### 8.5 Construction Joints and Keys

- 8.5.1 Concrete shall be placed without interruption until completion of the part of the work between predetermined construction joints, as specified hereinafter. Time lapse between the pouring of adjoining units shall be as specified on the Drawings or as directed by Employer.
- 8.5.2 If stopping of concreting becomes unavoidable anywhere, a properly formed construction joint shall be made where the work is stopped. Joints shall be either vertical or horizontal, unless shown otherwise on Drawings. In case of an inclined or curved member, the joint shall be at right angles to the axis of the member. Vertical joints shall be formed against a stop board; horizontal joints shall be level and wherever possible, arranged so that the joint lines coincide with the architectural features of the finished work. Battens shall be nailed to the formwork to ensure a horizontal line and if directed, shall also be used to form a grooved joint. For tank walls and similar works joints shall be formed as per IS: 3370. Concrete that is in the process of setting shall not be disturbed or shaken by traffic either on the concrete itself or upon the shuttering. Horizontal and vertical construction joints and shear keys shall be located and shall conform to the requirements of the plans unless otherwise directed by Employer. Where not described, the joint shall be in accordance with the following:

#### 1. Column Joint

In a column, the joint shall be formed 75 mm below the lowest soffit of the beams including haunches if any. In flat slab construction, the joint shall be 75 mm below the soffit of column capital. At least 2 hours shall elapse after depositing concrete in columns, piers or walls, before depositing in beams, girders or slabs supported thereon.

#### 2. Beam and Slab Joints

Concrete in a beam shall be placed throughout without a joint but if the provision of a joint is unavoidable the joint shall be vertical and at the centre or within the middle third of the span unless otherwise shown on Drawings. Where a beam intersects a girder, the joints in the girder shall be offset by a distance equal to twice the width of the beam and additional reinforcement provided for shear. The joints shall be vertical throughout the full thickness of the concrete member. A joint in a slab shall be vertical and parallel to the principal reinforcement. Where it is unavoidably at the right angles to the principal reinforcement, the joint shall be vertical and at the middle of the span.

#### 3. Joints in Liquid Retaining Structures

Vertical construction joints in watertight construction will not be permitted unless indicated on the Drawings. Where a horizontal construction joint is required to resist water pressure, special care shall be taken in all phases of its construction to ensure maximum water-tightness.

#### 8.5.3 Dowels

- 8.5.3.1 Dowels for concrete work, not likely to be taken up in the near future, shall be wrapped in tar paper & burlap.

#### 8.5.4 Mass Foundations

- 8.5.4.1 Mass Foundations shall be poured in lifts not exceeding 1.5m. in height unless otherwise indicated on the Drawings or approved by Employer.

#### 8.5.5 Treatment of construction joints on resuming concreting

- 8.5.5.1 A drier mix shall be used for the top lift of horizontal pours to avoid laitance. All laitance and loose stones shall be thoroughly and carefully removed by wire brushing / hacking and surface washed.
- 8.5.5.2 Just before concreting is resumed, the roughened joint surface shall be thoroughly cleaned and loose matter removed and then treated with a thin layer of cement grout of proportion specified by Employer and worked well into the surface. The new concrete shall be well worked against the prepared face before the grout mortar sets. Special care shall be taken to obtain thorough compaction and to avoid segregation of the concrete along the joint plane.

### **8.6 Curing, Protecting, Repairing and Finishing**

#### 8.6.1 Curing

- 8.6.1.1 All concrete shall be cured by keeping it continuously damp for the period of time required for complete hydration and hardening to take place. Preference shall be given to the use of continuous sprays, or ponded water, continuously saturated covering of sacking, canvas, hessian or other absorbent materials, or approved effective curing compounds applied with spraying equipment capable of producing a smooth, even- textured coat. Extra precautions shall be exercised in curing concrete during cold and hot weather as outlined hereinafter. The quality of curing water shall be the same as the one used for mixing concrete.
- 8.6.1.2 Certain types of finish or preparation for overlaying concrete must be done at certain stages of the curing process and special treatment may be required for specific concrete surface finish.
- 8.6.1.3 Curing of concrete made of high alumina cement and supersulphated cement shall be carried out as directed by Employer.
- 8.6.1.4 Curing with water

Fresh concrete shall be kept continuously wet for a minimum period of 10 days from the date of placing of concrete, following a lapse of 12 to 14 hours after laying concrete. The curing of horizontal surfaces exposed to the drying winds shall however begin immediately after the concrete has hardened. Water shall be applied to unformed concrete surfaces within 1 hour after concrete has set. Water shall be applied to formed surfaces immediately upon removal of forms. Quantity of water applied shall be controlled so as to prevent erosion of freshly placed concrete.

8.6.1.5 Continuous Spraying:

Curing shall be assured by use of an ample water supply under pressure in pipes, with all necessary appliance of hose, sprinklers and spraying devices. Continuous fine mist spraying or sprinkling shall be used, unless otherwise specified or approved by Employer.

8.6.1.6 Alternate Curing Methods:

Whenever, in the judgment of Employer, it may be necessary to omit the continuous spray method, a covering of clean sand or other approved means such as wet gunny bags which will prevent loss of moisture from the concrete, may be used. No type of covering will be approved which would stain or damage the concrete during or after the curing period. Covering shall be kept continuously wet during the curing period.

8.6.1.7 For curing of concrete in pavements, side-walks, floors, flat roofs or other level surfaces, the ponding method of curing is preferred. The method of containing the ponded water shall be approved by Employer. Special attention shall be given to edges and corners of the slabs to ensure proper protection to these areas. The ponded areas shall be kept continuously filled with water during the curing period.

8.6.1.8 Curing Compounds:

Surface coating type curing compounds shall be used only by special permission of Employer. Curing compounds shall be liquid type white pigmented, conforming to U.S. Bureau of Reclamation Specification. No curing compound shall be used on surfaces where future blending with concrete, water or acid proof membrane, or painting is specified.

8.6.1.9 Curing Equipment:

All equipment and materials required for curing shall be on hand and ready for use before concrete is placed.

8.6.2 Protecting fresh concrete:

8.6.2.1 Fresh concrete shall be protected from the elements, from defacements and damage due to construction operations by leaving forms in place for an ample period as specified later in this Specification. Newly placed concrete shall be protected by approved means such as tarpaulins from rain, sun and winds. Steps as approved by Employer shall also be taken to protect immature concrete from damage by debris, excessive loading, vibration, abrasion or contact with other materials etc. that may

impair the strength and / or durability of the concrete. Workmen shall be warned against and prevented from disturbing green concrete during its setting period. If it is necessary that workmen enter the area of freshly placed concrete, Employer may require that bridges be placed over the area.

#### 8.6.3 Repair and replacement of unsatisfactory concrete

8.6.3.1 Immediately after the shuttering is removed, the surface of concrete shall be very carefully gone over and all defective areas called to the attention of Employer who may permit patching of the defective areas or also reject the concrete unit either partially or in its entirety. Rejected concrete shall be removed and replaced by Contractor at no additional expense to Owner.

8.6.3.2 Holes left by form bolts etc. shall be filled up and made good with mortar composed of one part of cement to one and half parts of sand passing 2.36 mm IS sieve after removing any loose stones adhering to the concrete. Mortar filling shall be struck off flush at the face of the concrete. Concrete surfaces shall be finished as described under the particular items of work.

8.6.3.3 Superficially honeycombed surfaces and rough patches shall be similarly made good immediately after removal of shuttering, in the presence of Employer and superficial water and air holes shall be filled in. The mortar shall be well worked into the surface with a wooden float. Excess water shall be avoided. Unless instructed otherwise by Employer, the surface of the exposed concrete placed against shuttering to remove fine or other irregularities, care being taken to avoid damaging the surface. Surface irregularities shall be removed by grinding.

8.6.3.4 If reinforcement is exposed or the honey combing occurs at vulnerable positions e.g. ends of beams or columns it may be necessary to cut out the member completely or in part and reconstruct. The decision of Employer shall be final in this regard.

8.6.3.5 If only patching is necessary, the defective concrete shall be cut out till solid concrete is reached (or to a minimum depth of 25 mm) the edges being cut perpendicular to the affected surface or with a small under cut if possible. Anchors, tees or dovetail slots shall be provided whenever necessary to attach the new concrete securely in place.

8.6.3.6 An area extending several centimeters beyond the edges and the surfaces of the prepared voids shall be saturated with water for 24 hours immediately before the patching material is placed.

##### 8.6.3.7 Use of Polymers:

The use of polymers for bonding fresh concrete used for repairs will be permitted upon written approval of Employer In- Charge. polymers shall be applied in strict accordance with the instruction of the manufacturer.

##### 8.6.3.8 Method of Repair:

Small size holes having surface dimensions about equal to the depth of the hole,

holes left after removal of form bolts, grout insert holes and slots cut for repair of cracks shall be repaired as follows:

1. The hole to be patched shall be roughened and thoroughly soaked with clean water until absorption stops. A 5 mm thick layer of grout of equal parts of cement and sand shall be well brushed into the surface to be patched followed immediately by the patching concrete which shall be well consolidated with a wooden float and left slightly proud of the surrounding surface. The concrete patch shall be built up in 10 mm thick layers. After an hour or more, depending upon weather conditions, it shall be worked off flush with a wooden float and a smooth finish obtained by wiping with hessian, a steel trowel shall be used for this purpose. The mix for patching shall be of the same materials and in the same proportions as that used in the concrete being repaired, although some reduction in the maximum size of the coarse aggregates may be necessary and the mix shall be kept as dry as possible.
2. Mortar filling by air pressure (guniting) shall be used for repair of areas too large and / or too shallow for patching with mortar. Patched surfaces shall be given a final treatment to match the colour and texture of the surrounding concrete. White cement shall be substituted for ordinary cement, if so directed by Employer, to match the shade of the patch with the original concrete.

#### 8.6.3.9 Curing of Patched Work

The patched area shall be covered immediately with an approved non-staining, water-saturated material such as gunny bags which shall be kept continuously wet and protected against sun and wind for a period of 24 hours. Thereafter, the patched area shall be kept wet continuously by a fine spray, or sprinkling for not less than 10 days.

#### 8.6.3.10 Approval by Employer:

All materials, procedures and operations used in the repair of concrete and also the finished repair work shall be subject to the approval of Employer. All fillings shall be tightly bonded to the concrete and shall be sound, free from shrinkage cracks after the fillings have been cured and dried.

#### 8.6.4 Finishing:

- 8.6.4.1 This Specification is intended to cover the treatment of concrete surfaces of all structures. Areas requiring special finish not covered by this Specification shall be clearly indicated on the Drawings and special Specifications shall be furnished.

#### 8.6.4.2 Finish for Formed Surfaces

1. The type of finish for formed concrete surfaces shall be as follows, unless otherwise specified by Employer.
2. For surfaces against which backfill or concrete is to be placed, no treatment is required except repair of defective areas.

3. For surfaces below grade which will receive waterproofing treatment, the concrete shall be free of surface irregularities which would interfere with proper application of the waterproofing material which is specified for use.
4. Unless specified, surfaces which will be exposed when the structure is in service shall receive no special finish, except repair of damaged or defective concrete, removal of fins and abrupt irregularities, filling of holes left by form ties and rods and clean up of loose or adhering debris.

8.6.4.3 Surfaces which will be exposed to the weather and which would normally be level, shall be sloped for drainage. Unless the Drawing specifies a horizontal surface or shows the slope required, the tops of narrow surfaces such as stair treads, walls, curbs and parapets shall be sloped across the width approximately 1 in 30. Broader surfaces such as walkways, roads, parking areas and platforms shall be sloped about 1 in 50. Surfaces that will be covered by backfill or concrete, subfloors to be covered with concrete topping, terrazzo or quarry tile, and similar surfaces shall be smooth screeded and leveled to produce even surfaces. Surface irregularities shall not exceed 6 mm. Surfaces which will not be covered by backfill, concrete or tile toppings such as outside decks, floors of galleries and sumps, parapets, gutters, sidewalks, floors & slabs, shall be consolidated, screeded and floated. Excess water & laitance shall be removed before final finishing. Floating may be done with hand or power tools and started as soon as the screeded surface has attained a stiffness to permit finishing operations and these shall be the minimum required to produce a surface uniform in texture and free from screen marks or other imperfections. Joints and edges shall be tooled as called for on the Drawings or as directed by Employer.

#### 8.6.4.4 Standard Finish for Exposed Concrete

1. Exposed concrete shall mean any concrete, other than floors or slabs, exposed to view upon completion of the job.
2. Unless otherwise specified on the Drawings, the standard finish for exposed concrete shall be a smooth finish.
3. A smooth finish shall be obtained with the use of lined or plywood forms having smooth and even surfaces and edges. Panels and form linings shall be of uniform size and be as large as practicable and installed with closed joints. Upon removal of forms the joint marks shall be smoothed off and all blemishes, projections, etc. removed leaving the surfaces reasonably smooth and unmarred.

#### 8.6.4.5 Integral Cement concrete Finish

When specified on the Drawings an integral cement concrete finish of specified thickness for floors and slabs shall be applied either monolithic or bonded, as specified on the Drawings, as per IS: 2571. The surface shall be compacted and then floated with a wood float or power floating machine. The surface shall be tested with a straight edge and any high and low spots eliminated. Floating or trowelling of the finish shall be permitted only after all surface water has evaporated. Dry

cement or a mixture of dry cement and sand shall not be sprinkled directly on the surface of the cement finish to absorb moisture or to stiffen the mix.

#### 8.6.4.6 Rubbed Finish

A rubbed finish shall be provided only on exposed concrete surfaces as specified on the Drawings. Upon removal of forms, all fins and other projections on the surfaces shall be carefully removed, offsets leveled and voids and / or damaged sections immediately saturated with water and repaired by filling with a concrete or mortar of the same composition as was used in the surface. The surfaces shall then be thoroughly wetted and rubbed with carborundum or other abrasive. Cement mortar may be used in the rubbing, but the finished surfaces shall not be brush coated with either cement or grout after rubbing. The finished surfaces shall present a uniform and smooth appearance.

#### 8.6.5 Protection

- 8.6.5.1 All concrete shall be protected against damage until final acceptance by Employer / Owner.

### 8.7 Formwork

- 8.7.1 The formwork shall consist of shores, bracings, sides of beams and columns, bottom of slabs including ties, anchors, hangers, inserts and shall be properly designed and planned for the work. False work shall be so constructed that vertical adjustments can be made to compensate for take up and settlements. Wedges may be used at the top or bottom of timber shores, but not at both ends, to facilitate vertical adjustment or dismantling of the formwork.

#### 8.7.2 Design of formwork

- 8.7.2.1 The design and Employering of the formwork as well as its construction shall be the responsibility of Contractor. If so instructed, the Drawings and / or calculations for the design of the formwork shall be submitted to Employer In- Charge for approval before proceeding with work, at no extra cost to Owner. Employer's approval shall not however relieve Contractor of the full responsibility for the design and construction of the formwork. The design shall take into account all the loads vertical as well as lateral, that the forms will be carrying including live and vibration loadings.

### 8.8 Foundation Bedding, Bonding and Jointing

- 8.8.1 All surfaces upon or against which concrete will be placed shall be suitably prepared by thoroughly cleaning, washing and dewatering, as may be indicated in the plans or as Employer, may direct, to meet the various situations encountered in the work.



- 8.8.2 Soft or spongy areas shall be cleaned out and back filled with either a soil-cement mixture, lean concrete or clean sand fill compacted to a minimum density of 90% Modified Proctor, unless otherwise mentioned in Schedule of Quantities.
- 8.8.3 Prior to construction of formwork for any item where soil will act as bottom form, approval shall be obtained from Employer as to the suitability of the soil.
- 8.8.4 Preparation of rock strata of foundations
  - 8.8.4.1 To provide tight bond with rock foundations, the rock surface shall be prepared and the following general requirements shall be observed.
  - 8.8.4.2 Concrete shall not be deposited on large sloping rock surfaces. Where required by Employer or as indicated on the plans, the rock shall be cut to form rough steps or benches to provide roughness or a more suitable bearing surface.
  - 8.8.4.3 Rock foundation stratum shall be prepared by picking, barring, wedging and similar methods which will leave the rock in an entirely sound and unshattered condition.
  - 8.8.4.4 Shortly before concrete is placed, the rock surface shall be cleaned with high pressure water and air jet even though it may have been previously cleaned in that manner.
  - 8.8.4.5 Prior to placing concrete, the rock surface shall be kept wet for a period of 2 to 4 hours unless otherwise directed by Employer.
  - 8.8.4.6 Before placing concrete on work surfaces all water shall be removed from depressions to permit thorough inspection and proper bonding of the concrete to the rock.
- 8.8.5 Preparation of earth strata of foundations
  - 8.8.5.1 All earth surfaces upon which or against which concrete is to be placed, shall be well compacted and free from standing water, mud or debris. Soft, yielding solid shall be removed and replaced with suitable earth well compacted as directed by Employer. Where specified, lean concrete shall be provided on the earth stratum for receiving concrete. The surface of absorptive soils against which concrete is to be placed shall be moistened thoroughly so that no moisture will be drawn from the freshly placed concrete and later shall help to cure the concrete.
- 8.8.6 Preparation of concrete surfaces
  - 8.8.6.1 The preparation of concrete surfaces upon which additional concrete is to be placed later, shall preferably be done by scarifying and cleaning while the concrete is between its initial and final set. This method shall be used wherever practicable and shall consist of cutting the surface with picks and stiff brooms and by use of an approved combination of air and water jet as directed by Employer. Great care shall be taken in performing this work to avoid removal of too much mortar and the weakening of the surface by loosening of aggregate.

8.8.6.2 When it is not practicable to follow the above method, it will be necessary to employ air tools to remove laitance and roughen the surface.

8.8.6.3 The final required result shall be a pitted surface from which all dirt, unsound concrete, laitance and glazed mortar have been removed.

#### 8.8.7 Bonding Treatment (Mortar)

8.8.7.1 After rock or concrete surfaces upon which new concrete is to be placed have been scarified, cleaned and wetted as specified herein, they shall receive a bonding treatment, immediately before placement of the concrete.

8.8.7.2 The bonding medium shall be a coat of cement-sand mortar. The mortar shall have the same cement-sand proportions as the concrete which shall be placed on it. The water-cement ratio shall be determined by placing conditions and as approved by Employer.

8.8.7.3 Bonding mortar shall be placed in sufficient quantity to completely cover the surface about 10 mm thick for rock surface and about 5 mm thick for concrete surfaces. It shall be brushed or broomed over the surface and worked thoroughly into all cracks, crevices and depressions. Accumulations or puddles of mortar shall not be allowed to settle in depressions and shall be brushed out to a satisfactory degree, as determined by Employer.

8.8.7.4 Mortar shall be placed at such a rate that it can be brushed over the surface just in advance of placement of concrete. Only as much area shall be covered with mortar as can be covered with concrete before initial set in the mortar takes place. The amount of mortar that will be permitted to be placed at any one time, on the area which it is to cover, shall be in accordance with Employer's directions.

#### 8.8.8 Cleaning and bonding formed construction joints

8.8.8.1 Vertical construction joints shall be cleaned as specified above or by other methods approved by Employer. In placing concrete against formed construction joints, the surface of the joints, where accessible, shall be coated thoroughly with the specified bed-joint bonding mortar immediately before they are covered with concrete or by scrubbing with wire brooms dipped into the fresh concrete. Where it is impracticable to apply such a mortar coating, special precautions shall be taken to ensure that the new concrete is brought into intimate contact with the surface of the joint by careful puddling and spading with aid of vibrators and suitable tools.

#### 8.8.9 Expansion and contraction joints

8.8.9.1 Provision shall be made for expansion and contraction in concrete by use of special type joints at locations shown on the Drawing. Contraction joint surfaces shall be treated as per the Specifications on the Drawings or as directed by Employer.

#### 8.8.10 Hot weather requirement

8.8.10.1 All concrete work performed in hot weather shall be in accordance with IS: 456

except as herein modified.

- 8.8.10.2 Admixtures may be used only when approved by Employer.
- 8.8.10.3 Adequate provisions shall be made to lower concrete temperatures by cool ingredients, eliminating excessive mixing, preventing exposure of mixers and conveyors to direct sunlight and the use of reflective paints on mixers, etc. The temperature of the freshly placed concrete shall not be permitted to exceed 38°C.
- 8.8.10.4 Consideration shall be given to shading aggregate stockpiles from direct rays of the sun and spraying stockpiles with water, use of cold water when available, and burying, insulating, shading and / or painting white the pipe lines and water storage tanks and conveyances.
- 8.8.10.5 In order to reduce loss of mixing water, the aggregates, wooded forms, subgrade, adjacent concrete and other moisture absorbing surfaces shall be well wetted prior to concreting. Placement and finishing shall be done as quickly as possible.
- 8.8.10.6 Extra precautions shall be taken for the protection and curing of concrete. Consideration shall be given to continuous water curing and protection against high temperatures and drying hot winds for a period of at least 7 days immediately after concrete has set and after which normal curing procedures may be resumed.

## **8.9 Placing Concrete Underwater**

- 8.9.1 Under all ordinary conditions all foundations shall be completely dewatered and concrete placed in the dry. However, when concrete placement under water is necessary, all work shall conform to IS: 456 and the procedure shall be as described in the following paragraphs:
  - 8.9.2 Method of placement
    - 8.9.2.1 Concrete shall be deposited underwater by means of tremies, or drop bottom buckets of approved type.
  - 8.9.3 Direction, Inspection and Approved
    - 8.9.3.1 All work requiring placement of concrete underwater shall be designed, directed and inspected with due regard to local circumstances and purposes. All underwater concrete shall be placed according to the plans or Specifications and as directed and approved by Employer.

## **8.10 Precast Concrete**

- 8.10.1 Precast concrete shall comply with IS: 456 and with the following requirements:
  - 8.10.1.1 All precast units shall be cast on a suitable bed or platform with firm foundation and free from wind.
  - 8.10.1.2 Contractor shall be responsible for the accuracy of the level or shape of the bed or platform. A suitable serial number and the date of casting shall be impressed or painted on each unit.

### 8.10.2 Striking forms

- 8.10.2.1 Side shutters shall not be struck in less than 24 hours after depositing concrete and no precast unit shall be lifted until the concrete reaches a strength of at least twice the stress to which the concrete may be subjected to at the time of lifting.

### 8.10.3 Precast units

- 8.10.3.1 The lifting and removal of precast units shall be undertaken without causing shock, vibration or undue bending. Contractor shall satisfy Employer or his representative that the methods proposed to adopt for these operations will not over-stress or otherwise effect seriously the strength of the precast units. The reinforced side of the units shall be distinctly marked.

### 8.10.4 Curing

- 8.10.4.1 All precast work shall be protected from the direct rays of the sun for at least 7 days after casting and during that period each unit shall be kept constantly watered or preferably be completely immersed in water if the size of the unit so permits. Otherwise curing practice as given in Clause 7.12 shall be followed.

## 8.11 Slots, Openings, etc.

- 8.11.1 Slots, openings or holes, pockets etc. shall be provided in the concrete work in the positions indicated in the Drawings or as directed by Employer. Any deviation from the approved Drawings shall be made good by Contractor at his own expense, without damaging any other work. Sleeves, bolts, inserts, etc. shall also be provided in concrete work where so specified.

## 8.12 Grouting

### 8.12.1 Standard grout

- 8.12.1.1 Grout shall be provided as specified on the Drawings.

- 8.12.1.2 The proportions of grout shall be such as to produce a flowable mixture consistent with minimum water content and shrinkage. The grout proportions shall be limited as follows:

Use	Grout Thickness	Mix Proportions	Max W/C Ratio
Fluid Mix.	Under 25 mm	One part Portland Cement to one part sand.	0.44
General	25 mm and over but less than 50 mm.	One part Portland Cement to two parts of sand	0.53
Stiff Mix	50 mm and above.	One part Portland Cement to 3 parts of sand.	0.53

### 8.12.1.3 Sand

1. Sand shall be such, as to produce a flowable grout without any tendency to segregate.
2. Sand, for general grouting purposes, shall be graded within the following limits:  
Passing IS 2.36 mm sieve. 95 to 100%  
Passing IS 2.18 mm sieve. 65 to 95%  
Passing IS 300 micron sieve. 10 to 30%  
Passing IS 150 micron sieve. 3 to 10%
3. Sand for fluid grouts, shall have the fine material passing the 300 and 150 micron sieves at the upper limits Specified above.
4. Sand, for stiff grouts, shall meet the usual grading Specifications for concrete.

8.12.1.4 Surfaces to be grouted shall be thoroughly roughened and cleaned of all foreign matter and latency.

8.12.1.5 Anchor bolts, anchor bolt holes and the bottom of equipment and column base plates shall be cleaned of all oil, grease, dirt and loose material. The use of hot, strong caustic solution for this purpose will be permitted.

8.12.1.6 Prior to grouting, the hardened concrete surfaces to be grouted shall be saturated with water.

8.12.1.7 Water in anchor bolt holes shall be removed before grouting is started.

8.12.1.8 Forms around base plates shall be reasonably tight to prevent leakage of the grout.

8.12.1.9 Adequate clearance shall be provided between forms and base plate to permit grout to be worked properly into place.

8.12.1.10 Grouting, once started, shall be done quickly and continuously to prevent segregation, bleeding and breakdown of initial set. Grout shall be worked from one side of one end to the other to prevent entrapment of air. To distribute the grout and to ensure more complete contact between base plate and foundation and to help release entrapped air, link chains can be used to work the grout into place.

8.12.1.11 Grouting through holes in base plates shall be by pressure grouting.

8.12.1.12 Variations in grout mixes and procedures shall be permitted if approved by Employer.

### 8.12.2 Special grout

8.12.2.1 Special grout, where specified on the Drawings, shall be provided in strict accordance with the manufacturer's instructions / Specifications on the Drawings.

**8.13 Inspection**

- 8.13.1 All materials, workmanship and finished construction shall be subject to the continuous inspection and approval of Employer.
- 8.13.2 All materials supplied by Contractor and all work or construction performed by Contractor rejected as not in conformance with the Specifications and Drawings, shall be immediately replaced at no additional expense to the Owner.
- 8.13.3 Approvals of any preliminary materials or phase or work shall in no way relieve the Contractor from the responsibility of supplying concrete and or producing finished concrete in accordance with the Specifications and Drawings.
- 8.13.4 All concrete shall be protected against damage until final acceptance by Employer or his representative.

**8.14 Clean-up**

- 8.14.1 Upon the completion of concrete work, all forms, equipment, construction tools, protective coverings and any debris resulting from the work shall be removed from the premises.
- 8.14.2 All debris i.e. empty containers, scrap wood, etc. shall be removed to "dump" daily or as directed by Employer.
- 8.14.3 The finished concrete surfaces shall be left in a clean condition satisfactory to Employer.

**8.15 Measurement and Rate**

- 8.15.1 The cement concrete shall be measured in cubic meters. In reinforced concrete the volume occupied by the reinforcement shall not be deducted.
- 8.15.2 Any concrete used in excess of the theoretical dimensions as shown on the Drawings will not be paid for.
- 8.15.3 The unit rate for concrete work under various categories shall be all inclusive and no claims for extra payment on account of such items as leaving holes, embedding inserts, etc. shall be entertained unless separately provided for in the schedule of quantities. No extra claim shall also be entertained due to change in the number, position and / or dimensions of holes, slots or openings, sleeves, inserts or on account of any increased lift or scaffolding etc. All these factors should be taken into consideration while quoting the unit rates. Unless provided for in the Schedule of Quantities the rates shall also include fixing inserts in all concrete work, whenever required.
- 8.15.4 Payments of concrete will be made on the basis of unit rates quoted for the respective items in the schedule of quantities. No deduction in the concrete quantity will be made for reinforcements, inserts etc. and opening less than 1/20 of a sqm. in area where concrete is measured in sqm. and 1/150 cum. where concrete is measured in cum. Where no such deduction for concrete is made, payment for

shuttering work provided for such holes, pockets, etc. will not be made. Similarly the unit rates for concrete work shall be inclusive or exclusive of shuttering as provided for in the schedule of quantities. Where formwork is paid for separately, it shall be very clearly understood that payment for form propping, scaffolding, etc. complete.

8.15.5 Payment for beams will be made for the quantity based on the depth being reckoned from the underside of the slabs and length measured as the clear distance between supports. Payment for columns shall be made for the quantity based on height reckoned upto the underside of slabs.

8.15.6 The unit rate for precast concrete members shall include formwork, mouldings, finishing, hoisting and setting in position including setting mortar, provision of lifting arrangement etc. complete. Only if reinforcement is used, it shall be measured and paid for separately under item rate.

## **8.16 Preparation of Mortars and its Grade**

### **8.16.1 Grade of Masonry Mortar**

8.16.1.1 The grade of masonry mortar will be defined by its compressive strength in  $\text{N/mm}^2$  at the age of 28 days as determined by the standard procedure detailed in IS: 2250-1981.

8.16.2 For proportioning the ingredients by volume, the conversion of weight into volume shall be made on the following basis:

1. Dry hydrated lime	700 kg/cum
2. Burnt Clay Pozzolana	860 kg/cum
3. Lime Pozzolana mixture	770 kg/cum
4. Coarse Sand (dry)	1280 kg/cum
5. Fine sand (dry)	1600 kg/cum
6. fly Ash	590 kg/cum

### **8.16.3 Lime Mortar**

8.16.3.1 Lime mortar shall be prepared using lime putty obtained by slaking quick-lime or dry hydrated lime powder and sand with or without the addition of Pozzolana in the specified proportions.

#### **8.16.3.2 Proportioning**

The ingredient in specified proportions shall be measured using boxes of suitable sizes. Sand and pozzolanic material shall be measured on basis of their dry volume.

#### **8.16.3.3 Lime Putty**

1. Lime putty shall be prepared from quick lime which is quite fresh and in the form of lumps. For the preparation of lime putty, three large tanks shall be

made, one tank shall be at a level higher than the other, so that the contents from the upper tank can flow into the lower tank by gravity. The tank at the higher level may be 50 cm deep and the other tanks may be 80 cm deep.

2. The lumps of quick lime for slaking shall be broken to size between 50 mm and 100 mm. Medium and slow slaking limes may be broken to size smaller than 50 mm for expeditious slaking. The tank at the higher level shall be cleaned of all unslaked stones of lime and other materials left over from previous slaking and filled to half the depth with water and sufficient quick lime added gradually to fill up the tank to about half the depth of water. Lime shall be added to water and not water to lime. Stirring and hooing shall be started at once, taking care that lime does not get exposed above water. The mix shall be stirred all through the slaking process and continued at least 5 minutes after the boiling has stopped, and as the mix thickens more water shall be added. The lime in a state of suspension shall then be allowed to flow through IS sieve designation 4.75 mm into the tank at the lower level, where it shall be kept standing for at least 72 hours. Water at top is removed leaving lime putty in the form of paste. Lime putty so formed shall be kept wet till it is completely used. It can be stored without getting spoiled for a fortnight provided it is protected from drying out.

#### 8.16.3.4 Mixing and Grinding

1. Using lime putty: Lime putty and sand in the specified proportion shall be mixed on a water tight platform or in trough. Specified Pozzolanic material may also be added in the required proportion if its use has been indicated. The mix can be put to use after grinding by the following methods:
  - (i) Using power driven mobile roller pan mixer conforming to IS: 2438-1963 or as directed by the Employer.
  - (ii) Using manually driven or animal driven mortar mill where mortar shall be grounded by not less than 180 revolutions or, for a minimum of three hours. The mortar shall be continuously raked and turned over during grinding particularly from corners and sides. Water shall be added as required during grinding, so as to get a stiff plaster of necessary working consistency.

However, preference will be given to the method under Para (i) above.

2. Using lime powder: Where the mortar is to be made using dry hydrated lime powder, the mixing of ingredients shall be done in a mechanical mixer unless otherwise permitted by the Employer in writing. After dry mixing is complete, just sufficient quantity of water shall be added to get mortar of required working consistency. The mortar shall be mixed at least for three minutes after the addition of water.
3. Where mechanical mixer is not available, the mixing may be allowed by manually operated mixer with the written order to the Employer. The mixing time shall be suitably increased to get the mortar of working consistency.



4. The Employer may, however, permit hand mixing at his discretion, taking into account the nature, magnitude and location of the work and practicability of the use of these machines etc., of where items involving small quantities are to be done or if, in his opinion the use of the mechanical mixers is not feasible. In cases, where mechanical mixers are not to be used, the Contractor shall take permission of the Employer in writing before the commencement of work. The ingredients of the mortar which can be used within 30 minutes shall then be mixed dry on a watertight masonry platform or in troughs by hand mixing and then the mortar shall be kneaded back and forth for 10 to 15 minutes with the addition of required quantity of water to get mortar of necessary working consistency.

#### 8.16.3.5 Precaution

Lime mortar shall be used as soon as possible after mixing or grinding. As a rule mortar shall be used on the day it is made. If eminently hydraulic lime (Class A) as present as an ingredient, the mortar shall be used within four hours after mixing or grinding in mortar mill or mixture. Lime mortar made with semi-hydraulic lime (Class B) or fat lime (Class C) and Pozzolana as ingredients shall be used within 36 hours of mixing or grinding and lime sand mortar within 72 hours. After the close of each day's work, mixing trough pans shall be thoroughly washed and cleaned. Lime mortar shall be kept damp with wet sack or by any other suitable means and shall on no account be allowed to dry.

#### 8.16.4 Cement Mortar

- 8.16.4.1 This shall be prepared by mixing cement and sand with or without the addition of Pozzolana as specified.

- 8.16.4.2 Proportioning

Cement bag weighting 50 kg shall be taken as 0.035 cubic metre. Other ingredients in specified proportion shall be measured using boxes of size 40 X 35 X 25 cm. Sand shall be measured on the basis of its dry volume.

- 8.16.4.3 Mixing

The mixing of mortar shall be done in mechanical mixers operated manually or by power as decide by Employer. The Employer may, however, permit hand mixing at his discretion taking into account the nature, magnitude and location of the work and practicability of the use of mechanical mixers or where item involving small quantities are to be done or if in his opinion the used of mechanical mixer is not to be used, the Contractor shall take permission of the Employer in writing before the commencement of the work.

1. Mechanical Mixing: Cement and sand in the specified proportions shall be mixed dry thoroughly in a mixer. Water shall then be added gradually and wet mixing continued for at least three minutes. Only the required quantity of water shall be added which will produce mortar of workable consistency but not stiff paste. Only the quantity of mortar, which can be used within 30 minutes of its mixing shall be prepared at a time. Mixer shall be cleaned with

water each time before suspending the work.

2. Hand Mixing: The measured quantity of sand shall be leveled on a clean masonry platform and cement bags emptied on top. The cement and sand shall be thoroughly mixed dry by being turned over and over, backwards and forwards, several times till the mixture is of a uniform colour. The quantity of dry mix which can be used within 30 minutes shall then be mixed in a masonry trough with just sufficient quantity of water to bring the mortar to a stiff plaster of necessary working consistency.

#### 8.16.4.4 Precautions

Mortar shall be used as soon as possible after mixing and before it begins to set, and in any case within half hour, after the water is added to the dry mixture.

#### 8.16.5 Cement Lime Mortar

- 8.16.5.1 This shall be prepared by mixing cement, lime putty/dry hydrated lime powder and sand in specified proportions. Mixing shall be done in a mechanical mixer (Operated manually or by power as decided by Employer).

- 8.16.5.2 The Employer may, however, permit hand mixing at his discretion, taking into account the nature, magnitude and location of the work and practicability of the use of mechanical mixers or where item involving small quantities are to be done or if in his opinion the use of mechanical mixer is not feasible. In case, where mechanical mixers are not to be used, the Contractor shall take permission of the Employer in writing before the commencement of the work.

#### 8.16.5.3 Proportioning

Cement, lime putty/dry hydrated lime and sand shall be taken in specified proportions. Cement bag weighing 50 kg shall be taken as 0.035 cubic metre. Other ingredients in specified proportion shall be measured using boxes of size 40 x 35 x 25 cm. Sand shall be measured on the basis of its dry volume.

#### 8.16.5.4 Mixing and Grinding

1. Mechanical Mixing: Lime putty and sand shall be mixed and ground in the manner described in Clause 9.20.3.4.1(i) before mixing the same with cement. In case where factory made dry hydrated lime powder is used, prior grinding of lime and sand is not necessary. In that case mixing may be done in one operation in mechanical mixer. Only quantity of this mixture which could be used within two hours of its mixing with cement, shall be taken out and mixed thoroughly with specified quantity of cement in mechanical mixer.
2. Hand Mixing: Cement and sand shall be mixed dry thoroughly on clean and water tight masonry platforms or in troughs. Lime putty shall be mixed with water to make milk of lime, which shall be added to the mixture of cement and sand. The mixture shall be kneaded back and forth for about 10 minutes with addition of milk of lime to obtain mortar to workable consistency.

#### 8.16.5.5 Precautions

Mortar shall be used as soon as possible after mixing and maximum within two hours. Mortar unused for more than 2 hours shall be rejected and removed from the site of work. Mixture of lime putty and sand can be kept for 72 hours for preparation of lime cement mortar in respect of Class 'B' and 'C' lime and for six hours in case of Class 'A' lime provided it is kept damp and not allowed to dry.

## 9 BRICK MASONRY

### 9.1 Description

- 9.1.1 This work shall consist of construction of structures with bricks jointed together by cement mortar in accordance with the details shown on the Drawings or as approved by the Employer.

### 9.2 Applicable Codes

- 9.2.1 The following Indian Standard Codes, unless otherwise specified herein, shall be applicable. In all cases, the latest revision of the codes shall be referred to:

IS 1077	-	Specifications for common burnt clay building bricks
IS 1200	-	Measurements for Building works
IS 1725	-	Specifications for solid cement blocks used in general building construction
IS 1905	-	Code of practice for structural safety of buildings: Masonry walls.
IS 2116	-	Sand for masonry mortars
IS 2180	-	Specification for heavy duty burnt clay building bricks
IS 2185	-	Specification for concrete masonry units: Hollow and solid concrete blocks
IS 2212	-	Code of practice for brick work
IS 2222	-	Specification for burnt clay perforated building bricks
IS 2691	-	Specification for burnt clay facing bricks
IS 3115	-	Specification for lime based blocks
IS 3414	-	Code of practice for design and installation of joints in buildings
IS 3466	-	Specification for masonry cement
IS 3861	-	Method of measurement of plinth, carpet and rentable areas of buildings.
IS 3952	-	Specification for burnt clay hollow blocks for walls and partitions
IS 4098	-	Specification for lime-pozzolana mixture
IS 4139	-	Specification for sand lime bricks
IS	-	Code of practice for use of silicate type chemical resistant mortars.

4441		
IS	-	Code of practice for use of sulphur type chemical resistant mortars
4442		

- 9.2.2 Others I.S. Codes not specifically mentioned here but pertaining to the use of bricks for structural purposes form part of these Specifications.

### 9.3 Materials

- 9.3.1 All materials to be used in the work shall confirm to the requirements mentioned hereunder

### 9.4 Personnel

- 9.4.1 Only trained personnel shall be employed for construction and supervision.

### 9.5 Soaking of Bricks

- 9.5.1 All bricks shall be thoroughly soaked in a tank filled with water for a minimum period of one hour prior to being laid. Soaked bricks shall be removed from the tank sufficiently in advance so that they are skin dry at the time of actual laying. Such soaked bricks shall be stacked on a clean place where they are not contaminated with dirt, earth, etc.

### 9.6 Joints

- 9.6.1 The thickness of joints shall not exceed 10 mm. All joints on exposed faces shall be tooled to give concave finish.

### 9.7 Laying

- 9.7.1 All brickwork shall be laid in an English bond, even and true to line, in accordance with the Drawing or as directed by the Employer, plumb and level and all joints accurately kept. Half and cut bricks shall not be used except when necessary to complete the bond. Closer in such cases shall be cut to the required size and used near the ends of the walls. The bricks used at the face and also at the angles forming the junction of any two walls shall be selected whole bricks of uniform size, with true and rectangular faces.
- 9.7.2 All bricks shall be laid with frogs up on a full bed of mortar except in the case of tile bricks. Each brick shall be properly bedded as set in position by slightly pressing while laying, so that the mortar gets into all their surface pores to ensure proper adhesion. All head and side joints shall be completely filled by applying sufficient mortar to brick already placed and on brick to be placed. All joints shall be properly flushed and packed with mortar so that no hollow spaces are left. No bats or cut bricks shall be used except to obtain dimensions of the different courses for specified bonds or wherever a desired shape so requires.
- 9.7.3 The brick work shall be built in uniform layers, and for this purpose wooden straight edge with graduations indicating thickness of each course including joint

shall be used. Corners and other advanced work shall be raked back. Brickwork shall be done true to plumb or in specified batter. All courses shall be laid truly horizontal and vertical joints shall be truly vertical. Vertical joints in alternate courses shall come directly one over the other. During construction, no part of work shall rise more than one metre above the general construction level, to avoid unequal settlement and improper jointing. Where this is not possible in the opinion of the Employer, the works shall be raked back according to the bond (and not toothed) at an angle not steeper than 45 degrees with prior approval of the Employer. Toothing may also be permitted where future extension is contemplated.

- 9.7.4 Before laying bricks in foundation, the foundation slab shall be thoroughly hacked, swept clean and wetted. A layer of mortar not less than 12 mm thick shall be spread on the surface of the foundation slab and the first course of bricks shall be laid.

## **9.8 Jointing Old and New Work**

- 9.8.1 Where fresh masonry is to join the masonry that is partially/entirely set, the exposed jointing surface of the set masonry shall be cleaned, roughened and wetted, so as to effect the best possible bond with the new work. All loose bricks and mortar or other material shall be removed.
- 9.8.2 In the case of vertical or inclined joints, it shall be further ensured that proper bond between the old and new masonry is obtained by interlocking the bricks. Any portion of the brickwork that has been completed shall remain undisturbed until thoroughly set.
- 9.8.3 In case of sharp corners specially in skew bridges, a flat cutback of 100 mm shall be provided so as to have proper and bonded laying of bricks.

## **9.9 Curing**

- 9.9.1 Green work shall be protected from rain by suitable covering and shall be kept constantly moist on all faces for a minimum period of seven days. Brick work carried out during the day shall be suitably marked indicating the date on which the work is done so as to keep a watch on the curing period. Top of the masonry work shall be left flooded with water at the close of the day. Watering may be done carefully so as not to disturb or wash out the green mortar.
- 9.9.2 During hot weather, all finished or partly completed work shall be covered or wetted in such a manner as will prevent rapid drying of the brickwork.
- 9.9.3 During the period of curing of brick work, it will be suitably protected from all damages. At the close of day's work or for other period of cessation, watering and curing shall have to be maintained. Should the mortar perish i.e., become dry, white or powdery, through neglect of curing, work shall be pulled down and rebuilt as directed by the Employer. If any stains appear during watering, the same shall be removed from the face.

**9.10 Scaffolding**

- 9.10.1 The Scaffolding shall be sound, strong and safe to withstand all loads likely to come upon it. The holes which provide resting space for horizontal members shall not be left in masonry under one metre in width or immediately near the skew backs of arches. The holes left in the masonry work for supporting the scaffolding shall be filled with dense concrete and made good. Scaffolding shall be got approved by the Employer. However, the Contractor shall be responsible for its safety.

**9.11 Weep Holes**

- 9.11.1 Weep holes shall conform to Clause 2706 of MoST Specifications for Road and Bridge Works (IV Revision).

**9.12 Equipment**

- 9.12.1 All tools and equipment used for mixing, transporting and laying of mortar and bricks shall be clean and free from set mortar, dirt or other injurious foreign substances.

**9.13 Finishing of Surfaces****9.13.1 General**

- 9.13.1.1 All brickwork shall be finished in a workmanlike manner with the thickness of joints, manner of striking or tooling as described in these above Specifications.
- 9.13.1.2 The surfaces can be finished by “joining “ or “pointing” or by “plastering” as given in the Drawings.
- 9.13.1.3 For a surface which is to be subsequently plastered or pointed, the joints shall be squarely raked out to a depth of 15 mm, while the mortar is still green. The raked joints shall be well brushed to remove dust and loose particles and the surface shall be thoroughly washed with water, cleaned and wetted.
- 9.13.1.4 The mortar for finishing shall be prepared as per Clause 11.5.

**9.13.2 Jointing**

- 9.13.2.1 In jointing, the face of the mortar shall be worked out while still green to give a finished surface flush with the face of the brick work. The faces of brick work shall be cleaned to remove any splashes of mortar during the course of raising the brick work.

**9.13.3 Pointing**

- 9.13.3.1 Pointing shall be carried out using mortar not leaner than 1:3 by volume of cement and sand or as shown on the Drawing. The mortar shall be filled and pressed into the raked joints before giving the required finish. The pointing shall be ruled type for

which it shall, while still green, be ruled along the centre with half round tools of such width as may be specified by the Employer. The super flush mortar shall then be taken off from the edges of the lines and the surface of the masonry shall be cleaned of all mortar. The work shall conform to IS: 2212.

#### 9.13.4 Plastering

- 9.13.4.1 Plastering shall be done where shown on the Drawing. Superficial plastering may be done, if necessary, only in structures situated in fast flowing rivers or in severely aggressive environment.
- 9.13.4.2 Plastering shall be started from top and worked down. All putlog holes shall be properly filled in advance of the plastering while the scaffolding is being taken down. Wooden screeds 75 mm wide and of the thickness of the plaster shall be fixed vertically 2.5 to 4 meters apart, to act as gauges and guides in applying the plaster. The mortar shall be laid on the wall between the screeds using the plaster's float and pressing the mortar so that the raked joints are properly filled. The plaster shall be finished off with a wooden straight edge reaching across the screeds. The straight edge shall be worked on the screeds with a small upward and sideways motion 50 mm to 75 mm at a time. Finally, the surface shall be finished off with a plasterer's wooden float. Metal floats shall not be used.
- 9.13.4.3 When recommencing the plastering beyond the work suspended earlier, the edges of the old plaster shall be scrapped, cleaned and wetted before plaster is applied to the adjacent areas.
- 9.13.4.4 No portion of the surface shall be left unfinished for patching up at a later period.
- 9.13.4.5 The plaster shall be finished true to plumb surface and to the proper degree of smoothness as directed by the Employer.
- 9.13.4.6 The average thickness of plaster shall not be less than the specified thickness. The minimum thickness over any portion of the surface shall not be less than the specified by more than 3 mm.
- 9.13.4.7 Any cracks which appear in the surface and all portions which should hollow when tapped, or are found to be soft or otherwise defective, shall be cut in rectangular shape and re-done as directed by the Employer.

#### 9.13.5 Curing of Finishes

- 9.13.5.1 Curing shall be commenced as soon as the mortar used for finishing has hardened sufficiently not to be damaged during curing. It shall be kept wet for a period of at least 7 days. During this period, it shall be suitably protected from all damages.

#### 9.13.6 Scaffolding for Finishes

- 9.13.6.1 Stage scaffolding shall be provided for the work. This shall be independent of the structure.



**9.14 Architectural Coping for Wing / Return / Parapet Wall**

- 9.14.1 This work shall consist of providing an Architectural coping for wing/return/parapet walls.
- 9.14.2 The material used shall be cement mortar 1:3 or as shown on the Drawings prepared in accordance with Clause 10.5.
- 9.14.3 The cement mortar shall be laid evenly to an average thickness of 15 mm to the full width of the top of the wall and in continuation a band of 15 mm thickness and 150 mm depth shall be made out of the mortar along the top outer face of the walls.

**9.15 Acceptance of Work**

- 9.15.1 All work shall be true to the lines and levels as indicated on the Drawing or as directed by the Employer, subject to tolerances as indicated in these Specifications.
- 9.15.2 Mortar cubes shall be tested in accordance with IS: 2250 for compressive strength, consistency of mortar and its water retentivity. The frequency of testing shall be one sample for every 2 cubic metres of mortar, subject to a minimum 3 samples for a day's work.
- 9.15.3 In case of plaster finish, the minimum surface thickness shall not be less than the specified thickness by more than 3 mm.

**9.16 Measurements for Payment**

- 9.16.1 All brick work shall be measured in cubic metres. Any extra work done by the Contractor over the specified dimensions shall be ignored.
- 9.16.2 In arches, the length of arch shall be measured as the mean length between the extrados and intrados.
- 9.16.3 The work of plastering and pointing shall be measured in square meters of the surface treated.
- 9.16.4 Architectural coping shall be measured in linear metres.

**9.17 Rate**

- 9.17.1 The contract unit rate for brick work shall include the cost of all labour, materials, tools and plant, scaffolding and other expenses incidental to the satisfactory completion of the work, sampling, testing and supervision as described in these Specifications and as shown on the Drawings.
- 9.17.2 The contract unit rate for plastering shall include the cost of all labour, materials, tools and plant, scaffolding and all incidental expenses, sampling and testing and supervision as described in these Specifications.

- 9.17.3 The contract unit rate for pointing shall include erecting and removal of scaffolding, all labour, materials, and equipment incidental to complete the pointing, raking out joints, cleaning, wetting, filling with mortar, trowelling, pointing and watering, sampling and testing and supervision as described in these Specifications.
- 9.17.4 The contract unit rate for architectural coping shall include cost of all labour, materials, tools and plant, sampling and testing and supervision as described in these Specifications.

## **10 FINISHING**

### **10.1 Scope**

These Specifications cover the general requirements of different kinds of finishes.

#### **10.1.1 Application of Plaster**

10.1.1.1 Ceiling plaster shall be completed before commencement of wall plaster.

10.1.1.2 Plastering shall be started from the top and worked down towards the floor. All put-log holes shall be properly filled in advance of the plastering as the scaffolding is being taken down. To ensure even thickness and a true surface, plaster about 15 x 15 cm shall be first applied, horizontally and vertically, at not more than 2 metres intervals over the entire surface to serve as gauges. The surfaces of these gauged areas shall be truly in the plane of the finished plaster surface. The mortar shall then be laid on the wall, between the gauges with trowel. The mortar shall be applied in a uniform surface slightly more than the specified thickness. This shall be beaten with thin strips of bamboo about one metre long to ensure through filling of the joints, and then brought to a true surface, by working a wooden straight edge reaching across the gauges, with small upward and side ways movements at a time. Finally the surface shall be finished off true with trowel or wooden float according as a smooth or sandy granular texture is required. Excessive troweling or over working the float shall be avoided. During this process, a solution of lime putty shall be applied on the surface to make the later workable.

10.1.1.3 All corners, arrises, angles and junctions shall be truly vertical or horizontal as the case may be and shall be carefully finished. Rounding or chamfering corners, arrises, provision of grooves at junctions etc., where required shall be done without any extra payments. Such rounding, chamfering or grooving shall be carried out with proper templates or battens to the sizes required.

10.1.1.4 When suspending work at the end of the day, the plaster shall be left, cut clean to line both horizontally and vertically. When recommencing the plastering, the edge of the old work shall be scrapped cleaned and wetted with lime putty before plaster is applied to the adjacent areas, to enable the two to properly joint together. Plastering work shall be closed at the end of the day on the body of wall and not nearer than 15 cm to any corners or arrises. It shall not be closed on the body of the features such as plasters, bands and cornices, nor at the corners of arrises. Horizontal joints in plaster work shall not also occur on parapet tops and copings as these invariably lead to leakages.

10.1.1.5 No portion of the surface shall be left out initially to be patched up later on.

#### **10.1.2 Finish**

10.1.2.1 The plaster shall be finished to a true and plumb surface and to the proper degree of smoothness as required. The work shall be tested frequently as the work proceeds

with a true straight edge not less than 2.5 m long and with plumb bobs. All horizontal lines and surfaces shall be tested with a level and all jambs and corners with a plumb bob as the work proceeds.

## **10.2 Cement Plastering**

10.2.1 The cement plaster shall be 12 mm, 15 mm or 20 mm thick as specified in the item.

10.2.2 Scaffolding and preparation of surface shall be as specified under Clause 10.4.1 & 10.4.2.

10.2.3 Mortar

10.2.3.1 The mortar of the specified mix using the type of sand described in the item shall be used. For external work and under coat work, the fine aggregate shall conform to grading IV. For finishing coat work the fine aggregate conforming to grading zone V shall be used.

10.2.4 Application

10.2.4.1 The Specifications as in Clause 10.4.4 shall apply except in the following respects:

1. Beating with thin bamboo strips shall not be done on the cement plaster, and;
2. No lime putty solution shall be applied on the face when finishing. Further the plastering and finishing shall be completed within half an hour of adding water to the dry mortar.

10.2.5 Finishing shall be as specified under Clause 10.4.5

10.2.6 Thickness

10.2.6.1 Where the thickness required as per description of the item is 20 mm the average thickness of the plaster shall not be less than 20 mm whether the wall treated is of brick or stone. In the case of brick work, the minimum thickness over any portion of the surface shall be not less than 15 mm while in case of stone work the minimum thickness over the bushings shall be not less than 12 mm.

10.2.7 Curing

10.2.7.1 Curing shall be started as soon as the plaster has hardened sufficiently not to be damaged when watered.

10.2.7.2 The plaster shall be kept wet for a period of at least 7 days. During this period, it shall be suitably protected from all damages at the Contractor's expense by such means as the Employer may approve. The dates on which the plastering is done shall be legibly marked on the various sections plastered so that curing for the specified period thereafter can be watched.

## **10.3 Cement Plaster with a Floating Coat of Neat Cement**

- 10.3.1 The cement plaster shall be 12, 15 or 20 mm thick, finished with a floating coat of neat cement, as described in the item.
- 10.3.2 Specifications for this item of work shall be same as described in Clause 10.5 except for the additional floating coat which shall be carried out as below:
  - 10.3.2.1 When the plaster has been brought to a true surface with the wooden straight edge it shall be uniformly treated over its entire area with a paste of neat cement and rubbed smooth, so that the whole surface is covered with neat cement coating. The quantity of cement applied for floating coat shall be 1 kg per sqm. Smooth finishing shall be completed with trowel immediately and in no case later than half an hour of adding water to the plaster mix. The rest of the Specifications described in Clause 10.5 shall apply.
- 10.4 6 mm Cement Plaster on Cement Concrete and Reinforced Cement Concrete Work**
  - 10.4.1 Scaffolding
    - 10.4.1.1 Stage scaffolding shall be provided for the work. This shall be independent of the walls.
  - 10.4.2 Preparation of Surface
    - 10.4.2.1 Projecting burrs of mortar formed due to the gaps at joints in shuttering shall be removed. The surface shall be scrubbed clean with wire brushed. In addition concrete surfaces to be plastered shall be pock marked with a pointed tool, at spacings of not more than 5 cm. Centres, the pock being made not less than 3 mm deep. This is to ensure a proper key for the plaster. The mortar shall be washed off and surface, cleaned of all oil, grease etc. and well wetted before the plaster is applied.
  - 10.4.3 Mortars
    - 10.4.3.1 Mortars of the specified mix using the types of sand described in the item shall be used.
  - 10.4.4 Application
    - 10.4.4.1 To ensure even thickness and a true surface, gauges of plaster 15 X 15 cm. shall be first applied at not more than 1.5 m intervals in both directions to serve as guides for the plastering. Surface of these gauged areas shall be truly in the plane of the finished plaster surface. The plaster shall be then applied in a uniform surface to a thickness slightly more than the specified thickness and shall then be brought to true and even surface by working a wooden straight edge reaching across the gauges. Finally the surface shall be finished true with a trowel or with wooden float to give a smooth or sandy granular texture as required. Excess troweling or over working of the floats shall be avoided. The plastering and finishing shall be completed within half an hour of adding water to the dry mortar.

10.4.4.2 Plastering of ceiling shall not be commenced until the slab above has been finished and centering has been removed. In the case of ceiling of roof slabs, plaster shall not be commenced until terrace work has been completed. These precautions are necessary in order that the ceiling plaster is not disturbed by the vibrations set up in the above operations.

#### 10.4.5 Finish

10.4.5.1 The plaster shall be finished to a true and plumb surface and to the proper degree of smoothness as required. The work shall be tested frequently as the work proceeds with a true straight edge not less than 2.5 m long and with plumb bobs. All horizontal lines and surfaces shall be tested with a level and all jambs and corners with a plumb bob as the work proceeds.

#### 10.4.6 Thickness

10.4.6.1 The average thickness of plaster shall not be less than 6 mm. The minimum thickness over any portion of the surface shall not be less than 5 mm.

#### 10.4.7 Curing

10.4.7.1 The Specifications shall be as detailed in Clause 10.4.7.

#### 10.4.8 Precautions

10.4.8.1 These shall be as described in Clause 10.4.8.

#### 10.4.9 Measurements

10.4.9.1 Length and breadth shall be measured correct to a cm. and its area shall be calculated in sqm. correct to two places of decimal. Dimensions before plastering shall be taken.

10.4.9.2 Thickness of plaster shall be exclusive of the thickness of the key i.e., depth or rock marks and hacking.

10.4.9.3 Plastering on ceiling at height greater than 5 m above the corresponding floor level shall be so described and shall be measured separately stating the height in stages of 1 m or part thereof.

10.4.9.4 Plastering on the sides and soffits of the projected beams of ceiling at a height greater than 5 m above the corresponding floor level shall be measured and added to the quantity measured under Clause 10.4.9.3.

10.4.9.5 Plastering on spherical and groined ceiling and circular work not exceeding 6 m in radius, shall be measured and paid for separately.

10.4.9.6 Flowing soffits (viz., portion under spiral stair case etc.,) shall be measured and paid for separately.

10.4.9.7 Ribs and mouldings on ceiling shall be measured as for cornices, deductions being made from the plastering on ceiling in case the width of the moulding exceed 15 cm.

10.4.9.8 The mode of measurement of exterior plaster and patch plastering (in repairs) shall be as laid down in Clause 9.4.9

10.4.9.9 Deduction shall not be made for openings or for ends of columns, or columns caps of 0.5 sqm each in area and under. No additions will be made either for the plastering of the sides of such openings. For openings etc. of areas exceeding 0.5 sqm deduction will be made for the full opening but the sides of such opening shall be measured for payment.

#### 10.4.10 Rate

10.4.10.1 The rate shall include the cost of all labour and materials involved in all the operations described above.

### **10.5 6 mm Cement Plaster on top of wall for Slab Bearing**

10.5.1 Cement plaster shall be 6 mm thick finished with a floating coat of neat cement and thick coat of lime wash on top of walls for bearing of slabs.

#### 10.5.2 Application

10.5.2.1 The plaster shall be applied over the cleaned and wetted surface of the wall. When the plaster has been brought to a true surface with the wooden straight edge it shall be uniformly treated over its entire area with a paste of neat cement and rubbed smooth, so that whole surface is covered with neat cement coating. The quantity of cement applied for floating coat shall be 1 kg per sqm. Smooth finishing shall be completed with trowel immediately and in no case later than half an hour of adding water to the plaster mix. The rest of the Specifications described in Clause 13.5.4 shall apply.

#### 10.5.3 Lime wash

10.5.3.1 This shall be applied in a thick coat after curing the plaster for three days.

#### 10.5.4 Measurements

10.5.4.1 Length and breadth shall be measured correct to a cm and area worked out in sqm correct to two places of decimal.

#### 10.5.5 Rate

10.5.5.1 The rate shall include the cost of all labour and materials involved in all the operations described above.

### **10.6 Neat Cement Punning**

### 10.6.1 Measurements

- 10.6.1.1 The measurements for neat cement punning shall be taken over the finished work. The length and breadth shall be measured correct to a cm. The area shall be calculated in sqm correct to two places of decimal.
- 10.6.1.2 Punning over Plaster on bands, skirting, coping, cornices, drip courses, string courses etc., shall not be measured separately but only as wall surfaces. In these cases the measurements shall be taken girthed over the above features.
- 10.6.1.3 Punning over Plaster on circular work also, of any radius shall be measured only as wall surfaces, and not separately.
- 10.6.1.4 Neat cement punning in patch repairs irrespective of the size of the patch shall be measured as new work, and in this case the rate shall include for cutting the patch to rectangular shape before Neat cement punning.

### 10.6.2 Rate

- 10.6.2.1 The rate shall include the cost of all labour and materials involved in all the operations described above.

## 10.7 WASHED STONE GRIT PLASTER

### 10.7.1 Materials

Stone chippings obtained by crushing hard stone shall be free of dust and deleterious material.

10 mm nominal size stone chippings, where specified, shall pass 100% through 12.5 mm sieve and fully retained on 6.3 mm sieve. Stone chippings shall be thoroughly washed with water and sieved before use.

- 10.7.2 Mortar : Cement mortar for under coat and cement mortar to be mixed with stone chippings for top coat shall be as per relevant clauses.

### 10.7.3 Application of Plaster

Under Coat : Under coat of cement mortar 1:4 (1 cement : 4 coarse sand) shall be applied as specified in 13.1.3 except that the finishing, after the mortar has been brought to level with the wooden straight edge, shall be done with wooden float only. The surface shall be further roughened by furrowing with a scratching tool. Furrowing shall be done diagonally both ways and shall be about 2 mm deep to provide a key for the top coat. The scratched lines shall not be more than 10 cm apart. The surface shall be kept wet till top coat is applied.

Top Coat : Top coat comprising cement mortar and stone chippings shall have an overall proportion of 1:0.5:2 (1 cement : 0.5 coarse sand : 2 stone chippings 10 mm nominal size) or as specified. The top coat shall be applied a day or two after the under coat has taken the initial set. The surface of the under coat shall be cleaned and a coat of cement slurry at 2 kg of cement per sqm shall be applied before the application of coat. The top coat shall be applied in uniform thickness on the under coat after the application of slurry and sufficiently pressed with wooden float for proper bonding with the under coat. Vacant space, if any shall be filled with the specified mix.

### 10.7.4 Finish

The top coat of plaster shall be finished to a true and plumb surface. The surface shall be tested frequently as the work proceeds with a true straight edge not less than 2.5 m



long and with plumb bobs. All horizontal lines and surfaces shall be tested with a level and all jambs and corners with a plumb bob as the work proceeds. All the corners angles and junctions shall be truly vertical or horizontal as the case may be. Rounding or chamfering of corners junctions etc. Where required shall be true to template. Finished surface of the top coat after the mix has taken the initial set, shall be scrubbed and washed with suitable brushes and plain water. Scrubbing and washing shall continue till the stone chippings are sufficiently exposed. Stone chippings which may come out while scrubbing shall be replaced using the specified mortar mix. A sample of the washed stone grit plaster shall be got approved from the Engineer-in-Charge.

#### 10.7.5 FINISHING

##### 10.7.5.1 Grooves

Grooves of size 15 mm x 15 mm or as specified shall be provided as shown on the drawing or as required by the Engineer-in-Charge. Tapered wooden battens to match the size and shape of the grooves shall be fixed on the under coat with nails before the application of the top coat and these shall be removed carefully so that the edges of the panels of top coat are not damaged. Damage, if any, shall be made good by the contractor.

##### 10.7.5.2 Curing

Curing shall be started 24 hours after finishing the plaster. The plaster shall be kept wet for a period of seven days. During this period, it shall be suitably protected from all damages at the contractor's expense by such means as the Engineer-in-Charge may approve.

#### 10.7.6 Measurements

10.7.6.1 Length and breadth shall be measured correct to the nearest cm and the area shall be calculated in sqm correct to two places of decimal.

10.7.6.2 Measurements shall be taken for the work actually done with deductions for all openings and addition for all jambs soffits and sills. However, no deduction is to be made for the grooves provided as specified .

10.7.6.3 Washed stone grit plaster on circular surfaces not exceeding 6 m in radius and on external surfaces at a height greater than 10 m shall be measured separately.

#### 10.7.7 Rates

The rates shall include the cost of all labour and materials involved in all the operations described above except for providing grooves. The length of grooves shall be measured in running metres and paid for separately

### 10.8 Cement Water Proofing Compound

10.8.1 It shall be used for cement mortar for plastering or concrete work.

#### 10.8.2 Water Proofing Compound

10.8.2.1 Integral cement water proofing compound conforming to IS: 2645 and of approved brand and manufacture, enlisted by the Employer from time to time shall be used.

10.8.3 The Contractor shall bring the materials to the site in their original packing. The containers will be opened and the material mixed with dry cement in the proportion by weight, recommended by the manufacturers or as specifically described in the description of the item. Care shall be taken in mixing, to see that the water proofing material gets well and integrally mixed with the cement and does not run out separately when water is added.

10.8.4 It shall be measured by weight.

10.8.5 The rate shall include the cost of all labour and materials involved in all the operations described above.

## **10.9 White Washing with Lime**

### **10.9.1 Scaffolding**

10.9.1.1 Wherever scaffolding is necessary, it shall be erected on double supports tied together by horizontal pieces, over which scaffolding planks shall be fixed. No ballies, bamboos or planks shall rest on or touch the surface which is being white washed.

10.9.1.2 For all exposed brick work or tile work, double scaffolding having two sets of vertical supports shall be provided. The supports shall be sound and strong, tied together with horizontal pieces over which scaffolding planks shall be fixed.

*Note: In case of special type of brick work, scaffolding shall be got approved from Employer in advance.*

10.9.1.3 Where ladders are used, pieces of old gunny bags shall be tied on their tops to avoid damage or scratches to walls.

10.9.1.4 For white washing the ceiling, proper stage scaffolding shall be erected.

### **10.9.2 Preparation of Surface**

10.9.2.1 Before new work is white washed, the surface shall be thoroughly brushed free from mortar droppings and foreign matter.

### **10.9.3 Preparation of lime wash**

10.9.3.1 The lime wash shall be prepared from fresh stone white lime. The lime shall be thoroughly slaked on the spot, mixed and stirred with sufficient water to make a thin cream. This shall be allowed to stand for a period of 24 hours and then shall be screened through a clean coarse cloth, 40 gm of gum dissolved in hot water, shall be added to each 10 cubic decimeter of the cream. The approximate quantity of water to be added in making the cream will be 5 litres of water to one kg of lime.

10.9.3.2 Indigo (Neel) upto 3 gm per kg of lime dissolved in water, shall then be added and stirred well. Water shall then be added at the rate of about 5 litres per kg. of lime to produce a milky solution.

#### 10.9.4 Application

- 10.9.4.1 The white wash shall be applied with moonj brushes to the specified number of coats. The operation for each coat shall consist of a stroke of the brush given from the top downwards, another from the bottom upwards over the first stroke, and similarly one stroke horizontally from the right and another from the left before it dries.
- 10.9.4.2 Each coat shall be allowed to dry before the next one is applied. Further each coat shall be inspected and approved by the Employer-in-Charge before the subsequent coat is applied. No portion of the surface shall be left out initially to be patched up later on.
- 10.9.4.3 For new work, three or more coats shall be applied till the surface presents a smooth and uniform finish through which the plaster does not show. The finished dry surface shall not show any signs of cracking and peeling nor shall it come off readily on the hand when rubbed.

#### 10.9.5 Protective Measures

- 10.9.5.1 Doors, windows, floors, articles of furniture etc. and such other parts of the building not to be white washed, shall be protected from being splashed upon. Splashings and droppings, if any shall be removed by the Contractor at his own cost and the surfaces cleaned. Damages if any to furniture or fittings and fixtures shall be recoverable from the Contractor.

#### 10.9.6 Measurements

- 10.9.6.1 Length and breadth shall be measured correct to a cm. and area shall be calculated in sqm correct to two places of decimals.
- 10.9.6.2 Measurement for Jambs, Soffits and sills, etc. for openings shall be described in Clause 13.3.9.
- 10.9.6.3 Corrugated surfaces shall be measured flat as fixed and the area so measured shall be increased by the following percentages to allow for the girthed area.
- |                                       |      |
|---------------------------------------|------|
| Corrugated asbestos cement sheet      | 20 % |
| Semi corrugated asbestos cement sheet | 10 % |
- 10.9.6.4 Cornices and other such wall or ceiling features, shall be measured along the girth and included in the measurements.
- 10.9.6.5 The number of coats of each treatment shall be stated. The item shall include removing nails, making good holes, cracks, patches etc. not exceeding 50 sqcm each with material similar in composition to the surface to be prepared.
- 10.9.6.6 Work on old treated surfaces shall be measured separately and so described.

#### 10.9.7 Rate

10.9.7.1 The rate shall include all material and labour involved in all the operations described above.

#### 10.10 Satna Lime Washing

10.10.1 Satna lime wash shall be used as a base coat where so specified. The Specifications for 'white washing with lime' shall apply except that Satna or Katni quality lime shall be used in place of Narnaul or Dehradun quality lime and the wash will be mixed to a thicker consistency.

#### 10.11 Oil Emulsion (Oil Bound) Washable Distempering

##### 10.11.1 Materials

10.11.1.1 Oil emulsion (Oil Bound) washable distemper (IS: 428) of approved brand and manufacture shall be used. The primer where used as on new work shall be cement primer or distemper primer as described in the item. These shall be of the same manufacture as distemper. The distemper shall be diluted with water or any other prescribed thinner in a manner recommended by the manufacturer. Only sufficient quantity of distemper required for day's works shall be prepared.

10.11.1.2 The distemper and primer shall be brought by the Contractor in sealed tins in sufficient quantities at a time to suffice for a fortnight's work, and the same shall be kept in the joint custody of the Contractor and the Employing-in-charge. The empty tins shall not be removed from the site of work, till this item of work has been completed and passed by the Employer.

##### 10.11.2 Preparation of the Surface

10.11.2.1 For new work the surface shall be thoroughly cleaned of dust, old white or colour wash by washing and scrubbing. The surface shall then be sand papered to give a smooth and even surface. Any unevenness shall be made good by applying putty, made of plaster of Paris mixed with water on the entire surface including filling up the undulations and then sand papering the same after it is dry.

10.11.2.2 Pitting in plaster shall be made good with plaster of Paris mixed with the colour to be used. The surface shall then be rubbed down again with a fine grade sand paper and made smooth. A coat of the distemper shall be applied over the patches. The patches surface shall be allowed to dry thoroughly before the regular coat of distemper is applied.

##### 10.11.3 Application

10.11.3.1 The priming coat shall be with distemper primer or cement primer, as required in the description of the item.

*Note: If the wall surface plaster has not dried completely, cement primer shall be applied before distempering the walls, but if distempering is done after the wall*

*surface is dried completely, distemper primer shall be applied.*

10.11.3.2 Oil bound distemper is not recommended to be applied, within six months of the completion of wall plaster. However, newly plastered surfaces if required to be distempered before a period of six months shall be given a coat of alkali resistant priming paint conforming to IS: 109 and allowed to dry for at least 48 hours before distempering is commenced.

#### 10.11.3.3 Distemper Coat

1. For new work, after the primer coat has dried for at least 48 hours, the surface shall be lightly sand papered to make it smooth for receiving the distemper, taking care not to rub out the priming coat. All loose particles shall be dusted off after rubbing. One coat of distemper properly diluted with thinner (water or other liquid as stipulated by the manufacturer) shall be applied with brushes in horizontal strokes followed immediately by vertical ones which together constitutes one coat.
2. The subsequent coats shall be applied in the same way. Two or more coats of distemper as are found necessary shall be applied over the primer coat to obtain an even shade.
3. A time interval of at least 24 hours shall be allowed between successive coats to permit proper drying of the preceding coat.
4. 15 cm double bristled distemper brushes shall be used. After each day's work, brushes shall be thoroughly washed in hot water with soap solution and hung down to dry. Old brushes which are dirty and caked with distemper shall not be used on the work.

#### 10.11.4 Rate

10.11.4.1 The rate shall include the cost of all labour and materials involved in all the above operations (including priming coat) described above.

### 10.12 Cement Primer Coat

10.12.1 Cement primer coat is used as a base coat on wall finish of cement, lime or lime cement plaster or on asbestos cement surfaces before oil emulsion distemper paints are applied on them. The cement primer is composed of a medium and pigment which are resistant to the alkalis present in the cement lime or lime cement in wall finish and provides a barrier for the protection of subsequent coats of oil emulsion distemper paints.

10.12.2 Primer coat shall be preferably applied by brushing and not by spraying. Hurried priming shall be avoided particularly on absorbent surfaces. New plaster patches in old work should also be treated with cement primer before applying oil emulsion paints etc.

#### 10.12.3 Preparation of the Surface

10.12.3.1 The surface shall be thoroughly cleaned of dust, old white or colour wash by

washing and scrubbing. The surface shall then be allowed to dry for at least 48 hours. It shall then be sand papered to give a smooth and even surface. Any unevenness shall be made good by applying putty, made of plaster of Paris mixed with water on the entire surface including filing up the undulations and then sand papering the same after it is dry.

#### 10.12.4 Application

10.12.4.1 The cement primer shall be applied with a brush on the clean dry and smooth surface. Horizontal strokes shall be given first and vertical strokes shall be applied immediately afterwards. This entire operation will constitute one coat. The surface shall be finished as uniformly as possible leaving no brush marks. It shall be allowed to dry for at least 48 hours, before oil emulsion paint is applied.

### 10.13 Cement Paint

#### 10.13.1 Materials

10.13.1.1 The cement paint shall be (conforming to IS: 5410) of approved brand and manufacture.

10.13.1.2 The cement paint shall be brought to the site of work by the Contractor in its original containers in sealed condition. The material shall be brought in at a time in adequate quantities to suffice for the whole work or at least a fortnight's work. The materials shall be kept in the joint custody of the Contractor and the Employer.

#### 10.13.2 Preparation of Surface

10.13.2.1 For new work, the surface shall be thoroughly cleaned of all mortar dropping, dirt dust, algae, grease and other foreign matter by brushing and washing. Pitting in plaster shall be made good and a coat of water proof cement paint shall be applied over patches after wetting them thoroughly.

#### 10.13.3 Preparation of mix

10.13.3.1 Cement paint shall be mixed in such quantities as can be used up within an hour of its mixing as otherwise the mixture will set and thicken, affecting flow and finish. Cement paint shall be mixed with water in two stages. The first stage shall comprise of 2 parts of cement paint and one part of water stirred thoroughly and allowed to stand for 5 minutes. Care shall be taken to add the cement paint gradually to the water and not vice versa. The second stage shall comprise of adding further one part of water to the mix and stirring thoroughly to obtain a liquid of workable and uniform consistency. In all cases the manufacturer's instructions shall be followed meticulously.

10.13.3.2 The lids of cement paint drums shall be kept tightly closed when not in use, as by exposure to atmosphere the cement paint rapidly becomes air set due to its hygroscopic qualities.

10.13.3.3 In case of cement paint brought in gunny bags, once the bag is opened, the contents

should be consumed in full on the day of its opening. If the same is not likely to be consumed in full, the balance quantity should be transferred and preserved in an airtight container to avoid its exposure to atmosphere.

#### 10.13.4 Application

10.13.4.1 The solution shall be applied on the clean and wetted surface with brushes or spraying machine. The solution shall be kept well stirred during the period of application. It shall be applied on the surface which is on the shady side of the building so that the direct heat of the sun on the surface is avoided. The method of application of cement paint shall be as per manufacturer's Specification. The completed surface shall be watered after the day's work.

10.13.4.2 The second coat shall be applied after the first coat has been set for at least 24 hours. Before application of the second or subsequent coats, the surface of the previous coat shall not be wetted.

10.13.4.3 For new work, the surface shall be treated with three or more coats of water proof cement paint as found necessary to get uniform shade.

#### 10.13.5 Precaution

10.13.5.1 Water proof cement paint shall not be applied on surface already treated with white wash, colour wash, distemper dry or oil bound, varnishes, paints etc. It shall not be applied on gypsum, wood and metal surfaces.

### 10.14 Painting

#### 10.14.1 Materials

10.14.1.1 Paints, oils varnishes etc. of approved brand and manufacture shall be used. Only ready mixed paint (exterior grade) as received from the manufacturer without any admixture shall be used.

10.14.1.2 If for any reason, thinning is necessary in case of ready mixed paint, the brand of thinner recommended by the manufacturer or as instructed by the Employer shall be used.

10.14.1.3 Approved paints, oil or varnishes shall be brought to the site of work by the Contractor in their original containers in sealed condition. The material shall be brought in at a time in adequate quantities to suffice for the whole work or at least of fortnight's work. The empties shall not be removed from the site of work till the relevant item of work has been completed and permission obtained from the Employer.

#### 10.14.2 Commencing Work

10.14.2.1 Painting shall not be started until the Employer has inspected the items of work to be painted satisfied himself about their proper quality and given his approval to commence the painting work. Painting of external surface should not be done in

adverse weather condition like hail storm and dust storm.

10.14.2.2 Painting, except the priming coat, shall generally be taken in hand after practically finishing all other building work.

10.14.2.3 The room should be thoroughly swept out and the entire building cleaned up, at least one day in advance of the paint work being started.

#### 10.14.3 Preparation of Surface

10.14.3.1 The surface shall be thoroughly cleaned and dusted off. All rust, dirt, scales, smoke splashes, mortar droppings and grease shall be thoroughly removed before painting is started. The prepared surface shall have received the approval of the Employer after inspection, before painting is commenced.

#### 10.14.4 Application

10.14.4.1 Before pouring into smaller containers for use, the paint shall be stirred thoroughly in its containers, when applying also, the paint shall be continuously stirred in the smaller containers so that its consistency is kept uniform.

10.14.4.2 The painting shall be laid on evenly and smoothly by means of crossing and laying off, the latter in the direction of the grains of wood. The crossing and laying off consists of covering the area over with paint, brushing the surface hard for the first time over and then brushing alternately in opposite direction, two or three times and then finally brushing lightly in a direction at right angles to the same. In this process, no brush marks shall be left after the laying off is finished. The full process of crossing and laying off will constitute one coat.

10.14.4.3 Where so stipulated, the painting shall be done by spraying. Spray machine used may be (a) high pressure (small air aperture) type, or (b) a low pressure (large air gap) type, depending on the nature and location of work to be carried out. Skilled and experienced workmen shall be brought to the requisite consistency by adding a suitable thinner.

10.14.4.4 Spraying should be done only when dry condition prevails. Each coat shall be allowed to dry out thoroughly and rubbed smooth before the next coat is applied. This should be facilitated by thorough ventilation. Each coat except the last coat, shall be lightly rubbed down with sand paper or fine pumice stone and dust cleaned off before the next coat is laid.

10.14.4.5 No left over paint shall be put back into the stock tins. When not in use, the containers shall be kept properly closed.

10.14.4.6 No hair marks from the brush or clogging of paint puddles in the corners of panels, angles of mouldings etc. Shall be left on the work.

10.14.4.7 In painting doors and windows, the putty round the glass panes must also be painted but care must be taken to see that no paint stains etc. are left on the glass. Tops of shutters and surfaces in similar hidden locations shall not be left out in painting.



However, bottom edge of the shutters where the painting is not practically possible, need not be done nor any deduction on this account will be done but two coats of primer of approved make shall be done on the bottom edge before fixing the shutters.

10.14.4.8 On painting steel work, special care shall be taken while painting over bolts, nuts, rivets overlaps etc.

10.14.4.9 The additional Specifications for primer and other costs of paints shall be as according to the detailed Specifications under the respective headings.

#### 10.14.5 Brushes and Containers

10.14.5.1 After work, the brushes shall be completely cleaned of paint and linseed oil by rinsing with turpentine. A brush in which paint has dried up is ruined and shall on no account be used for painting work. The containers when not in use, shall be kept closed and free from air so that paint does not thicken and also shall be kept safe from dust. When the paint has been used, the containers shall be washed with turpentine and wiped dry with soft clean cloth, so that they are clean, and can be used again.

#### 10.14.6 Measurements

10.14.6.1 The length and breadth shall be measured correct to a cm. The area shall be calculated in sqm (correct to two places of decimal), except otherwise stated.

10.14.6.2 Small articles not exceeding 0.1 sqm of painted surfaces where not in conjunction with similar painted work shall be enumerated.

10.14.6.3 Painting upto 10 cm in width or in girth and not in conjunction with similar painted work shall be given in running metres and shall include cutting to line where so required.

10.14.6.4 Components of trusses, compound girders, stanchions, lattices and similar work shall, however, be given in sqm. irrespective of the size or girth of members. Priming coat of painting shall be included in the work of fabrication.

10.14.6.5 In measuring painting, varnishing, oiling etc. of joinery and steel work etc. the coefficients as indicated in following tables shall be used to obtain the area payable. The coefficients shall be applied to the areas measured flat and not girthed.

10.14.6.6 Width of moulded work of all other kinds, as in hand rails, cornices, architraves shall be measured by girth.

10.14.6.7 For trusses, compound girders, stanchions, lattice girders, and similar work, actual areas will be measured in sqm. and no extra shall be paid for painting on bolt heads, nuts, washers etc. even when they are picked out in a different tint to the adjacent work.

10.14.6.8 Painting of rain water, soil, waste, vent and water pipes etc. shall be measured in

running metres of the particular diameter of the pipe concerned. Painting of specials such as bends, heads, branches, junctions, shoes, etc., shall be included in the length and no separate measurements shall be taken for these or for painting brackets, clamps etc.

10.14.6.9 Measurements of wall surfaces and wood and other work not referred to already shall be recorded as per actual.

10.14.6.10 Flag staffs, steel chimneys, aerial masts, spires and other such objects requiring special scaffolding shall be measured separately.

#### 10.14.7 Precautions

10.14.7.1 All furnitures, fixtures, glazing, floors etc. shall be protected by covering and stains, smears, splashings, if any shall be removed and any damages done shall be made good by the Contractor at his cost.

#### 10.14.8 Rate

10.14.8.1 Rates shall include cost of all labour and materials involved in all the operations described above and in the particular Specifications given under the several items.

### 10.15 Painting Priming Coat on Wood, Iron or Plastered Surfaces

#### 10.15.1 Primer

10.15.1.1 The primer for wood work, iron work or plastered surface shall be as specified in the description of item.

10.15.1.2 Primer for plaster/wood work/iron and steel/aluminium surfaces shall be as specified below:

Sr.	Surfaces	Primer to be used
1.	Wood work (hard and soft wood)	Pink conforming to IS: 3536
2.	Resinour wood and plywood	Aluminium primer conforming to IS: 3585
3.	(A) Aluminium and light alloy (B) Iron, Steel Galvanized steel	Zinc chromate primer conforming to IS: 104 Oxide Zinc chromate Primer conforming IS: 2074
4.	Cement/Conc/RCC/brick work, Plastered surfaces, asbestos surfaces to receive Oil bound distemper or paint finish.	Cement primer conforming to IS: 109

10.15.1.3 The primer shall be ready mixed primer of approved brand and manufacture.

10.15.1.4 Where primer for wood work is specified to be mixed at site, it shall be prepared from a mixture of red lead, white lead and double boiled linseed oil in the ratio of

0.7 kg: 1 litre.

10.15.1.5 Where primer for steel work is specified to be mixed at site, it shall be prepared from a mixture of red lead, raw linseed oil and turpentine in the ratio of 2.8 kg: 1 litre: 1 litre.

10.15.1.6 The Specifications for the base vehicle and thinner for mixed on site primer shall be as follows:

1. White lead: The White lead shall be pure and free from adulterants like barium sulphate and whiting. It shall conform to IS: 103.
2. Red lead: This shall be in powder form and shall be pure and free from adulterants like brick dust etc. It shall conform to IS: 102.
3. Raw Linseed Oil: Raw linseed oil shall be lightly viscous but clear and of yellowish colour with light brown tinge. Its specific gravity at a temperature of 30 degree C shall be between 0.923 and 0.928.

*Note: The oil shall be mellow and sweet to taste with very little smell. The oil shall be of sufficiently matured quality. Oil turbid or thick, with acid and bitter taste and rancid odour and which remains sticky for a considerable time shall be rejected. The oil shall conform in all respects to IS: 75. The oil shall be of approved brand and manufacture.*

4. Double boiled linseed oil: This shall be more viscous than the raw oil, have a deeper colour and specific gravity between 0.931 and 0.945 at a temperature of 30 degree C. It shall dry with a glossy surface. It shall conform in all respects to IS: 77. The oil shall be of approved brand and manufacture.
5. Turpentine: Mineral turpentine i.e., petroleum distillate which has the same rate of evaporation as vegetable turpentine (distillate product of oleoresin of conifers) shall be used. It shall have no grease or other residue when allowed to evaporate. It shall conform to IS: 533.

10.15.1.7 All the above materials shall be of approved manufacture and brought to site in their original packing in sealed condition.

#### 10.15.2 Preparation of surface

##### 10.15.2.1 Wooden surface

The wood work to be painted shall be dry and free from moisture. The surface shall be thoroughly cleaned. All unevenness shall be rubbed down smooth with sand paper and shall be well dusted. Knots, if any shall be covered with preparation of red lead made by grinding red lead in water and mixing with strong glue sized and used hot. Appropriate filler material conforming to IS: 345 with same shade as paint shall be used where specified. The surface treated for knotting shall be dry before paint is applied. After obtaining approval of Employer for wood work, the priming coat shall be applied before the wood work, is fixed in position. After the priming coat is applied, the holes and indentation on the surface shall be stopped with glazier's putty or wood putty. Stopping shall not be done before the priming coat is applied as the wood will absorb the oil in stopping

and the latter is therefore liable to crack

#### 10.15.2.2 Iron & Steel Surface

1. All rust and scales shall be removed by scrapping or by brushing with steel wire brushes. Hard skin of oxide formed on the surface of wrought iron during rolling which becomes loose by rusting, shall be removed.
2. All dust and dirt shall be thoroughly wiped away from the surface.
3. If the surface is wet, it shall be dried before priming coat is undertaken.

#### 10.15.2.3 Plastered Surface

The surface shall ordinarily not be painted until it has dried completely. Trial patches of primer shall be laid at intervals and where drying is satisfactory, painting shall then be taken in hand. Before primer is applied, holes and undulations, shall be filled up with plaster of Paris and rubbed smooth.

#### 10.15.3 Application

- 10.15.3.1 The primer shall be applied with brushes, worked well into the surface and spread even and smooth.

#### 10.15.4 Treatment on steel for aggressive environment

- 10.15.4.1 A second coat of ready mixed red oxide zinc chromate primer may be applied where considered necessary in aggressive environment such as near Industrial Establishment and Coastal regions where the steel members are prone to corrosion. The second coat (which shall be paid for separately) is to be applied after placing the member in position and just before applying paint. The second coat of primer is not necessary in case of painting with synthetic enamel paint as it is applied over an under coat of ordinary paint.

### **10.16 Painting with Ready Mixed Paint**

- 10.16.1 Ready mixed paints of approved brand and manufacture and of the required shades shall be used. They shall conform in all respects to the relevant IS Specifications.

#### 10.16.2 Painting on New Surface

- 10.16.2.1 The surface which has not been painted earlier, or the paint had been removed by paint remover, burning, caustic soda etc. shall be considered to be new surface.

#### 10.16.3 Preparation of Surface

##### 10.16.3.1 Wood work

The surface shall be cleaned and all unevenness removed as specified in Clause 12.22.2.1 knots if visible, shall be covered with a preparation of red lead. Holes and indentations on the surface shall be filled in with glazier's putty or wood putty

conforming to IS: 419 and rubbed smooth before painting is done. The surface should be thoroughly dry before painting.

#### 10.16.3.1 Iron and Steel work

The priming coat shall have dried up completely before painting is started. Rust and scaling shall be carefully removed by scraping or by brushing with steel wire brushes. All dust and dirt shall be carefully and thoroughly wiped away.

#### 10.16.3.2 Plastered surface

The priming coat shall have dried up completely before painting is started. All dust or dirt that has settled on the priming coat shall be thoroughly wiped away before painting is started.

#### 10.16.4 Application

10.16.4.1 The number of coats to be applied will be as stipulated in the item. The painted surface shall present a uniform appearance and glossy finish, free from streaks, blisters etc.

### 10.17 Painting Ready Mixed Paint over G.S. Sheets

10.17.1 Ready mixed paint, suitable for painting over G.S. sheets, of approved brand and manufacture and of the required shade shall be used. New or weathered G.S. Sheets shall be painted with a priming coat of one coat of red oxide zinc chromate paint. Primer shall be applied before fixing sheets in place.

#### 10.17.2 Preparation of Surface

##### 10.17.2.1 Painting new surface

1. The painting of new G.S. sheets not usually be done till the sheets have weathered for about a year. When new sheets are to be painted before they have weathered they shall be treated with a mordant solution prepared by the mixing 38 gm of copper acetate in a litre of soft water or 13 gm hydrochloric acid in a solution of 13 gm each of copper chloride, copper nitrate and ammonium chloride dissolved in a litre of soft water. This quantity of solution is sufficient for about 235 sqm. to 280 sqm of area and is applied for ensuring proper adhesion of paint. The painting with the mordant solution will be paid for separately.
2. Before painting on new or weathered G.S. sheets, rust patches shall be completely cleaned with coarse emery paper and brush. All grease marks shall also be removed and the surface washed and dried and rusted surface and the surface washed and dried and rusted surface shall be touched with ready mixed paint of red lead.

#### 10.17.3 Application

10.17.3.1 The number of coats to be applied shall be as in the description of item. In the case

of C.G.S. sheets, the crowns of the corrugations shall be painted first and when these get dried the +general coat shall be given to ensure uniform finish over the entire surface.

10.17.3.2 The second or additional coats shall be applied when the previous coat has dried.

### **10.18 Painting Cast Iron Rain Water, Soil, Waste and Vent Pipes and Fittings**

10.18.1 The primer shall be prepared on site or shall be of approved brand and manufacture as specified in the item.

10.18.2 Paint shall be anti-corrosive bitumastic paint aluminum paint or other type of paint as specified in the description of the item.

10.18.3 Painting New Surface

10.18.3.1 Application

The number of coat of painting over the priming coat shall be as stipulated in the description of the item. The application of paint over priming coat shall be carried out as specified in Clause 9.23.

10.18.4 Measurements

10.18.4.1 Measurements will be taken over the finished line of pipe including specials etc. In running meters, correct to a cm.

10.18.4.2 Pipes of different diameters of bore shall be measured and paid for separately.

10.18.4.3 Specials and fittings such as holder bet clamps, plugs etc. will not be measured separately.

10.18.5 Rate

10.18.5.1 The rate shall include the cost of all materials and labour involved in all the operations described above, including painting of all specials and fittings.

### **10.19 Painting with Wood Preservative**

10.19.1 Oil type wood preservative of specified quality and approved make, conforming to IS: 218 - 1983 shall be used. Generally, it shall be Creosote Oil Type -1 or Anthracene Oil.

10.19.2 Painting of New Surface

10.19.2.1 Preparation of surface

Painting shall be done only when the surface is perfectly dry to permit of good absorption. All dirt, dust or other foreign matter shall be removed from the surface to be painted. All roughness shall be sand papered and cleaned.

#### 10.19.3 Application

- 10.19.3.1 The preservative shall be applied liberally with a stout brush and not daubed with rags of cotton waste. It shall be applied with a pencil brush at the joints of the wood work. The first coat shall be allowed at least 24 hours to soak in before the second (the final) coat is applied. The second coat shall be applied in the same manner as the first coat. The excess of preservative which does not soak into the wood shall be wiped off with a clean dry piece of cloth.

### 10.20 Coal Tarring

- 10.20.1 Coal tar of approved manufacture conforming to IS: 290 shall be used. The tar, to every litre of which 200 gm of unslaked lime had been added, shall be heated till it begins to boil. It must then be taken off the fire and kerosene oil added to it slowly as the rate of one part of kerosene oil to six or more parts by volume and stirred thoroughly. The addition of lime is for preventing the tar from running.

#### 10.20.2 Coal Tarring New Surface

##### 10.20.2.1 Preparation of surface

This shall be done as specified in Clause 10.22 except that sand papering is not necessary. Where iron work is to be painted it shall be freed from scales and rust before painting.

##### 10.20.2.2 Application

The mixture shall be applied as hot as possible with a brush. The second coat shall be applied only after the first coat has thoroughly dried up. Where possible, the article to be tarred, shall be dipped in the hot mixture for better results. The quantity of tar to be used for the first or second coat shall be not less than 0.16 and 0.12 liter per sqm respectively. Thinning with kerosene oil shall be suitable done to ensure this. The Specifications described in Clause 9.21 shall hold good in all other respects, so far as they are applicable.

### 10.21 Wall Painting with Plastic Emulsion Paint

- 10.21.1 The plastic emulsion paint is not suitable for application on external, wood and iron surface and surfaces which are liable to heavy condensation. These paints are to be used on internal surfaces except wooden and steel.
- 10.21.2 Plastic emulsion paint as per IS: 5411 of approved brand and manufacture and of the required shade shall be used.

### 10.21.3 Painting on new surface

10.21.3.1 The wall surface shall be prepared as specified in Clause 10.21.3.

### 10.21.4 Application

10.21.4.1 The number of coats shall be as stipulated in the item. The paint will be applied in the usual manner with brush, spray or roller. The paint dries by evaporation of the water content and as soon as the water has evaporated the film gets hard and the next coat can be applied. The time of drying varies from one hour on absorbent surface to 2 to 3 hours on non-absorbent surfaces.

10.21.4.2 The thinning of emulsion is to be done with water and not with turpentine. Thinning with water will be particularly required for the under coat which is applied on the absorbent surface. The quantity of water to be added shall be as per manufacture's instructions.

10.21.4.3 The surface on finishing shall present a flat velvety smooth finish. If necessary more coats will be applied till the surface presents a uniform appearance.

### 10.21.5 Precautions

10.21.5.1 Old brushes if they are to be used with emulsion paints, should be completely dried of turpentine or oil paints by washing in warm soap water.

10.21.5.2 Brushes should be quickly washed in water immediately after use and kept immersed in water during break periods to prevent the paint from hardening on the brush.

10.21.5.3 In the preparation of wall for plastic emulsion painting, no oil base putties shall be used in filling cracks, holes etc.

10.21.5.4 Splashes on floors etc. Shall be cleaned out without delay as they will be difficult to remove after hardening.

10.21.5.5 Washing of surfaces treated with emulsion paints shall not be done within 3 to 4 weeks of application.

10.21.5.6 Other details shall be as specified in Clause 10.21 as far as they are applicable.

## 10.22 Painting with Enamel Paint

10.22.1 Enamel Paint (conforming to IS: 2933-1975) of approved brand and manufacture and of the required colour shall be used.

10.22.2 For the under coat, the paint of same quality but of shade to suit that of the top coat shall be used.



10.22.3 Preparation of surface and application shall be as specified under Clause 10.23 for painting of new surfaces or old surfaces, as the case may be.

10.22.4 Other details shall be as specified in Clause 10.21 as far as applicable.

### **10.23 Painting with Synthetic Enamel Paint**

10.23.1 Synthetic enamel paint (confirming to IS: 2932) of approved brand and manufacture and of the required colour shall be used for the top coat and an undercoat of ordinary paint of shade to match top coat as recommended by the same manufacture as for the top coat shall be used.

#### **10.23.2 Painting of New Surface**

10.23.2.1 Preparation of surface shall be as specified in Clause 10.23.

##### **10.23.2.2 Application**

The number of coats including the undercoat shall be as stipulated in the item.

##### **10.23.2.3 Under Coat**

One coat of the specified ordinary paint of shade suited to the shade of the top coat, shall be applied and allowed to dry overnight. It shall be rubbed next day with the finest grade of wet abrasive paper to ensure a smooth and even surface, free from brush marks and all loose particles dusted off.

##### **10.23.2.4 Top Coat**

Top coats of synthetic enamel paint of desired shade shall be applied after the undercoat is thoroughly dry. Additional finishing coats shall be applied if found necessary to ensure properly uniform glossy surface.

10.23.2.5 Other details shall be as specified in Clause 10.21 as far as they are applicable.

### **10.24 Painting with Aluminium Paint**

10.24.1 Aluminium paint shall be (conforming to IS: 2339) of approved brand and manufacture. The paint comes in compact dual container with the paste and the medium separately. The two shall be mixed together to proper consistency before use.

#### **10.24.2 Preparation of Surface**

##### **10.24.2.1 Steel Work (New Surface)**

All rust and scales shall be removed by scraping or brushing with steel wire brushes and then smoothened with sand paper. The surface shall be thoroughly cleaned of dust.

#### 10.24.2.2 C.G.S. Sheets (New Surfaces)

The preparation of surface shall be as described in Clause 10.24.

#### 10.24.3 Application

10.24.3.1 The number of coats to be applied shall be as given in the item. Each coat shall be allowed to dry for 24 hours and lightly rubbed down with fine grade sand paper and dusted off before the next coat is applied. The finished surface shall present an even and uniform appearance.

10.24.3.2 As aluminium paste is likely to settle in the container, care shall be taken to frequently stir the paint during use. Also the paint shall be applied and laid off quickly, as surface is otherwise not easily finished.

10.24.4 Other details shall be as specified in Clause 10.21 as far as they are applicable.

#### 10.25 Painting with Acid Proof Paint

10.25.1 Acid proof paint of approved brand and manufacture and of the required shade shall be used.

10.25.2 Preparation of surface and application shall be as specified under Clause 10.23.

10.25.3 Other details shall be as specified in Clause 10.21 as far as they are applicable.

#### 10.26 Painting with Anti-Corrosive Bitumastic Paint

10.26.1 Ready mixed paint (conforming to IS: 158-1981) shall be of approved brand and manufacture. It shall be black, lead free, acid-alkali-heat-water resistant.

10.26.2 Preparation of surface and application shall be as specified for painting on new or old surfaces as the case may be.

10.26.3 The drying time between consecutive coats, however, shall be not less than 3 hours.

10.26.4 Other details shall be as specified as far as applicable.

#### 10.27 Lettering with Paint

10.27.1 Black Japan paint (conforming to IS: 341) or ready mixed paint as ordered by the Employer shall be used. The paint shall be of approved brand and manufacture. Ordinary ready mixed paint shall be of the shade required by the Employer.

#### 10.27.2 Lettering on New Surface

##### 10.27.2.1 Application

1. The letters and figures shall be to the heights and width as ordered by the

Employer. These shall be stenciled or drawn in pencil and got approved before painting. They shall be of uniform size and finished neatly. The edges shall be straight or in pleasant smooth curves. The thickness of the lettering shall be as approved by the Employer. Lettering shall be vertical or slanting as required.

2. Two or more coats of paint shall be applied till uniform colour and glossy finish are obtained.

#### 10.27.2.2 Measurements

1. Measurements shall be taken in terms of letter cm (the measurement related to the vertical height of the lettering). The letter heights shall be measured correct to a cm.
2. Dots, dashes, punctuations and other similar marks or lines shall not be measured for payment.
3. In Devanagari / Kannada script Dots & Matras occurring with the letters shall not be measured. Half letter shall be measured as full letter. The height of letters shall be measured excluding the Matras projecting above the heading and Matras below the letters.

#### 10.27.2.3 Rate

Rate shall include the cost of all labour and materials involved in the operations described above. The rate per cm height of letter shall hold good irrespective of the width of the letters or figures or the thickness of the lettering. The same rate will apply irrespective of whether black Japan or ready mixed paint of any shade as required is used.

## 11 SUPPLYING, LAYING AND JOINTING OF M.S. PIPES

### 11.1 M.S. PIPES

Scope -This specification covers the general requirements for supply, fabrication, delivery at site laying, jointing, testing and commissioning of all welded M.S pipeline, above / below ground, including Civil works required for the same. For pipe-to-pipe joints, butt-welding is preferred, however, collar jointing is permitted in special case as per site condition with approval of Engineer-in-charge.

#### 11.1.1 Applicable codes & Specifications (M.S. pipes)

The following specifications, standards and codes are made a part of the specification. All standards, tentative specifications, specifications, codes of practice referred to herein shall be the latest editions including all applicable official amendments and revisions.

In case of discrepancy between this specification and those referred to herein, this specification shall govern.

IS : 814 Covered Electrodes for manual Metal Arc Welding of carbon and C-Mn steel.

IS : 816 Code of practice for use of Metal Arc Welding for General Construction in mild steel.

IS : 817 Code of practice for Training and Testing of Metal Arc Welders.

IS : 1182 Recommended practice for Radiographic examination of Fusion - Welded Butt Joints in steel plants

BS EN 499 Welding Consumables. Covered Electrodes for Manual Metal Arc Welding of Non Alloy and Fine Grain Steel. Classification

AWS : A-5.1 Specification for Mild Steel Covered Arc Welding Electrodes.

IS : 1377 Technical Supply Conditions for Threaded Fasteners (Parts 1 to 3).

IS : 1608 Mechanical testing of Metals.

IS : 2016 Plain Washers.

IS : 2062 Steel for general structural purposes.

IS : 2595 Code of Practice for Radiographic Testing.

IS : 2598 Safety Code for Industrial Radiographic Practice

IS : 3589 Seamless or Electrically welded steel pipes for Water Gas and sewage (168.3 to 2032 Outside Diameter)

IS : 3658 Code of Practice for Liquid Penetrant Flaw Detection

ASTM E 94 Guide for Radiographic Testing

ASTM E 709 Guide for Magnetic Particle Examination.

ASTM E 165 Test Method for Liquid Penetrant Examination.

IS : 3700 Methods of Testing Fusion Welded Joints and weld metal in steel (Parts 1 to 9)

IS : 4853 Recommended Practice for Radiographic Inspection of Fusion Welded Butt Joints in Steel Pipes.

IS : 5334 Code of practice for Magnetic Particle Flaw Detection of welds.

IS : 5504 Code for SAW pipes and I.S. 10748 requirement of weldable hot rolled carbon steel strip in coils.

IS : 5822 Code of Practice for Laying of Electrically Welded steel pipes

for water supply

IS : 6631 Steel pipes for Hydraulic Purposes

IS : 7343 Code of practice for ultrasonic Testing of Ferrous Welded Pipes and Tubular Products

IS : 9595 Metal Arc welding of Carbon and Carbon-Manganese Steels.

#### 11.1.2 MATERIALS:

##### 11.1.2.1 Steel Plates

The steel plates for pipes, fittings, specials and stiffeners shall be of mild steel conforming to IS: 2062, grade Fe 410. The width of MS plates/HR Coil used for fabrication of pipe drums preferably 1.5m but should not be less than 1.2 m.

The procedure for cutting plates to sizes, rolling of plates post bending, tack welding, internal and external welding, facing should be such that it results in pipes of required inner diameter conforming to IS : 3589.

##### 11.1.2.2 Welding Consumables

Such as electrodes, filler rods and wires shall conform to IS:814, IS:3613, IS:6419 and IS : 816 & IS: 7280.

##### 11.1.2.3 Cement

The cement used shall be Ordinary Portland Cement of minimum grade 43 conforming to IS: 8112.

#### 11.1.3 INSPECTION

All works and material under specification will be rigidly inspected during all phases of manufacture and testing and such inspection shall not relieve the contractor of his responsibility to furnish materials and performed work in accordance with this specification.

The contractor shall notify the engineer-in-charge, in advance of the production schedule of materials and fabrication thereof, in order that, if need arises, the employer may arrange for inspection.

The engineer-in-charge may reject any or all materials or work that do not meet with any of the requirements of this specification. The contractor shall rectify or replace such rejected material / performed work at his own cost, to the satisfaction of the engineer-in-charge.

The engineer-in-charge shall have free access to those parts of all plants or any other premises and sites that are concerned with the furnishing of materials or the performance of work under this specification.

The contractor shall furnish to the employer's inspector reasonable facilities and space without charge for inspection, testing and obtaining of any information he desires in respect of the character of material used and the progress and manner of the work.

The contractor shall supply free of cost the required specimen of materials for testing by the employer at any time during the progress of work and shall bear the cost of all such tests or retests to the satisfaction of engineer-in-charge.

The contractor shall provide 2 (two) sets of accurate gauges to measure plate thickness of pipes and specials for the use of the engineer-in-charge at no extra cost.

#### 11.1.4 MANUFACTURE OF M.S. PIPE

##### General

All pipes and specials shall be manufactured out of new mild steel plates or coil with no negative tolerance which shall be free from any cracks, surface flaws, laminations, excessive pittings or any other defects. The pipe shall be mill manufactured of either plate welded or spiral welded variety with longitudinal or spiral welds conforming to relevant codes (IS:3589) and shall be truly cylindrical, and straight in axis. The ends shall be accurately cut and prepared for welding. No site-fabricated pipes are allowed. The external circumference of the pipe pieces, which are to be fixed adjacent to flange adapter with fixed outer diameter, shall not deviate from theoretical one by more than 1 mm. To obtain this accuracy the pipe shall be rolled several times, if necessary, as pipe pieces should be truly cylindrical. The external longitudinal / spiral welding of the pipe shall be ground smooth flush with surface to the satisfaction of the Engineer-in-Charge. No extra cost shall be charged by the Contractor for this grinding work. The minimum length of the barrel shall be 6.0 m.

Minor repair by welding or otherwise shall be permitted at the discretion of the Engineer-in-Charge, but such repairs shall be done only after obtaining the permission of the Engineer-in-Charge. Any pipe or part thereof which develops injurious defects during shop welding or other operations shall be rejected.

Spirally (SAW) welded pipe manufactured by SAIL / other manufactures at their manufacturing units are to be used in standard length. After manufacturing and testing, the pipes can be transported from depot / manufacturing shop by rail / road to lining and coating yard. Each pipe shall be hydrostatically tested in the mill / plant. The pipe shall be subjected to ultrasonic and radiographic testing of weld seam and body of pipes as specified.

#### 11.1.4.1 Fabrication

The Contractor shall get the fabrication work done in a duly valid licensed factory of his own or that of an approved nominated sub-contractor. This factory meant for fabrication of pipes, specials etc. shall also be involved with testing, machining as well as lining by centrifugal process, out coating etc. For completing the work under the present contract within the contract period, the factory shall be equipped with adequate number of various equipment and plant.

The factory shall have adequate area, and shall also have stacking yard for the stacking of plates, structural, fabricated pipes and scrap etc.

The Bidder shall furnish the details of the factory where he intends to get the fabrication done, such as its location and the equipment, plant and other facilities available in the factory for the manufacture of M.S. Pipes and special required under this contract.

#### 11.1.4.2 WELDING

All components of a standard shell, either straight or bent etc. shall be welded by use of automatic Submerged Arc welding process with alternating current. Hand welding shall not be permitted except for sealing runs and such other minor works at the discretion of the Engineer-in-Charge. The strength of the joint shall be at least equal to that of the parent material.

The Contractor shall use electrodes either of Advani- Orlecon, D&H (Medio), WELDWELL make (SFA 5.1 AWSE-6013) or other equivalent approved make and the size depending on the thickness of plate and the type of joint. The contractor shall also use standard current and arc voltage required for the machine in use with such modifications as may be found necessary after experimental welding. For this purpose, samples of welded joints shall be prepared and tested in

the presence of the Engineer-in-Charge. The values once determined shall be maintained throughout the work and if any modifications are to be made, a written permission of the Engineer-in-Charge shall be obtained. In the case of thin sheets, electric arc welding may not give satisfactory results and gas welding shall be resorted to. Gas welding shall be subject to the same specifications and tests as those for electric welds. Welding should be carried out inside as well as outside.

All the shop and field welding shall conform to the requirements of IS 823- and IS 4353, IS: 816, IS:3600 (Part-1). The sequence of welding shall be such as will avoid undue distortion and minimize residual shrinkage stresses, recommendation of IS:9595 shall be followed.

All longitudinal and circumferential joints shall be double welded butt joints. Field joints shall be from outside, with a sealing weld from inside. End preparation for such welding shall conform to IS: 2825.

All circumferential welds involving plates of unequal thickness shall be so kept that the inside surfaces of plates match to provide stream lined joints without alteration in the internal diameter. As far as practicable, welding of dissimilar thickness of shells shall be carried out in the shops.

The welding shall be of the best workmanship free from flaws, burns, etc. and the Contractor shall provide for his own electrodes and equipments, ovens to keep the electrodes at the desired temperatures and dry. In order to maintain a good standard in welding, welders shall be tested by the Contractor before they are entrusted with the job. Qualification standard for welding procedures, welders and welding operation shall conform to the requirements of IS: 7307 and IS: 7310 (latest). Test for welders shall be taken and those found inefficient shall be removed from the job. Only those who pass the test, shall be posted on the job. If an incompetent welder has already welded some pipes, all welding done by him previously shall be fully checked by X-ray in addition to the regular X-ray inspections. The defects, if any, shall be set right to the satisfaction of the Engineer-in-Charge. All such check tests and rectifications of defects shall be entirely at the cost of the Contractor. No pipes or steel sections shall be erected unless the work of the welder concerned has been proved to be satisfactory. Site



welds shall be done by specially selected welders.

A record shall be maintained showing the names of welders and operators who have worked on each individual joint. Hand welding shall preferably be carried out by a pair of welders so that, by observing proper sequence, distortion can be avoided. A joint entrusted to a particular individual or a pair shall be as far as possible, completed by them in all respects, including sealing run. No helper or other unauthorized person shall be permitted to do any welding whatsoever. In case of infringement of above, the persons shall be punished as directed by the Engineer-in-Charge.

The welded joint after welding should not become brittle or sensitive to blows and there should be no loss of toughness due to welding or heat treatment. The material after welding and heat treatment is to be tougher than the base metal and is to retain its original ductility. No allowance will be made for thinning of weld and the weld should in no point be less than the nominal thickness of plate. Final welding of closure gaps should be carried out within a temperature range of average air temperature + 8 °C as per IS: 5822.

Upon receipt of the order and prior to the start of fabrication, the Contractor shall submit to the Engineer-in-Charge for his approval the "Marking system" to record and identify the welds performed on the pipe along with information such as welder name, date, time and ambient temperature at the time of welding. The Contractor shall also submit to the Engineer-in-Charge for his approval the "welding procedure" he intends to use in the shop work. Similarly, prior to the start of the field welding, procedure for the field welding must be submitted to the Engineer-in-Charge for his approval. Manual welding shall be adopted only when machine welding is not possible.

#### 11.1.4.3 RADIOGRAPHY OF WELDED JOINTS

For the mild steel pipes manufactured in factory / workshop, fabricated from mild steel plate, 15 % of the weld length shall be subjected to recordable ultrasonic test. All 'T' junction joints shall be tested in full length.

15% of total field joint length at random shall be subjected to ultrasonic test. In case of failure of joints the contractor shall be required to carry out ultrasonic of

thrice the number of field joints failing during the radiography test. Even after such ultrasonic testing, if any one of the joint fails, the contractor shall be required to carry out ultrasonic of 100% of the joints. All these testing shall be carried out by the contractor at his own risk and cost. In case radiography is not permitted, then recordable ultrasonic testing of joints will be permitted.

The weld ripples or weld surface irregularities and slag etc, on both inside and outside shall be removed by any suitable mechanical process to a degree such that resulting radiographic contact due to any remaining irregularities cannot mark or be confused with that of objectionable defect. The radiograph shall be made in strict accordance with the latest requirements and as per the latest and most efficient technique either with X-ray or gamma ray equipment. The safety requirements during radiography shall be in accordance with IS : 2598.

The photographs are to be marked in such a way that the corresponding portion of the welded seam can be readily identified. All radiographs will be reviewed by the Engineer-in-Charge to identify the defect and determine those, which must be removed. Defects that are not acceptable shall be removed by chipping, machining or flame gouging to sound metal and the resulting cavities shall be welded. After rectification, the joint is to be radiographed again to prove the quality of the repair. The radiographs will be judged as acceptable or unacceptable by the Engineer-in-Charge based on the latest standards prescribed by Indian Standard specification.

All X-ray shall be made with equipment and by personnel furnished by the Contractor. Films shall be developed within 24 hours of exposure and be readily accessible at all times for inspection by the Engineer-in-Charge. The Contractor shall provide for the use of the Engineer-in-Charge suitable X-ray viewing equipment. X-ray films shall be properly maintained by the Contractor and shall be handed over to the department on completion of the Contract. All films shall be identified by the no. and chart prepared indicating location of the joint each X-ray photo represents. In the event of additional radiographic inspections required of any work associated with the pipe erection, such inspection shall be performed by the Radiographer at the discretion of the Engineer-in-Charge at no extra cost to the Employer.

#### 11.1.5 Radiographic Inspection

##### General

The Engineer-in-Charge shall assure himself that the welding procedure adopted in the construction of pipes have been of specified quality. The Contractor shall submit evidence to the Engineer-in-Charge that the requirements have been met. The Contractor shall certify that the welding of pipes has been done only by qualified welders and welding operators and the Engineer-in-Charge shall ensure himself that only qualified welders and welding operators have been used.

The Contractor shall make available to the Engineer-in-Charge a certified copy of the records of the qualification tests of each welder and welding operator. The Engineer-in-Charge shall have the right at any time to call for and witness tests of welding procedure or of the ability of any welder and welding operator.

##### Radiographic Inspection of welded joints

All welded joints to be radiographed shall be examined in accordance with

IS : 2595      Code of Practice for Radiographic Testing

IS : 4853      Recommended Practice for Radiographic Inspection of Fusion Welded butt joints in Steel

Pipes.

IS :1182      Recommended Practice for Radiographic Examination of Fusion Welded Butt-Joints in

steel plates.

IS :2598      Safety Code for Industrial Radiographic Practice.

The reinforcement on each side of all butt-welded joints shall not exceed 1.5 mm.

A complete set of radiographs and records as described in IS : 2595 Clause 14, for each job shall be retained by the Contractor and kept on file for a period of at least ten years (defect liability period).

Final acceptance of radiographs shall be based on the ability to see the prescribed penetrometer image and the specified hole.

Sections of welds that are shown by radiography to have any of the following types of imperfections shall be judged unacceptable and shall be repaired by the contractor at his own cost.

- ❖ any type of crack, or zone of incomplete fusion or penetration,
- ❖ any elongated slag inclusion which has length greater than 6 mm,
- ❖ any group of slag inclusion in line that have an aggregate length greater than thickness in a length of 12 times thickness, except when the distance between the successive imperfections exceeds 6L where L is the length of the longest imperfection in the group,
- ❖ rounded indications in excess of that specified by the acceptance standards given earlier.

#### Destructive Test

The destructive test of pipe joints on the field shall be carried out as per IS 3600. It will be one joint for every two Km. of laid length.

#### Tolerance

Tolerance for pipes in respect of diameter and straightness shall be in accordance with IS: 3589-2001.

The shell in the completed work shall be substantially rounded. The difference between maximum and minimum inside diameters at any cross section shall not exceed 1% of the nominal diameter of the cross section.

Straight pipes shall have their faces perpendicular to the axis of the section with a maximum deviation as per IS : 3589. Pipe ends shall be beveled as per IS : 3589.

The shell thickness shall conform to IS-3589 and no negative tolerance in shell thickness allowed.

#### Shop Testing

After fabrication, but before application of lining and coatings all pipes shall be subjected to a shop hydraulic test. Standard lengths of pipes shall be directly subjected to test and non-standard pipe and elbows can be tested as standard pipe before being cut to size.

Each pipe shall be filled with water and the pressure slowly and uniformly increased until the required test pressure as per IS: 3589 is reached.

The pipe to be tested shall be given a serial no. which shall be painted on its inside together with details such as pipe No. Shell thickness, diameter, length etc. as directed. It shall be entered in the register to be maintained by the Contractor.

Prior to testing, the pipe shall be inspected thoroughly and all the apparent defects in welding such as jumps, porosity etc. shall be repaired by gouge and re-welding.

In case of use of spirally welded and plate welded pipes conforming to IS: 5504 all types of required tests shall be carried out as given in the respective clauses of the said code. Test reports of all such tests shall be made available to the Employer along with the running bills.

The hydraulic test shall be carried out under cover at the fabrication shop, in the presence of and to the satisfaction of the Engineer-in-Charge or the inspection agency appointed by the Employer.

For indicating the pressure inside the pipe an accurate pressure gauge of approved make duly tested and calibrated for the accuracy of readings shall be mounted on one of the closures, which close the pipe ends.

The pressures shall be applied gradually by approved means and shall be maintained for at least 1 minute or till the inspection of all welded joints is done during which time the pipe shall be hammered throughout its length with sharp blows, by means of a 1 kg. hand hammer.

The pipe shall withstand the test without showing any sign of weakness, leakage, oozing or sweating. If any leak or sweating is observed in the welded joints, the same shall be repaired by gouging and re-welding after dewatering the pipe. The repaired

pipe shall be re-tested to conform to the specified pressure.

If any leak or sweating is observed in pipe shell the pipe under test shall be rejected temporarily. The Contractor shall stack such rejected pipes separately in his yard. The Engineer-in-Charge, shall inspect the same and after taking cuts if necessary, shall determine the nature of repairs to be carried out thereon and shall then decide as to how and where they shall be used. No payment shall be made for handling or carrying out repairs, but, payment for the fabrication and hydraulic testing of the pipe shall be released only after acceptance of the pipe with necessary repairs and subsequent testing etc. are carried out by the Contractor to the satisfaction of the Engineer-in-Charge. The Engineer-in-Charge shall be supplied with two copies of the results of all the tests carried out.

#### 11.1.6 Testing Of Site Welded Joints

- (i) The welded joints shall be tested for Tensile test, Bend test in accordance with procedure laid down in IS No. 3600 "Code of procedure for testing of fusion welded joints and weld metals in steel".
- (ii) Test pieces shall be taken by the contractors from the welded joints at the position on fabricated pipes pointed out by the Engineer-in-Charge in-charge.
- (iii) The sample so taken shall then be cut to the exact shape and dimensions and machined as described below and handed over to the Engineer-in-Charge-in-charge for testing. All the work upto and including machining and arranging for test shall be done by the contractors.
- (iv) Field Hydrostatic test pressure will be 1.5 times the working pressure or 12 Kg/cm<sup>2</sup> , whichever is higher.

#### 11.1.7 Submission of Daily Progress Report

The Contractor shall submit to the Engineer-in-Charge a daily progress report in the Performa approved by the Engineer-in-Charge, wherein all the details of the work carried out in the factory shall be fully recorded. Similarly, works done in the various units in the factory shall be separately mentioned. The Contractor shall maintain a register of all the finished materials giving dates of carrying out important operations such as testing, transport, etc. The register shall be presented at least once a week to the Engineer-in-Charge who shall initial the entries after verification.

#### 11.1.8 TRANSPORTING OF PIPES, SPECIALS ETC.

All pipes and specials fabricated in the factory and temporarily stacked in the Contractor's yard shall be transported to the site of laying after shop testing and cleaning them internally. The loading in the factory shall be carried out by means of either a crane, gantry or with shear legs, so as not to cause any damage to the finished material. Similarly, while unloading and stacking, great care shall be taken to ensure that the material is not damaged or dented. The equipments to be used for unloading will be different in different situations and in each case the one approved by the Engineer-in-Charge shall be adopted. The material stacked at site shall be jointly inspected by the Engineer-in-Charge and the Contractor and defect or damage noticed shall be repaired to the satisfaction of the Engineer-in-Charge before payment is admitted / released.

Props of approved designs shall be fixed to the pipes during transit to avoid undue sagging and consequent distortion. After the pipes are carefully stacked, props may be removed and re-used for subsequent operations. The stacking ground, both in the Contractor's yard and at the site of laying shall be selected in such a way as not to get waterlogged during monsoon. If this cannot be done, the pipes shall be supported on sleepers to avoid contact with wet earth and subsequent rusting. In order to prevent sagging during transit, savings of steel plates can be utilized by cutting to the required length and tacking the same to the pipe ends, in place of props, if approved by the Engineer-in-Charge. In any case, distance between 2 consecutive supports shall not exceed 1.5 m.

As explained in earlier paragraphs, materials such as pipes, tapers, etc. may be transported to the site of laying as soon as the material is finished in all respects with the permission of the Engineer-in-Charge to avoid congestion in the Contractor's yard. However, materials such as expansion joints, composite bends, 'T' branches and other complicated materials shall be stacked in the Contractor's yard until they are required for laying in the field. In view of this, the work of fabrication of such materials shall be properly synchronized as far as possible with the laying operations.

Fabricated materials such as appurtenances (bends, Tees, etc) , bolts, nuts, distance pipes, flanges, saddles, collars, bypass arrangements etc. shall be transported to the site of laying from the fabrication shop according to the needs of the laying operations

only. Whatever may be the mode of transport he uses it shall be incumbent on the Contractor to carry and stack the pipes and specials duly supported on sand / earth filled bags along the alignment as close as possible to the site of laying but without causing obstruction to traffic.

#### 11.1.9 Procedure For Receiving Steel Pipes

##### General

To ensure that the work of erecting pipes is not held up at any stage and place, the Contractor shall maintain an adequate stock of standard specials, flange rings, plug plates, etc. and short length of smaller diameter pipelines, etc. at site in his field stores, in consultation with the Engineer-in-Charge. Wherever possible, the Contractor shall arrange one full month's requirement of pipes, specials, etc. stacked along the alignment in such a way that no obstruction is caused to the traffic, residents or for repairs to other utilities.

##### Stacking of pipes, etc. and inspection

The Contractor shall keep in each section a responsible representative to take delivery of the pipes, specials and appurtenances, etc. transported from the fabricating stockyard or received from any other work site to the site of laying and to stack along the route on timber skids. Padding shall be provided between coated pipes and timber skids to avoid damage to the coating. Suitable gaps in the pipes stacked shall be left at intervals to permit access from one side to the other. The pipes, specials, appurtenances so received on site shall be jointly inspected and defects recorded, if any, such as protrusions, grooves, dents, notches, damage to the internal coating etc. shall be pointed out immediately to the Engineer-in-Charge at the site and in the acknowledgement challans. Such defects shall be rectified or repaired to the satisfaction of the Engineer-in-Charge entirely at the Contractor's risk and cost.

##### Handling of Pipes, specials, appurtenances etc.

It is essential to avoid damage to the pipes, fittings and specials, etc. or their coatings at all stages during handling. The pipes and specials shall be handled in such a manner as not to distort their circularity or cause any damage to their surface treatment. Pipes shall not be thrown down from the trucks nor shall they be dragged or rolled along



hard surfaces. Slings of canvas or equally non-abrasive materials of suitable width of special attachment shaped to fit the pipe ends shall be used to lift and lower coated pipes to prevent damage to the coating.

Great care shall be taken in handling the pipe right from the first operation of manufacture until they are laid and jointed. The Contractor will provide temporary props in order to prevent any sagging of the pipes while they are stacked in their yard and while transporting to the site of delivery, i.e. laying. The props shall be retained until the pipes are laid. If at any time these props are found to be dislodged or disturbed, the Contractor shall immediately reinstate them in such a way that the true shape of the pipe shell or specials is maintained to the satisfaction of the Engineer-in-Charge. No defective or damaged pipe or special shall be allowed to be used in the work without rectification to the satisfaction of the Engineer-in-Charge. Any damage to the coating shall be repaired by the Contractor at his own cost to the satisfaction of the Engineer-in-Charge.

Contractor shall take care in limiting the number of pipes that can be stacked over one another so as to avoid any dents and deformation in circular shape of the pipe. The Contractor will provide temporary props in order to evenly distribute the weight of pipe stacked in upper layers to pipes at bottom layers.

#### Dents

Whenever any dent, i.e. a significant alteration of the curvature of the pipe shell is noticed, the depth of the dent shall be measured between the lowest point of the dent and the pipe shell curvature line. All dents exceeding 2 percent of the outer diameter of the pipe shall be removed by cutting out a cylindrical portion of the pipe and replacing the same by an undamaged piece of the pipe. The Engineer-in-Charge may permit insert patching if the diameter of the patch is less than 25 percent of the nominal diameter of the pipe. Repairs by hammering with or without heating shall not be permitted. Any damage to the coating shall also be carefully examined and rectified fully by the contractor at his own cost as per IS: 5822.

#### Marking

The component parts of the pipes shall be carefully marked for identification in the

field.

The marking operation shall be conducted with full size rulers and templates.

The plates used for fabrication of pipes shall be laid out in such a way that when the shells are completed one set of original identification markings for the material will be plainly visible. In case these markings are unavoidably cut out, they shall be accurately transferred by the Contractor to a location where these markings will be visible on the completed work.

After the hydraulic tests on the specials and other items, the number of the shell in the line as it will be erected and the direction of flow shall be stamped in a prominent manner on each piece.

A register shall be maintained in suitable proforma giving the following information for each shell tested:

- (a.) Serial No.
- (b.) Shell No.
- (c.) Date of test
- (d.) Thickness and specification of steel
- (e.) Weight of shell tested
- (f.) Maximum test pressure
- (g.) Details of test performance
- (h.) Details of radiographic examination of welds
- (i.) Name of Engineer-in-Charge's representative witnessing tests

A copy of these details shall be furnished to the owner free of cost. No separate payment will be made for these markings and the rates for the items concerned shall be deemed to include the cost of such markings.

**11.1.10 CEMENT MORTAR LINING FOR INTERNAL SURFACE OF PIPELINE****11.1.10.1 Scope**

This Specifications covers the requirements of providing materials and application of shop applied cement mortar lining confirming to Annex-A of IS:3589 - 2001 by a centrifugal spinning process to the internal surfaces of pipeline. The mortar lining shall be completely free from cavities or visible air bubbles and pinholes and shall be thoroughly compacted throughout. The consistency of mortar and time and speed of centrifuging of the pipe shall be so adjusted that the segregation of the sand and cement is not there. The mixed used of cement mortar lining shall be 1:2 (1 cement: 2 sand) as per Clause 2.4 of IS : 11906. Before starting the cement lining work, the contractor shall also ensure that all related works required are completed by him. The work shall be started only after obtaining the written approval of the Engineer-in-Charge.

**11.1.10.2 Applicable Codes and Specifications**

The following specifications, standards and codes in addition to those listed earlier to this specification are made a part of this specification. All standards, specifications, codes of practices referred to herein shall be the latest edition including all applicable official amendments and revisions. In case of discrepancy between this specification and those referred to herein, this specification shall govern.

IS : 11906:1986 Recommendation for Cement Mortar Linings for C.I., Mild Steel and Ductile Iron pipes & fittings.

IS : 3696 Safety Code for scaffolds and ladders (Part 1 & 2)

IS : 460 – 1985 Test Sieves

IS : 2386 (Part 2) Methods of test for aggregates for concrete Part – 2 Estimation of deleterious material and organic impurities from natural sources.

**11.1.10.3 General**

Engineer-in-Charge shall have the right to inspect the source/s of material/s, the operation of procurement and storage of materials, Cement mortar batching and mixing equipment and the quality control system. Such an inspection shall be arranged and the Employer or his representative's approval obtained prior to starting of lining work.

**11.1.10.4 Method of application**

All lining work shall be done by machine in factory as per specifications. However for joints in situ smooth lining shall be acceptable.

#### 11.1.10.5 Workmanship

All works shall be performed in a thorough and workmanlike manner by trained personnel with previous experience under the supervision of experienced men skilled in the application of centrifugally applied cement-mortar lining to pipelines. After award of the contract, the contractor shall give the names of such specialized agencies he will be deploying. The contractor shall also clearly indicate the methodology he will be adopting for lining in straight reaches, at bends (Horizontal & Vertical) at compound bends, at tee positions and for other specials / fittings etc.

#### 11.1.10.6 Programme of lining and plant and equipment

The contractor on award of the contract shall furnish the plant and equipment proposed for carrying out the cement mortar lining application. Contractor shall furnish complete details of similar work executed by him or his proposed pipe manufacturer.

#### 11.1.10.7 Materials of Construction

##### a) Cement

Cement required for mortar lining shall be "Portland Cement" conforming to IS-8112 grade 43 cement or of higher grade.

##### b) Admixture

To improve workability, density and strength of the mortar, admixtures as approved by the Employer or his representative may be used by the Contractor at his own cost. No admixtures shall be used that would have a deleterious effect on water flowing in the pipe, which is required for drinking proposes.

##### c) Sand

i) The quality of sand used shall be as per Clause – 2, Para 2.2.1 and Table –1 under the above Clause of IS 11906.

ii) Organic impurities – Test for Organic Impuritites in Sand for Concrete / Cement mortar for linings shall be checked as per IS : 2386 (Part-2).

d) Water

Water used for mixing the mortar shall be meet the requirement of IS : 456.

11.1.10.8 Workmanship of Lining

General

- a) Composition of mortar for the lining shall be composed of cement, sand and water mixed to such consistency as to produce a dense and homogenous lining that will adhere firmly to the pipe surface.
- b) The contractor shall provide cement mortar lining in such a way that the lining surface shall be able to deliver a guaranteed “C” value of 140 as is provided in the “Manual on Water Supply for New Pipes”.

11.1.10.9 Proportion

Dry proportions of cement and sand shall be 1 part of cement to 2 parts of sand by weight as mentioned in Clause 2.4 of IS : 11906 and Annexure – A 6.1 of IS : 3589-2001. The minimum cement content shall be 1000 Kg/m<sup>3</sup> and water cement ratio of between 0.3:1 and 0.45:1 by mass. The works strength of the mortar as stated in Annexure – A-7.3 of IS : 3589-2001 should be not less than 31 N/ mm<sup>2</sup> after 28 days of curing.

Water Content

Water content shall be the minimum that is required to produce a workable mix, with full allowance made for water collecting on the interior of pipe surface.

Mixing

Mortar shall be well mixed and of proper consistency to obtain a dense, homogenous lining. Where premixed mortar is used, it shall be done so before initial set.

Thickness of Lining

Minimum lining thickness of pipes shall be as per specifications given in bill of quantities, with no negative tolerance. However positive tolerances as per Clause 7.2 of IS: 11906 shall be acceptable.

Method of Construct

### **Preparation of Pipe Surface**

The interior surface of pipe to be lined shall be cleaned to remove all rust, chemical or other deposits, loose mill scale and deteriorated remains of old coating materials, oil, grease, and all accumulations of water, dirt, and debris. The cleaning of the surface shall be carried out by the use of suitable chemical and by mechanical means i.e. by sand blasting to near white (SA 2.5). The extent of cleaning shall be to the satisfaction of the Engineer-in-Charge. The pipes so cleaned shall be subjected to lining within 4 hours.

After sand blasting, the sand remaining inside the pipeline shall be cleaned by use of a power-driven cleaner, incorporating revolving brushes on rotating arms. After this cleaning the pipe shall be flushed with potable water and all standing water removed.

Immediately prior to application of cement mortar lining by centrifugal spinning or by centrifugal sprinkler or by combination of both, all foreign material shall be removed. This includes sand and loose mortar that might have accumulated since the work of preparation of surfaces was last completed.

### **Lining Procedure**

The lining mortar shall be placed by centrifugal method as is already mentioned in specifications. The mortar must be densely packed and shall adhere to the pipe wherever applied. The lining of specials shall be as per Clause 4.1 of IS: 11906 and hand rendering of specials shall be as per Clause 11.1.1 of the above code.

### **Surface Finish**

The surface of cement mortar lining shall be uniformly and perfectly smooth and shall be free from voids. The lining shall not have flaky areas. It shall not be crumbly and shall not have waves or grooves and shall also conform to Clause 10.1 and 10.2 of IS: 11906.

Pipes shall not be dispatched until 21 days have elapsed since the date of lining. In case of steam curing dispatch can be made after 8 days from date of lining.

### **Examining procedure**

In the stretch of pipe that has been lined the thickness of lining shall be measured at

both ends of the pipe, in at least, one section perpendicular to the pipe axis.

#### Keeping Circulatory – During Lining

During the processes of lining the inside surface of the MS pipes, the contractor shall ensure that roundness of the pipes is maintained.

#### Hand Application of Mortar Lining

Hand placed mortar shall have a uniform and smooth surface with smooth transitions to adjacent centrifugally placed linings.

Cement mortar lining of bends, specials, areas closely adjacent to valves and other such places where machine placing may not be practical shall be performed by hand. The Engineer-in-Charge may order the correction for any defect by hand application.

Cement mortar for hand work shall be of the same materials as the mortar for machine placed lining.

The areas to be lined shall be thoroughly cleaned as specified earlier and, if necessary, shall be moistened with water / cement grout immediately prior to placing the hand-applied mortar.

Steel finishing trowels shall be used for the hand application of cement mortar, except at bends the outer edges of hand trowelled areas may be brushed in order to reduce the abutting offset.

All hand finishing work in a section of the pipeline shall be completed within 24 hours after completion of the machine application of mortar lining to that section. If necessary, application of mortar lining by machine shall be delayed or stopped to assure compliance with this schedule.

#### Special requirements at Laterals and Service connections

Laterals and connections to the pipe that is being lined shall not be left obstructed by the lining operations.

Before the lining is placed, the openings in the pipeline leading to air valves, blow offs and appurtenances, as well as to laterals and connections that transmit pressure to

carry water from the pipeline, shall be temporarily covered or plugged with suitable devices. These shall be removed later without damaging the cement-mortar.

#### Curing

Curing shall commence immediately after completion of the mortar lining and hand finishing of a section of pipeline. This shall, however, not be later than 8-hours after mixing of mortar. The lining shall be kept continuously in moist condition for a period of 14 days. During the operation of lining, finishing and curing, exterior surface of the pipe exposed to sunlight shall be sprinkled with enough water to keep the pipe cool. Open ends of pipes shall be suitably closed so as to maintain a moist atmosphere and prevent draught. Curing of mortar lining and simultaneous cooling of the pipeline externally shall be continued even beyond the period of 14 days as directed by the Engineer-in-Charge. In the opinion of Engineer-in-Charge, if the water for curing as per the specification may not be available, Engineer-in-Charge shall order the Contractor to use chemical curing which shall be carried out as per the manufacturers specifications. No extra payment will be made on this account. If the contractor desired so, use of approved curing compound will be permitted. Steam curing is also permitted.

#### Tests of cement mortar used for lining

As per clause A-7-3 of IS : 3589-2001, the mortar test cylinders shall obtain a minimum compressive strength of 18 MPa in 7 days and 31 MPa in 28 days. Pipe made with mortar lining that does not meet the strength requirements set forth herein shall be subject to rejection.

##### 11.1.11 INSPECTION

###### 11.1.11.1 Responsibility of Engineer-in-Charge and Contractor

The entire procedure of applying cement mortar lining shall be subject to inspection by the Engineer-in-Charge or his authorized representative but such inspection shall not relieve the Contractor of his responsibility to furnish material and perform work in accordance with this specification. All cement mortar lining not applied in accordance with this specification shall be subject to rejection by the Engineer-in-Charge. Lining so rejected shall be removed and replaced by the Contractor at his



own expense.

A manual visual inspection of the lined pipe shall be by means of CC TV to determine the quality of the lining and to identify defective areas in linings for repair. The contractor shall procure / hire suitable equipment required for his purpose at his own cost.

#### 11.1.11.2 Defective Lining

Defects in lining including but not restricted to sand pockets such as voids, over sanded areas, blisters, cracked and dummy areas, and thin spots shall be removed, and the area shall be repaired by hand application to the full required thickness of the mortar lining. Defective areas encompassing the full diameter of the pipe shall be replaced by machine wherever practical. Defective lining rejected removed before initial set of the mortar. Defective lining rejected after initial set shall be replaced or repaired by the most practical method as determined by the Engineer-in-Charge as per IS : 11906.

#### 11.1.11.3 Guarantee

If on examination by the Engineer-in-Charge of the cement-mortar lining work within defect liability period after final completion and acceptance of the Contract Work reveals evidence of defective materials or workmanship as defined in this specification, then the Contractor shall perform the remedial work at his own expense in a manner acceptable to the Engineer-in-Charge.

The inside coating shall also not contain any constituent soluble in drinking water or any ingredient, which could impart any taste or whatsoever to potable water after sterilization and suitable washing of the mains.

#### 11.1.12 Food Grade Polyurethane Epoxy Coating

Contractor is allowed to provide food grade, polyurethane epoxy coating in lieu of cement mortar lining at inside surface of M.S. specials. The dry thickness of epoxy coating shall be not less than 450 micron (primer – 50 micron, Intermediate coat – 300 micron & Final sealing coat – 100 micron)

#### 11.1.13 External Coating of M.S. Pipes Laid below Ground

Fiber Reinforced Coal tar Enamel Coating

##### 11.1.13.1 general

- i) Unless otherwise specified or stated on the drawings the M.S. pipeline to be laid underground shall be shop approved external coating with Fiber Reinforced/coal tar enamel or tape coating in a shop / factory
- ii) Fiber Reinforced Coal Tar Enamel shall be in accordance with IS 10221-1982.
- iii) Shop applied - Hot applied Coal Tar Enamel Coating complete with inner and outer reinforcing wraps
- iv) Field Applied - Hot applied adhesive PVC backed tape for field joints
- i) Sampling and testing of materials and coating shall be in accordance with ISI0221/A WWAC203.

#### 11.1.13.2 Primer

The primer shall be coal - tar or synthetic base primer in accordance with IS: 10221 and shall be highly compatible with the coal tar enamel used.

Coal tar primer shall consist of processed or coal tar pitch and refined coal tar oils only suitably blended to produce a liquid to be applied by spraying and that shall produce an effective bond between the metal and subsequent coating of coal tar enamel as per Clause 4.11 of IS: 10211.

The primer shall not contain Benzol or other toxic or highly volatile solvents. There shall be no added pigments and inert fillers and shall show no tendency to settle out in the container and shall have characteristics as specified in table 1 of above code. The coverage shall be uniform and shall result in a dry film thickness of minimum of 50 microns.

#### 11.1.14 Coal Tar Enamel

Coal Tar Enamel used for coating shall be of make: STP. Eastern coating or equivalent confirming to IS: 10221. The enamel shall consist of specially processed tar pitch, blended with inert and non hygroscopic mineral fillers, properly graded, clear dust free and without asphalt to be applied at the manufacturer recommended temperature as mentioned in Clause 4.2.1, 4.2.2 of above code.

The enamel should be impermissible to water and shall also be immune to attack of calcium, magnesium and other salts normally encountered in the route of the pipeline.

#### 11.1.15 Inner Wrap

The inner Wrap or reinforcement to coal tar enamel shall be non-woven fiber glass tissue consisting of uniform porous mat of chemically resistance Boro-silicate glass. Glass fiber monofilaments making up the mat shall be bonded with suitable inert material like phenolic or urea type resin compatible with coal tar enamel. The fibrous glass mat is reinforced in the longitudinal direction with continuous filament glass yarn at 10 mm centers as per Clause 4.3.1 and table –7 of above code.

The glass fiber shall have characteristics in accordance with IS 10221/ A WWA C 203.

#### 11.1.16 OUTER Wrap

The outer wrap shall be non-woven fiberglass felt type in accordance with IS 7193 . It shall have glass fiber tissue saturated with plasticized coal tar enamel in accordance with IS 10221,4.3.2.1 and table 10 of IS:10221. The outer wrap shall be of make: STP, Eastern Coating or equivalent confirming to IS: 10221.

The resultant outer wrap shall be uniform, flexible and have random pinhole to facilitate the release of hot gases and to allow sufficient bleed-through of the enamel to achieve better adhesion of the outer wrap.

The outer surface of outer wrap shall be lightly dusted with talc or other approved mineral powder sufficient to prevent sticking in the roll under conditions likely to be met in application at site.

The inside surface shall receive minimum dusting necessary in order that the bond between the outer wrap and the enamel shall not be impaired.

The physical characteristics of the outer wrap shall be in accordance with IS 10221 / A WWA C 203.

#### 11.1.17 Shop Application

Prior to coating, the external surfaces of pipe shall be thoroughly cleaned free from all loose mill scale, dirt, rust, scale corrosion products, grease, moisture and other foreign material and prepared for priming by one of the following methods:

- a) Blast cleaning of grade SA2 to whiten in accordance with ISO 8501 (Part I)
- b) Chemical cleaning to include degreasing, acid picking and phosphates with intermediate washing as recommended by the primer / enamel manufacturer's instructions.

After surface preparation by shot blasting, before flash rusting can occur the pipe exterior shall be coated with primer spread at a controlled rate to the manufacturer's recommendations and thereafter allowed to dry.

The primer shall be applied to clear, dust-free and dry pipe and thereafter should be kept free from moisture, dust or any other containment. The coating shall be uniform and free from runs, drips, flooded in base areas, particularly in weld areas.

When the pipe surface temperature is below 7oC or moisture is present on the pipe surface, the pipe shall be warmed for sufficient time to dry the pipe before priming.

The enamel for coating shall be drawn from heating appliances recommended by manufacturer. The enamel temperature at the time of application shall be in accordance with manufacturer's instructions. The maximum temperature in the boilers shall be limited to 2700c. Enamel held at this temperature for above six hours or longer shall not be used.

Enamel should not be applied to the primed pipe when the pipe metal temperature is below 70c. There shall be two coats of coal tar enamel. Each coat of enamel shall have a minimum thickness of 4 mm if any point with an overall thickness of minimum 5 mm on the pipe body and shall be reinforced by a spiral inner wrap of fiber glass tissue pulled into the hot enamel in such a manner that the fiber glass tissue is embedded half way into the enamel without touching the steel surface or appearing at the enamel surface.

The coal tar impregnated outer wrap shall be simultaneously applied with the inner wrap. Both inner wrap and outer wrap shall be overlapped by 25mm. The overlaps of the inner and outer wraps shall be staggered from each other by a minimum distance of 100 mm. There should be a minimum of 0.8mm of enamel between pipe surface and the inner wrap.

The completed coating shall be well bounded to the pipe metal, uniform, smooth and free from holidays, laminations or other defects. The coating and wrapping shall be carefully trimmed off 150 mm from the ends of each pipe.

The pipes shall be finally dressed with latex emulsion in accordance with AWWA C 203/ IS: 10221.

#### 11.1.18 Field Application

On completion of welding and hydrostatic testing, the expressed section of pipe shall be thoroughly cleaned free from loose mill scale, metal bars, weld spatter and any dirt, rust, grease, moisture and any foreign matter.

Adjoining area of shop coating near field joint of approximately 150 mm shall be prepared by hand wire brushing where field applied tape will overlap. The primer shall be applied to joint area ensuring coverage is complete, especially at welds.

Tapes shall be wrapped in accordance with manufacturer's instructions. Application rate and time for overlapping shall be in accordance with tape manufacturer's recommendations.

Tape shall be applied with a 50% overlap and even tensioning to ensure good conformation with no wrinkles or air pockets. Wrapping shall start and finish to give a minimum 75 mm overlap onto the adjoining shop coating.

#### 11.1.19 Tests and Inspection

Tests on primer and enamel shall be in accordance with IS 10221 / AWWA C203.

Before coating, test results determining the characteristics of primer, enamel and fiberglass shall be submitted to the Employer for approval. Different tests on coal tar and enamel like high temperature test, deflection test, impact test and peel test shall comply with the requirements specified in IS 10221. All test certificates shall be submitted to the Employer.

The completed coating shall be solid, free of wrinkles and pockets or tears and thoroughly bonded to pipe throughout and shall be inspected using a Holiday detector (Electrical Inspection).

The voltage of the Holiday Detector shall be set depending upon the coating thickness and manufacturer's recommendations

The voltage of the Holiday Detector shall be recalibrated at the start of each day's work and after every four hours of coating operation.

Contractor should note that all the works connected with wrapping/out-coating shall be done as per IS: 10221 and the bidder shall submit all test reports as are mentioned in IS: 10221.

#### 11.1.20 Tolerances

Permissible tolerance for straight pipe and fittings shall be as per Clause 12.5 of IS: 3589.

#### 11.1.21 Outside Diameter

The permissible tolerance for outside diameter shall be as per Clause 12.3 of IS: 3589

#### 11.1.22 Three layer PE coating of M.S. Pipes and specials. It is acceptable in lieu of coal tar wrapping 4 (four) coatings as per Clause 2.9.

### General

The minimum requirement for the application of three layer polyethylene coating to the external surface of steel pipes are given in this section.

For the factory applied coating the system shall comprise of a layer of fusion bonded epoxy (FBE), overlaid with adhesive with an outer layer for high density polyethylene (HDPE).

The principal stages of pipe coating shall be as follows:

Solvent cleaning followed by steam or hot bath cleaning. (if required)

- Abrasive blasting
- Application of fusion bond epoxy (FBE) layer

- Application of adhesive layer
- Application of polyethylene layer

### Surface Cleaning

All the surfaces of steel pipes and specials to be painted shall be cleaned by grit blasting as per the specifications. Earlier to grit blasting, oil and grease shall be removed by applying a suitable metal cleaning solution (quality, make and properties of the cleaning solution to be clarified by the Bidder at the time of submission of the bid) and wiping with clean rags. Also the Bidder shall remove all foreign matter, which cannot be removed even by blasting to the satisfaction of the Engineer-in-Charge.

### Coating of Pipes.

#### A) General

The application of the coating shall be in accordance with the material manufacturer recommendations and the procedure outlined below. The Contractor shall perform coating procedure qualification testing (PQT) prior to commencing production or on his own risk at the start of production in accordance with these specifications.

#### B) FBE Layer

The FBE shall be applied to a minimum thickness of 100 microns and a maximum of 200 microns.

#### C) Adhesive Layer

The adhesive shall be applied to a thickness of 150 to 200 microns. The adhesive layer shall be applied before gel time of the FBE has expired. Application of the adhesive shall not be permitted after the FBE has fully cured. The contractor shall establish to the satisfaction of the Engineer in Charge that the adhesive is applied within gel time window of the FBE and at the temperature recommended by the adhesive manufacture. The contractor shall state the proposed minimum and maximum time interval between FBE and adhesive application at the proposed pre-heart temperature.

#### D) Polyethylene Layer /Cutback

The polyethylene layer shall be applied to a minimum thickness as per DIN 30670 over the pipe body and to a minimum of 90% body thickness over the production welds.

A polyethylene layer cutback of 150mm (+10/-10mm) shall be provided at pipe ends.

PIPE OD	STANDARD THICKNESS ON BODY	ON WELDS
Upto to DN 100mm	1.8mm	90%
>DN 100 to DN 250mm	2.0mm	90%
>DN 250 to DN 500mm	2.2mm	90%
>DN 500 to DN 800mm	2.5mm	90%
>DN 800 & higher	3.0	90%

The polyethylene shall be applied over the adhesive within the time limits established during pre-production testing. The coating shall be cooled to below 60 deg C before handling.

The ends of the coating shall be chamfered and beveled to 30 to 45 deg

Immediately after the coating is fully cured, pipe identification marks shall be re-applied to the coated pipe using a method approved by Engineer in charge.

Inspection, Testing and Certification of 3 layer PE coating of MS pipes and specials

General



In order to demonstrate that the manufacture's proposed coating procedure is capable of meeting the specification, the contractor shall undertake coating procedure qualification testing (PQT) prior to commencing production, or at his own risk at the start of production. The Contractor shall also be required to test the finished coating during production to demonstrate continued compliance with this specification. Details of all inspection and testing shall be fully documented in accordance with this section.

All states of the surface preparation, coating and testing shall be subject to 100% inspection by the contractor. The Engineer in charge shall be informed at least two weeks prior to the start of surface preparation to allow scheduling of inspection supervision work.

#### Applicable Codes and Standards

For all referred codes, latest editions are implied.

ANSI/AWWA C213 Standard for Fusion-bonded Epoxy Coating for the Interior and Exterior of steel Water Pipelines

ASTM D1928 Standard practice for preparation of compression-molded polyethylene test sheets and test specimens.

CAN/CSA Z 245.20-02 External fusion bond epoxy coating for steel pipes.

DIN 30670 Polyethylene Coating of Steel pipes and Fittings - Requirements and Testing.

DIN EN ISO 9001 2000 Quality management systems – Requirements Etc., and all other relevant codes.

#### Abbreviations:

ANSI American National Standards Institute

ASTM American Society For Testing and Materials

DIN

German Standards Institute

AWWA

American Water Works Association.

## 11.1.23 Laying Of Pipeline

## 11.1.23.1 General

Unless specified otherwise, the pipeline shall be buried with minimum cover of 1.0 meters at top. No material shall be erected unless it has been previously passed by the Engineer-in-Charge.

11.1.23.2 Erection of fabricated shells shall be carried out by the Contractor who shall equip himself, at his cost, with all necessary tools, machinery, labour etc. required for the purpose.

## 11.1.23.3 Erection of Shells

11.1.23.4 The erection shall be true to position, lines and grade or as directed by the Engineer-in-Charge. The Contractor shall provide at his cost necessary saddles, pads, spider etc., all necessary instruments and other materials and labour required for proper erection of shells in position and for the Engineer-in-Charge in checking the correctness of the erection.

11.1.23.5 Alignment of sections at edges to be butt welded shall be such that the maximum offset is not greater than the values given below:

Thickness 't' (mm)	Offset in Longitudinal joints (mm)	Offset in Girth joints (mm)
Upto 12	0.25 t	0.25 t
12 to 20	3 mm	0.25 t
20 to 40	3 mm	5 mm
40 to 50	3 mm	1/8 t
Over 50	11.1.23.5.1.1.1 Lesser of 0.0625 t or 10 mm	Lesser of 0.125 t or 20 mm

The best of welders as selected from their work in the Contractor's workshop shall be selected for in-situ welding of the shells. The relevant provision under welding such as qualification standard for welding procedures, tests on welder's work and removal of defects etc., shall also apply to in-situ welding.

### General Sequence of operations

Before commencing the work of pipe laying, the Contractor shall study the L section of the pipeline for the section concerned. The difference in depth due to uneven excavations shall be made up by sand cushioning in case of rocky area without any extra cost.

Anchor blocks shall be constructed before commencing the pipe laying work in any section. The construction of the blocks shall be carried out in 3 stages: in the first stage the lower part upto 150 mm below the invert of the pipeline including concrete chairs to support it shall be constructed; in the second stage the pipeline on this part of the block shall be laid; and lastly, the remaining block around and over the pipeline shall be constructed.

#### 11.1.24 Specials 11.1.24.1 General

Specials, such as tees, Y-pieces, bends (single or composite), tapers, etc. shall necessarily be in steel and shall be manufactured as per standards and tested and laid in the same manner as the pipes. Small branches, single piece bends, etc. may be fabricated at site, care being taken to ensure that the fabricated fittings have at least the same strength as the pipeline to which they are to be jointed.

#### 11.1.24.2 Bends

- (a) Bends shall be fabricated taking into account the vertical and horizontal angles for each case.
- (b) The bends shall have welded joints and the upstream and downstream ends of each bend shall have a straight piece of variable lengths as required.
- (c) Bends shall be designed with deflection angle of maximum 10 deg. between segments.
- (d) When the point of intersection of a horizontal angle coincides with that of a vertical angle, or when these points can be made to coincide, a single combined or compound bend shall be used, designed to accommodate both the angles. The combined bend should have a pipe angle equal to the developed angle, arrived at from appropriate formula.

- (e) All joints in bends shall be thermally stress relieved as specified.
- (f) Details of thrust collars anchor bolts, holding down straps, saddle plates should be furnished together with full specifications in Contractor's fabrication drawing.

#### **11.1.24.3 Closing or Make up sections**

Closing or make up sections shall be furnished at appropriate locations on the line to permit field adjustments in pipeline length to compensate for shrinkage in field welded joints, differences between actual and theoretical lengths and discrepancies in measurements.

#### **11.1.24.4 Heads**

Test heads may be ellipsoidal, standard dished as per ASME code or hemispherical heads. They shall be welded in the shop and removed after the test. Allowance should be made in the length of the pipe section receiving the test head for the welding and removal of the head and preparation of the plate edges for the final weld after testing.

No separate payment will be made for such test heads. The rate quoted for the hydraulic test shall be deemed to cover the cost of such installations.

#### **11.1.24.5 Flanges**

Flanges shall be provided at the end of pipes or special where sluice valves, blank flanges, tapers, etc. have to be introduced conforming to IS: 7322. The flanges received from the manufacturers will have necessary bolt holes drilled to IS: 1538 (Part IV). The Contractor shall assemble the flanges in the exact position by marginal cutting, if necessary, so as to get the desired position of the sluice valves, etc. either vertical or horizontal and shall then fully weld the flanges from both sides in such a way that no part of the welding protrudes beyond the face of the flanges. In case the welding protrudes beyond the flanges and if the Engineer-in-Charge orders that such protrusions shall be removed, the Contractor shall file or chip them off. If required and when ordered by the Engineer-in-Charge, the Contractor shall provide and weld gusset stiffeners, as directed on site. The drilling pattern shall be matching with the drilling pattern of flanges of valves and other fittings.

#### 11.1.24.6 Blank Flanges

Blank flanges shall be provided at all ends left unattended for the temporary on daily closure of work and also for commissioning a section of the pipeline or for testing the pipeline laid. For temporary closures, non-pressure blank flanges consisting of mild steel plates, tack welded at the pipe ends may be used. For pipes subjected to pressures, the blank flanges or domes suitably designed as per site requirements shall be provided.

#### 11.1.24.7 Field Hydraulic Test

After erection at site and after the concrete anchor blocks have been constructed, the entire pipeline shall be subjected to a hydraulic test as follows, to the test pressure according to the provisions of IS : 5822 and as mentioned below:

The test pressure shall be 1.5 times the design working pressure or 12.0 Kg / cm<sup>2</sup>, whichever is greater, but not to exceed a pressure that would result in a stress greater than 60% of the yield point of the steel plates used.

The pressure test shall be conducted in dry weather with pressure held constant for 2 hours to observe whether any pressure drop takes place. If a drop in pressure occurs the quantity of water added in order to reestablish the test pressure shall be carefully measured and the leakage allowed shall only be to the limit specified in IS code for the pipe material adopted.

Hydrotesting is required to be done for the whole length . For this purpose MS Plate of suitable thickness & strength is to be fixed at required places.

The Pressure gauge and other instrument / equipment will be suitably installed during Hydrotesting as per direction of Engineer-in-charge and the entire system will be tested at a specified pressure for 24 hours.

#### 11.1.25 Progress in Laying

The contractor shall submit after being awarded the contract his detailed bar chart for manufacturing and laying of the pipeline. While preparing his bar chart, the Contractor shall plan his activities such that the laying of pipes shall closely follow the manufacturing schedule and no pipes shall remain stacked in factory or

at site for a period more than two months.

It is mandatory that he shall submit an approach note on how he will carry out this work within the contractual period and on the compatible resources in terms of construction equipment and other facilities that he shall utilize to complete the tendered Work.

**11.1.26 Sand Bedding (Wherever Required)**

Where site situation require necessity of Sand bedding, the sand bedding of minimum 150 mm thickness or as approved by Engineer-in-charge shall be provided below pipe, prior to laying the pipe in trenches. It shall be compacted with a light hand rammer. Any reduction in thickness due to composition shall be made up by adding sand during ramming. For the purpose of the bedding under this item only Yamuna sand of grain size not larger than 2 mm shall be used. The sand shall be clean, uncoated and free from clay lumps, injurious amounts of dust, soft particles, organic matter, loam or other deleterious substances. Noting extra shall be paid.

If the sand supplied is unclean it shall be washed. In no case shall sand containing more than 3.5% by dry volume or 5% by wet volume of clay, loam or silt be accepted. Tests specified for determining silt in sand and organic impurities as described in IS: 383 shall apply. Sieved and washed sand shall be stored on the works in such a manner as to prevent intrusion of any foreign matter, including coarser particles of sand or any clay of metal or chips. Tests as indicated above shall be performed if called for by the Engineer-in-Charge at the expense of the contractor.

During the work of providing sand bedding and laying the pipeline over it, loose material from the sides or edges of the trench shall be prevented from falling inside the trench, by providing shoring and taking other measures. Also where necessary, trench shall be kept dry by pumping out seepage leakage waters continuously at no extra cost to the employer.

**11.1.27 Lowering and jointing**

The pipe shall be lowered into the trenches by removing only one or two struts at a time. It shall be seen that no part of the shoring is disturbed or damaged and, if

necessary, additional temporary struts may be fixed during the lowering operations. It shall also be necessary to see that the coating of pipe is not damaged in anyway during the lowering and assembling. After the pipe is lowered into the trench, it shall be laid in correct line and level by using the leveling instruments, sight rails, theodolite, etc. Care shall be taken to see that the longitudinal joints of two consecutive pipes at each circumferential joint are staggered by 30°. While assembling the pipes, the ends shall have to be brought close enough to leave a uniform gap not exceeding 4mm. If necessary, a marginal cut may be taken to ensure a close fit of the pipe faces. For this purpose, only experienced cutters who can make uniform and straight cuts, shall be permitted to cut the faces of the pipes. No extra payment shall be made for such marginal cutting. There shall be no lateral displacement between the pipe faces to be joined. If necessary, spiders from inside and tightening rings from outside shall be used to bring the two ends in perfect contact and alignment. It may also be necessary to use jacks for this purpose. In no case shall hammering or longitudinal slitting be permitted. When the pipe is properly assembled and checked for correct line and level, it shall be firmly supported on wooden beams and wedges and tack welded. Some portion of the trench may be refilled at this stage so as to prevent the pipeline from losing its alignment. The tack welded circumferential joints shall then be welded fully. Only experienced welders, who shall be tested from time to time shall be permitted to carry out the welding work.

On completion of the pipe jointing and external protection, the trench and the welding pits shall be cleaned of guniting rebound. The welding shall be filled and compacted in 150mm layers with the bedding material.

Backfilling shall be carried out as detailed here under.

#### 11.1.28 Cleaning, Disinfectioning And Commissioning Of The Pipeline

Upon completion of a newly laid main, the main shall be disinfected as directed by the Engineer-in-Charge. The main shall be flushed prior to disinfection. After initial flushing, the hypochlorite solution shall be applied to the water main with mechanically or electrically powered chemical feed pump designed for feeding chlorine solutions. For small applications, the solution may be fed with a hand pump.

The water shall receive a dose of chlorine also fed at a constant measured rate. The chlorine shall be applied continuously and for a sufficient period to develop a solid column of 'Slug' of chlorinated water that will as it passes along the line expose all interior surfaces to a concentration of at least 300 mg/l. for atleast 3 hours. As the chlorinated water flows past tees and other fittings the related valves shall be operated so as to disinfect the appurtenances.

After the applicable retention period the heavily chlorinated water shall be flushed from the main until the chlorine concentration in the water leaving the main is not higher than that generally prevailing in the system or less than 1 mg/ litre.

Nothing extra shall be payable on account of above.

#### Distance Indicators And Markings

The Contractor shall supply and fix indicators at all points of change of direction, at all valves and at every one kilometer intervals or part thereof along the buried pipe line. Indicators shall consist of 10 cm x 10 cm precast concrete posts 1.25 metre long, set 0.75 metre into the ground and painted white above ground level. The description shall be written in blue at one face of the precast post. The cost towards the same is deemed to be included in the awarded rate.

#### 11.1.29 FIELD HYDRAULIC TEST

The pipelines shall be subjected to hydraulic pressure test in the presence of the Engineer, which shall comply with IS:5822 unless otherwise specified.

Testing shall be carried out in two stages:-

- (i) Test of sections as construction proceeds before internal cement mortar lining.
- (ii) A test of the whole of the pipeline on completion.

The contractor shall equip with all plant, equipment, fittings and water necessary for the hydraulic tests. The contractor shall submit to the Engineer, well in advance of the time of tests, details of his proposals, including the supply of water either by tankers or boreholes. Neither any connection from the existing pipelines will be



allowed, nor will any connection to the pipeline and pipe work, which would involve cutting, tapping or altering the permanent works, be allowed.

The general procedure for testing the pipelines shall be as per Sub-Clause under Clause 11.0 of IS:5822.

When the field test pressure is less than  $\frac{2}{3}$  the works test pressures the period of test should be at least 24 hours. The test pressure shall be gradually raised at a rate of 0.1 N/mm<sup>2</sup> per minute.

If drop in pressure occurs the quantity of water added in order to reestablish the test pressure shall be carefully measured and the leakage allowed should only be to the limits specified in IS code for the pipe material adopted.

## 12 SUPPLY OF DUCTILE IRON PIPES, SPECIALS, VALVES AND LAYING OF PIPES FOR WATER SUPPLY

### 12.1 General

#### 12.1.1 Standards

12.1.1.1 Except as otherwise specified in this technical specification, the Indian/International Standards and Codes of Practice in their latest version shall be adhered to for the design, manufacturing, inspection, factory testing, packing, handling and transportation of product. Should any product be offered conforming to other standards, the equipment or products shall be equal to or superior to those specified and the documentary confirmation shall be submitted for the prior approval of the Employer.

12.1.1.2 This specification requires a reference to the following standard specifications

IS: 10500	Drinking water specification
IS: 1387	General requirements for the supply of metallurgical material
IS: 210	Grey iron casting
IS: 1536	Centrifugally cast (spun) iron pressure pipe for water, gas and sewage
IS: 1537	Vertically cast iron pressure pipe for water, gas and sewage
IS: 1538	Cast iron fittings for pressure pipes for water, gas and sewage
IS: 5531	CI specials for Asbestos cement pressure pipes for water gas & sewage
IS: 1363	Hexagon head bolts, screws and nuts of product grade A and B (part:1-5)
IS: 1367	Technical supply conditions for threaded steel fasteners
IS: 780	Sluice valve for water works purposes
IS: 2906	Specifications for sluice valves for water works purposes
IS: 318	Leaded tin bronze ingots and casting
IS: 8543	Methods of testing plastics: Determination of density of solid plastics
IS: 7181	Horizontally cast iron double flanged pipes for water, gas and sewage.
IS: 8794	CI detachable joints for use with Asbestos cement pressure pipes
IS: 5382	Rubber sealing rings for gas mains, water mains and sewers
IS: 5531	Cast iron specials for asbestos cement pressure pipes for water, gas and sewage
IS: 779	Water meters
IS: 3624	Pressure and vacuum gauges
IS: 341	Black japan, types A, B and C
IS: 9862	Ready mixed paint, brushing, bituminous, black, lead free, acid, alkali, water and chlorine resisting
IS: 1239	Mild steel tubes, tubular and other wrought steel fittings
IS: 7328	High density polyethylene materials for moulding and extrusion
IS: 4984	Specification for high density polyethylene pipes for potable water supplies; sewage and industrial effluents
IS: 554	Dimensions for pipe threads where pressure tight joints are required on the threads
IS: 1592	Asbestos cement pressure pipes - Specifications
IS: 778	Specifications for copper alloy gate, globe and check valves for water

	works purposes
IS: 12820	Dimensional requirements for rubber gaskets for mechanical joints and push on joint for use with cast iron pipes and fittings for carrying water, gas and sewage.
IS: 9523	Specification for DI fittings for pressure pipes for water, gas, and sewage.
ISO: 1167	Thermoplastics pipes for the transport of fluids - Resistance to internal pressure - Test method and basic specification
ISO 3451-5	Determination of Ash: Part-5 - Poly vinyl chloride
ASTM: D 2152	Standard test method for degree of fusion of extruded PVC pipe and moulded fittings by Acetone immersion
MTNL	Mahanagar Telephone Nigam Limited; Technical specifications for cable ducts.
BS: 4772	Specification for DI fittings
IS: 7634-Parts 1-3	Code of practice for plastic pipe works for potable water supplies
IS: 8329	Centrifugally cast (spun) ductile iron pressure pipes for water, gas and sewage.
IS: 12288	Code of practice for use and laying of ductile iron pipes
CPHEEO	Manual on Water Supply and Treatment, III edition, Ministry of Urban Development, New Delhi- 2010.

## 12.2 Ductile Iron Pipes

### 12.2.1 Ductile Iron Pipes:

The pipes will be centrifugally cast (spun) Ductile Iron pipes confirming to the IS 8329 with all upto date ammendments and revisions. The pipes used will be either with push on joints (Rubber Gasket Joints) or Flanged joints. The class of pipe to be used shall be of the class K-7 & K-9.

The pipes will be supplied in standard length of 5.50 and 6.00 meters length with suitably rounded or chamfered ends. Each pipe of the push on joint variety will also be supplied with a rubber EPDM/(SBR) gasket. Any change in the stipulated lengths will be approved by the Employer – in charge. The gaskets will confirm to the IS 5382:1985.

The gaskets should also be supplied by the manufacturer of the pipes. They should preferably be manufactured by the manufacturer of the pipes. In case they are not, it will be the responsibility of the manufacturer of the pipes to have them manufactured from a suitable manufacturer under it's own supervision and have it tested at his/sub contractors premises as per the contract. The pipe manufacturer will however be responsible for the compatibility and quality of the products.

The flanged joints will confirm to the Clause 6.2 of IS 8329. The pipe supply will also include one rubber gaskets for each flange.

#### 12.2.1.1 Inspection and Testing:

The pipes will be subjected to following tests for acceptance:

- Visual and dimensional check as per Clause 13 and 15 of IS 8329
- Mechanical Test as per Clause 10 of IS 8329
- Hydrostatic Test as per Clause 11 of IS 8329
- The test reports for the rubber gaskets shall be as per acceptance tests of the IS 5832 and will be in accordance to Clause 3.8

The sampling shall be as per the provisions of the IS 8329

#### 12.2.1.2 Marking

- All pipes will be marked as per Clause 18 of IS 8329 and show as below:
- Manufacturer name/ stamp
- Nominal diameter
- Class reference
- A white ring line showing length of insertion at spigot end

#### 12.2.1.3 Packing and Transport:

The pipes should be preferably transported by road from the factory and stored as per the manufacturer specifications to protect damage.

#### 12.2.2 Hydraulic Testing

12.2.2.1 Pipes shall be given different hydraulic tests for ensuring quality of manufacture as per clause 12.9.4.6 of this specification.

### 12.3 Specials for Ductile Iron Pipes

#### 12.3.1.1 General

This section covers the general requirements for Ductile Iron (DI) fittings suitable for Tyton joints to be used with Ductile Iron pipes with flanged and Tyton jointing system.

#### 12.3.1.2 Types of specials

The following types of DI fittings shall be manufactured and tested in accordance with IS: 9523 or BS: 4772.

- flanged socket
- flanged spigot
- double socket bends (90<sup>0</sup>, 45<sup>0</sup>, 22 1/2<sup>0</sup>, 11 1/4<sup>0</sup>)
- double socket branch flanged tee
- all socket tee
- double socket taper
- restrained joints
- All the fittings shall be of class K-12.

#### 12.3.2 Supply

All the DI fittings shall be supplied with one rubber ring for each socket. The rubber ring shall conform to IS: 12820 and IS: 5382 as described in the preceding chapter. Flanged fittings shall be supplied with one rubber gasket per flange and the required number of nuts and bolts.

### 12.3.3 Lubricant for ductile iron pipes and specials

#### 12.3.3.1 General

This section covers the requirements for lubricant for the assembly of Ductile Iron pipes and specials suitable for Tyton push-in rubber ring joints

#### 12.3.3.2 Specification

The lubricant has to have the following characteristics:

- must have a paste like consistency and be ready for use
- has to adhere to wet and dry surfaces of DI pipes and rubber rings
- to be applied in hot and cold weather; ambient temperature 0 - 50 °C, temperature of exposed pipes up to 70 °C
- must be non toxic
- must be water soluble
- must not affect the properties of the drinking water carried in the pipes
- must not have an objectionable odour
- has to inhibit bacterial growth
- must not be harmful to the skin
- must have a shelf live not less than 2 years

Acceptance tests

- They shall be conducted in line with the provisions of the IS 9523

### 12.3.4 Packing

All the DI fittings shall be properly packed with jute cloth. Rubber rings shall be packed in polyethylene bags. Rubber rings in PE bags and nuts, bolts etc. shall be supplied in separate jute bags.

- 12.3.5 The fittings should preferably be manufactured by the manufacturer of the pipes. In case they are not, it will be the responsibility of the Contractor to have them manufactured from a reputed manufacturer. The Contractor however shall be responsible for the compatibility and quality of the products.

## 12.4 Specifications for Laying and Jointing of Pipe Line System for Water Supply

### 12.4.1 Preparatory work

The contractor will inspect the route along which the pipe line is proposed to be laid. He should observe/ findout the existing underground utilities/ construction and propose an alignment along which the pipeline is to be laid. He should make all efforts to keep the pipe as straight as possible with the help of ranging rods. Whereever there is need for deviation, it should be done with the use of necessary

specials or by deflection in pipe joints (limited to 75% of permissible deflection as per manufacturer). The alignment as proposed should be marked on ground with a line of white chalk and got approved from Employer Incharge. The Contractor will then prepare an L-Section along this alignment showing the location of proposed pipe line. The L-section should be got approved from the site Employer. The position of fittings, valves, should be shown on the plan.

#### 12.4.2 Alignment and the L-Sections

The alignments, L-section (depth of laying) and location of specials, valves and chambers may be changed at site in co-operation with and after approval of the Employer.

#### 12.4.3 Standards

Except as otherwise specified in this technical specification, the Indian Standards and Codes of Practice in their latest version, National Building code, CPWD specification and Manual of water supply of GOI shall be adhered to for the supply, handling, laying, installation, and site testing of all material and works.

#### 12.4.4 Tools and equipment

The contractor has to provide all the tools and equipment required for the timely, efficient and professional implementation of the work as specified in the various sections of the contract and as specified by the instructions of manufacturers of the pipes and other material to be handled under this contract. On demand he shall provide to the Employer a detailed list of tools and equipment available. If in the opinion of the Employer Charge the progress or the quality of the work cannot be guaranteed by the available quantity and type of tools and equipment the contractor has to provide additional ones to the satisfaction of the Employer. The Contractor will always have a leveling instrument on site.

##### Handling and laying of pipes

#### 12.4.4.1 Transportation of pipes and specials

The Contractor has to transport the pipes and other materials from manufacturer to the site of laying as indicated by the Employer. Pipes should be handled with care to avoid damage to the surface and the socket and spigot ends, deformation or bending. Pipes shall not be dragged along the ground or the loading bed of a vehicle. Pipes shall be transported on flat bed vehicles/trailers. The bed shall be smooth and free from any sharp objects. The pipes shall rest uniformly on the vehicle bed in their entire length during transportation. Pipes shall be loaded and un-loaded manually or by suitable mechanical means without causing any damage to the stacked pipes.

The transportation and handling of pipes shall be made as per IS 12288. Handling instructions of the manufacturers of the pipes shall be followed. All precautions set out shall be taken to prevent damage to the protective coating, damage of the jointing surfaces or the ends of the pipes.

Whatever method and means of transportation is used, it is essential that the pipes are carefully placed and firmly secured against uncontrolled movement during transportation to the satisfaction of Employer.

Cranes or chain pulley block or other suitable handling and lifting equipment shall be used for loading and un-loading of heavy pipes. However, for pipes up to 400 mm nominal bore, skid timbers and ropes may be used. Where using crane hooks at sockets and spigot ends hooks shall be broad and protected by rubber or similar material, in order to avoid damage to pipe ends and lining. Damage to lining must be repaired before pipe laying according to the instructions of the pipe manufacturer. Pipes shall not be thrown directly on the ground.

When using mechanical handling equipment, it is necessary to employ sufficient personnel to carry out the operation efficiently with safety. The pipes should be lifted smoothly without any jerking motion and pipe movement should be controlled by the use of guide ropes in order to prevent damage caused by pipes bumping together or against surrounding objects.

Rolling or dragging pipes along the ground or over other pipes already stacked shall be avoided too.

#### 12.4.4.2 Stringing of pipes along the alignment

The pipes shall be laid out properly along the proposed alignment in a manner that they do not create any significant hindrance to the public and that they are not damaged.

Stringing of the pipes end to end along the working width should be done in such a manner that the least interference is caused in the land crossed. Gaps should be left at intervals to permit the passing of equipment across the working area. Pipes shall be laid out that they remain safe where placed and that no damage can occur to the pipes and the coating until incorporated in the pipeline. If necessary, pipes shall be wedged to prevent accidental movement. Precautions shall be made to prevent excessive soil, mud etc. entering the pipe.

Generally, the pipes shall be laid within two weeks from the date of their dispatch from the manufacturer/store.

The joint gaskets shall be kept in wooden boxes or their original packing and stored in cool conditions and not exposed to direct sunlight. Gaskets must not be deformed. They shall be taken out only shortly before they are needed. All PVC pipes when stored shall be protected from sunlight and heat at all stages.

#### 12.4.4.3 Pipe trench

##### 12.4.4.3.1 Trench excavation

The trench excavation of pipe line shall be in accordance with IS 12288. Pipe trenches shall be excavated to the lines and levels shown on the drawings or as

directed by the Employer. The depth of the excavated trench shall be as given in the drawings or as directed by the Employer. The width of the trench at bottom between the faces of sheeting shall be such as to provide 200/150 mm clearance on either side of the DI CI / PVC pipe except where rock excavation is involved. No pipe shall be laid in a trench until the section of trench in which the pipe is to be laid has been approved by the Employer.

In agricultural land the depth should be sufficient to provide a cover not less than 900 mm so that the pipe line will not interfere with the cultivation of land. It may be necessary to increase the depth of pipeline to avoid land drains or in the vicinity of roads, railways or other crossings. Care should be taken to avoid the spoil bank causing an accumulation of rainwater.

The bottom of the trench shall be trimmed and levelled to permit even bedding of the pipes. It should be free from all extraneous matter which may damage the pipe or the pipe coating. Additional excavation shall be made at the joints of the pipes, so that the pipe is supported along its entire length.

All excavated material shall be stacked in such a distance from the trench edge that it will not endanger the work or workmen and it will avoid obstructing footpaths, roads and drive ways. Hydrants under pressure, surface boxes, fire or other utility controls shall be left unobstructed and accessible during the construction work. Gutters shall be kept clear or other satisfactory provisions made for street drainage, and natural water-courses shall not be obstructed.

To protect persons from injury and to avoid damage to property, adequate barricades, construction signs, torches, red lanterns and guards, as required, shall be placed and maintained during the progress of the work and until it is safe for traffic to use the roadways. All materials, piles equipment and pipes which may serve as obstruction to traffic shall be enclosed by fences or barricades and shall be protected by illuminating proper lights when the visibility is poor.

As far as possible, the pipe line shall be laid below existing services, like water and gas pipes, cables, cable ducts and drains but not below sewers, which are usually laid at greater depth. Where it is unavoidable, pipe line should be suitably protected. A minimum clearance of 150 mm shall be provided between the pipe line and such other services.

Trees, shrubbery fences, poles, and all other property and surface structures shall be protected. Tree roots shall be cut within a distance of 50 cm from pipe joints in order to prevent roots from entering them. Temporary support, adequate protection and maintenance of all under ground and surface structures, drains, sewers and other obstructions encountered in the progress of the work shall be provided. The structures, which will be disturbed shall be restored after completion of the work.

Where water forms or accumulates in any trench the Contractor shall maintain the trench free of water during pipe laying.



Wherever necessary to prevent caving, trench excavations in soils such as sand, gravel and sandy soil shall be adequately sheeted and braced. Where sheeting and bracing are used, the net trench width after sheeting shall not be less than that specified above. The sides of the excavation shall be adequately supported at all times and, except where described as permitted under the Contract, shall be not battered.

The Contractor shall decide about the sheeting/ bracing of the trench according to the soil conditions in a particular stretch and taking into account the safety requirements of the Contractor's and obtain approval from Employer. Generally, safety measures against caving have to be provided for trenches with vertical walls if they are deeper than 2.0 m.

#### 12.4.4.3.2 Trench excavation to commensurate with the laying progress

The work of trench excavation should be commensurate with laying and jointing of the pipe line. It should not be dug in advance for a length greater than 500 m ahead of work of laying and jointing of pipeline unless otherwise defined by the Employer. The Contractor has to ensure the following:

- safety protections as mentioned above have to be incorporated in the work process
- hindrances to the public have to be minimised
- the trench must not be eroded before the pipes are laid
- the trench must not be filled with water when the pipes are laid
- the trench must not be refilled before laying of the pipes

The bed for the laying of the pipes has to be prepared according to the L-Section immediately before laying of the pipes.

#### 12.4.4.3.3 Bedding of the pipes

The trench bottom shall be even and smooth so as to provide a proper support for the pipe over its entire length, and shall be free from stones, lumps, roots and other hard objects that may injure the pipe or coating. Holes shall be dug in the trench bottom to accommodate sockets so as to ensure continuous contact between the trench and the entire pipe barrel between socket holes.

#### 12.4.4.4 Laying and jointing of pipes

##### 12.4.4.4.1 General

The pipes will be cleaned in the whole length with special care of the spigot and sockets on the inside/ outside to ensure that they are free from dirt and unwarranted projections. The whole of the pipes shall be placed in position singly and shall be laid true to profile and direction of slope indicated on longitudinal sections. The pipes shall be laid without deflection in a straight alignment between bends and between high and low points. Vertical and horizontal deflections

between individual pipes need the approval of the Employer. In no case the deflection shall be more than 75 % of those recommended by the manufacturer.

Before pipes are jointed they shall be thoroughly cleaned of all earth lumps, stones, or any other objects that may have entered the interior of the pipes, particularly the spigot end and the socket including the groove for the rubber ring.

Pipes and the related specials shall be laid according to the instructions of the manufacturers and using the tools recommended by them.

Cutting of pipes shall be reduced to a minimum required to conform with the drawings. Cutting has to be made with suitable tools and according to the recommendations of the manufacturer. The spigot end has to be chamfered again at the same angle as the original chamfered end. Cutting shall be perpendicular to the centre line of the pipe. In case of ductile iron pipes the cut and chamfered end shall be painted with two coats of epoxy paint. If there is no mark for the insertion depth on the spigot end of the (cut) pipe it shall be marked again according to the instructions of the manufacturer.

Before pipes are jointed they shall be thoroughly cleaned of all earth lumps, stones, or any other objects that may have entered the interior of the pipes, particularly the spigot end and the socket including the groove for the rubber ring. End caps are removed only just before laying and jointing

All specials like bends, tees etc. and appurtenances like sluice or butterfly valves etc. shall be laid in synchronisation with the pipes. The Contractor has to ensure that the specials and accessories are ready in time to be installed together with the pipes.

At the end of each working day and whenever work is interrupted for any period of time, the free ends of laid pipes shall be protected against the entry of dirt or other foreign matter by means of approved plugs or end caps.

When pipe laying is not in progress, the open ends of installed pipe shall be closed by approved means to prevent entrance of trench water and dirt into the line.

No pipe shall be laid in wet trench conditions that preclude proper bedding, or when, in the opinion of the Employer, the trench conditions or the weather are unsuitable for proper installation.

The pipe line laid should be absolutely straight unless planned otherwise. The accuracy of alignment should be tested before starting refilling with the help of stretching a string between two ends of the straight stretch of pipes to rectify possible small kinks in laying.

#### 12.4.4.4.2 Laying and jointing of DI pipes

The laying and jointing of DI pipe line shall be in accordance with IS 12288. Pipes should be lowered into the trench with tackle suitable for the weight of pipes. For smaller sizes, up to 200 mm nominal bore, the pipe may be lowered by the use of ropes but for heavier pipes suitable mechanical equipment have to be used.

All construction debris should be cleared from the inside of the pipe either before or just after a joint is made. This is done by passing a pull-through in the pipe, or by hand, depending on the size of the pipe. All persons should vacate any section of trench into which the pipe is being lowered

On gradients of 1:15 or steeper, precautions should be taken to ensure that the spigot of the pipe being laid does not move into or out of the socket of the laid pipe during the jointing operations. As soon as the joint assembly has been completed, the pipe should be held firmly in position while the trench is back filled over the barrel of the pipe.

The designed anchorage shall be provided to resist the thrusts developed by internal pressure at bends, tees, etc.

Where a pipeline crosses a watercourse, the design and method of construction should take into account the characteristics of the watercourse to ascertain the nature of bed, scour levels, maximum velocities, high flood levels, seasonal variation, etc. which affect the design and laying of pipeline.

The assembly of the pipes shall be made as recommended by the pipe manufacturer and using the suitable tools.

The socket and spigot ends of the pipes shall be brushed and cleaned. The chamfered surface and the end of the spigot end has to be coated with a suitable lubricant recommended by the manufacturer of the pipes. Oil, petroleum bound oils, grease or other material which may damage the rubber gasket shall not be used as lubricant. The rubber gasket shall be inserted into the cleaned groove of the socket. It has to be checked for correct positioning.

The two pipes shall be aligned properly in the pipe trench and the spigot end shall be pushed axially into the socket either manually or with a suitable tool specially designed for the assembly of pipes and as recommended by the manufacturer. The spigot has to be inserted up to the insertion mark on the pipe spigot. After insertion, the correct position of the socket has to be tested with a feeler blade

Deflection of the pipes -if any- shall be made only after they have fully been assembled. The deflection shall not exceed 75 % of the values indicated by the pipe manufacturer.

#### 12.4.4.5 Anchoring of the pipeline

Thrust blocks shall be provided at each bend, tee, taper, end piece to prevent undue movements of the pipeline under pressure. They shall be constructed as per design according to the highest pressure during operation or testing of the pipes, the safe bearing pressure of the surrounding soil and the friction coefficient of the soil.

#### 12.4.4.6 Testing of the pipelines

#### 12.4.4.6.1 Sectional tests

After laying and jointing the pipeline shall be tested for tightness of barrels and joints, and stability of thrust blocks in sections approved by the Employer. The length of the sections depends on the topographical conditions. Preferably the pipeline stretches to be tested shall be between two chambers (air valve, scour valve, bifurcation, other chamber). At the beginning, the Contractor shall test stretches not exceeding 1 km. After successful organization and execution of tests the length may be extended to more than 1 km after approval of the Employer.

The water required for testing shall be arranged by the contractor himself. The Contractor shall fill the pipe and compensate the leakage during testing. The Contractor shall provide and maintain all requisite facilities, instruments, etc. for the field testing of the pipelines. The testing of the pipelines generally consists in three phases: preparation, pre-test/saturation and test, immediately following the pre-test. Generally, the following steps are required which shall be monitored and recorded in a test protocol if required:

- complete setting of the thrust blocks.
- partial backfilling and compaction to hold the pipes in position while leaving the joints exposed for leakage control
- opening of all intermediate valves (if any)
- fixing the end pieces for tests and after temporarily anchoring them against the soil (not against the preceding pipe stretch)
  - at the lower end with a precision pressure gauge and the connection to the pump for establishing the test pressure
  - at the higher end with a valve for air outlet
- If the pressure gauge cannot be installed at the lowest point of the pipeline, an allowance in the test pressure to be read at the position of the gauge has to be made accordingly
- slowly filling the pipe from the lowest point(s).
- the water for this purpose shall be reasonably clear and free of solids and suspended matter
- complete removal of air through air valves along the line.
- closing all air valves and scour valves.
- slowly rising the pressure to the test pressure while inspecting the thrust blocks and the temporary anchoring.
- keeping the pipeline under pressure for the duration of the pre-test / saturation of the lining by adding make-up water to maintain the pressure at the desired test level. Make up water to be arranged by Contractor himself at his own cost.
- start the test by maintaining the test pressure at the desired level by adding more make-up water; record the water added and the pressure in intervals of 15 minutes at the beginning and 30 minutes at the end of the test period.
- Water used for testing should not be carelessly disposed off on land which would ultimately find its way to trenches.
- The testing conditions for the pipelines shall be as per the test pressures and condition laid out in IS 8329 for DI pipes and IS 4985 for uPVC pipes.

The pipeline stretch will pass the test if the water added during the test period is not exceeding the admissible limits. No section of the pipework shall be accepted by the Employer until all requirements of the test have been obtained.

On completion of a satisfactory test any temporary anchor blocks shall be broken out and stop ends removed. Backfilling of the pipeline shall be completed.

#### 12.4.4.6.2 Leakage Test

After the successful completion of the pressure test (i.e. pressure testing at factory/works), Leakage test at site after proper installation of pipeline shall be conducted at a pressure to be specified by the Employer for a duration as specified below:

- [illegible]

No pipe installation shall be accepted until the leakage is less than the amount

‘Q’, as determined by the above formula:

All pressure testing at site should be carried out hydrostatically. The pipes shall be accepted to have passed the pressure test satisfactorily, if the quantity of water required to restore the test pressure does not exceed the amount ‘Q’, calculated by the above formula. Where any test of pipe laid indicates leakage greater than that specified as per the above formula, the defective pipe(s) or joints(s) shall be repaired/replaced as per the satisfaction of Employer until the leakage is within specified limits. The Contractor has to make his own arrangements for water of approved quality, required for testing pipeline

The table, hereunder, gives recommended test pressure for uPVC pipes.

Maximum continuous working pressures and recommended test pressures				
Class of pipe	Working pressure		Recommended site/ field Test Pressure	
	Kg/ sq cm	Bar	Kg/ sq cm	Bar
3	6.0	6.0	9.0	9.0
4	10.0	10.0	15.0	15.0

Due to the elastic characteristics and relatively high thermal expansion and contraction of uPVC, it is advisable to avoid prolonged pressure tests.

If it is required to test a section of a pipe line with a free end, it is necessary to provide temporary support against the considerable end thrust developed by the application of the test pressure. The end support can be provided by inserting a wooden beam or similar strong material in a short trench excavated at right angle to the main trench and inserting suitable packing between the support and pipe end.

The pipeline stretch will pass the test if the water added during the test period is not exceeding the admissible limits. No section of the pipework shall be accepted by the Employer until all requirements of the test have been obtained.

On completion of a satisfactory test any temporary anchor blocks shall be broken out and stop ends removed. Backfilling of the pipeline shall be completed.

#### 12.4.4.6.3 Failure to pass the test

All pipes or joints which are proved to be in any way defective shall be replaced or remade and re-tested as often as may be necessary until a satisfactory test shall have been obtained. Any work which fails or is proved by test to be unsatisfactory in any way shall be redone by the Contractor.

#### 12.4.4.7 Flushing and disinfecting of pipelines

After testing and commissioning the contractor shall flush the pipes with a velocity not less than 1 m/s or as approved by the Employer. Disinfection of drinking water pipelines shall be made by Employer- in charge.

#### 12.4.4.8 Backfilling of the pipe trench

For the purpose of back-filling, the depth of the trench shall be considered as divided into the following three zones from the bottom of the trench to its top:

Zone A: From the bottom of the trench to the level of the centre line of the pipe	Back-filling by hand with sand, fine gravel or other approved material placed in layers of 150 mm and compacted by tamping. The back-filling material shall be deposited in the trench for its full width of each side of the pipe, specials and appurtenances simultaneously. Special care shall be taken to avoid damage of the pipe and the coating or moving of the pipe.
Zone B: From the level of the centre line of the pipe to a level 300 mm above the top of the pipe	Back-filling and compaction shall be done by hand or approved mechanical methods in layers of 150 mm, special care shall be taken to avoid damage of the pipe and the coating or moving of the pipe.
Zone C: From a level 300 mm above the top of the pipe to the top of the trench.	Back-filling shall be done by hand or approved mechanical methods in 15 cm layers after compacting and carried to the level necessary to allow for the temporary restoration of road and path surfaces, and also for hard-core (if and where ordered) on roads or to such level as will leave the requisite space for the top soil, road surface etc. to be reinstated as directed by the Employer. In case of agricultural or waste land and after approval by the Employer back-filling may be made in thicker layers and with less compaction up to 200 - 300 mm above the initial ground level.

Where the excavation is made through permanent pavements, curbs, paved footpaths, or where such structures are undercut by the excavation, the entire back-fill to the subgrade of the structures shall be made with sand in accordance with IS 12288.

The excavated material may be used for back-fill in the following cases, provided it complies with IS 12288 Clause 4.11.1:

- a) In Zone C: In cases where settlement is unimportant the back-fill shall be neatly rounded over the trench to a sufficient height to allow for settlement to the required level.
- b) In any zone, when the type of back-fill material is not indicated or specified, provided that such material consists of loam, clay, sand, fine gravel or other materials which are suitable for back-filling in the opinion of the Employer.

All excavations shall be backfilled to the level of the original ground surfaces unless otherwise shown on the drawings or ordered by the Employer, and in accordance with the requirements of the specification. The material used for backfill, the amount thereof, and the manner of depositing and compacting shall

be subject to the approval of the Employer, but the Contractor will be held responsible for any displacement of pipe or other structures, any damage to their surfaces, or any instability of pipes and structures caused by improper depositing of backfill materials.

Trenches crossing a road shall be backfilled with selected material placed in layers not exceeding 15 cm in thickness after compacting, wetted and compacted to a density of not less than 90 percent of the maximum dry density at optimum moisture content of the surrounding material. Any deficiency in the quantity of material for backfilling the trenches shall be supplied by the Contractor at his expense.

The Contractor shall at his own expense make good any settlement of the trench backfill occurring after backfilling and until the expiry of the defects liability period.

On completion of pressure and leakage tests exposed joints shall be covered with approved selected backfill placed above the top of the pipe and joints in accordance with the requirements of the above specifications. The Contractor shall not use backfilling for disposal of refuse or unsuitable soil.

#### 12.4.5 Sequence of works for ensuring good pipe laying

- 12.4.5.1 The required fittings, valves and jointing material should be carefully worked out in beginning. This material should be received in full first of all on site and stored as predirections of manufacturer or as directions given elsewhere in this manual on Standards.
- 12.4.5.2 The pipes should be received on site only after the above fittings, valves and material for joints has been received and all necessary preparation for laying has been made.
- 12.4.5.3 The material received should be checked for inspection certification as per contract and damage during transportation. All damaged material should be separated and not used.
- 12.4.5.4 The pipes received should be stored strictly as per directions of the manufacturer or as mentioned elsewhere in this manual or standards.
- 12.4.5.5 The pipes and other material should be again inspected for any damage before use in the trench.
- 12.4.5.6 The fittings and valves should be installed in sequence with the laying of pipes without leaving any gaps.
- 12.4.5.7 It is desirable to lay the pipe lines from the end from where it can be connected to the water source to enable regular flushing of laid pipes.
- 12.4.5.8 The entry of dirt or any foreign material in the pipe should be religiously prevented.



12.4.5.9 Each joint should be carefully checked for its completeness before covering up.

12.4.5.10 There should be a commensurate progress in trench excavation, laying and jointing of pipes, fittings, valves etc. and testing of laid pipes in sections so as to complete testing of all pipes laid in quick follow up of completing laying and jointing.

12.4.5.11 Disinfection of pipe lines should be carried out before commissioning.

#### 12.4.6 Installation of valves

##### 12.4.6.1 General

The installation of valves shall be made according to the instructions of the manufacturer and the Employer.

##### 12.4.6.2 Installation of valves

Sluice or butterfly valves shall be installed between flanges according to the instructions of the manufacturer.

Valves shall be placed on a support of concrete so that no shear stress is in the flanges. In case of axial thrust due to closure of a valve against pressure the valve shall be anchored in the support in a suitable manner to transfer the thrust into the floor slab of the chamber.

Air valves shall be installed on top of air valve tees.

#### 12.4.7 Chambers for valves

##### 12.4.7.1 Valve chambers

Valve chambers shall be constructed according to the typical drawings suitable for the respective valve and special arrangement as given in Bid document. They shall be constructed in reinforced cement concrete M15 in situ. The top slab cover shall be cast in situ or made by precast RCC or Ferrocement slabs. Above big valves prefabricated slabs shall be provided for a length and width which allows dismantling of the valve without problems. The roof and the slabs have to be designed for a live load of IRC appropriate for the location.

The chambers shall be constructed after the laying of the pipes and the assembly of specials and valves. The size of the chambers shall be according to the following criteria as per direction of Employer.

- distance of flanges from walls: 30 cm
- distance of sockets from walls: 30 cm
- distance between highest point of equipment and roof slab: 30 cm

Pipes passing through walls should be coated by two layer of soft material (hessian felt) to allow for differential settling and longitudinal expansion if

directed by Employer. Only metallic pipes may be cast into the walls for anchoring purposes.

A suitable locking device may be got constructed by Employer, if required at site.

In case of chambers deeper than 120 cm MS iron ladder of 60 cm wide, cast iron steps or rungs shall be provided at the inner side wall with a vertical spacing as per arrangement shown in drawing.

The work shall include excavation, consolidation, levelling, 10 cm of lean concrete, foundations, finishing, refilling. It shall include all labour and material required for the complete chamber.

#### 12.4.7.2 Scour valve chambers

Scour valve chambers shall be constructed according to the typical drawings enclosed suitable for the respective scour valve and special arrangement. The chambers for scour valves shall be off-line and placed on the scour pipe. There is a closed chamber containing the scour valve, according to the chambers for sluice valves.

All specifications and constructional details for the valve chambers apply for the scour chambers accordingly.

#### 12.4.7.3 Pillars for Ductile Iron Pipes

In case of unstable subsoil or in case of ductile iron pipes laid above ground they shall be laid on pillars. Each pipe is supported at the plain end and behind the socket. One pillar shall support the socket end of one and the plain end of the other pipe. The pillars shall be of RCC and shall be founded on solid soil, not subject to erosion by wind or water. The foundation of the pillars has to be calculated according to the soil conditions.

The top of the pillar shall form two saddles for the pipe having the same radius as the pipe. The socket will be lying free between the two saddles. The pipes shall be laid on a coat of polyethylene of 2 mm thickness, put on mortar. It has to be ensured that the spigot end of the pipe is supported by the saddle and does not unduly compress the rubber ring in the lower part. Each pipe is fixed by one adjustable galvanised steel spanner, fixed to the pillar with anchor bolts.

In case of vertical deviations the pipes shall be protected against uplift by additional reinforced clamps of mild steel. In this case, the design of the pillar has to be made taking in account these uplift forces. and design will be given by EMPLOYER- IN- CHARGE.

#### 12.4.7.4 Thrust blocks

The thrust blocks shall be of concrete M15 cast on site with/without proper reinforcement as per design and drawings to be given by contractor and to be approved by Employer. The thrust blocks shall be cast directly against the undisturbed soil. If this is not possible, the backfilled soil at the contact surface

shall be compacted well to full satisfaction of Employer so that anchor block is not displaced during operation and testing.

#### 12.4.7.5 Backfilling around chambers and thrust blocks

After the completion of chambers and thrust blocks the space between the structure and the excavation shall be backfilled with compacted material. Such backfill shall be placed in layers of 15 cm measured before compaction, wetted, if necessary, to optimum moisture and compacted well as per instruction of Employer

Embankment around structures shall be done at levels and with slopes as shown in the drawings.

#### 12.4.8 Other civil and related works

##### 12.4.8.1 Crossing of existing Distribution Pipes and connecting pipes

Existing transmission and distribution pipes and connecting pipes of standpipes have to be protected during the laying of the pipes. In case of impossibility of deviation, the pipes have to be replaced according to the instructions of the Employer and in co-operation with the local representative (for eg. Assistant Employer) of PHED. The Contractor has the full responsibility in case of destruction of pipes due to inattention of his staff. All costs for the reinstatement of the original status of the pipes in case of damage have to be borne by him.

##### 12.4.8.2 Poles of electrical or telephone lines

In case of impossibility of deviation of pipeline, poles of electricity lines (33, 11, 0.4 KV), telephone lines or anchor cables of poles have to be relocated. These works have to be executed by the respective department or according to its instructions. The Contractor has the full responsibility in case of destruction of lines or poles due to inattention of his staff. All costs for the reinstatement to the original status of the lines have to be borne by contractor.

#### 12.4.9 Testing and commissioning

##### 12.4.9.1 Commissioning general

After successful sectional tests after pipe laying and other pre-commissioning tests after physical completion, the pipeline shall be commissioned by the Contractor. Dynamic commissioning shall be made in conjunction with or after the commissioning of the respective system.

During testing/commissioning, the Contractor shall supply all material and labour to supervise, adjust, test, repair and do all things necessary to maintain the testing/commissioning. This shall include labour on a 24 hour-a-day basis during the test period and for such other period of continuous operation as the Employer may consider necessary to establish the efficient operation of the cluster distribution system.

If any test result shows noticeable variation from the specification requirements for the system the Contractor shall immediately take steps to rectify the deficiency without any extra cost to Employer..

The Contractor shall test and commission the system for 7 days at a stretch, from the date of commissioning. On expiry of this period the system shall be taken over by the Employer and a taking-over certificate shall be issued by the Employer, provided all defects and/or deficiencies noticed are rectified to the satisfaction of the Employer.

Generally, the timing of most of the commissioning tests will depend on the availability of the respective pumps, the water and power availability at the pumping station and the completion of the reservoir.

Should the supply of water from the pumping station fail or should any other event beyond the Contractor's control interfere, the commissioning shall be during such a number of operational periods as the Employer may consider equivalent. Any repairs or replacement required during this period shall be done by the Contractor at his own cost.

The Contractor shall allow for commissioning to be conducted at any time during the commissioning period without extra charges under the Contract.

The main indicators for the successful commissioning are:

- no leaks in pipes, joints, specials and valves
- all valves are properly installed and operational
- execution of the entire work including finishing according to the drawings and the specifications
- submission of as built drawings

#### 12.4.9.2 Dynamic commissioning

- The dynamic commissioning shall commence after the work has been physically completed to the satisfaction of the Employer. It shall simulate the design and operation conditions which are as follows:
- All branches into existing lines (if already in position) to be shut off.
- Pump in operation, pump discharging into the transmission main. This is for the commissioning of the transmission pipe only.
- Water being put into the system through overhead tank or direct pumping as the case maybe.
- Closing of the valves against full static or dynamic pressure.
- Operation of all valves including scour valves (open-close-open).
- Operation of all air valves.
- Operation of all locking arrangements of valve chambers.

## **13 PIPELINE APPURTENANCES**

### **13.1 Scope**

- 13.1.1 This Specification covers the requirements for various pipeline appurtenances like Public Stand Posts, Fire Hydrants, Valve Chambers, Anchor Blocks, Thrust Blocks, Pipe Supports, etc., required to be provided for various water supply pipelines.

### **13.2 Fire Hydrant**

- 13.2.1 The fire hydrants shall be of spindle type with 65 mm outlet combined with sluice valve, unless otherwise specified. The hydrant shall conform to IS: 909 and shall consist of the following components:

1. One Sluice Valve of Class 1 type conforming to IS: 780;
2. A duck foot bend;
3. A 65 mm male coupling instantaneous pattern; and
4. Cast iron cap permanently secured to the duck foot bend by means of a chain. Where the fire service requirement of coupling differs from the above, the requisite coupling as shown on the Drawing shall be provided at no extra cost.

- 13.2.2 The body and cover shall be of good quality Cast Iron, spindle of Bronze and the nut and valve seat of Leaded Tin Bronze. The body, spindle and other parts shall be truly machined with its surface smoothly finished.

### **13.3 Valve Chambers**

- 13.3.1 Valve chambers shall be provided for valves such as Sluice valves, Scour valves etc., at the places shown in the Drawings, with 0.6 m minimum clear space on all sides of the valves.

- 13.3.2 Base course for foundations for valve chambers shall be in Cement Concrete (1:3:6) using 40 mm and down size metal, with hard broken granite, trap, basalt or with any other approved grade as per the Specifications. Base coarse shall be 150 mm thick, laid at a level not less than 1 m below the natural ground level.

- 13.3.3 Over the base coarse, foundation for the walls of the valve chamber shall be constructed in stone masonry, in cement mortar 1:6, as per the specifications mentioned under relevant chapter. The stones for the stone masonry in foundation shall be hammer dressed. The courses shall be not less than 20 cm high with bond stones 2 m apart in each course.

- 13.3.4 Over the foundation courses, a Damp Proof Course (DPC) in Cement Concrete (1:3:6), using 20 mm and down size granite or basalt or trap jelly, in 100 mm thickness shall be provided.

- 13.3.5 Over the DPC, walls of the valve chambers (superstructure) shall be constructed in stone masonry, in Cement Mortar 1:6, as per the Specifications in Chapter 11. The stones for the stone masonry in superstructure shall be chisel dressed and all quoins

2 line dressed, 5 cm wide on each face. The courses shall be not less than 15 cm high with bond stones 2 m apart in each course.

- 13.3.6 For the walls of the valve chambers, cement pointing in cement mortar 1:3, with 2 coats of water proof cement paint of approved colour over one coat of primer coat shall be provided. Pointing shall be 20 mm to 25 mm deep.
- 13.3.7 Roof shall be constructed in RCC, M150 grade (1:2:4) and provided with projections over all sides. Roof shall be plastered with cement mortar 1:3, in 12 mm thickness. RCC perforated ventilators and door openings with rolling shutters as per Specifications shall be provided as per the Drawings, in such chambers.
- 13.3.8 Hand railing as per Specifications shall be provided to get down into the valve chambers from door level.
- 13.3.9 Cement concreting and cement mortar shall be done as per the Specifications in Chapter 9.
- 13.3.10 Necessary earth work in excavation and backfilling etc. complete, as per the requirements shall be done as per the Specifications in Chapter 5.

#### **13.4 Anchor Blocks and Thrust Blocks**

- 13.4.1 Anchor Blocks and Thrust blocks in Reinforced Cement Concrete Garde 25 of adequate size and shape shall be provided at all places shown in the Drawings, to transmit the hydraulic thrust / force to the ground, spreading over a sufficient area, depending upon the type of soil met with, shall be provided. These shall be provided as per the relevant Drawings or as directed by Employer. The exposed surfaces shall be finished in cement mortar 1:4, 12 mm thick.
- 13.4.2 Cement concreting and cement mortar shall be done as per the specifications provided in relevant chapter.
- 13.4.3 Necessary earth work in excavation and backfilling etc. complete, as per the requirements shall be done as per the specifications provided in relevant chapter.

#### **13.5 Pipe Supports**

- 13.5.1 Pipe supports shall be provided wherever required, in cement concrete (1:2:4), using granite or trap jelly of 20 mm and down size and of approved gradation, for the required dimensions and as per the approved Drawings. These shall be finished with cement mortar 1:3.
- 13.5.2 A base coarse in cement concrete 1:3:6, 150 mm thick, using 40 mm and down size aggregate of approved gradation shall be provided for the pipe supports, at a level not less than 1 m below natural ground level.
- 13.5.3 Necessary earth work in excavation and backfilling etc. complete, as per the requirements shall be done as per the specifications provided in relevant chapter.

## 14 WOOD WORK AND JOINERY

### 14.1 Scope

- 14.1.1 These specifications refer to wood work in general including carpentry and joinery work in the buildings.

### 14.2 Applicable Codes

- 14.2.1 The provision of the latest revisions of the following IS. codes shall form a part of these specifications. Other I.S. codes not specifically mentioned here, but pertaining to wood work and joinery form part of these specifications.

IS: 205	Specifications for non-ferrous metal butt hinges
IS: 287	Recommendation for maximum permissible moisture content of timber used for different purposes.
IS: 303	Specification for plywood for general purpose
IS: 362	Specification for parliament hinges
IS: 419	Specification for putty for the use on window frames
IS: 883	Code of practice for design of structural timber in building.
IS: 1003	Specification for Timber paneled and glazed shutters Part II - Window and ventilator shutters
IS: 1200	Method of measurement of building and Civil Employering Works - Wood Work and Joinery
IS: 1341	Specification for steel butt hinges
IS: 1658	Specification for Fiber Hard Boards
IS: 1761	Specification for transparent sheet glass for glazing and framing purposes.
IS: 3087	Specification for wood particle boards (medium density for structural timber building)

### 14.3 Materials

#### 14.3.1 Sawn Timber

- 14.3.1.1 First class Indian teak wood shall be used. The timber shall be of high quality and well seasoned. It shall have uniform color free from defects such as cracks, dead knots, shakes, sapwood etc. No individual hard and wound knot shall be more than 6 sq. Cm in size and the aggregate age of such knots shall not be more than 1% of the area of the piece. The timber shall be close grained having not less than 2 growth rings per cm. Width in cross section. The maximum permissible percentage of moisture content for well seasoned timber used in building work shall be as specified in the IS: 287.

#### 14.3.2 Glazing Materials

##### 14.3.2.1 Glass Panels:

14.3.2.1.1 Unless otherwise specified, glass panes used in glazed or paneled and glazed shutters, shall be of good quality glass of thickness not less than 2 mm for panes upto 0.1 sqm in area and not less than 3 mm for glass panes of area larger than 0.1 sqm with a tolerance of 0.2 mm in both cases. The glass shall be free from flaws such as specks, bubbles, smoke waves, air holes, etc. and shall conform to IS: 1761.

14.3.2.1.2 Unless otherwise specified, glass panes used in shutters of bath room and lavatories shall be frosted and of thickness as mentioned above and shall be free from any flaws.

14.3.2.1.3 Where so specified, special quality glass such as plate glass, pin heads glass, wired glass etc. shall be used. They shall conform to relevant IS standards.

#### 14.3.3 Putty for glazing in wooden frames of doors and windows

14.3.3.1 Putty shall be prepared by mixing one part of white lead with three parts of finely powdered chalk and then adding boiled linseed oil and mixing the whole thing into a homogeneous stiff paste. It shall be free from impurities like dust, grit, etc. and shall conform to IS: 419

#### 14.3.4 Fittings

14.3.4.1 The item of wood work of joinery generally includes fittings such as hinges and screws for fixing of door shutters and is explicitly so mentioned in the item.

#### 14.3.4.2 Hinges

14.3.4.2.1 Hinges shall be of iron, brass, aluminium or any other material as specified. They shall present a neat appearance and shall operate smoothly, and their riveted heads shall be well formed and smooth. Hinges shall be of the type specified and shall conform to the relevant Indian Standard Specifications.

### 14.4 Workmanship

#### 14.4.1 Wood work, wrought, framed and fixed

##### 14.4.1.1 General

14.4.1.1.1 The work shall be carried out as per detailed drawings and/or as directed by the Employer. The wooden members of the frame shall be planned smooth and accurate to the full dimensions. Rebates, roundings, mouldings, etc. As shown in the Drawing shall be done before the members are joined into frames. Where wood work is not exposed to view as in the case of frames for false ceiling, however, no planning is required to be done unless specified expressly as wrought timber work.

*Note: The work wrought shall mean 'planed'.*

14.4.1.1.2 Jointing in timber frames must be made carefully and accurately. They shall be strong, neat and shall fit without wedging or filling. The joints shall be pinned with



- hard wood or bamboo pins of 10 to 15 mm diameter after the members of the frame are pressed together in a suitable vice-mechanism.
- 14.4.1.1.3 The door and window frame shall have rebate to house the shutters and the depth of such rebate shall be 1.25 cm.
- 14.4.1.1.4 Wood work shall be painted, oiled, polished or otherwise treated as specified. All portions of timber abutting against masonry or concrete portion of building shall be coated with boiling coal tar or other type of approved wood preservatives primer, before placing them in final position.
- 14.4.1.1.5 Before any surface treatment is applied in the wood, work shall be got approved by the Employer.
- 14.4.1.2 Fixing in position
- 14.4.1.2.1 The forms shall be fixed only after acceptance by the Employer. In case of door frames without stills, the vertical members shall be buried in floor for the full thickness of the floor and the door frame shall be temporarily braced at the still level so as to prevent warping or distortion of frame during construction.
- 14.4.2 Paneled, glazed or paneled and glazed shutters:
- 14.4.2.1 General
- 14.4.2.1.1 The work shall be carried out as per detailed Drawing. The wooden members shall be planed smooth and accurate. They shall be cut to the exact shape and sizes without patching or plugging of any kind. Mouldings, rebates, roundings, etc. Shall be done, as shown in the Drawing, before the pieces are assembled into the shutter.
- 14.4.2.2 Joinery work
- 14.4.2.2.1 The thickness of the styles and rails shall be as specified in the item of work. The minimum thickness of panels shall normally be 15 mm where the clear width of panel is not more than 300 mm and 20 mm where the clear width of panel is not more than 300 mm. However, where the Employer so considers, lesser thickness upto 12 mm and 15 mm respectively may be allowed by him instead of 15 mm and 20 mm specified above. Solid wood panel for door and window shutters be made out of one or more strips of timber planks of not less than 125 mm width. It is preferable to use strips of not more than 200 mm width to reduce chances of warping, splitting or other defects. The timber strips shall be joined together with continuous tongued and grooved joints, glued together and reinforced with metal dowels. The groovings of the solid panel shall normally run along the longer dimensions of the panel unless otherwise directed. The corners and edges of panels shall be finished as shown in the Drawing and these shall be feather tongued into styles and rails. Sash bars shall have mitres joints with the styles.
- 14.4.2.2.2 Styles and rails of shutters shall be made out of single piece. Lock and intermediate rails exceeding 200 mm in width if permitted by the Employer may be made out of one or more pieces of timber but the width of each pieces shall not be less than 125

mm. Where more than one piece of timber is used, they shall be joined with a continuous tongued and grooved joint glued together and reinforced with metal dowels (rust proof) at regular intervals of 20 cm or pinned with not less than three 40 mm rust proof pins of the lost head type.

14.4.2.2.3 The tenons shall pass clear through styles. The styles and rails shall have a 12 mm groove to receive the panel.

14.4.2.2.4 In case the double shutters the rebate at the closing junction of the two shutters shall be of depth not less than 2 cm.

14.4.2.2.5 Shutters shall not be painted or otherwise treated before these are passed by the Employer and fixed in position.

#### 14.4.3 Glazing:

14.4.3.1 The glazing work shall be done in accordance with the specification given separately elsewhere.

#### 14.4.4 Hold Fast:

14.4.4.1 Hold fasts used for fixing doors and window frames shall be made of 40 x 3 mm flat iron and 40 cm long. It shall have two holes on one end for fixing to frame with long screws at the other end. The flat iron shall be split and bent at right angles in the opposite direction. The hold fast shall be tightly fixed to the frame by means of bolts, the bolt hole in frame being plugged suitably and finished neat. The hold fast shall be embedded into masonry by concrete block of 200 x 250 x 400 mm size.

### 14.5 Measurements

14.5.1 Woodwork and joinery work shall be measured in square meters. Length and width of unfinished opening shall be measured to the nearest 0.01 m.

14.5.2 Areas shall be worked out correct upto 3rd place of decimal of a sqm All work shall be measured net as fixed, that is, no extra allowance in measurement shall be made for shape, joints, etc. However, where the dimensions as fixed exceeds the specified dimension (as per Drawing, etc.) only the specified dimension(s) shall be measured and where one or more dimension of the piece as fixed is less than the fixed dimension the actual dimension shall measured without prejudice to the right of Employer to reject the piece and order replacement of such pieces.

### 14.6 Rate

It should include

1. Supply of specified species of timber sawn to requisite size without any defect, wrought, framed and fixed in position with the required standard of workmanship including supply and fixing of fixtures, straps, bolts, holdfasts, spikes, nails, screws, etc., applying contractors glue or other joining materials,

coal tarring embedded pasts, glazing and supplying and fixing of all specified fittings.

2. All material, labour, scaffolding, use of equipment etc., for framing, fixing and completing the item as specified.

#### **14.7 Flush Door Shutters**

##### **14.7.1 General**

- 14.7.1.1 The door shall be of flush type solid core with single or double shutter as the case may be.

##### **14.7.2 Shutters**

- 14.7.2.1 The shutters shall be decorative or non-decorative type of the exterior or interior grade as described in the item and as shown in the drawings. It shall conform to the relevant specifications for the type and grade in I.S. 2202/1983, Specifications of wooden Flush door shutters (solid core type). The finished thickness shall be as mentioned in the item. Face veneers used shall be of the pattern and color approved by the Employer.

##### **14.7.3 Fixtures and Fastenings**

- 14.7.3.1 These shall be as shown on the drawings or as indicated in the specifications. Where it is not specified they shall be of oxidised brass and shall be of good quality and workmanship. All fixtures and fastenings shall be sound and strong. They shall be sectional and of the best quality. The size, shape, design and finish shall be as shown on the drawings and approved by the Employer.
- 14.7.3.2 Unless otherwise specified each leaf shall be hung with three brass butt hinges for back flap with brass screws. Each door shall be furnished with aldrop and latch, brass flush bolts, etc. The fixtures shall comply with the relevant Indian Standards. Samples of all fixtures and fastening shall be got approved by the Employer and deposited in his office for reference.
- 14.7.3.3 All the fixtures shall be fixed to the joinery in a secure and efficient manner. Metal sockets shall be provided to all bolts where the shoots enter, stone, concrete, etc.

##### **14.7.4 Measurement**

- 14.7.4.1 Flush door shutters shall be measured in square metres. Length and width of unfinished opening shall be measured to the nearest 0.01 m.

### **15 METAL DOORS, WINDOWS AND VENTILATORS**

#### **15.1 Scope**

15.1.1 This specifications the requirements of metal doors, windows and ventilators.

## 15.2 Applicable Codes:

15.2.1 The provisions of the latest Indian Standards mentioned below shall form a part of these specifications. Other IS Codes not specifically mentioned here but pertaining to Metal Doors, Windows & Ventilators form part of these specifications.

IS: 1956	Glossary of terms relating to iron and steel
IS: 814 (Part I)	Specifications for covered electrodes for metal are welding of structural steel.
IS: 814 (Part II)	1.For welding products other than sheets, Specifications for covered electrodes for metal are welding of structural steel. 2.For welding sheets
IS: 815	Classification and coding of covered electrodes for metal are welding and cutting operation.
IS: 1948	Aluminium doors, windows & ventilators.
IS: 6227	Code of Practice for use of metal are welding in tubular structure
IS: 6248	Specifications for metal rolling shutters and rolling grill
IS: 1081	Code of Practice for fixing and glazing of metal (steel and aluminium) doors, windows and ventilators.
IS: 2062	Weldable Structural Steel
IS: 1361	Specifications for steel windows for Industrial Buildings
IS: : 1200 (Part VIII)	Measurements for steel work and iron work
IS: 1038	Specifications for steel doors, windows, and ventilators.
IS: 226	Specifications for structural steel (Standard quality)
IS: 823	Code of procedure for manual metal arc welding of metal steel
IS: 102	Ready mixed paint, brushing, red lead non sitting, priming.
IS: 1363	For black hexagon bolts, nut and lock nuts (dia 6 to 39 mm) and black hexagon screws (dia 6 to 24 mm)
IS: 813	Scheme of symbols for welding.

## 15.3 Materials

### 15.3.1 Structural Steel

15.3.1.1 Standard quality mild steel of various varieties and designations shall be used for different works as mentioned below:

15.3.1.2 St. 42 - S.: This variety of steel (standard quality) shall conform to specifications given in IS: 2062 (latest) and shall be used for (i) Reveted steel work (ii) bolted steel work (iii) steel work where welding is employed for fabrication provided that the thickness of material does not exceed 20 mm. When material conforming to this standard is over 20 mm thick special precautions may be required in case the material is to be welded (see IS; 823 - latest).

15.3.1.3 St. 30 - 0: This variety of steel (ordinary quality) shall conform to specifications given in IS: 1977 and is intended for general purposes such as door and window frames, window bars, grills steel gates, hand railing, builder's hardware, fencing post, tie bars, etc. All finished steel material shall be properly and neatly rolled to dimensions, sections and weights as specified. The finished material shall be free from visible as well as hidden defects and excessive rusting. The ends of the tubes shall be cut square, unless otherwise specified.

15.3.1.4 Steel sections and tubes shall be well protected and kept free from excessive rust and scaling. In this regard, decision of Employer shall be final and binding on the Contractor.

#### 15.3.2 Black Bolts:

15.3.2.1 Also known as machine bolts, these bolts shall be made from rods and they come from the rolling mills and are not finished to exact size. A lower working stress is taken for these types of bolts than those of rivets and 'turned fitted bolts'.

#### 15.3.3 Rolling Grills:

15.3.3.1 The grills shall conform to specifications given in IS: 6248. Rolling grills shall be supplied in the following alternative types as specified. The grills shall be complete with accessories. The fixing arrangement shall be as per the Drawing with regard to whether it shall be fixed on the inside or outside between jamb of opening on or below the lintel etc.

1. Gear operated type (push and pull type or manually operated type): It shall be used upto a maximum of about 8 sqm. clear area without ball bearings and upto a clear area of about 12 sq. m with ball bearings.
2. Gear Operated Type (Mechanical Type): It shall be fitted with ball bearings. It shall be used upto a maximum of about 25 sq. M. Clear area, if the rolling grill is operated by a bevel gear box and crank handle upto a maximum of about 35 sqm. clear area, if the rolling grill is operated by chair wheel and hand chain, mounted directly on the work shaft.

15.3.3.2 Grills shall be manufactured out of 8 mm dia. Mild steel round bars. Rolling grills shall be of mid bar type or of any other approved design.

15.3.3.3 The guide channels shall be of mild steel deep channel section and of rolled pressed or built up (fabricated) jointless construction. The thickness of sheet used shall not be less than 3.15 mm. Hood covers shall be made of mild steel sheet not less than 0.90 mm thick. For grills having width 3.5 mm and above thickness of M.S. sheet for the hood cover shall be not less than 1.25 mm.

#### 15.3.4 Steel Doors, Windows and Ventilators:

15.3.4.1 Steel doors, windows and ventilators and sashes shall be manufactured from fusion welding quality steel (St. 42 W) sections conforming to specifications given in IS: 2062.

- 15.3.4.2 In case of composite units consisting of a combination of two or more units of doors, windows and ventilators, etc. As the case may be, different shall be coupled by using coupling sections made from M S sheet 3.15 mm thick as per IS: 1038 para 5.2. the weight of different rolled steel sections use for manufacture of doors, windows and ventilators shall be as per those specified in IS: 1038, unless other wise specified.

#### 15.3.5 Painting

- 15.3.5.1 Where a coat of red lead paint is specified approved quality of red lead paint conforming to IS: 102 shall be used.

#### 15.3.6 Welding Equipment:

- 15.3.6.1 The welding plant and equipment shall be of modern design and shall be got approved by the Employer.
- 15.3.6.2 The electrodes required for metal arc welding shall be 'covered electrodes' and shall conform to IS: 814 (Part I) for welding products other than sheets and IS: 814 (Part II) for welding sheets.
- 15.3.6.3 The type of covering shall be as per IS: 815 for classification and coding of covered electrodes for metal welding of structural sheets.

### 15.4 Workmanship

#### 15.4.1 Structural Steel Work

- 15.4.1.1 The steel sections as specified or required shall be out, square and to correct lengths, as per Drawing and design. The cuts ends exposed to view shall be finished smooth. No two pieces shall be welded or otherwise jointed to make up the required length of a member, except as indicated in the Drawings or directed by the Employer. All straightening and shaping to form shall be done by application of pressure and not by hammering. Any bending or cutting shall be carried out in such a manner as not to impair the strength of the metal. All operations shall be done in cold state unless otherwise directed/permitted.
- 15.4.1.2 All holes shall be generally drilled to the required size and at the required position. Sub-punching shall be permitted, provided it is done 3 mm less in diameter and reared thereafter to the required size.
- 15.4.1.3 Holes for rivets and black bolts shall be larger by 0.4 to 0.6 mm than the nominal diameter of the rivets of black-bolts depending upon the dia of rivets.
- 15.4.1.4 Holes for counter-sunk bolts shall be made in such manner that their heads fit flush with the surface after fixing.
- 15.4.1.5 All bolt heads and nuts shall be hexagonal and of equal size, unless specified otherwise. The screwed threads shall conform to IS: 1363 and the threaded surface shall not be tapered. The bolts shall be of such length as to project two clear threads beyond the nuts when fixed in position and these shall fit in the bolts without any

shake. The nuts shall fit in the threaded ends of bolts properly. Tapered washers shall be provided for all heads and nuts bearing the leveled surfaces. The threaded portion of the bolt shall not be within the thickness of the parts bolted together. The faces of bolt heads and nuts shutting against steel members shall be machine finished.

#### 15.4.2 Welding

15.4.2.1 Welding shall generally be done by electric process. The electric arc method being economical, is usually adopted. Where public electricity is not available a suitable generator shall be arranged. Gas welding shall be resorted to using oxyacetylene flame with specific prior approval of the Employer.

##### 15.4.2.2 Types of welding

15.4.2.2.1 Welds used for joining structural members are generally of the following two types as under:

1. Fillet weld: The cross section of fillet weld is triangular and it is used to join two surfaces normally at right angles to each other. This type of weld is used more frequently in structural connections than any other type, and is usually in the form of isosceles triangle. The fillet welds shall be continuous or in intermittent as specified in the design.
2. Butt welds: These are classified according to the method of grooving or preparing of the base metal. The metal pieces shall be fitted or bevelled to the required shape for butt welding at the throat for which no extra payment shall be made.

15.4.2.3 Fillet and Butt welds shall conform to IS: 816. Special type of welds as slot-welds shall be used where so specified. Either direct or alternating current (but not both types) may be used throughout the whole work. An ammeter shall be provided to each arc and so situated that the Employer can easily check the current being used by the operator. Each welder shall be supplied with a portable current regulator to enable him to adjust the welding current within the approved limits without leaving his work. Only qualified operators shall be employed for welding and they shall have been trained and shall be tested after every three months as per provisions of IS: 817 for "Code of Practice for training and testing of Metal Arc Welders".

15.4.2.4 In welded structure holes are necessary for service bolts required during erection. These holes shall be made as specified above. The holes in the various sections shall be filled with punches and welded properly to form a composite section.

15.4.2.5 Surfaces which are to be welded together, shall be free from loose mill-scale, rust, paint, grease or other foreign matter. A coating of boiled linseed oil shall be permitted.

15.4.2.6 Before welding is commenced, the plates shall first be brought together and firmly clamped or spot welded at specified distance. This temporary connection has to be strong enough to hold the parts accurately in place without displacement.

15.4.2.7 All operators connected with welding and cutting equipment conform to the safety requirement given in IS: 818 for “Safety and health requirements in Electric and Gas welding and cutting operations”.

15.4.2.8 The following points shall be borne in mind during the process of welding:

1. Welds shall be made in the flat position, wherever applicable.
2. Arc length, voltage and amperage shall be suited to the thickness of material, type of groove and other circumstances of the work.
3. The sequence of welding shall be such that where possible the members which offers the least resistance to compression are welded first.

15.4.2.9 Process of Welding:

15.4.2.9.1 The electrode manipulation during welding shall be such as to ensure that:

1. The base metal is in a fused state when the filler metal makes contact with it
2. The filler metal does not overflow upon any unfused based metal
3. The base metal is not under-cut along the weld edges.
4. The flowing metal floats the slags, the oxides, and the gas bubbles to the surface behind the advancing pool.

In case any of these requirements is unattainable by manipulation, the current shall be adjusted or the electrode size changed. Each time the arc is started, the electrode shall be moved in such a way that the fusion of base metal at the starting point is assured. At the completion of a run the movement of electrode shall be slowed down to fill the arc crater. After every interruption of the arc except at completion of a run the arc shall be restarted ahead of the previous deposit and then moved back to fill the crater, or such alternative technique shall be used as will ensure complete filling of the crater or complete fusion between the new and old deposits and the base metal at the point of junction and result in continuity of weld. Before welding operation is completed, all traces of slag shall be removed from the deposit, by chipping if necessary and the deposited and adjoining base metal be wire brushed and cleaned at all points. The requirements shall apply not only to successive layers but also to successive beats, and to the overlapping area whatever a junction is made on starting a new electrode:

5. The welds shall be free from cracks, discontinuity is welding and other defects such as
  - I. under size
  - II. over size
  - III. undercutting
  - IV. overcutting

15.4.2.10 All defective welds which shall be considered harmful to the structural strength shall be cut out and re-welded.



15.4.2.11 Finished welds and adjacent parts shall be protected with clean boiled linseed oil and after all slag has been removed, welds and adjacent parts shall be painted after the same are approved by the Employer.

15.4.2.12 Inspection and testing of welds:

15.4.2.12.1 The method of inspection and testing shall be as under:

1. Dimensions of weld deposit: The size of the weld shall be as specified and it may be slightly over but not under.
2. Shape of profile: The profile of the weld is affected by the position of the joint, but it shall be uniform. In the case of butt and corner welds, the profile shall be slightly convex and in the case fillet welds it shall be usually slightly concave.
3. Uniformity of Surface: The height and spacing of the ripple shall be uniform; these being indicative of workmanship.
4. Degree of under cut: Undercutting is undesirable. The weld joint shall be free from undercut but slight intermittent occurrences may be disregarded.
5. Smoothness of joints: The joints in the weld run where welding has been adopted, shall be as uniform and smooth as possible and shall show no pronounced bump or crater in the weld surface.
6. Freedom from surface defects: The surface of the weld shall be free from porosity, cavities and burnt on scale.
7. Penetration bead in Butt welds: A slight penetration bead shall be present and it should be reasonably uniform in width and appearance. Intermittent occurrences of lack of penetration bead may be disregarded.
8. Degree of fusion: Fusion shall be complete over the whole area of the joint surface.
9. Degree of Root Penetration: These defects are most likely to occur at the root of the weld and in this position they are liable to have the maximum effects in reducing the strength of the weld. A close examination of the root shall, therefore, be made. In butt-welds, the penetration should extend to the underside of the plates producing a penetration bead of the right size. In fillet welds with good root penetration, the weld metal should reach the corner.

*Note:*

1. *In case of fusion welding or non-fusion weld and fillet welds will appear in joint, fillets being at the crotch.*
2. *In case of non-fusion welding of cast iron the joints shall show satisfactory penetration and adhesion.*
3. *Gas Cavities and Flux Entrapments: Unless they are caused by the use of unsuitable material, they are attributable to the quality of workmanship, the desired result being to achieve uniform appearance and freedom from cavities and flux entrapments (where flux is used). In fusion welding of mild-steel, cast iron and aluminium where neutral flame is used, and in fusion welding of brass or braze welding of cast iron where oxidising flame is used in current welding technique may result in rough, porous, discolored and lusterless appearance in the fracture.*

4. *In case of fusion welding or non-fusion welding of cast iron isolated blow holes or concentration of pinholes in the weld metal shall be regarded as grounds for rejection but isolated pinholes shall not be so regarded.*
5. *Bending Testing (for ductility): The elongation shall be not less than 30 percent for stress relieved welds and not less than 25 percent for non-stress relieve welds.*
6. *Tensile Testing: (Reduced Section Tensile Testing): The tensile strength shall be not less than minimum of the specified tensile range of the parent metal.*
7. *Radiographic Examination: This shall be done as given in IS: 6227.*

#### 15.4.3 Rolling Grills:

- 15.4.3.1 The springs shall be of best quality and shall be manufactured from tested high tensile spring steel wire or strip of adequate strength to balance the shutters in all positions. The spring pipe shaft etc. shall be supported on strong mild steel or malleable cast iron brackets. Brackets shall be fixed on the or under the lintel as specified with rawl plugs, and screw bolts, etc.
- 15.4.3.2 Both the side guides and bottom rail shall be jointless and of single piece of a pressed steel.
- 15.4.3.3 Grill shall be laid on ground and the side-guide channels shall be bound with it with ropes, etc. The shutter shall then be placed in position and top fixed with suspension shaft with bolts and nuts. The side guide channels and the cover frame shall then be fixed by means of screw bolts, end rawl plugs drilled in the wall. The plates and screw bolts shall be concealed in plaster to make their location invisible. Fixing shall be done accurately in a workmen like manner so as to ensure easy and smooth operation of the grill.

#### 15.4.4 Rolling Shutter

- 15.4.4.1 Same as above for Rolling Grills but with 18 gauge x 65 mm steel laths of deep convex corrugation. The rolling steel shutters shall be of approved make and design.

#### 15.4.5 Steel Doors, Windows and Ventilators ;

##### 15.4.5.1 General

- 15.4.5.1.1 The type, over all sizes, side opening position of steel doors, Windows and ventilators, shall be specified as per details given in IS: 1038, specifications for steel doors, windows and ventilators.

##### 15.4.5.2 Fabrication

- 15.4.5.2.1 Both the fixed and opening frame shall be constructed of sections which have been cut to length and mitered. The corners of fixed and opening frames shall be electrically flash butt welded to form a solid and true right angle and all frames shall square and flat.
- 15.4.5.2.2 Sub-dividing bars of the units shall be tensioned and riveted into the frame. No face welding at the joint of sub-dividing bars and frame is required. The horizontal

glazing bars shall pass through the vertical bars and the joints closed by hydraulic pressure.

15.4.5.2.3 The sizes of door, windows or ventilators frames shall not be more than + 1.3 mm.

15.4.5.2.4 The size of opening of steel doors, windows, and ventilators will be on a 10 mm module, i.e. the width as well as height will be in multiple to 10 cm.

#### 15.4.5.3 Side-hung shutter windows

15.4.5.3.1 Window shutters shall be hung on projecting type hinges (not less than 65 mm and not more than 75 mm wide). One leaf of the hinge shall be welded into a slot in the outer frame and the other leaf of the hinge riveted to the opening shutters. Friction hinges may be provided for side-hung shutter windows in which case peg-stay may not be required. In cases where non-friction type hinges are provided, the windows shall be fitted with per-stays which shall be either of hot pressed brass, aluminium or steel protected against rusting and shall be 100 mm long with steel peg and locking bracket. The peg stay shall have three holes to open the side hung casements in three different angles.

15.4.5.3.2 The handle for side hung shutters shall be of hot pressed brass, aluminium or steel protected against rusting and shall be mounted on a steel or aluminium handle plate molded, screwed or riveted to the opening frame in such a manner that it could be fixed before the shutter in glazed and may not be removed after glazing. The handle shall have a two point nose, which shall engage with a brass or aluminium striking plate on the fixed frame in a slightly open position as well as in a fast position.

#### 15.4.6 Ventilator

15.4.6.1 A brass or aluminium spring catch shall be fitted in the center of the top bar of the ventilator. A brass or aluminium cord pulley wheel in galvanised mild steel on malleable iron bracket shall be fitted at the sill of the ventilator with mild steel screws or alternatively welded together with a mild steel or malleable iron cord eye riveted or welded to the bottom inner frame bar of the ventilator in a position corresponding to that of the pulley.

#### 15.4.6.2 Top Hung Ventilator

15.4.6.2.1 The steel butt hinges for top hung ventilators shall be riveted to the fixed frame or welded to it after cutting a slot in it. Hinges to the opening frame shall be riveted or welded and cleaned off. Top hung casements shall be provided with a peg stay three holes which when closed shall tightly by the locking bracket. The locking bracket shall either be fitted to the fixed frames or to the window.

#### 15.4.6.3 Center Hung Ventilator

15.4.6.3.1 This shall be hung on two pairs of brass or aluminium cup pivots riveted to the inner and outer frames of the ventilator to permit it to swing to an angle of approximately 85 Degree. The opening portion of the ventilator shall be so

balanced that it remains open at any desired angle under normal weather conditions.

#### 15.4.6.4 Position of Holes, fixing Screws and Lugs:

15.4.6.4.1 Outer frames shall be provided with fixing holes, screws and lugs centrally in the web of the section as directed.

#### 15.4.6.5 Fixing of Steel Doors, Windows and Ventilators:

15.4.6.5.1 General Steel doors and windows shall be stacked in upright position on level ground, preferably on wooden battens to keep them in true shape without damage.

15.4.6.5.2 Steel work opening shall be so designed that the outer flange of the door, window or ventilator from section overlaps the steel surface by 10 mm.

### 15.5 Fixing Procedure (Masonry Opening)

15.5.1.1 Where large units shall be bound by coupling individual units together (with coupling sections) the mullions and transoms shall be bedded in mastic to ensure water tightness. Mastic shall be applied liberally to the channels of the outside frame sections before assembling and other coupling. All oozing mastic shall be trimmed out neatly.

15.5.1.2 MULLIONS normally project 2.5 cm at head and sills are fixed in pockets made into the masonry timber or steel with opening. But where it is at cross joint with a transom the shorter coupling unit shall run through unbroken and other coupling until shall be cut square to form a butt joint with other members.

### 15.6 Finish

#### 15.6.1 Door and windows

15.6.1.1 Doors, windows or composite units shall be either hot dip galvanised or painted. All the steel surfaces shall be thoroughly cleaned free of rust, mill-scale, dirt, oil, etc., either by mechanical means e.g. sand or shot blasting or by chemical means e.g. pickling and then painted or hot-dip galvanised as given in IS: 1038. Final finishing coats shall be given after the doors, windows and ventilators are erected and fixed in final position. Non-ferrous parts and working parts such as handles, stays, catches handle pins, hinge-pins, etc. Shall not be painted.

#### 15.6.2 Precautions

15.6.2.1 Steel doors, windows, etc. shall not be used for centering or scaffolding and shall not be rested on the steel door and window frames or glazing bars.

15.6.2.2 All fitting and hinges shall be covered with Hessain cloth so that these may not be damaged during construction.

15.6.2.3 The doors, windows and ventilators shall be measured in square meters of finished

opening and item shall include painting, glazing and all necessary fixtures and fittings.

### 15.6.3 Weld Mesh

- 15.6.3.1 The welded mesh shall be of 10 gauge of standard wire products or equivalent. The measurements of weld mesh shall be taken from inside of MS angle and shall be in square meters. The method of fixing will be either by tack welding or by using a MS strip which shall then be welded. The weight of MS strip/angle etc. used shall be measured and paid for separately in the MS structural item.

### 15.6.4 M S Fabricated Gates and Wicket Gate

- 15.6.4.1 M S Fabricates gates etc. will be as per the design and Drawings and shall include all hold fasts, hinges (either roller bearing or otherwise) of any type, locking arrangements as specified, strap and stoppers, guide wheels and embedded runners for guide wheels all as specified. It shall include all necessary costs for fixing in position to RCC columns including all necessary temporary supports etc. and involve for one coat of primer and two coats of synthetic enamel paint of approved makes quality and shade.

### 15.6.5 Heavy Duty Sliding Windows

- 15.6.5.1 Aluminium windows and doors to be used in the work shall be manufactured using suitable heavy gauge (3.2 mm) Aluminium extruded sections of Indal or Jindal anodised to natural satin finish for 18 to 20 micron. For any work whose purpose made steel windows are specified., the same shall be obtained from Alumilite or Jindal or any other approved manufacturer. The Employers and the Architect's approval for windows to be supplied by non-specified manufacturer shall be obtained in writing on the Contractor furnishing him at his own cost a sample of each window or door type., Only then a firm order shall be placed with the approved manufacturer. All windows and doors shall conform to the samples so approved.

#### 15.6.5.2 Materials

##### 15.6.5.2.1 Windows

Heavy duty sliding windows shall be made from extruded aluminium sections of alloy HF: 9-WF of IS: 733 - 1956. Height of the windows shall not be more than 1900 mm.

##### 15.6.5.2.2 Frames

Frames shall be 2 or 3 track as required having in-built grooves to accept weather strip for weather sealing.

##### 15.6.5.2.3 Shutters

The shutter vertical, interlock sections shall be hollow sections and horizontal sections shall be non-hollow and suitable for glazing with PVC gaskets. Interlock section shall have in-built grooves for weather stripping.

#### 15.6.5.2.4 Gutter and valves

In heavy rainfall areas, the sill member shall be hollow section with special gutter section clipped on to the bottom track so as to have hollow chamber of minimum cross-sectional area of 1000 sqm. for 2 track and 1500 sq. Mm. For 3 track. The slots of size 75 x 5 mm shall be provided in the bottom track and gutter sections for vertical drainage of rain water. PVC valves shall be provided in the gutter sections acting as pressure equalization cum non-return valves.

### 15.7 Section Sizes and Other Requirements

#### 15.7.1 Doors and windows

Item	Size
Frame - 2 track on the slides, top and bottom	63.5 x 34.4 x 1.4 mm
Frame - 3 track on the sides, top and bottom	94.6 x 34.4 x 1.5 mm
Shutter - vertical, interlock and horizontals	43 x 20 x 1.4 mm

Glazing gaskets: Soft PVC glazing gaskets shall be used for glazing the shutters. Rubber gaskets shall not be allowed.

Weather strips: Soft PVC weather strips shall be provided in the in-built grooves of the sections and rubber weather strips shall not be allowed. Use of pile weather strips in lieu of PVC is optional.

Hardware: The sliding shutters shall be provided with:

- (a) Needle bearing nylon rollers, encased in plated MS brackets.
- (b) Flush type handle-cum-lock having aluminium body and stainless steel spring/receiving latch.
- (c) Nylon and cover-cum-guide on the top and bottom of the shutters.
- (d) Nylon anti-lift with pile insert to prevent lifting and tilting of the shutters.

Construction: The frames shall be mechanically jointed with 3 mm thick aluminium angle cleats. The shutters shall be mechanically jointed with plated self tapping screws and aluminium safety plate or aluminium alloy blind rivets and nickel plated self tapping.... two shall be used for the joints and fittings.

Anodising: The aluminium sections shall be brushed and anodised to natural matte finish or electro colour anodised to any shade of bronze as per IS: 1868 - 1968. For general interior and exterior use the anodising shall be average 18 to 20 microns. For highly corrosive environment, anodising shall be average 18 to 20 microns. Gummed paper tapes shall be provided on the exposed surface of the sections as protective coating.

### 15.7.2 Openable Louvered Windows

Material	:	Heavy duty made from Aluminium extruded section HE-9-WP of I.S. 733
Frame	:	40 x 23 x 1.4 MM in-built top and bottom repeated sections 40 x 23 x 1.2 mm.
Coupling	:	Coupling bar panel shape 12.5 x 6 x 2 mm Bar
Louvers blade clip	:	One piece 18 gauge above sheets riveted to jambs by 89 mm c/c, after fixing the blade from inside and attached to coupling bart.
Ground Glass	:	4 mm thick for louver upto width of 760 mm and 5.5 mm thick for louvers above 760 mm.
Weather Strip	:	Soft P.V.C. Weather strip
Hardware	:	Louvers window with self locking type handle.
Construction & Anodising	:	Shall be average 18 to 20 micron and gum paper tape provided to sections as protective coating.

### 15.7.3 Medium Range Openable and Fixed Windows

Material	:	Heavy duty made from Aluminium extruded section He-9-WP of I.S. 733
Frame	:	Frames shall have in-built grooves to accept the weather strip for weather sealing.
Shutters	:	Vertical interlock will be hollow section Horizontal shall non-hollow suitable for glazing with suitable gaskets.
Sections:	:	
Frame	:	Equal Log 63.5 x 43.0 x 1.6 mm
Shutter	:	Hollow section 57.4 x 40.0 x 1.6 mm
Mullion	:	Hollow section 62.0 x 40.0 x 1.6 mm
Glazing	:	Beading 30.0 x 19.0 x 1.1 mm 4 mm thick clear glass
Hardware	(Openable Shutter)	
a)	Heavy duty alum butt hinges having stainless steel pins, dowels and P.C. Washers.	
b)	Peg Stay - Aluminium extruded section.	
c)	Aluminium fasteners angle with nylons striking plate.	
Construction & Anodising	:	Same as General Specifications for Sliding Windows

### 15.7.4 Doors

Material	:	Heavy duty made from Aluminium extruded section HE-9-WP of I.S. 733
Frame	:	Outer frame including intermediate vertical and horizontal members shall be rectangular extruded section for weather shipping.

Shutter	:	Shutter horizontal and vertical section provision for snap on glazing. Vertical section have mullion groove beading shipping.
Glazing	:	Screwless snap on square aluminium above beading with PVC glazing gasket, - 5.5 mm thick clear glass.
Section	:	Outer frames including intermediate, horizontal and vertical members - Size 101.6 x 44.5 x 2 mm.
		Shutter Vertical                      57 x 44.5 x 2.2 mm
		Shutter Top                            48 x 44.5 x 2.2 mm
		Shutter Bottom                      100 x 44.5 x 2.2 mm
		Square above beading            16 x 15.5 x 1.2 mm
Hardware	:	
a)		Lever lock, brass body, key operating from both sides.
b)		Standard push and pull horizontal full length.
c)		Double action hydraulic floor spring of approved make and quality with G.I. top and bottom pivots.
Construction		
Frame	:	Frame shall be mechanically jointed with 3 mm thick aluminium cleat.
Shutters	:	Mechanically jointed with plated self tapping screws and aluminium safety plates, blind rivets and nickel plated self tapping for joints and fittings.
Anodising	:	Shall be average 18 to 20 micron and gumbed paper tape provided opt sections as protective coating.

## 15.8 Aluminium Doors, Windows, Ventilators & Partitions

### 15.8.1 Materials

Aluminium alloy used in the manufacture of extruded sections of the fabrication of doors, windows, ventilators shall conform to designation HE9-WP of BIS: 733.

Transparent sheet glass shall conform to the requirements of BIS: 2835. Wired and figured glass shall be as per BIS: 5437.

All Aluminium doors, windows, ventilators and partitions shall be of the type and size as specified. The doors, windows, ventilators shall conform to the requirements of BIS: 1948. Aluminium windows shall conform to BIS: 1949; if so specified.

All Aluminium units shall be supplied with anodized finish, the minimum anodic film thickness shall be 0.015mm.

Doors windows and ventilators shall be of an approved manufacture. Fabrication of the units shall be with the extruded sections, cut to correct lengths, mitred and



welded at the corners to a true right angle conforming to the requirements of BIS: 1948. Tolerance in overall dimensions shall be within + 1.5 mm. The frames and shutters shall be free from warp or buckle and shall be square and truly plane. Punching of holes, slots and other provisions to install fittings or fixtures later shall be made at the correct locations, as per the requirements.

Aluminium swing type doors, Aluminium sliding windows, partitions shall be as specified.

BIS: 1948 and BIS: 1949 referred to incorporates the sizes, shapes, thickness and weight per running metre of extruded sections for the various components of the units. However, new sizes, shapes, thickness with modifications to suit snap-fit glazing clips etc. are being continuously being added by various leading manufacturers of extruded sections, which are available in the market. as such, the sections of the various components of the unit proposed by the Bidder, will be reviewed by the Engineer-in-Charge and will be accepted only if they are equal to or marginally more than that given in the codes/ad specified.

The framework of partitions with mullions and transomes shall be with anodised Aluminium box sections. Anodised Aluminium box sections shall be in-filled with timber of class 3 (silver oak or any other equivalent) as per BIS: 4021. The outer frame shall be of size 101.6 x 44.45 x 3.11mm rectangular tubular section and the shutter shall be made out of specially extruded tubular section of size for sill member shall be 99.2 x 44.45 x 3.18mm including glazing of 5.5 mm thick plain glass PVC/Neoprene weather stripping screw less Aluminum bidding fixer such as lock, handle, tower bolt and self closing device of approved make. Panels of double / single glazing/plywood shall be fixed as per details indicated in the Drawing to be prepared by the Bidder. Partitions shall be fixed rigidly between the floor and the structural columns/beams including provision of necessary shims for wedging etc. Finished work shall be of rigid construction, erected truly plumb to the lines and levels, at locations as per the construction Drawings to be prepared by the bidder.

Specific provisions as stipulated for steel doors, windows, ventilators under clause 7.6 shall also be applicable for this item work. Glazing beads shall be of the snap-fit type suitable for the thickness of glazing proposed as indicated in the items of works prepared by the bidder. a layer of clear transparent lacquer shall be applied on aluminium sections to protect them from damage during installation. This lacquer coating shall be removed after the installation is completed.

## **16 FLOORING**

### **16.1 Scope**

- 16.1.1 These Specifications cover the general requirements of different kinds of floor finishes.

### **16.2 Cement Concrete Flooring**

#### **16.2.1 Cement Concrete**

- 16.2.1.1 Cement concrete of specified mix shall be used and it shall generally conform to the specifications provided in relevant chapter.

#### **16.2.2 Base Concrete**

- 16.2.2.1 Flooring shall be laid on base concrete where so provided. The base concrete shall be provided with the slopes required for the flooring. Flooring in verandah Courtyard kitchens & baths shall have slope ranging from 1:48 to 1:60 depending upon location and as decided by the Employer. Floors in water closet portion shall have slope of 1:30 or as decided by the Employer to drain off washing water. Plinth masonry off set shall be depressed so as to allow the base concrete to rest on it.
- 16.2.2.2 If the base consists of lime concrete, it shall be allowed to set for seven days and the flooring shall be laid within the next three days.
- 16.2.2.3 If the base is of lean cement concrete, the flooring shall be commenced preferably within 48 hours of the laying of base concrete. The surface of the base shall be roughened with steel wire brushes without disturbing the concrete. Immediately before laying the flooring, the base shall be wetted and a coat of cement slurry at 2 kg of cement spread over an area of one sqm so as to get a good bond between the base and concrete floor.
- 16.2.2.4 If the cement concrete flooring is to be laid directly on the RCC slab, the top surface of RCC slab shall be cleaned and the laitance shall be removed and a coat of cement slurry at 2 kg of cement spread over an area of one sqm so as to get a good bond between the base and concrete floor.

#### **16.2.3 Thickness**

- 16.2.3.1 The thickness of floor shall be as specified in the description of the item.

#### **16.2.4 Laying**

##### **16.2.4.1 Panels**

Flooring specified thickness shall be laid in the pattern including the border/or as given in the Drawings or as directed by the Employer. The border panels shall not

exceed 450 mm in width and the joints in the border in line with panel joints. The panels shall be of uniform size and no dimension of a panel shall exceed 2 m and the area of a panel shall not be more than 2 sqm.

#### 16.2.4.2 Laying of flooring with strips

1. Normally cement concrete flooring shall be laid in one operation using glass/plain asbestos/aluminium/PVC/brass strips or any other strips as required as per Drawing or instructions of the Employer, at the junction of two panels. This method ensures uniformity in colour of all the panels and straightness at the junction of the panels. 4 mm thick glass strips or 5 mm thick plain asbestos sheet, 2 mm PVC strips or 2 mm aluminium or brass strips shall be fixed with their tops at proper level, giving required slopes. Cost of providing and fixing strips shall be paid for separately.

2. Concreting

Cement concrete shall be placed in the panels and be levelled with the help of straight edge and trowel. The blows shall be fairly heavy in the beginning but as consolidation takes place, light rapid strokes shall be given. Beating shall cease as soon as the surface is found covered with a thin layer of cream of mortar. The evenness of the surface shall be tested with straight edge and made true to required slopes. While laying concrete, care shall be taken to see that the strips are not damages/distributed by the labourers. The tops of strips shall be visible clearly after finishing with cement slurry.

#### 16.2.4.3 Laying of flooring without Strips

Laying of cement concrete flooring in alternate panels may be allowed by the Employer in case strips are not to be provided.

1. Shuttering

The panels shall be bounded by angle iron or flats. The angle iron/flat shall have the same depth as the concrete flooring. These shall be fixed in position, with their top at proper level giving required slopes. The surface of the angle iron or flats, to come in contact with concrete shall be smeared with soap solution or non-sticking oil (Form oil or raw linseed oil) before concreting. The flooring shall butt against the unplastered masonry wall.

2. Concreting

The angle iron/flats used for shuttering, shall be removed on the next day of the laying of cement concrete. The ends thus exposed shall be repaired, if damaged with cement mortar 1:2 (1 cement: 2 coarse sand) and allowed to set for minimum period of 24 hours. The alternate panels shall then be cleaned of dust, mortar, droppings etc. and concrete laid. While laying concrete, care shall be taken to see that the edges of the previously laid panels are not damaged and fresh mortar is not splashed over them. The joints between the

panels should come out as fine straight lines.

#### 16.2.5 Finishing

- 16.2.5.1 The finishing of the surface shall follow immediately after the cessation of beating. The surface shall be left for some time, till moisture disappears from it or surplus water can be mopped up. Use of dry cement or cement and sand mixture sprinkled on the surface to stiffen the concrete or absorb excessive moisture shall not be permitted. Excessive trowelling shall be avoided.
- 16.2.5.2 Fresh cement shall be mixed with water to form a thick slurry and spread at the rate of 2 kg of cement over an area of one sqm of flooring while the flooring concrete is still green. The cement slurry shall then be properly processed and finished smooth.
- 16.2.5.3 The edges of sunk floors shall be finished and rounded with cement with a floating coat of neat cement
- 16.2.5.4 The junctions of floor with wall plaster, dado or skirting shall be rounded off where so specified.
- 16.2.5.5 The men engaged on finishing operations shall be provided with raised wooden platform to sit on so as to prevent damage to new work.

#### 16.2.6 Curing

- 16.2.6.1 The curing shall be done for a minimum period of ten days. Curing shall not be commenced until the top layer has hardened. Covering with empty gunnies shall be avoided as the colour of the flooring is likely to be bleached due to the remnants of cement dust from the bags.

#### 16.2.7 Precautions

- 16.2.7.1 Flooring in lavatories and bath room shall be laid only after fixing of water closet and squatting pans and floor traps. Traps shall plugged while laying the floors and opened after the floors are cured and cleaned. Any damage done to W.C.'s squatting pans and floor traps during the execution of work shall be made good.
- 16.2.7.2 During cold weather, concreting shall not be done when the temperature falls below 4 degree Centigrade. The concrete placed shall be protected against frost by suitable covering. Concrete damaged by frost shall be removed and work redone. During hot weather, precautions shall be taken to see that the temperature of wet concrete does not exceed 38 degree Centigrade. No concreting shall be laid within half a hour of the closing time of the day, unless permitted by the Employer. To facilitate rounding of junction of skirting, dado and floor, the skirting/dado shall be laid along with the border or adjacent panels of floor.

#### 16.2.8 Measurement

- 16.2.8.1 Length and breadth shall be measured before laying skirting dado or wall plaster. No deduction shall be made nor extra paid for voids not exceeding 0.20 sqm.

Deductions for ends of dissimilar materials or other articles embedded shall not be made for areas not exceeding 0.10 sqm.

16.2.8.2 The flooring done either with strips (in one operation) or without strips (in alternate panels) shall be treated as same and measured together.

#### 16.2.9 Rate

16.2.9.1 The rate shall include the cost of all materials and labour involved in all the operations described above including application of cement slurry on RCC slab or on base concrete including roughening and cleaning the surface but excluding the cost of strips which shall be paid separately under relevant item. Nosing of steps where provided shall be paid for separately in running metre. Nothing extra shall be paid for laying the floor at different levels in the same room or courtyard and rounding off edges of sunk floors. In case the flooring is laid in alternate panels, nothing extra shall be paid towards the cost of shuttering used for this purpose.

### 16.3 Cement Concrete Flooring with Topping of Red Oxide of Iron

#### 16.3.1 Cement Concrete

16.3.1.1 Cement concrete of specified mix shall be used and it shall generally conform to the specifications provided in relevant chapter.

#### 16.3.2 Under Layer

16.3.2.1 The under layer of flooring shall be of cement concrete of specified thickness. The mix shall be 1:2:4 (1 Cement: 2 coarse sand: 4 graded stone aggregate 12.5 mm nominal size) by volume otherwise described in the item (See 4.2). As regards laying, the work shall be carried out in the manner specified in Clause 16.3.4 except that:

1. Angle or flat iron used for shuttering shall be to the height of both the under and top layers of the floor.
2. The under layer shall not be left smooth but roughened with 2 mm deep diagonal lines at 7.5 cm centres both ways with a scratching tool to form a key for the finishing coat of red oxide of iron. No cement slurry be added to the concrete surface, and
3. The angle or flat shall removed only 24 hours after the top layer has been laid. The surface of under layer shall be left even and true to slope.

#### 16.3.3 Top Layer

16.3.3.1 This shall consist of uniform and smooth layer of plaster of 10 mm thickness unless otherwise specified and of mix 1:3 (1 Cement: 3 coarse sand) unless otherwise specified, finished with a floating coat the ratio of cement to red oxide of iron specified in the description of item shall be adopted. Normally 3.5 kg, of red oxide of approved quality to 50 kg of cement shall be mixed. This ratio may, however, be

adjusted to the tinge ordered by the Employer. The red oxide shall be dry mixed thoroughly with the cement and then sand added and mixed. The full quantity of dry mortar required for a room shall be prepared in one lot in order to ensure uniform colour. Wet mortar shall be prepared in the usual manner as and when required.

1. Laying: The top layer shall be laid, the following day after the under layer has been laid. The plaster shall be done to a uniform thickness of 10 mm and finished smooth with cement slurry (2.0 kg of cement, red oxide used) for the plaster. The surface shall then be brought to a fine polish by use of polishing stones.
2. The angle or flats used for shuttering of panels shall be removed the next day, after the laying of the top layer and broken edges repaired with the same coloured mortar as in plaster.
3. The under layers of the alternate panels and the coloured plaster on top shall then be laid as described above. In laying such alternate panels care shall be taken that concrete and coloured mortar droppings do not disfigure the coloured topping previously finished.
4. The junction of floor with wall plaster, dado or skirting shall be rounded off neatly where so required, upto 25 mm radius. Men engages on the finishing operations shall be provided with raised wooden platforms to sit on, so as to prevent damage to new work.

#### 16.3.4 Thickness

- 16.3.4.1 The thickness of the under layer panels shall be as specified in the description of the item and shall be measured correct to 1 cm. The thickness of the top layer shall not be less than that specified.

#### 16.3.5 Curing

- 16.3.5.1 The curing shall be done for a minimum period of ten days. Curing shall not be commenced until the top layer has hardened. Covering with empty cement gunnies shall be avoided as the colour is likely to be bleached with the remnants of cement matter from the bags.

#### 16.3.6 Precautions

- 16.3.6.1 These shall be as specified in Clause 16.2.7.

#### 16.3.7 Rate

- 16.3.7.1 The rate shall include the cost of all materials and labour involved in all the operations described above including application of cement slurry on base concrete including roughening and cleaning shall be paid for separately. Strips and noising of steps where provided shall be paid for separately in running metre.

- 16.3.7.2 Where the quantity of red oxide used is different from what is described in the item to get the tinge required by the Employer. The difference in quantity shall be subject to corresponding adjustment in the rate for the item.

#### **16.4 Cement Concrete Flooring with Metallic Hardener Topping**

Wherever floors are required to withstand heavy wear and tear, use of floor hardener shall be avoided as far as possible by using richer mixes of concrete, unless the use of a metallic hardener is justified on the basis of cost. Where metallic hardener topping is used, it shall be 12 mm thick.

##### **16.4.1 Metallic Hardening Compound**

- 16.4.1.1 The compound shall be approved quality consisting of uniformly graded iron particles, free from non-ferrous metal particles, oil, grease sand, soluble alkaline compounds.

##### **16.4.2 Base Concrete**

- 16.4.2.1 It shall be as specified in Clause 16.3.

##### **16.4.3 Under Layer**

- 16.4.3.1 Cement concrete flooring of specified thickness and mix shall be laid as under layer (Clause 16.6.3). The top surface shall be roughened with brushes while the concrete is still green and the forms shall be kept projecting up 12 mm over the concrete surface, to receive the metallic hardening compound topping.

##### **16.4.4 Topping**

- 16.4.4.1 This shall consist of 12 mm thick layer of mix 1:2 (1 cement: 2 stone aggregate 6 mm nominal size) by volume or as otherwise specified with which metallic hardening compound is mixed in the ratio of 1:4 (1 metallic concrete hardener: 4 cement) by weight. Metallic hardener shall be dry mixed thoroughly with cement on a clean dry pucca platform. The dry mixture shall be mixed with stone aggregate 6 mm nominal size or as otherwise specified in the ratio of 1:2 (1 cement: 2 stone aggregate) by volume, and well turned over. Just enough water shall then be added to this dry mix as required for floor concrete.
- 16.4.4.2 The mixture so obtained shall be laid in 12 mm thickness, on cement concrete floor within 2 to 4 hours of its laying. The topping shall be laid true to provide a uniform and even surface. It shall be firmly pressed into the bottom concrete so as to have good bond with it. After the initial set has started, the surface shall be finished smooth and true to slope with steel floats.
- 16.4.4.3 The junction of floor with wall plaster, dado or skirting and finishing operations shall be dealt with as described in Clause 16.3.
- 16.4.4.4 The men engaged on finishing operations shall be provided with raised wooden platform to sit on, so as to prevent damage to new work.

## **16.5 Cement Plaster in Risers of Steps, Skirting, Dado**

A band of plaster at the bottom of wall not exceeding 30 cm in height above the floor shall be classified as skirting. It shall be flush with wall plaster as specified. The work shall be preferably carried out simultaneously with the laying of floor. It's corners and junctions with floor shall be finished neatly as specified.

### **16.5.1 Thickness**

- 16.5.1.1 The thickness of the plaster specified shall be measured exclusive of the thickness of key i.e., grooves or open joints in brick work. The average thickness should be regulated at the time of plastering by keeping suitable thickness of the gauges. Extra thickness required in rounding of corners at junctions of wall shall be ignored.

### **16.5.2 Preparation of Wall Surface**

- 16.5.2.1 The joints shall be raked out to depth of at least 15 mm in masonry walls. In case of concrete walls, the surfaces shall be roughened by hackings. The surface shall be cleaned thoroughly, washed with water and kept wet before skirting is commenced.

### **16.5.3 Application**

- 16.5.3.1 Skirting with specified mortar and to specified thickness shall be laid immediately after the surface is prepared. It shall be laid along with the border or adjacent panels of floor. The joints in skirting shall be kept true and straight in continuation of the line of joints in borders or adjacent panels. The skirting shall be finished smooth and true, with top truly horizontal and joints truly vertical except where otherwise indicated.

### **16.5.4 Finishing**

- 16.5.4.1 The finishing of surface shall be done simultaneously with the borders of the adjacent panels of floor. The cement to be applied in the form of slurry for smooth finishing shall be at the rate of 2 kg of cement per litre of water applied over an area of 1 sqm.
- 16.5.4.2 Where skirting is flush with plaster, a groove 10 mm wide and upto 5 mm deep shall be provided in plaster at the junction of skirting with plaster.

### **16.5.5 Curing**

- 16.5.5.1 Curing shall be commenced on the next day of plastering when the plaster has hardened sufficiently and shall be continued for a minimum period of 7 days.

### **16.5.6 Measurements**

- 16.5.6.1 Length and height shall be measured correct to a cm and its area shall be calculated in sqm correct to two places of decimals stating the thickness. Length shall be



measured as the finished length of skirting. Height shall be measure from the finished level of floor correct to 5 mm.

#### 16.5.7 Rate

16.5.7.1 Rate shall include the cost of all materials and labour involved in all the operations described above.

### **16.6 Cement Plaster Skirting Finished with Red Oxide of Iron.**

#### 16.6.1 Under Coat

16.6.1.1 The undercoat of skirting shall be of cement plaster of the thickness and mix described in the item. As regards application, the under coat shall be finished rough with a scratching tool to form a key for to the top coat.

#### 16.6.2 Top Coat

##### 16.6.2.1 Mortar

This shall consist of uniform and smooth layer of plaster of specified thickness and of mix 1:3 (1 Cement: 3 coarse sand) unless otherwise specified, finished with a floating coat of neat cement. In both plaster and floating coat the ratio specified in the description of item shall be adopted. Normally 3.5 kg of red oxide of approved quality to 50 kg of cement shall be mixed. This ratio may however, be adjusted to the tinge order by the Employer. The red oxide shall be mixed with the cement and then sand added and mixed. The full quantity of dry mortar required for a room shall be prepared in one lot in order to ensure uniform colour. Wet mortar shall be prepared in the usual manner as and when required.

##### 16.6.2.2 Application

The top coat shall be done the next day after the under coat has been applied. The plaster shall be done with the thickness specified and finished smooth, by application of cement-red oxide mix, at the rate of 1.0 kg. Per square metre of surface. The ratio adopted for the mix being the same as that of the plaster. When the surface has hardened sufficiently it shall be brought to a fine polish by use of polishing stones.

#### 16.6.3 Thickness

16.6.3.1 The thickness of the bottom and top coats shall be as specified. The total thickness of skirting specified is of total thickness of skirting specified is of total thickness of plaster as measured from the unplastered face of the masonry. Average thickness of the under coat shall not be less than 6 mm and minimum thickness over any portion of the surface shall not be less than 4 mm. The thickness of top coat shall not be less than the thickness specified.

#### 16.6.4 Curing

16.6.4.1 Curing shall be commenced on the next day of plastering when the plaster has hardened sufficiently and shall be continued for a minimum period of 7 days.

16.6.5 Measurements

16.6.5.1 Length and height shall be measured correct to a cm and its area shall be calculated in sqm correct to two places of decimal stating the thickness. Length shall be measured as the finished length of skirting. Height shall be measured from the finished level of floor correct to 5 mm.

16.6.6 Rate

16.6.6.1 The rate shall include the cost of all materials and labour involved in all the operations described above.

16.6.6.2 Where the quantity of red oxide used is different from what is described in the item to get the tinge required by the Employer, the difference in quantity used will be subject to corresponding adjustment in the rate for the item.

**16.7 Cement Concrete Pavement in Courtyard and Terrace Etc.**

16.7.1 Specifications described in Clause 26.5 shall hold good as far as applicable except that:

1. The panels shall be of uniform size and no dimension of a panel shall exceed 1.25 m and the area of panel should not exceed 1.25 sqm for the thickness of panels upto 50 mm.
2. Concrete shall be done in alternate panels only and no glass/asbestos strips shall be provided.

16.7.2 Finishing

16.7.2.1 The finishing of the surface shall follow immediately after the cessation of beating. The surface shall be left for some-time, till moisture disappears from it or surplus water can be mopped up.

16.7.2.2 Use of dry cement or cement and sand mix sprinkled on the surface to stiffen the concrete or to absorb excessive moisture shall not be permitted. Excessive troweling shall be avoided. When surface becomes fairly stiff, it shall be finished rough with wooden floats or where so specified chequered uniformly by pressing a piece of expanded metal of approved size.

16.7.3 Rate

16.7.3.1 The rate shall include the cost of all materials and labour involved in all the operations described above except the base concrete below flooring which shall be paid for separately. Chequering to pattern shall be paid for separately unless otherwise specified.

## **16.8 Chequered Tile Flooring**

### **16.8.1 Chequered Tiles**

- 16.8.1.1 The tiles shall be of nominal sizes such as 20 x 20 cm 25 x 25 cm and 30 x 30 cm or of standard sizes with equal sides. The size of tiles to be used shall be as shown in Drawings or as required by the Employer. The centre to centre distance of chequers shall not be less than 2.5 cm and not more than 5 cm.
- 16.8.1.2 The overall thickness of the tiles shall not be less than 22 mm. The grooves in the chequers shall be uniform and straight. The depth of the grooves shall not be less than 3 mm. The chequered tiles shall be cement tiles, or terrazzo tiles as specified in the description of the item. The thickness of the upper layer, measured from the top of the chequers shall not be less than 6 mm.
- 16.8.1.3 The terrazzo tiles shall be given the first grinding with machine before delivery to site.
- 16.8.1.4 The tiles shall conform to the Specifications for plain cement concrete or terrazzo tiles in respect of method of manufacture and the mix of the backing and wearing layers.

### **16.8.2 Laying, curing, Polishing and Finishing**

- 16.8.2.1 These shall be as specified in Clause 16.2. except that the polishing of the tiles and the chequer grooves, after laying, may be done by hand. Special care shall be taken to polish the grooves in such a manner as to get a uniform section and that their finish shall match with the finish of flat portion of the tiles. Cement concrete files normally do not require polishing concrete tiles normally do not require polishing but where polishing is required the same shall be done as described above.

## **16.9 Chequered Tiles in Stair Treads**

### **16.9.1 Chequered Tiles**

- 16.9.1.1 The Specifications for tiles shall be as specified in Clause 16.1 except in the following respects:
1. The length of the tiles including nosing shall be as specified.
  2. The nosing edge of the tile shall be rounded.
  3. The minimum thickness of the tile shall be 30 mm.
  4. The front portion of the tile for a minimum length of 75 mm from and including the nosing shall have grooves running to the nosing and at centres not exceeding 25 mm. Beyond that the tiles shall have the normal chequer pattern.
  5. The nosing shall also have the same wearing layer as the top.

### **16.9.2 Preparation of Surface and Laying**

- 16.9.2.1 RCC or brick work in treads on which the tiles are to be laid shall be cleaned wetted

and mopped. The bedding for tiles shall be with lime mortar of either 1:1:1 (1 lime putty: 1 surkhi: 1 coarse sand) or 1:4 (1 cement: 4 coarse sand) or of specified mix. The minimum thickness of bedding mortar at any place shall be 10 mm. Bedding mortar shall be spread, tamped and corrected to proper levels. After laying bedding mortar, neat grey cement slurry of honey like consistency shall be spread over the mortar at the rate of 4.4 kg of cement per square metre over each tread. Tiles shall be washed cleaned and shall be fixed in this grout one at another. Each tile being gently tapped with a wooden mallet till it is properly bedded, and is in level and line with the adjoining tiles. The joints shall be kept as thin as possible and in straight lines. The surface shall be checked with a straight edge during laying to obtain a true surface.

16.9.2.2 The square end of the tile shall, as far as possible butt against the riser face of the concrete or brick tread and in any case shall be embedded under the side wall plaster, skirting or dado and under the riser tile or other finish to a depth of not less than 10 mm.

16.9.2.3 Where full size tiles cannot be fixed, these shall be cut (sawn) to the required size (along the groove of the chequers where the cut edge is exposed) and used. The cut in the case of embedded edges will be neat and true while the cut in the case of exposed edges shall in addition be rubbed smooth to ensure a straight and true joints.

16.9.2.4 After the tiles have been laid surplus cement grout shall be cleaned off.

#### 16.9.3 Curing, Polishing and Finishing

16.9.3.1 The Specifications shall be as described in Clause 16.8.2 except that polishing of the treads nosing and chequered grooves, after laying, may be done by hand in the same manner as specified under terrazzo the flooring. Special care shall be taken to polish the nosing and the grooves in such a manner as to get a uniform, section for the grooves and the nosing and their finish shall match with the finish of the flat portion of the tiles.

#### 16.9.4 Measurements

16.9.4.1 Chequered tiles on stair treads shall be measured in square metre correct to two places of decimal. Length shall be measured correct to a mm before laying skirting, dado or wall plaster. Width shall be measured correct to a mm from the outer edge of the nosing, as laid, before providing the riser. In the case of the edge tiles of the landing and wide steps, width shall be measured upto the near edge of the chequered stair tread tiles. Deductions for ends of dissimilar materials or other articles embedded shall not be made for areas exceeding 0.10 square metre.

#### 16.9.5 Rate

16.9.5.1 The rate shall include the cost of all materials and labour involved in the all the operations described above.

16.9.5.2 Nothing extra shall be payable for cutting the tiles to suit the size of treads and also for nosing.

## **16.10 Glazed Tile Flooring**

### **16.10.1 White glazed tiles**

16.10.1.1 The tiles shall be of approved make and shall generally conform to IS: 777-1988. They shall be flat, and true to shape and free from blisters crazing, chips, welts, crawling or other imperfections detracting from their appearance. The tiles shall be tested as indicated in Appendix of IS: 777-1988.

16.10.1.2 The tiles shall be square or rectangular of nominal size as 150 X 150 mm, 100 x 100 mm, 100 x 200 mm or as directed by the Employer. The thickness of the tiles shall be 5 mm, or 6 mm as specified. The length of all four sides shall be measured correct to 0.1 mm and average length breadth shall not vary more than  $\pm 0.8$  mm from specified dimension. The variation of individual dimension from average value of length/breadth shall not exceed  $\pm 0.5$  mm. Tolerance in thickness shall be  $\pm 0.4$  mm.

*Note (1): Where tiles of nominal sizes of 150 x 150 mm or 100x100 mm are not available tiles of nominal sizes 152 mm x 152 mm or 108 mm x 108 mm may be allowed to be used with prior approval of the Employer.*

*Note (2): The actual size of tiles supplied shall be 1 mm less so that with 1 mm joint, the tile when laid shall conform to the nominal size.*

16.10.1.3 The top surface of the tiles shall be glazed and glaze shall be either glossy or matt as specified. The underside of the tiles shall not have glaze on more than 5 percent of the area in order that the tile may adhere properly to the base. The edges of the tiles shall be preferably to the base. The edges of the tiles shall be preferably free from glaze. However, any glaze if unavoidable, shall be permissible on only upto 50 per cent of the surface area of the edges.

### **16.10.2 Coloured Tiles**

16.10.2.1 Only the glaze shall be coloured as specified. The sizes and Specifications shall be the same as for the white glazed tiles.

### **16.10.3 Preparation of Surface and Laying**

16.10.3.1 Base concrete or the RCC slab on which the tiles are to be laid shall be cleaned, wetted and mopped. The bedding for the tile shall be with cement mortar 1:3 (1 cement: 3 coarse sand) or as specified. The average thickness of the bedding shall be 10 mm while the thickness under any portion of the tiles shall not be less than 5 mm.

16.10.3.2 Mortar shall be spread, tamped and corrected to proper levels and allowed to harden and corrected to proper levels and allowed to harden sufficiently to offer a fairly rigid cushion for the tiles to be set and to enable the mason to place wooden plank across and squat on it.

16.10.3.3 Over this mortar bedding neat grey cement slurry of honey like consistency shall be

spread at the rate of 3.3 kg of cement per square metre over such an area as would accommodate about twenty tiles. Tiles shall be soaked in water washed clean and shall be fixed in this grout one after another, each tile gently being tapped with wooden mallet till it is properly bedded and in level with the adjoining tiles. The joints shall be kept as thin as possible and in straight lines or to suit the required pattern.

16.10.3.4 The surface of the flooring during laying shall be frequently checked with a straight edge about 2 m long, so as to obtain a true surface with the required slope.

16.10.3.5 Where full size tiles cannot be fixed these shall be cut (sawn) to the required size, and their edge rubbed smooth to ensure straight and true joints.

16.10.3.6 Tiles which are fixed in the floor adjoining the wall shall enter not less than 10 mm under the plaster, skirting shall be cleaned off.

16.10.3.7 After tiles have been laid surplus cement slurry shall be cleaned off.

#### 16.10.4 Pointing and Finishing

16.10.4.1 The joints shall be cleaned off the grey cement slurry with wire/coir brush or trowel to a depth of 2 mm to 3 mm and all dust and loose mortar removed. Joints shall then be flush pointed with white cement added with pigment if required to match the colour of tiles. The floor shall then be kept wet for 7 days. After curing, the surface shall be washed and finished clean. The finished floor shall not sound hollow when tapped with a wooden mallet.

#### 16.10.5 Measurements

16.10.5.1 Length and breadth shall be measured correct to a cm before laying skirting, dado or wall plaster and the area calculated in square metre correct to two places of decimal. Where covers are used at the junctions, the length and breadth shall be measured between the lower edges of the cover.

16.10.5.2 No deduction shall be made nor extra paid for voids not exceeding 0.20 square metre. Deductions for ends of dissimilar materials or other articles embedded shall not be made for areas not exceeding 0.10 square metre.

#### 16.10.6 Rate

16.10.6.1 The rate for flooring shall include the cost of all materials and labour involved in all the operations described above. Nothing extra shall be paid for the use of cut (sawn) tiles in the work.

16.10.6.2 Extra over and above the normal rate for white tiles shall be paid where coloured or any other type of decorative tiles have been used.

### 16.11 Glazed Tiles in Skirting and Dado

- 16.11.1 The tiles shall be of approved make and shall generally conform to IS: 777-1988. The tiles shall be earthenware covered by a glaze thoroughly matured and fitted to the body. The tiles shall be sound, true to shape, flat and free from flaws and other manufacturing defects affecting their utility. The top surface of the tiles shall be glazed. The underside of the tiles shall not have glaze on more than 5% of the area in order that the tile may adhere properly to the base. The edges of the tiles shall be free from glaze, however, any glaze if unavoidable shall be permissible on only up to 50 percent of the surface area of edges. The glaze shall be free from welts, chips, craze, specks, crawlings or other imperfections detracting from the appearance when viewed from a distance of one metre. The glaze shall be either glossy or matt as specified. The glaze shall be white in colour except in the case of coloured tiles when colours shall be specified by the Employer. There may be more than one colour on a tile.

#### 16.11.1.1 Dimensions and Tolerances

1. Glazed earthenware tiles shall be made square or rectangular in sizes such 149 x 149 mm and 99 x 99 mm or 99 x 199 mm or as specified and shall be straight of cushion edge type.
2. Half tiles for use as full tiles shall be dimensions which shall be such as to make the half tiles when jointed together (with 1mm joint) match with dimensions of full tiles. Tiles may be manufactured in sizes other than those specified. Above.

*Note: Commonly manufactured sizes include 108 x 108 mm, 152 x 152 mm, 200 x 200 mm, 200 x 150 mm and 200 x 100 mm.*

3. The thickness of the tiles shall be 5 mm or 6 mm as specified.
4. The dimensions of fittings associated with the glazed tiles namely cove base, round edge tile, angles corner cups, ridge and legs, cornices and capping beads shall be of the shape and dimensions as required and the thickness of fittings shall be the same as the thickness of tiles given above.

#### 16.11.1.2 Tolerances

1. Facial dimensions - The lengths of all the four sides of the tile shall be measured to the nearest 0.1 mm. The average value of lengths/breadth shall not vary more than  $\pm 0.8$  mm from the above specified dimension.
2. The variation of individual dimensions from average value of length/breadth shall not exceed  $\pm 0.56$  mm Tolerances on thickness shall be  $\pm 0.4$  mm.
3. Tiles shall be checked for squareness and warpage as described thereafter.

#### 16.11.1.3 Trueness of shape (squareness)

Any variation from a right angle in the angle contained by any two adjoining sides shall be limited so that if a builder's steel square is placed against the angle, the

distance between the inner edge of the square and the adjacent side of the tile or fitting shall not be more than 0.5 mm per 100 mm run.

#### 16.11.1.4 Warpage

The tiles when tested for warpage on the edges and on the diagonal as per Appendix - A - IS: 777-1988 shall not have warpage exceeding the value as specified below:

Size of tile (mm)	Warpage (mm)
149 x 149	-0.4 +0.7
99 x 99	-0.3 +1.5

#### 16.11.1.5 Performance Requirements Water absorption

The average water absorption of the tiles when tested and evaluated in accordance with IS 777-1988 shall not exceed 20 per cent.

Crazing: Tiles subjected to two cycles of crazing test as per IS: 777-1988 shall not show any sign of crazing.

Impact Resistance: tiles when tested for impact resistance as per IS: 77-1988 shall remain intact, apart from surface marking.

Chemical Resistance: when tested as per IS: 777-1988 the glazed surface of tiles and /or the fittings having a white or cream coloured glossy glaze shall show no modification.

#### 16.11.2 Preparation of Surfaces

16.11.2.1 The joints shall be raked out to a depth of atleast 15 mm in masonry walls.

16.11.2.2 In case of concrete walls, the surface shall be hacked and roughened with wire brushes. The surface be cleaned thoroughly, washed with water and kept wet before skirting is commenced.

#### 16.11.3 Laying

16.11.3.1 12 mm thick plaster of cement mortar 1:3 (1 cement: 3 coarse sand) mix of as specified shall be applied and allowed to harden. The plaster shall be roughened with wire brushes or by scratching diagonal at closed intervals.

16.11.3.2 The tiles should be soaked in water, washed clean, and a coat of cement slurry applied liberally at the back of tiles and set in the bedding mortar. The tiles shall be tamped and corrected to proper plane and lines. The tiles shall be set in the required pattern and jointed. The joints shall be as fine as possible. Top of skirting or dado shall be truly horizontal and joints truly vertical except where otherwise indicated. Skirting and dado shall rest on the top of the flooring. Where full size tiles cannot be fixed these shall be cut (sawn) to the required size and their edges rubbed smooth.



#### 16.11.4 Curing and finishing

16.11.4.1 The joints shall be cleaned off the grey cement grout with wire/coir brush or trowel to a depth of 2 mm to 3 mm and all dust and loose mortar removed. Joints shall then be flush pointed with white cement added with pigments if required to match the colour of tiles. The work shall then be kept wet for 7 days.

16.11.4.2 After curing, the surface shall be washed and finished clean. The finished work shall not sound hollow when tapped with a wooden mallet.

#### 16.11.5 Measurements

16.11.5.1 Length shall be measured correct to a cm. Height shall be measured correct to a cm in the case of dado and 5 mm in the case of riser and skirting. The area shall be calculated in square metre, correct to two places of decimal. Length and height shall be measured along the finished face of the skirting or dado including curves where specials such as coves, internal and external angles and beads are used. Where cornices are used the area of dado shall be measured excluding the cornices. Nothing extra will be paid for cutting (sawn) the tiles to sizes.

16.11.5.2 In addition to payment for areas of skirting and dado, specials such as coves, internal and external angles and beads shall be measured separately and paid for in running metres. Cornices shall also be similarly measured for payment in running metres. Areas where coloured tiles or different types of decorative tiles used will be measured separately to be paid extra over and above the normal rate of white tiles.

#### 16.11.6 Rates

The rate shall include the cost of all material and labour involved in all the operations described above. The specials such as coves, internal and external angles and beading shall be measured and paid for separately. The rate shall not include cost of cornices which shall be measured and paid for in running meters separately.

### 16.12 Marble Flooring

#### 16.12.1 Dressing of slabs

16.12.1.1 Every stone shall be cut to the required size and shape, fine chisel dressed on all sides to the full depth so that a straight edge laid along the side of the stone shall be fully in contact with it. The top surface shall also be fine chisel dressed to remove all waviness. In case machine cut slab are used, fine chisel dressing of machine cut surface need not be done provided a straight edge laid any where along the machine cut surfaces is in contact with every point on it. The sides and top surface of slab shall be machine rubbed or table rubbed with coarse sand before paving. All angles and edges of the marble slabs shall be true, square and free from chippings and the surface shall be true and plane.

16.12.1.2 The thickness of the slabs shall be 20,30 or 40 mm as specified in the description of

the item. Tolerance of + 3 % shall be allowed for the thickness. In respect of length and breadth of slabs a tolerance of + 2 % shall be allowed.

#### 16.12.2 Laying

16.12.2.1 Base concrete or the RCC slab on which the slabs are to be laid shall be cleaned, wetted and mopped. The bedding for the slabs shall be with cement mortar 1:4 (1 Cement: 4 coarse sand) or with lime mortar (1 lime putty: 1 surkhi: 1 coarse sand) as given in the description of the item.

16.12.2.2 The average thickness of the bedding mortar under the slab shall be 20 mm and the thickness at any place under the slab shall be not less than 12 mm.

16.12.2.3 The slabs shall be laid in the following manner:

1. Mortar of the specified mix shall be spread under the area of each slab, roughly to the average thickness specified in the item. The slab shall be washed clean before laying. It shall be laid on top, pressed, tapped with wooden mallet and brought to level with the adjoining slabs. It shall be lifted and laid aside. The top surface of the mortar shall then be corrected by adding fresh mortar at hollows. The mortar is allowed to harden a bit and cement slurry of honey like consistency shall be spread over the same at the rate of 4.4 kg of cement per sqm. The edges of the slab already paved shall be buttered with grey or white cement with or without admixture of pigment to match the shade of the marble slabs as given in the description of the item.
2. The slab to be paved shall then be lowered gently back in position and tapped with wooden mallet till it is properly bedded in level with and close to the adjoining slabs with as fine a joint as possible. Subsequent slabs shall be laid in the same manner. After each slab has been laid, surplus cement on the surface of the slabs shall be cleaned off. The flooring shall be cured for a minimum period of seven days. The surface of the flooring as laid shall be true to levels, and, slopes as instructed by the Employer.
3. Due care shall be taken to match the grains of slabs which shall be selected judiciously having uniform pattern of Veins/streaks or as directed by the Employer.
4. The slabs shall be matched as shown in Drawings or as instructed by the Employer.
5. Slabs which are fixed in the floor adjoining the wall shall enter not less than 12 mm under the plaster and floor shall be finished neatly and without waviness.

#### 16.12.3 Polishing and Finishing

16.12.3.1 Slight unevenness at the meeting edges of slabs shall then be removed by fine chiselling and finished in the same manners as specified in Clause 16.10.4. except

that cement slurry with or without pigments shall not be applied on the surface before each polishing.

#### 16.12.4 Measurements

16.12.4.1 Marble stone flooring with different kind of marble shall be measured separately and in square metre correct to two places of decimal. Length and breadth shall be measured correct to a cm before laying skirting, dado or wall plaster. No deduction shall be made nor extra. Paid for voids not exceeding 0.20 square metre. Deductions for ends of similar materials or other articles embedded shall no be made for areas not exceeding 0.10 square metre. Nothing extra shall be paid for laying the floor at different levels in the same room. Steps and treads of stairs paved with marble stone slabs shall also be measured under the item of Marble Stone flooring. Extra shall, however, be paid for. Such areas where the width of treads does not exceed 30 cm. Nosing for treads shall be measured in running metre and paid for extra. The width of treads shall be measured from the outer edge of the nosing, as laid, before providing the riser.

#### 16.12.5 Rate

16.12.5.1 The rate shall include the cost of all materials and labour involved in all the operations described above.

### 16.13 Marble Stone in Risers of Steps and Skirting

16.13.1 Dressing of Slabs shall be as specified in Clause 16.12.1 except that the thickness of slabs shall be 30 mm. A tolerance of  $\pm 3$  mm shall be allowed unless otherwise specified in the description of the item.

#### 16.13.2 Preparation of Surface

16.13.2.1 It shall be as specified in Clause 16.11.2 where necessary, the wall surface shall be cut uniformly to the requisite depth so that the skirting face shall have the projection from the finished face of wall as shown in Drawings or as required by the Employer.

#### 16.13.3 Laying

16.13.3.1 The risers of steps and skirting shall be in grey or white cement admixed with or without pigment to match the shade of the stone, as specified in the description of the item, with the line of the slab at such a distance from the wall that the average width of the gap shall be 12 mm and at no place the width shall be less than 10 mm, if necessary, the slabs shall be held in position by temporary MS hooks fixed into the wall at suitable intervals. The skirting or riser face shall be checked for plane and plumb and corrected. The joints shall thus be left to harden then the rear of the skirting or riser slab shall be packed with cement mortar 1:3 (1 cement: 3 coarse sand) or other mix as specified in the description of the item. The fixing hooks shall be removed after the mortar filling the gap has acquired sufficient strength.

16.13.3.2 The joints shall be as fine as possible. The top line of skirting and riser shall be truly horizontal and joints truly vertical, except where otherwise indicated

16.13.3.3 The risers and skirting slab shall be matched as shown in Drawings or as instructed by the Employer-in Charge.

#### 16.13.4 Curing, Polishing and Finishing

16.13.4.1 It shall be as specified in Clause 16.12.3 as far as applicable, except that cement slurry with or without pigment shall not be applied on the surface and polishing shall be done only with hand. The face and top of skirting shall be polished.

#### 16.13.5 Measurements

16.13.5.1 Length shall be measured along the finished face of riser or skirting, correct to a cm. Height shall be measured from the finished level of tread or floor, to the top (the underside of tread, in the case of steps) correct to 1 mm. The areas shall be calculated in square metre correct to two places of decimal.

16.13.5.2 Dado and lining of pillars etc. Shall be measured as 'Marble work in wall lining'. If the thickness is up to 25 mm or as "Marble Work" in Jambs, walls, columns and other plain work' if the thickness is more.

#### 16.13.6 Rate

16.13.6.1 The rate shall include the cost of all materials and labour involved in all the operations described above.

### 16.14 Kota Stone Flooring

#### 16.14.1 Kota Stone Slabs

16.14.1.1 The slabs shall be of selected quality, hard, sound, dense and homogenous in texture free from cracks, decay, weathering and flaws, The shall be hand or machine cut to the requisite thickness. They shall be of the colour indicated in the Drawings or as instructed by the Employer.

16.14.1.2 The slabs shall have the top (exposed) face polished before being brought to site, unless otherwise specified. The slabs shall conform to the size required. Before starting the work the Contractor shall get samples of slabs approved by the Employer.

#### 16.14.2 Dressing

16.14.2.1 Every slab shall be cut to the required size and shape and fine chisel dressed on the sides to the full depth so that a straight edge laid along the side of the stone shall be in full contact with it. The sides (edges) shall be table rubbed with coarse sand or machine rubbed before paving. All angles and edges of the slabs shall be true, square and free from chippings and the surface shall be true and plane.

16.14.2.2 The thickness of the slab after it is dressed shall be 20, 25, 30 or 40 mm as specified in the description of the item. Tolerance of  $\pm 2$  mm shall be allowed for the

thickness. In respect of length and breadth of slabs Tolerance of  $\pm 5$  mm for hand cut slabs and  $\pm 2$  mm for machine cut slabs shall be allowed.

#### 16.14.3 Preparation of Surface and Laying

16.14.3.1 The Specification shall be as described in Clause 16.12.2 except that the edges of the slabs to be jointed shall be buttered with grey cement, with admixture of pigment to match the shade of the slab.

#### 16.14.4 Polishing and Finishing

16.14.4.1 The Specifications shall be as described in Clause 16.12.3 except that (a) first polishing with coarse grade carborundum stone shall not be done, (b) cement slurry with or without pigment shall not be applied on the surface before polishing.

### 16.15 Kota Stone in Risers of Steps, Skirting and Dado

16.15.1 Kota Stone Slabs and Dressing shall be as specified in Clause 16.12 except that the thickness of the slabs shall be 25 mm or as specified in the description of the item. The slabs may be of uniform size if required.

16.15.2 Preparation of surface shall be as specified in Clause 16.12

16.15.3 Laying shall be as specified in Clause 16.12 except that the joints of the slabs shall be set in grey cement mixed with pigment to match the shade of the slabs.

16.15.4 Curing, Polishing and Finishing shall be as specified in Clause 16.12 except that first polishing with coarse grade carborundum stone shall not be done.

#### 16.15.5 Measurements

16.15.5.1 Length shall be measured along the finished face of riser, skirting or dado correct to a cm. Height shall be measured from the finished level of tread of floor at the top (the underside of tread in the case of steps). This shall be measured correct to a mm in the case of risers of steps and skirting and correct to a cm in the case of dado. The area shall be calculated in square metre correct to two places of decimal.

16.15.5.2 Lining of pillars etc. Shall also be measured under this item.

#### 16.15.6 Rate

16.15.6.1 The rate shall include the cost of all materials and labour involved in all the operations described above.

### 16.16 Red or White Rough Dressed Sand Stone Flooring

#### 16.16.1 Stone Slabs

16.16.1.1 The slabs shall be red or white as specified in the description of the item. The stone slabs shall be hard, sound, durable and tough, free from cracks, decay and

weathering. In case of red sand stone, white patches or streaks shall not be allowed. However, scattered spots upto 10 mm diameter will be permitted. Before starting the work the Contractor shall get samples of slabs approved by the Employer.

- 16.16.1.2 The slabs shall be hand or machine cut to the requisite thickness along planes parallel to the natural bed of stone and should be of uniform size if required.

#### 16.16.2 Dressing of Slabs

- 16.16.2.1 Every slab shall be cut to the required size and shape, and rough chisel dressed on the top, so that the dressed surface shall not be more than 6 mm from a straight edge when placed on it. The edge of depressions or projections shall be chisel dressed in a slant so that the surface does not have sharp unevenness. The sides shall also be chisel dressed to a minimum depth of 20 mm so that the dressed edge shall at no place be more than 30 mm from a straight edge butted against it. Beyond this depth the sides may be dressed slightly splayed so as to form inverted 'V' shaped joint with adjoining slabs. All angles and edges of the slabs shall be true, square and free from chippings and the surface reasonably true and plane.

- 16.16.2.2 Where slabs are used for treads without nosing, the exposed edges shall be rough chisel dressed to full depth and cut to uniform thickness.

- 16.16.2.3 The thickness of the slabs after it is dressed shall be 40 mm or as specified in the description of the item with a permissible tolerance of  $\pm 2$  mm.

#### 16.16.3 Laying

- 16.16.3.1 Base concrete on which the slabs are to be laid shall be cleaned, wetted and mopped. The bedding for the slabs shall be with cement mortar 1:5 (1 cement: 5 coarse sand) or with the lime mortar 1:1:1 (1 lime putty: 1 surkhi: 1 coarse sand) or as given in the description of the item.

- 16.16.3.2 The average thickness of the bedding mortar under the slabs shall be 20 mm and the thickness at any place under the slabs shall not be less than 12 mm.

- 16.16.3.3 The slab shall be laid in the following manner:

- 16.16.3.4 Mortar of specified mix shall be spread under each slab. The slab shall be washed clean before laying. It shall then be laid on top, pressed and lapped, so that all hollows underneath get filled and surplus mortar works up through the joints. The top shall be tapped with a wooden mallet and brought to level and close to the adjoining slabs, with thickness of joint not exceeding 5 mm. Subsequent slabs shall be laid in the same manner. After laying each slab surplus mortar on the surface of slabs shall be cleaned off and joint finished flush.

- 16.16.3.5 In case pointing with other mortar mix is specified, the joint shall be left raked out uniformly and to a depth of not less than 12 mm when the mortar is still green. The pointing shall be cured for a minimum period of 7 days. The surface of the flooring as laid shall be true to levels and slopes as instructed by the Employer.

16.16.3.6 Slabs which are fixed in the floor adjoining the wall shall enter not less than 12 mm under the plaster, skirting or dado. The junction between wall plaster skirting and floor shall be finished neatly and without waviness.

16.16.3.7 The finished floor shall not sound hollow when tapped with wooden mallet.

#### 16.16.4 Finishing

16.16.4.1 Any unevenness existing between the edges of slabs at joints shall be removed by chiselling in a slant.

#### 16.16.5 Rate

16.16.5.1 The rate shall include the cost of all materials and labour involved in all the operations described above. Where pointing is to be done, this will be paid extra unless specifically included in the description of the item.

### **16.17 Red or White Fine Dressed Sand Stone Flooring**

16.17.1 Stone slab shall be as specified in Clause 16.16.1.

#### 16.17.2 Dressing

16.17.2.1 Every slab shall be cut to the required size and shape and chisel dressed on all sides to a minimum depth of 20 mm. The top and the joints shall be fine tooled so that straight edge laid along the face is fully in contact with. In case machine cut stones are used, chisel dressing and fine tooling of machine cut surface need not be done provided a straight edge laid anywhere along the machine cut surface is in contact with every point on it.

16.17.2.2 The thickness of the slabs after dressing shall be 40 mm or as specified in the description of item with a permissible tolerance of  $\pm 2$  mm.

#### 16.17.3 Laying

16.17.3.1 Shall be as specified in Clause 16.12.

#### 16.17.4 Finishing

16.17.4.1 In case of chisel dressed stone flooring slight unevenness, if any existing between the edges of slabs at joints shall then be removed by chiselling in a slant.

### **16.18 Red or White Fine Dressed and Rubbed Sand Stone Flooring**

16.18.1 Stone slabs shall be as specified in Clause 16.12.

#### 16.18.2 Dressing

16.18.2.1 The Specifications for dressing the top surface and the sides shall be as described in

Clause 16.12 In addition the dressed top and sides shall be table rubbed with coarse grade carborundum stone before paving, to obtain a perfectly true and smooth surface free from chisel marks.

16.18.2.2 The thickness of the slabs after dressing shall as specified with a permissible tolerance of  $\pm 2$  mm

#### 16.18.3 Laying

16.18.3.1 The slab shall be laid with 3mm/5mm thick joint or as specified in the item.

16.18.3.2 Where the joints are to be limited to 5 mm thickness, the slabs shall be laid as specified in Clause 16.12 except that sides of the slabs to be jointed shall be buttered with cement mortar 1:2 (1 cement: 2 stone dust) admixed with pigment to match the shade of the slab.

16.18.3.3 Where the slabs are to be laid with 5 mm thick joints, the Specifications for laying shall be as described in Clause 16.12.

#### 16.18.4 Finishing

16.18.4.1 Finishing shall be specified in Clause 16.12 except that chisel marks and unevenness shall be removed by rubbing with coarse grade carborundum stone.

#### 16.18.5 Measurement and Rate

16.18.5.1 Measurement and Rate shall be as specified in Clause 16.12

### **16.19 Cast Iron Grid Tiles Flooring**

16.19.1 Cast Iron Grid tiles flooring shall consist of cast iron grids to give design, laid on a strong, with the hollows filled with cementing materials. This type of flooring is suitable in factories bakeries, dairies and similar structures where resistance to abrasion from iron tyred trolleys is a prime consideration

#### 16.19.2 Cast Iron Grid Tiles

16.19.2.1 Tiles shall be manufactures from cast iron conforming to IS: 210-1978. The tile shall be of the dimensions and weight per square metre specified in the description of the item. Variation in weight to the extent of 5% on either side shall be permissible. The ribs of the tiles shall be tapering down with the thicker end at top so that the cementing materials filling the hollows between them is held fast and prevented from getting loose on the top. The tiles shall be of size such 20 x 20 cm, 30 x 30 cm or 38 x 38 cm as shown in the Drawings or as directed by the Employer. Where the room lengths and widths are not exact multiples of the size of the tiles, the end rows shall be laid with fractional tiles. The top surface of the tiles shall be ground smooth while sides of the hollows shall be left in the rough cast state.

#### 16.19.3 Base concrete



- 16.19.3.1 The cast iron grid flooring shall be laid on a base which shall conform to the Specifications given in Clause 22.5.2 of cement concrete flooring. The base shall be designed to withstand the load coming on the floor.

#### 16.19.4 Laying

- 16.19.4.1 The base concrete or the RCC slab on which the grid tiles are to be laid shall be cleaned, wetted and mopped. The bedding for the grid tiles shall consist of 1:2 cement and concrete (1 cement: 2 stone aggregate 6 mm nominal size) laid to 12 mm thickness tamped and corrected to proper levels. The bedding concrete shall be laid each time, over such an area as would accommodate about 8 to 10 tiles. The grid tiles shall be laid one by one pressed into the bedding tapped with a wooden mallet so that the concrete works up into the hollows of the grid tiles about 3 mm and the top face of the tile as at the correct finished level and plans.
- 16.19.4.2 The hollow shall be immediately filled in with cement concrete of the same mix tamped with 10 mm dia iron bars and the entire surface including width of joints finished 6 mm below the top. Subsequent tiles shall be laid in the same manner, the joints between adjacent tiles being not more than 3 mm wide. The joints and top 6 mm of the hollows shall then be grouted with neat cement slurry. The surface of the flooring shall be frequently checked with a straight edge at least 2 metre long during laying, so as to obtain a true surface. The surface shall then be cleaned of all mortar droppings. The finished surface shall have no raised edges. The surface of the flooring shall be made smooth where necessary.
- 16.19.4.3 Tiles which are fixed adjoining the wall shall enter not less than 12 mm under the plaster, skirting or dado.
- 16.19.4.4 The surface shall be kept wet for a period of not less than seven days.
- 16.19.4.5 In special cases it may be required that the concrete bedding and the filling of the hollows and joints shall be acid or alkali resistant, in which case special type of cement to meet the particular requirements shall have to be used instead of ordinary grey cement. In such cases, the types of special cement shall be specified in the description of the item.

#### 16.19.5 Measurements

- 16.19.5.1 Length and breadth shall be measured correct to a cm before laying skirting, dado or wall plaster. The area shall be calculated in square metre correct to two places of decimal. No deduction shall be made nor extra paid for void not exceeding 0.20 square metre. Deductions for ends of dissimilar material or other articles embedded shall not be made for areas not exceeding 0.10 square metre.

#### 16.19.6 Rate

- 16.19.6.1 The rate shall include the cost of all materials and labour involved in all the operations described above except the cost of base concrete. Nothing extra shall be paid for use of fractional tiles.

## 16.20 Acid Proof Flooring

### 16.20.1 General

16.20.1.1 The finishing as specified below shall be applied on the surface to be finished, i.e., RCC floor slab, PCC layer in ground floor or masonry wall, depending on the conditions.

### 16.20.2 Materials

16.20.2.1 The following materials shall be used.

1. BITROK Primer or equivalent conforming to IS: 3384
2. BITROK Mastic or equivalent conforming to IS: 1195
3. KERA SINTERED acid-proof tiles or equivalent conforming to IS: 4457
4. VICRON silicate based acid-proof cement mortar or equivalent conforming to IS: 4832 (Part-1).
5. RESILAX acid-proof cement mortar or equivalent conforming to IS: 4382 (Part -2).

### 16.20.3 Laying the flooring:

16.20.3.1 The flooring shall be laid over the clean, green surface. Before laying the primer coats, the sub-base shall be cleaned off all dirt, scum or laitance, and of loose materials. The surface shall be left rough by suitable means.

16.20.3.2 Above the prepared surface, two coats of bitrok primer as specified shall be applied. Above it a layer of acid resistant Bikrock mastic shall be laid. The thickness shall be 6 mm. This layer shall be allowed to dry for sufficient time. A bed of silicate based acid proof cement mortar 6 mm shall then be laid.

16.20.3.3 Over this surface 100 mm x 200 mm size acid-proof tiles shall be laid correct to line and alignment. The thickness of tiles shall be 20 mm. The dimensions shall be varied if so required in the Bill of Quantities.

16.20.3.4 The joints of the tiles thus laid shall be pointed using acid-proof mortar. The surface shall be rendered smooth to suit the best serviceable conditions.

16.20.3.5 Similar operations shall be carried out in skirting and dadoing.

16.20.3.6 The surface shall be kept wet for 7 days.

### 16.20.4 Measurement of Payment

16.20.4.1 The floor area shall be worked out correct to a sqm from the lengths measured correct to 10 mm for flooring and dadoing. For skirting, the length shall be measured correct to 10 mm. The payment for skirting will be for length only, the width being specified. The quoted rate is deemed to include all the materials and workmanship required for the execution of the work as specified above.

16.20.5 Rate

The rate shall include the cost of all materials and labour involved in all the operations described above except the cost of base concrete. Nothing extra shall be paid for use of fractional tiles.



**6.2.1.2**  
**Standard Specifications**  
**(Mechanical Works)**



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## **1. HORIZONTAL SPLIT CASE PUMP**

The Contractor shall furnish and install the specified horizontal double suction centrifugal pumps complete with motors and appurtenances as specified herein.

Each pumping unit shall consist of a horizontal double suction centrifugal pump, couplings, squirrel cage induction motor and all necessary appurtenances to provide complete pumping systems. The Contractor shall require that a single manufacturer supplies the pumping units specified herein. The Contractor shall supply install commission and hand over all equipment to the satisfaction of the Engineer.

Each pump shall be of the horizontally split volute casing, enclosed impeller, double suction centrifugal type, designed so that the mechanical seal and bearings can be removed without disturbing the connecting piping or bottom casing. The pump and motor shall be mounted on a fabricated common steel base.

### **1.1 Pump Design**

Pumps shall be designed and constructed to satisfactorily meet the design conditions and requirements specified in the Particular Specifications. Pumps are required to deliver treated water with specific gravity of 1.0,

The head/capacity characteristics of pumps shall be stable at all rates of flow between closed valve and fully-open valve, and the characteristics shall be steep enough for satisfactory operation in parallel under all conditions specified.

Pump efficiency shall be well maintained over the whole of the specified duty range. Minimum pump efficiency expected at the duty point for each pump shall be as per the requirements specified in the Particular Specifications. The efficiency at the duty point will be a consideration in the evaluation of the offer, as both capital and operational costs will be taken into consideration in evaluating bids.

The pump shall be designed to work satisfactorily for the entire range of operation. Pumps shall have head/flow drooping characteristics with maximum pressure at shut-off condition. The total Head curve shall be continuously rising towards the shut off. The shut off head shall be at least 115 % of the total head. The pump should deliver at least 125 % of its rated capacity at 75 % of the specified total Head.

The Power rating of the pump motor shall be the larger of the following:

- The maximum power required by the pump in the entire operating range.
- 115 % of the power required at the duty point. Power requirement shall be worked out considering 1 % negative tolerance on quoted figure of efficiency. Pump efficiency at duty point shall be with zero negative tolerance.

Pumps shall run smooth without undue noise and vibration. The velocity of vibration shall be within the 4.5 mm/sec. noise level shall be limited to 85dBA at a distance of 1.86m.

Pumps of a particular category shall be identical. Identical pumps shall be suitable for parallel operation, with equal load division. Components of identical pumps shall be interchangeable.

Lubrication arrangements shall be designed to avoid any contamination of the pumped fluid.

The bearing shall be L10 an anti-friction ball bearing, and suitable lubrication system shall be provided. Pump bearings shall have a design running life of not less than 50000 hours. Bearings shall be designed for loadings 20% in excess of calculated maximum loading and shall be suitable for reverse rotation at 150% of rated speed or the maximum reverse speed the pump can reach in installed conditions when driven backwards by reverse flow if this is greater.

Rotating assemblies shall be statically and dynamically balanced in accordance with ISO 1940–1. They shall be designed so that the first critical speed of the pump and its drive is at least 30% higher than the maximum operating speed. For each pump, the manufacturer shall state whether or not balancing has been completed. Excessive vibration shall be sufficient cause for rejection of the equipment. In any case, the amplitude of vibration as measured at any point on the pumping unit shall not exceed the limits set forth in the latest edition of the Hydraulic Institute Standards.

The NPSH requirements of pumps, based on the 3% output drop criterion, shall be at least 1m less than the NPSH available at every working condition at site maximum ambient temperature.

Unless otherwise specified, the water velocity in the suction branches of a pump shall not exceed 1.5m/s and in the discharge branch shall not exceed 2.0m/s when the pump is operating within its specified working range. There shall be no discernible noise due to hydraulic turbulence or cavitation within the pump or its associated pipework and valves.

If discharge branch velocities exceed 2.0m/s in the working range, the use of profiled taper pipes will be allowed. Taper pipes shall be designed to reduce velocity progressively using profiled internal contours which contain no steps or angles from which turbulence or cavitation can be generated. The taper pipes shall be considered as part of the pump and be included in performance calculations and tests

## 1.2 Pump Material

Pump shaft	Stainless Steel conforming to AISI 431
Impeller	Stainless Steel casting conforming to CF 8M
Casing	Cast Iron conforming to IS 210 FG 260
Casing wear rings	Stainless Steel SS (CF8M), Bronze
Seat Type	Shaft mounted, self aligning, non-split, cartridge type mechanical seal.
Bearing Housing	Cast Iron conforming to IS 210 FG 260
Bolts, Studs & Nuts	Stainless Steel conforming to SS 316

## 1.3 Pump Construction

Casing shall be of close-grained Cast Iron free from crack impurities and any other casting defect and shall incorporate replaceable casing wear rings made bronze casting/ SS. The surfaces of all water passages shall be smooth and free from projections, which might cause undesirable turbulence. Casing shall withstand the usual moments and thrust without expansion joint.

Pumps shall be fitted with mechanical seals with the seals have a proven record of satisfactory running when fitted to the pump design in question, and with prior approval. Mechanical seals shall be readily adjustable and replaceable.

Pump shaft shall be of a diameter sufficient to prevent distortion from stresses imposed on them and shall be machined all over. The shaft shall be of ample size and rigidity to ensure low working stress under all conditions of operation.

Impeller shall be enclosed double suction type of one piece construction and shall be dynamically balanced including coupling, shaft and wear rings prior to final assembly up to 130% of the operating speed. All exterior surfaces shall be accurately machined. The impeller shall be tightly mounted on the pump shaft with a key so that it will not become loose.

The impeller shall be properly balanced so as not to cause any vibration during operation. Impeller shall be made in one piece and securely keyed to the shaft. Means shall be provided to prevent loosening during operation including rotation in reverse direction. Impeller fastening nuts (if provided) shall be of cap type and shall tighten in the direction of normal rotation.

Wearing rings shall be labyrinth profile of renewable type. These shall be held in place by screwing against rotation, press fit and locked with pins. Opposed wear surfaces or hardenable material shall have a hardness difference of at least 50 BHN. The rotary components shall have higher Brinell hardness.

Pumps shall be furnished complete with an approved type of flexible coupling. Spacer type couplings shall be provided to permit disassembling the pump without removing the pipe connections or to permit. Coupling halves shall be bored and keyed to fit shafts of the pump and the motor. Both halves of the coupling shall be match marked.

Coupling guards, made of expanded metal and bolted to the base plate shall be furnished for all coupled pumps.

Suction and delivery flanges shall be drilled in conformity with BS 4504 / BSEN 1092 / DIN 2527 standards and other equivalent standard as applicable and incorporate two tappings in each flange for mounting suction and delivery pressure gauges, the spare tapping being plugged. The tappings shall be fitted with suitable metallic plugs for transport. Flange shall be machined on face and edge and spot faced at seating surfaces of the bolt heads and nuts.

All bolts, cap screws, anchor-bolts nuts and washers shall be stainless steel.

Lifting lugs or eye bolts shall be provided at well balanced positions and also tapings shall be available for priming, gland lubrication and drainage connections at low points and air releasing cocks at high points shall be provided on pump casings to permit air release during

priming. All parts of each pump shall be designed to withstand the stresses that will be imposed upon them during their handling, shipping, erection, and operation

Bearing cooling arrangements shall use closed circuits. Open discharge of cooling water into the pumping station drainage system is not permissible. The coolant flow shall be easily visible and local indication of bearing metal temperature shall be provided. Excessive metal temperatures shall result in safe shutdown of the pump.

Ease of access to the parts to be serviced shall be ensured without removing the upper half casing, recourse to disturb either pipe work or prime mover.

All the pumps shall be supplied with machined pads to allow the fitting of portable vibration monitoring transducers.

The common base plate for pump and motor shall be in one piece. Suitable holes shall be provided for grouting and they shall be so located that they base can be grouted in place without disturbing the pump and motor. All pumps and motors shall be properly aligned, bolted to the base plates. Between pump drain connections and base plate of a minimum 15mm drain piping shall be installed.

Each pump shall be provided with a name plate indicating the details: Design capacity, Total head, Speed, Motor rating, Model number, Manufacturer's serial number, Weight of equipment, and Tag number.

Unless otherwise approved, pumps shall be set at levels which ensure they are primed automatically at the lowest inlet water level which is possible in normal operation.

In order to avoid bare metal casing from getting oxidized and to reduce the relative surface roughness of the pump casing, a Coating with properties of good erosion and corrosion protection including protection against cathodic action shall be applied on casing internal surface coming in contact with water. The coating applied should be suitable for potable water application and certified by Authorised National Lab.

The supplied pumps shall offer low operation cost by way of sustained efficiency with no degradation for first two years and thereafter by maximum 0.25% every year up to economical life i.e. 10 years. Periodic energy audits will be conducted to check on efficiency degradation.

Operator shall submit an undertaking from pump manufacturer confirming that the offered pump offers "Lowest cost of ownership to DJB" and the pump is Designed for low life cycle cost by way of sustained efficiency and low maintenance cost.

#### **1.4 Pump performance**

Pump performance guarantees shall relate to the flow rate, the total head and the efficiency of the pump when tested at the manufacturer's works. Verification of factory test results shall form part of the Site Tests on Completion.

Pumps shall operate at design duty within the acceptance tolerances for flow and total head

laid down in ISO 3555 or IS 10981 or IS 9137.

Unless otherwise specified, at the time of tender the Contractor shall supply the performance curves for the pumps he is providing. The curves shall show total head, pump efficiency, power absorbed by the pump, and NPSHr plotted against flowrate for the full operating range required. The curves shall be extended to show shut valve conditions, and to show performance at flowrates at least 20% in excess of the maximum flowrate expected in normal operation at site conditions.

Where appropriate, curves shall also be included to show the variations in station losses and internal plant losses plotted against flowrate, to enable the complete pump performance curves to be shown.

If the Purchaser's estimated system curves for head against flow have been provided, the Contractor's pump curves shall be superimposed on the system curves to show conveniently the expected performance in site conditions.

Power consumption details needs to be furnished and guaranteed for each pump assembly for the loading conditions as required to be operated. The details should be furnished under Technical particulars.

### **1.5 Quality Assurance**

The equipment to be furnished shall be new and as a standard product of a manufacturer experienced in the design, fabrication and construction of pumping equipment. The pumps shall be the product of an experienced manufacturer and:

- 1) Must demonstrate equal or larger capacity installations using similar equipment and equipment installed and successfully operating for at least 5years;
- 2) Provide names and phone numbers of contacts at referenced installations to verify performance;
- 3) Demonstrate to satisfaction of Engineer that equipment to be provided is equal to that specified;
- 4) The pump manufacturer's machining and assembly shops must be ISO 9002 certified in order to assure conformance to the highest quality standards.

### **1.6 Unit Responsibility**

The Contractor shall cause all equipment specified under this contract to be furnished by the pump manufacturer who shall be responsible for the adequacy and compatibility of all pumping unit components. Any component of each pumping unit not provided by the pump manufacturer shall be designed, fabricated tested and installed by factory authorized representatives experienced in design and manufacture of such components. This requirement, however, shall not be construed as relieving the contractor of the overall responsibility for this portion of work.

The arrangements shown on the drawings is based upon the best information available to the Engineer at the time of design and is not intended to show exact dimensions peculiar to any specific equipment unless otherwise shown or specified. Therefore, it may be anticipated that

the structural supports, foundations connecting piping and valves shown in part or whole, may have to be changed in order to accommodate the pumping equipment furnished. Any such changes shall be submitted to the Engineer for his approval. Pumping units shall be designed to operate without cavitations or damaging vibration at the specified speed, flow and head conditions.

The pump base shall be designed for anchor bolting to a concrete foundation, assuming that the pump, without restraint at the suction and discharge connections, is subjected to a displacing force equal to that developed by an internal pressure equal to three times shut-off head at the operating-speed. The motor shall be connected to the pump by a flexible coupling. The complete pumping unit shall be designed to operate without overload on any component at any point along the pump curve at the specified speed.

### **1.7 Installation**

The Contractor shall provide the complete pumping system and factory – trained personnel to supervise installation and initial operation of all components. The pumps shall be aligned, connected and installed at the locations shown and in accordance with the manufacture's recommendations. Contractor shall certify that the equipment is installed in a manner to ensure proper operation.

### **1.8 Factory Testing**

- 1) Each assembled pump shall be shop tested by the manufacturer to determine the following characteristics. All tests shall be performed in accordance with the latest Hydraulic Institute Standards or BS ISO 14686 or JIS B 8301 and 8302/IS standard as applicable.

1. head-capacity curve
2. power curve
3. efficiency curve.
4. NPSH(R) curve

Each motor shall be shop tested by the manufacturer in accordance with the requirements of General Provisions for Electrical Installations.

- 2) Each major component of the pumping equipment shall be performed to a complete site test to ensure compliance with the performance requirements as specified herein, witnessed by the Engineer if so desired. All costs for the site tests shall be borne by the Contractor.

- 3) Materials

Melt and strength tests of the cast iron used in the manufacture of the pumps major components shall be performed in accordance with the applicable BS standards as indicated in the specification. The contractor shall furnish the Engineer with certified copies of the results of all tests.

- 4) Hydrostatic Tests

Each pump shall be hydrostatically tested. Test pressure shall not be less than 1.5 times the maximum working pressure as shown the approved head-capacity curve. At no time during this test shall the casing show undue deflection or signs of weakness at any point nor shall the external surface surfaces of the casing show sweating through porous metal or leaking through gasket or cracks or other detects. The contractor shall furnish the Engineer with certified results of the tests.

#### 5) Performance Tests

Pumps shall be factory tested for performance in accordance with BS EN ISO 9906 or IS 8034 and IS 1710 by a testing agent approved by the Engineer and shall be to accuracy class C. The supplier shall submit these test curves prior to shipment of the equipment. These test curves shall include Head, Efficiency, Power absorbed and NPSH required against Capacity. The Engineer may witness these tests. Pumps with motors of higher than 30 kW shall be tested with its distinctive contract motor, unless otherwise approved by the engineer.

Pump shall be tested in the Manufacturer's Works with job motors. Pumps shall be given running test over the entire operating range covering from the shut off head to the run-out flow. A minimum of five readings approximately equidistant shall be taken for plotting the curves.

#### 6) Vibration Tests

Vibration tests shall be carried out in accordance with ISO 2372 or IS 3483.

#### 7) Motor Tests

Motors shall be tested in accordance with NEMA and IEEE Procedures. The tests shall include.

- Routine Tests
  - No load current
  - Locked Rotor Current
  - Winding Resistance
  - High Potential Test
- Complete Tests
  - Rated Load Temperature Rise
  - Slip.
  - Locked Rotor Torque
  - Break down Torque.
  - Efficiencies at 100,75 and 50 percent of Full load
  - Power factor at 100,75 and 50 percent of Full Load.

The Contractor shall furnish the all certified test results before shipment.

### 1.8.1 Submittals

The Contractor shall submit complete information including fabrication, assembly, foundation and installation data together with detailed specifications and

performance information covering materials of construction, power drive assembly, parts, devices, wiring diagrams and all other accessories of the equipment furnished. The submittals shall include but not be limited to the following:

- 1) Manufacturer's product data
- 2) Shop Drawings to and describe pump construction and materials
- 3) Motor data including:
  - Manufacturer
  - Minimum guaranteed efficiency
  - Power factor at full load, 3/4 load and 1/2 load
  - Locked rotor current
  - Motor speed
  - Mounting details
- 4) Pump characteristic curves
  - Plot flow, total dynamic head, brake power, shut off head, efficiency and net positive suction head required for full operating range of pump
  - Show recommended limits of continuous operation
- 5) Certificates of compliance
- 6) Certified test reports
- 7) Operation and maintenance manuals
- 8) Training program

### **1.8.2 Information to be provided**

The Contractor shall provide the following details in three copies at least 14 days before handing over of the equipment.

- 1) Certified copies of all performance tests of pumps and motors
- 2) Manufacture's Certification that all pumping units and motor control equipment is fully in conformance with the specification
- 3) Operation and Maintenance manuals of Pumps and Motors Control wiring diagrams for Electrical Panels
- 4) Spare Parts Manuals

### **1.9 Submersible sump drain and dewatering pumps**

Sump pumps shall be of the open-impeller centrifugal-type, vertically-mounted and close coupled to their fully-submersible electric motors.

Sump pumps of 1.5kW and under shall incorporate an integral level detector, control and motor starter and shall be powered only with a suitably-fused three-phase or single-phase low-voltage supply and with supply isolation at the supply point.

Sump pumps over 1.5kW shall be controlled and started from the supply point. Control shall be by means of adjustable float level switches mounted near the pump.

Pumps shall be supplied with all necessary pipework to discharge to surface drainage. Each pump shall be provided with delivery reflux and isolating valves, and suitable lifting gear for lowering and lifting the pump from the sump.



Pumps weighing 40kg or more shall be lowered into the sump on guide rails and be located to their respective discharge pipework with an angle flange connection and self-locating clamps.

Pump impellers shall be designed to pass solids of the sizes which pass through the inlet ports of the pump and shall be capable of pumping solids of up to 50 mm diameter.

Provide submersible, corrosion resistant, industrial quality pump complete with electric motor of submersible design IP 68 protection, discharge piping, mercury switch actuated controls, power cord, control panel, cover, and other accessories required for proper installation and operation.

The impeller shall be semi-open statically, dynamically, and hydraulically balanced, accurate machined and filed for smoothness.

Shaft shall be of Double mechanical seal with Tungsten-Carbide carbon ring with stainless steel parts and Oil filed chamber to lubricate running faces.

### **Materials**

- |    |             |   |                                      |
|----|-------------|---|--------------------------------------|
| 1) | Pump Casing | : | Cast iron                            |
| 2) | Impeller:   | : | Cast iron                            |
| 3) | Shaft       | : | Stainless steel ground and polished. |
| 4) | Fasteners   | : | Stainless steel.                     |

### **1.10 Vacuum Priming Pump**

Pumps shall be sized for the air extraction rate and the vacuum needed to prime the main pumps they serve. Unless otherwise specified, priming shall take no longer than 5 minutes with the lowest possible inlet water level.

Vacuum pumps shall be of the horizontally mounted water- ring rotary type, with no contacting parts except for bearings and shaft seals. They shall be directly coupled to horizontal shaft caged induction motors and mounted with the motor on a combined cast or fabricated steel base plate.

Pump maximum speed shall not exceed 1500 rpm and pump shall operate within permissible vibration levels and with the minimum of noise.

Material of pump components shall be chosen for long life in specified service conditions with minimum maintenance. Design life shall not less than 30,000 operating hours.

### **Casing**

Pump casings shall be provided with feed water tappings at the top part of the casing to provide sealing water. The tappings shall be individually valves, and connected to the delivery manifold of the main pumps they serve. If required to ensure initial supply of sealing water on starting, a suitable header tank shall be provided, which shall be filled through ball valve from the delivery manifold of the main pump and connected to the feed water tappings

of each vacuum pump.

### **Rotors**

Pump rotors shall be of water-ring type and shall be suitable for operation in a mixture of air and water.

### **Pump Shafts**

Pump shaft shall be designed to minimize deflection. Deflector plates shall be provided to prevent water seepage to the bearing housings.

### **Bearings**

Pump bearings shall be designed for a minimum service life of 30,000 hours. Bearings shall be heavy duty, single or double row anti-friction type, designed to support the rotating parts and to withstand any axial loads.

## **2. VALVES**

### **2.1 General**

Valves shall be suitable for use with the fluid being conveyed at the temperatures and pressures required for the application. Unless otherwise approved, pressure designation shall not be less than PN 10.

Valves shall have integral flanges drilled as specified in relevant codes where applicable. Flanges to other standards shall be used only if approved and provided that any differences do not affect mating dimensions. Back faces of flanges shall be machined.

Sluice valves and butterfly valves shall be suitable for flow in either direction.

Sluice valves shall comply with BS EN 1171 or , IS 14846 as appropriate

Non return Valves shall be Swing Check type conform to IS : 5312 .

Valves shall be suitable for both frequent operation, and for infrequent operation after long periods of standing either open or closed.

Rubber used in valves shall be ethylene propylene rubber (EPDM or EPM) or styrene butadiene rubber (SBR). It shall comply with the requirements of Appendix B of BS 5155, be suitable for making a long term flexible seals, and be resistant to anything causing deterioration of the flexible seal.

### **2.2 Sluice valves**

Sluice Valves shall conform to the provisions of AWWA C509; JIS B 2062; DIN 3352 Part 4A & B, BS 5150, BS 5163, IS 14846 or approved equivalent and as further specified herein. Valves shall be of non-rising stem, clockwise closing wedge and suitable for above ground use

and flow in both directions. Valves pressure rating shall be equal to, or greater than the adjoining pipe or fitting but a minimum of 10 bars.

Valves shall be designed for the "Closed End Test" and shall be of resilient seal design with bolted bonnet connection and straight-through port. Wedges shall be low clearance- guided in the body and shall have an inner core. They shall be encapsulated with a synthetic EPDM rubber covering on the inside and outside by vulcanizing up to 200 mm. The rubber covering shall have a minimum thickness of not less than 2.5 mm on both flow sides and 2.0 mm on sealing surfaces with nobody- metal exposed. EPDM wedge rubber shall be approved to be used for potable water and be selected to meet the chemical properties and temperatures of the fluid being handled by the valves. Flanges shall be in accordance with NP 10 of BS 4504/ IS 1538.

Stems shall be non-rising and manufactured of stainless steel, Stem threads shall be of the rolled type. Sealing and bearings shall be corrosion proof and maintenance- free and shall be designed in the form of a series of 'O' –rings of synthetic rubber. Stem bearing gap shall be sealed against entry of dust by a wiper ring. Stem sealing should be replaced when required. Stem nuts shall be of zinc-free bronze. The gate face rings shall be screwed into the gate or alternatively securely pegged over the full circumference.

The valve shall be furnished with a bushing arrangement for replacement of packing without leakage. They shall also have renewable channel and shoe linings. The gap between the shoe and channel shall be limited to 1.5 mm

The body and bonnet shall be of ductile iron and shall be internally and externally fusion bonded epoxy coated/ Liquid coated 250 microns as specified here-in. Prior to assembly, the entire valve body and bonnet shall be tested internally and externally.

Gear operated valves shall be provided with operating nuts as specified. Gear cases shall be totally enclosed and equipped with indicators to show valve position and designed for full differential pressure of 10 bars. Valves of size 450 mm and above shall be supplied with enclosed spur gear arrangement. The housing for the gearing must be enclosed and sealed in such a way that there is no leakage of oil/ grease even after long period of in use and there is no ingress of rain water. A mechanical indicator is to be provided to show door travel and end of travel. Gear housing shall have IP 54 protection class.

Valve spindles shall be of the non-rising type. The valve spindle seal shall be replaceable with the valve fully open and the main under pressure. Valves used with potable water shall not use any brasses which contain more than 5% zinc. Valves less than 250mm diameter may be of the resilient-seated type unless otherwise specified. Valves 450mm and over shall be fitted with gate jacking screws. Valves below 80mm NB shall comply with BS 5154.

#### Material of Construction

a.	Body	:	Ductile Iron IS 1865 Gr 500/7 DIN 1693-GGG 50/ EN 1563 GJS 500-7
b.	Wedge	:	Ductile Iron IS 1865 Gr 500/7 DIN 1693-GGG 50/ EN 1563 GJS 500-7
c.	Spindle	:	AISI 410/ AISI 420/ SS 304
d.	Seat Rings	:	St. Steel to CF – 8 / AISI 304

- e. Spindle Nut : High Tensile Brass to IS-320 HT2/Gun metal IS 318 Gr LTB 2

### 2.3 Butterfly valves

The valves shall be manufactured with integral body seats, suitable for open-closed and throttling service. Each valve shall be capable of withstanding the rated pressure from either side. The valves shall be furnished with double flanged ends.

The valves shall be ductile iron body, rubber seated, tight-closure butterfly valve and shall be designed and manufactured in accordance with IS 13095 or AWWA C504 or equivalent valves for raw water and clear water pumping main. Metal seat of stainless steel shall be used for flow control valve. All butterfly valves shall be equipped with manual operator with hand wheel unless otherwise specified. Valves pressure rating shall be equal to, or greater than the adjoining pipe or fitting but a minimum of 10 bars.

Valve shafts shall be made of stainless steel and shall be a one-piece unit extending completely through the valve disc, or of the “stub shaft, which comprises two separate shafts inserted into the valve disc hubs. If of “stub shaft” construction, each stub shaft shall be inserted into the valve disc hubs for a length of at least 1.5 times of the shaft diameter. Valve shafts shall have an enough diameter against the maximum operating torque under the specified pressure and extending through the valve bearing into the valve disc.

Valve shall be seat-in body and seat shall be designed to be replaceable in-line without use of special tools. Rubber sheets shall mate with surfaces of stainless steel conforming to IS 1309 or AWWA C504. Sprayed or plated mating seat surface shall not be used. Rubber seat for valves of 600 mm and smaller shall be clamped, mechanically secured, bonded or vulcanized to the valve body. Rubber seat for valves of 700 mm or larger shall be mechanically clamped or secured to the valve body. All clamps and retaining rings for rubber sheet shall be of corrosion-resistance materials. All nuts and screws used with clamps and retaining rings shall be of stainless steel.

Valve discs shall be of a cast fabricated design with no external ribs transverse to the flow. The thickness of the valve disc shall not be more than 2.25 times the shaft diameter. Valve discs shall be of stainless steel. Shaft seal shall be provided wherever shafts project through the valve body. Shaft provide a long life for the seal. All fasteners shall be set flush so as to offer the least possible resistance to the flow through the valve. All valves shall be suitable for throttling purpose.

All valve spindles and hand wheels shall be positioned to give good access for operational personnel. Valve of diameter 450 mm and above shall be provided with an enclosed gear arrangement for ease of operation. The gearing shall be such that the valve can be opened and closed by one man against an unbalanced head of 1.15 times the specified rating. Valve and gearing shall be such as to permit manual operation in a reasonable time and not exceed a required rim pull of 80 N. All hand wheels shall be arranged to turn in a clockwise direction to close the valve, the direction of rotation for opening and closing being indicated on the hand wheels.

## Material of Construction

Body	:	SGI IS 1865 Grade 500/7
Disc	:	SGI IS 1865 Grade 500/7
Shaft	:	Stainless Steel BS 970, Grade 431 S29
Body and Disc Seat	:	Stainless Steel AISI 316
Bearing	:	Steel backed PTFE (Teflon)
Internal Fasteners	:	Stainless Steel SS316

## 2.4 Non Return valves

Reflux/check valves shall be designed for rapid closing without slamming no later than the moment forward flow stops. Valves up to 600 mm dia. shall conform to IS 5312 Part 1 & above to IS 5312 Part 2. The valves shall be double flanged machined and drilled to IS- 1538 Part 4 & 6. The Non Return Valves shall be Swing Check type with Non Slam Characteristics. Non Slam Characteristics to be achieved by combination of hydraulic passage and additional disposition of weight on doors without any external clamping arrangements or passages. The angle of sealing and door weight shall be designed to provide the most efficient working with least restriction to flow.

The valve should be of PN 1.0 rating based on working pressure in the pipeline. The Valve sizes 50 to 600 mm should be of Single door design & above 600 mm should be Multi door design. Valve of diameter greater than 450 mm shall be provided, in addition to others, supporting feet and jacking screws. Hinge pins / shaft shall preferably be square in section to ensure positive location of flaps and provide for secure fixing. If self-closing without slamming cannot be achieved, external mechanisms may be used to control the closure rate. Details of mechanisms shall be subject to approval. Valves shall preferably be fitted with resilient faces or seats.

The backside of the drill holes to be spot faced for proper seating of bolts & nuts. Reasonable clearance behind the rear face of the flange on body to be kept to provide free access to use spanners for assembling & dismantling. No tap hole is acceptable.

The valves shall be suitable for mounting on a horizontal pipeline and flow direction shall be clearly embossed on the valve body. Nominal size, PN rating, Brand name & Direction of Flow should cast on the body.

### Material of Construction

a.	Body / Door	:	Ductile Iron IS 1865 Gr. 500/7 DIN 1693-GGG 50/ EN 1563 GJS 500-7
b.	Hinge Pin	:	SS AISI 420/ SS 304 / SS AISI 410
c.	Seat Rings	:	Integral Nickel weld overlay, microfinished / SS304
d.	Shaft sealing (if applicable)	:	EPDM Rubber
e.	Surface Protection	:	Epoxy powder/liquid coated inside and outside, Min 250 microns, colour RAL Blue

### Shop Testing Witnessing

1.	Seat Leakage Test (2 Minutes)	:	10Kg/cm <sup>2</sup>
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2. Body Leakage Test (5 Minutes) : 15Kg/cm<sup>2</sup>

## 2.5 Air Valves

The air valve shall be of double orifice tamper proof type conforming to latest issue of IS 14845.

The size of valve shall be as per CPHEEO manual and capable of exhausting air from pipe work automatically when been filled. Air shall be released at a sufficiently higher rate to prevent the restriction of the Inflow rate. Placing of air valves shall be on pipe and hydraulic gradient peaks and as required by surge analysis / hydraulic design. Similarly the valve shall be capable of ventilating pipe work automatically when being emptied. The air inflow rate shall be sufficiently high to prevent the development of a vacuum in pipeline. The valve shall automatically release air accumulating in pipe line work during normal working condition. The valve shall be of single chamber, double orifice with Triple action (Venting, admitting and venting during operation), Tamper proof in one piece construction (both large and small orifice housed in the housing itself).

All air valves shall be provided with isolating sluice valve and flanged end connection.

The aperture of valves must be properly designed for which the Contractor shall submit design calculations for necessary approvals before the procurement of valves.

All branched outlets including air valve tee's will be provided with one ½" BSP coupling duly plugged for measurement of pressure in due course. The closing plug will be in Stainless Steel (AISI 304 or equivalent) with Hex. Head and will be provided with copper washer for sealing.

1. All flanges will be drilled as per I.S. 1538 , Table IV and VI
2. Each valve shall be provided with an isolating valve.

### Material of Construction

Body	Ductile Iron IS 1865 Gr 500/7 DIN 1693-GGG 50/ EN1563 GJS 500-7
Float	SS 304/ SS 316,
Internal Shell	Stainless steel SS 304
Gasket & Seal	EPDM Rubber
Screws	SS 304
Surface Protection	Epoxy powder coating min. 250 microns thickness

## 2.6 Valve Operation

### 2.6.1 Shafts and caps for tee-key operated valves

Operating and extension shafts for valves operated by tee key shall be capped.

Extension shafts shall be circular section. For valves installed in chambers, extension shafts shall be provided with split bearings, rigidly held on brackets spaced no more than 1,500 mm apart. For buried valves, the shaft shall be supported inside a protecting tube held on a purpose-made support, which shall be fixed to the top of the valve and provided with a shaft guide.

Bearings and shafts shall be suitably protected against corrosion.

Extension shaft couplings shall be provided with locking arrangements.

### **2.6.2 Manual operating mechanisms**

Manual closing of valves shall be by the clockwise rotation of a tee key or hand wheel.

Tee-key operated valves shall be provided with detachable cast iron shaft caps, with keys to match the cap. One key shall be supplied for every five valves installed, with a minimum requirement of two keys in any one size.

Handwheels shall be shaped to give a safe grip without sharp projections, clearly marked with the direction of opening and closing and shall be fitted with integral locking devices. A padlock and chain will not be acceptable for locking.

Manually-operated valves and penstocks shall be capable of being opened and closed by one person, when the specified maximum unbalanced pressure is applied to the valve or penstock. Under this condition the total force required at the rim of the handwheel or at the tee key to open the valve or penstock from the closed position shall not exceed 30 kg (15 kg each hand). Where necessary, gearing and bearings shall be provided and the handwheel sized to fulfil this requirement.

Gearboxes shall be totally enclosed oil bath lubricated. Thrust bearings shall be provided so that the gearcase may be opened for inspection or be dismantled without releasing the stem thrust or taking the valve or penstock out of service. Oil and grease lubricated gearing, bearings and glands shall be protected against the ingress of dust and moisture.

Operating mechanisms shall be of the weatherproof type and those parts subject to submergence shall have a degree of protection IP68 to BS 5490 at a depth of submergence of 5 m. Where practicable, operating mechanisms shall be fitted with mechanical position indicators clearly visible from the operating position.

### **2.6.3 Electric actuators**

The sluice valve on pump suction and discharge lines and butterfly valve on pump discharge line and pumping main shall be operated by electric actuator. Electric actuators shall operate valves at opening and closing rates that will not impose unacceptable surge pressures on the pipework.

Actuators shall be rated at not less than 20 percent in excess of the power required to operate the valve or penstock under maximum working conditions.

Actuator enclosures shall have a minimum protection IPW 67 to BS EN 60529.

Actuator electric motors shall comply with BS 4999. For non-modulating type actuators, the motor short-time rating (STR) shall allow the successive full travel operation of the travel from open to closed and vice versa but shall be not less than 15 minutes. For modulating type actuators the motor shall have a duty-type rating (DTR) to meet the varying cyclic load requirements of the valve.

Electric motors shall be provided with built-in thermal protection complying with BS 4999: Part 111.

Actuators shall be complete with:

- (a) An alternative system for manual handwheel and reduction gear operation which shall be lockable.
- (b) An interlock, to prevent engagement of the handwheel whilst the actuator is being power driven and to disengage the manual drive positively when the power drive is started.
- (c) Reversing type motor starter complete with isolating switch.
- (d) Local and remote control selector switch when specified, which shall be lockable.
- (e) Open, stop and close push-buttons.
- (f) Potentiometer for remote valve position indication when remote control is specified.
- (g) Torque switches for mechanical disengagement of the drive at the extremes of valve operation to limit excess torque.
- (h) Supply failure and remote control available monitoring relays. The supply failure relay shall operate under single phasing and phase reversal conditions.
- (i) Auxiliary and interposing relays as necessary.
- (j) Voltage-free changeover type contacts for the remote indication of:
  - Motor tripped on overload
  - Fully open
  - Fully closed
  - Operating
  - Supply failed
  - Remote control available



The rating of volt-free contacts shall be not less than 15 A at 240V a.c. and 2 A at 50V d.c. unless otherwise specified. The contacts shall be suitable for inductive load switching.

(k) Anti-condensation heater

Separate or segregated terminal boxes shall be provided for the connection motor, heater and control cables.

## **2.7 Valve packaging and installation**

### **2.7.1 Marking and packing**

Each valve shall be indelibly marked with the diameter and pressure rating and shall carry a unique reference number to enable each item to be clearly identified with works fabrication records, works test certificates, delivery notes and the like.

Wherever possible, the identification marks shall be painted on the outside of the item but where there is not enough smooth surface area for the identification marks they shall be put on rust-proofed metal tags secured to the item with galvanised wire or chain (not through flange holes).

Valves shall be packed in the 'closed' position except that uncrated resilient seat gate valves for transport to tropical areas shall be in the 'open' position.

### **2.7.2 Valve handling**

The Contractor shall provide all equipment needed to handle and install valves and associated equipment without damage. The equipment shall include lifting beams, reinforced canvas slings, protective padding, cradles and the like. Unprotected wire rope or chain slings shall not be used for handling.

Temporary packing, coverings or crates provided for protection in transit shall not be removed (except for inspections, after which they shall be replaced) until immediately before installation.

### **2.7.3 Valve installation**

Valves shall be installed and commissioned in accordance with the manufacturer's instructions. After installation, valves shall be cleaned, and gates, discs, seats and other moving parts closely inspected, foreign matter removed, and the valves checked for ease of operation. Moving parts shall be lightly greased or otherwise treated in accordance with the manufacturer's recommendations.

Unless otherwise specified or directed by the Engineer, butterfly valves shall be enclosed in chambers, installed with the shaft horizontal, and supported as detailed on the Drawings. They shall be installed so that when the valve is opening the lower portion of the disc moves in the direction of the main or normal flow.

Unless shown otherwise on the Drawings, gate valves shall be installed with their shafts vertical.

Gate valves without external gearing, and not otherwise required to be in a chamber, may be buried. The buried part of the valve shall be protected as specified. Unless otherwise specified, backfilling shall be to just below the top of the valve or shaft shroud, and a surface box shall be provided.

Jointing, sleeving, external wrapping, anchor and thrust blocks, valve chambers, valve marker posts and the cleaning and disinfection of valves shall be executed as specified for the associated pipeline.

## **2.8 Expansion Bellows**

All Sluice valves, Check Valves, Flow meters shall be installed between flanges with a flexible expansion bellows at one side. The expansion bellows on suction and delivery pipes within the Pump House Campus shall be of metallic bellow type. The bellows must allow dismantling of the valve, meters etc. without causing stress to the joints of the attached pipes. The minimum clearance of the bellows shall be five (5) cm. The pressure class of the expansion bellows shall be the same as that of the pipe. Drawings of the expansion bellows shall be submitted to the Employer for approval. The Nuts and Bolts of the joint shall be galvanised. The joints shall be painted/coated as per specification given for exposed pipes.

General Specifications for the Bellow type dismantling joints shall be as below.

1. Internal Sleeve : SS 316
2. Bellow : SS 304
3. Limit Rod : CS IS 1367 Gr 4.0, GI (electroplated)
4. Pressure Class : Min PN 1.0 (Working Pressure)

## **2.9 Sluice Gate**

Sluice gate shall be wall thimble mounted type. The construction of Sluice Gates shall be in accordance specification and generally to IS:13349. The Sluice Gate shall be designed for Seating & Unseating Head without sacrificing reasonable degree of leak tightness. The frame of Sluice gate shall be flanged back type and shall be machined on the rear face to bolt directly to the machined face of the wall thimble. The seating faces shall be made of solid section strip of Stainless steel. They shall be secure firmly by means of counter sunk fixing in finished grooves in the frame and slide face in such a way as to ensure that they will remain permanently in place, free from distortion and loosening during the life of the Sluice Gate. Sluice Gates shall be equipped with adjustable Side & Top wedging devices as required to provide contact between the slide and frame facing when the gate is in closed position. The gates shall be of Rising Spindle Type. They shall be operated through a suitable operating mechanism. The Lifting mechanism shall incorporate gearing arrangement, if required to keep the torque requirement within 7 KgM except electrically actuated gate. In case of gearing, those to be enclosed grease packed Bevel or Worm Gear box type. Lifting mechanism shall be provided with suitable position indicator to show the position of the gate

from full open to full close. The indicator to be provided in the head stock only. Stem Cover to be provided on the top of head stock for the rising spindle. The cross section of the wall thimble shall have the shape of the English letter 'F'. The Sluice gate shall be provided with Flush bottom seal. This is a solid square cornered resilient rubber seal provided on the bottom facing of the slide. The seal may be secured fastened to the bottom of the face of the slide by a retainer bar and fasteners. The top surface of the bottom facing of frame shall be flush with invert of the gate opening. Bottom facing of the slide shall be accurately machined to make contact with the seal when the slid is closed.

### Material of Construction

The materials of construction of important components of gates will be as under:

a. Frame & Shutter	:	Cast Iron IS: 210 Gr. FG 200
b. Wall Thimble	:	Cast Iron IS: 210 Gr. FG 200
c. Seating Faces & Counter Sunk Fixing	:	Stainless Steel ASTM A276 type 316
d. Wedging Device	:	Cast Iron IS: 210 Gr. FG 200
e. Wedge Linings	:	Stainless Steel ASTM A276 type 316
f. Stem & Stem Coupling	:	Stainless Steel ASTM A276 type 316
g. Stem Nut	:	Stainless Steel ASTM A743 CF8M
h. Flush Bottom Rubber Seal	:	EPDM ASTM D200
i. Seal retainer bar	:	Stainless Steel ASTM A276 type 316
j. Fasteners, Studs Anchor Bolt & Nuts	:	Stainless Steel ASTM A276 type 316
k. Lift Nut	:	Bronze IS: 318 Type LTB-2
l. Headstock, Stem Guide	:	Cast Iron IS: 210 Gr. FG 200
m. Hand wheel	:	Mild Steel IS: 2062
n. Painting	:	Ordinary Black Bituminous Paint

### Standard Painting

Unless otherwise specified elsewhere provide following standard painting.

- Surface preparation: Blast clean or Ground to near white metal finish
- Priming: 1 coat of red oxide primer before and after shop testing. Total priming thickness 75 microns.
- Finish painting for gate assembly: 2 coats of black bitumen paint for gate assembly. Total paint thickness inclusive of priming 200 microns.
- Finish painting for headstock: Grey enamel paint. Total paint thickness inclusive of priming 150 microns.

### Shop Testing Parameters

- Leakage test at operating pressure for gate leakage performance.
- Movement test for checking interference free movement of complete assembly.
- Seat clearance check for checking clearance between mating sealing faces.
- Positive Material Identification test for all material other than cast iron.

### **3. PIPE WORK**

#### **3.1 Pipework within structures**

The term “pipe work” means pipe of any description and includes associated flanges, adopters, couplings, jointing materials, fittings, supports, valves, traps and the like which are necessary to complete station pipe work systems associated with Pumping Station.

Pipe work layout within pumping stations shall be agreed with the pump manufacturer.

Pipes and fittings within building shall be DI. The Ductile Iron Pipes to be supplied and erected shall be with ISI marking conforming to latest revision of IS 8329.

The Contractor shall design, manufacture, supply, fabricate, and install the pipe work in accordance with the Specification and to satisfy pipe work function of Pump Station. The Contractor’s specification for the fabrication of pipe work shall be submitted for the Employer’s approval.

All pipe work and fittings shall be rated to the higher pressure class in excess of the maximum pressure attained in service including any surge pressure.

The pipe work installation shall be so arranged to offer ease of dismantling and removal of pumps or other major items of equipment. Stainless steel AISI 304 expansion bellows which can take radial and axial misalignment of minimum 1 percent of valve nominal size with tie rods shall be included in the suction and delivery pipework of all pumps as well as on delivery header for easy dismantling, and provision shall be made for a flexible joint arrangement to building structures.

All necessary supports, saddles, slings, fixing bolts and foundation bolts shall be supplied to support the pipe work and its associated equipment in an approved manner. When passing through walls, pipework shall incorporate a puddle flange or other suitable sealing device.

Flange adapters and unions shall be supplied and fitted in pipework runs, wherever necessary, to permit the simple disconnection of flanges, valves and equipment. The final outlet connection of the pipework shall match the connecting point of the transmission main.

Pipe work shall be laid out and designed to facilitate the erection, painting in situ and dismantling of any section for maintenance and to give a constant and uniform flow of working fluid with a minimum of head loss. Positions of flanges shall take account of any concrete pipe supports or thrust blocks needed.

Flexible joints shall be provided where needed to facilitate removal of Plant or to allow for differential settlement of the building. Wherever practical, flexible joints shall be provided with tie-bolts or other approved means to transfer thrust or tension axially along the pipe work.

Flanges shall be finished truly square with the pipe axis. Wherever possible, standard fittings shall be used in preference to special fittings.

Facilities shall be provided for draining the pipe system and releasing air. The drained fluid

shall be piped into the appropriate drainage system and the time for drainage shall not exceed 30 minutes.

Valves, strainers and other devices mounted in the pipework shall be supported independently of the pipes to which they connect.

Flanges shall be drilled in accordance with the appropriate pressure rating.

Unless otherwise approved, steel pipework in pumping stations shall be internally and externally coated with an approved two-component solvent-free, spray-applied epoxy coating.

Where necessary, the high-pressure pipe work shall be of seamless or welded steel, complying with API Specification 52/ IS 3589 for line pipe. Test and test certificates will be required for the pipe work supplied under this Contract in accordance with Clauses 3.3 and 3.5 of API Specification 5L/ IS 3589 including ladle and check analyses of the steel. Carbon steel pipes shall be in accordance with BS EN 10216 or IS 3589-01. Carbon steel fittings shall comply with IS 3589-01.

Pipe work and fittings shall be completely fabricated and corrosion-protected at the maker's works.

Flexible couplings for each size of pipe shall also be capable of withstanding the shear force applied by the weight of a 4m length of pipe of that diameter full of water suspended between two couplings.

Pressure ratings shall match the pressure rating of the pipe work in which they are installed, and materials used and methods of protection shall not be inferior to those used for the pipe work.

The metal components of flexible couplings and flange adaptors shall be protected by thermoplastic polyamide or fusion-bonded epoxy coatings unless otherwise specified or detailed in the Drawings.

### **3.2 Pipe protection**

The internal and external surfaces of the pipe shall be smooth, clean and free from grooving and other defects which might impair its functional properties. The pipe shall be homogeneous throughout and uniform in colour, opacity, density and other physical properties.

The pipe shall be delivered in the longest lengths possible to keep site jointing to a minimum. Pipes shall be given external and internal protection as per relevant BIS/ IS codes. Testing of pipe protection shall be done as directed by the Engineer using elcometers, coating thickness gauges, bond test and holiday detectors.

All underground pipe work having a cover less than 1.5 m and more than 4.5 m shall be encased with M 15 concrete of minimum 200 mm thick all around. All above ground and pipes in galleries shall be externally painted with two coats of epoxy with minimum thickness of 180 microns. No internal and external painting to be given to SS pipes.

#### **4. SURGE PROTECTION SYSTEM**

Contractor shall be responsible to perform surge analysis on each transmission main at each clear water pumping station Phase-II & Phase-III. The surge analyses shall be performed using an industry recognized software program and through some recognized institute/agency acceptable to the Employer's Representative. The surge designs shall be performed based on survey and field data to be collected by the Contractor. The designs and recommendations shall be submitted to the Employer's Representative for approval.

Preliminary surge analysis indicate that all pumping mains are subjected to sever negative pressures (down surge). Thus purpose-designed, economical and dependable water hammer control devices are necessary to ensure the following;

- Sub-atmospheric pressures shall be avoided over entire length of pumping main. However, in some special case, where it is difficult to control the negative pressure by any means (mostly at peak points), negative pressure can be allowed (up to 1/3 of vacuum).
- Maximum positive pressure are to be restricted to safe level such that sum of working pressure and controlled surge pressure are within safe design pressure of the pumping mains.
- surge control system shall be designed so as to ensure that the maximum operating pressure (sum of working pressure and residual surge pressure) at any point in the pipeline is not more than 1.1 times the working pressure

The selection of surge protection device for a specific rising main must be based on a consideration of the surge picture both upsurge or pressure rise and down surge or pressure drop, the pipe strength with specific reference to withstanding upsurge and down surge. Only use of air cushion valve is not acceptable for down surge protection. As air vessel can control both down surge and upsurge, however it is suggested to provide combination of Air vessel and Air cushion valves. Air cushion valves will have an important role to play in any protection option, as supplementary down surge control devices.

##### **4.1 Specification for Air Vessel**

Air Vessel should be suitable to take care the water hammer occurring in the transmission system of clear water pumping mains. Air Vessel will be manufactured out of MS plates as per IS 2002 or equivalent. The design and fabrication will be carried out as per latest version of IS 2825. Air Vessel will be provided with manhole and water outlet at the bottom, which will be connected to the rising main along with an isolating valve and a differential orifice. Suitable drain will be provided for maintenance. Air Vessel will have standard fittings such as pressure relief valve, visual level indicator, control circuit inlet and outlet etc, with isolating valve.

Two nos. air Compressors shall be provided along with each surge protection system. The compressor will be operating at slightly higher pressure than the line pressure, and compressed air will be stored in the receiver from which requisite supply will be made to Air Vessel. The Air Vessel and air receiver will be painted internally and externally with zinc

rich food grade epoxy paint. The following additional equipment will be supplied as standard accessories to the Air Vessel:

- Receiver with compressor, with automatic on/off system.
- Visual water level indicator, covering full height or length of the air vessel.
- Isolating and drain valves for maintenance purpose.

### **Control System**

The systems shall be fully automatic and of sound construction with alarm systems tied into the SCADA network. The Contractor shall install, test and commission each full system after approval of their designs.

The automatic control system shall be generally as described below however bidder may propose any alternative arrangement.

A compressor with receiver shall be provided to get compressed air in receiver. Compressed air is stored at higher pressure than working pressure of pumps to avoid frequent 'on' 'off' of compressor. To maintain the level in the vessel between the working limits, electrical /electronic level control system shall be provided. The system will basically consist of the following:

#### **a. Level Sensors:**

Level of water is sensed at five levels. Their significance is given below: -

- Upper emergency level
- Upper working level
- Mean working level
- Lower working level
- Lower emergency level

### **Constructional features**

Capacity of Air Vessel	As per design ( Tentative capacity as per specification)
Design Pressure	As per design
Installation	Horizontal
Size of differential orifice	As per design
Size of Valve	As per design
Pressure gauge (0-20Kg/cm <sup>2</sup> )	150mm dial size with needle type isolation valve

### **Air Compressor (1W + 1 S) for each system:**

The Compressors shall be reciprocating type air cooled, electric motor driven through belt drive. The compressor and motor shall be mounted on common fabricated steel base plate

with suitable belt guard. The crank shaft shall be precision balance. Bearing shall be adequately sized for heavy duty. Crank pin bushing shall be replaceable and precision ground. Inter cooler shall be made of finned copper tube and provided with safety valves to prevent over pressurization. Connecting rod shall be made in one piece with solid end construction with integral splash lubrication. Cylinder shall have large number of radial fins to dissipate heat. Cylinder bore shall be smoothly machined. Cylinder head shall be easily accessible for inspection. Pistons shall be designed for a smooth running and fitted with compression rings and oil control rings suitable for high pressure and minimum wear. Valves shall be made of stainless steel for wear resistance and longer life.

## 4.2 Air cushion Valves

The Air Cushion valve of diameter 150 mm to 200 mm diameter consists of a 'Main Body' and 'Top Housing'. On the side of main body, one 'Air Inlet ports' loaded with a light spring is fitted. The 'Inlet' is protected by a cover. The 'Top Housing' has an opening for air escape. A spring loaded 'Poppet' with a brass seat and Neoprene 'Sealing Ring' covers the top of the opening. The spring pressure on the valve is adjustable by a screw (S.S. as per AISI-304). The 'Housing' has a tapered outlet, the opening of which is adjustable by a tapered plug and Screw (S.S. as per AISI-304). The outlet is protected by a cover. On its lower side a cage holding a ball float is fitted. 'Main Body', 'Top Flange', are fabricated from M.S. (as per I.S.2062). The 'Top Housing' is made from high grade cast iron. Stems of valves are in stainless steel (as per AISI-304). Bushes for stem should be of Brass. Sealing rings are of good quality rubber and seats are of brass. Mounting flanges drilling as per I.S. 1538. Zinc rich epoxy primer with two coats of Coal tar Epoxy Paint from inside and outside with total DFT of 200 microns.

The Air Cushion Valves shall be subjected to Hydrostatic body test by applying the rated pressure for the hydrostatic test. The valves will be closed from the mounting flange using the dummy ends/blind flanges and hydrostatic pressure will be applied. A pressure gauge shall be mounted on the nipple provided at main body.

The 'Hydro Static Body Test Pressure' specified in the approved GA drawing shall be applied using the hand pump or motor pump for a duration of 15 (fifteen) Minutes. No water leakage is permissible through the main body of the valve during this period.

### Material of Construction

Main Body	:	M.S. – IS :1239/IS:3589/ ASTM A 106 B
Flanges	:	M.S. – IS : 2062 E250-BR
Top Housing	:	C.I. IS : 210 FG 200
Seal (Inlet & Outlet)	:	Neoprene Rubber
Spring	:	S.S. AISI 304

Each Air cushion valves shall be installed with Isolation Gate valves.



## **5. ELECTRICALLY OPERATED TRAVELLING (EOT) CRANE**

### **5.1 General**

This Section specifies the requirements for the design, manufacture, construction, installation, testing and commissioning of double girder electric overhead travelling crane.

#### **5.1.1 Reference Standards**

Applicable standards referred to in this section shall be listed below:

BS	302	Stranded steel wire ropes or equivalent standard
BS	466	Power driven overhead travelling cranes, semi Goliath and Goliath chain for general use or equivalent standard
BS	2573	Rules for the design of cranes or equivalent standard
BS	2853	The design and testing of steel overhead runway beams or equivalent standard
BS	2903	Higher tensile steel hooks for chains, slings, blocks, and general engineering purposes or equivalent standard

#### **5.1.2 System Description**

Lifting equipment shall be provided as required to remove equipment for replacement and/or maintenance purposes. The design shall ensure safe access is provided for the operation of the lifting equipment. Overhead cranes will also be required to grant access for maintenance of roof mounted equipment such as light fittings or fans, etc., and shall be designed.

### **5.2 Submittals**

The Contractor shall furnish the following data:

- 1) Complete structural calculations of crane and monorail member and component sizing and design, shall be submitted, as required by BS 2573, BS 2853.
- 2) Shop drawings shall be submitted. Layout drawings shall clearly show the lifting height of the equipment and clearances in relation to other equipment and structures where the largest items are lifted.
- 3) The Contractor shall include all the documentation required on the lifting equipment in the operation and maintenance manuals. A copy of the design data, factory and site tests shall be included in the manuals.

#### **5.2.1 Design Conditions**

- 1) Cranes shall be suitable for indoor or outdoor installation, as shown and designated. The high ambient temperature in which lifting equipment and particularly cranes may be required to operate shall be taken into consideration, particularly with respect to the electrical load ratings of motors, switchgear, resistors, cables and wiring, as well as mechanical heat sources such as brakes, bearings and gearing. Due allowance shall be made for possibly higher temperatures than the maximum recorded shade temperature near the roofs of buildings, if the lifting equipment is mounted in a building, or for the effect of

direct sunlight if mounted externally.

- 2) Design of travelling hoist crane and incidental accessories will be based upon the use of a factor of safety of 5, structural beams shall have a factor of safety of 2 with capacity load on all mechanical parts of the system. The factors of safety shall be based upon the ultimate strength of the material used.
- 3) Lifting equipment shall be rated for the load of the heaviest installed item of plant, and designed such that one man can operate it without difficulty.
- 4) Hook and load wire shall reach to the floor of the lowest level.
- 5) The crane IS: 3177, class 2, medium duty and meet specified operational requirements.
- 6) The crane shall be of double girder type.

### **5.3 Electrically Operated Over Head Travelling Crane**

- 1) The hoist rope drum shall be of high quality seamless pipe with left and right hand spiral grooves to accommodate the hoist rope in one layer. As far as possible, the drive gearing shall be fixed directly to the rope drum to obviate high torsional stress in the drum shaft. The rope shall be securely clamped to the drum.
- 2) The hoist drum shall incorporate a wire rope, rewind system and guides to prevent the hoist rope skipping and damaging the lay.
- 3) The bridge structure shall be formed by a single cross girder or double girder as per design requirement with the hoist units traveling along the lower flange of the bridge girder. The end carriages shall be fabricated adequately stiffened throughout their length to produce a section with high torsional resistance designed to eliminate and tendency for the bridge to cross whip. The carriage wheel base shall be adequately proportioned in relation to its span to give a widely distributed load on the crane rails and ensure freedom from cross working.
- 4) The hoist braking system shall be of the automatic electro-mechanical fail safe type which, when the current is cut off or fails will automatically arrest the motion and hold at rest any load up to and including the rated load. The system shall safely control the lowering of the same load from the highest to the lowest point of lift and shall not allow any slippage of the suspended load to occur when the 'Raise' motion is initiated.
- 5) The hoist rope shall be a flexible wire rope specially designed for usage with cranes and in accordance with BS 302, with a safety factor of not less than six times the maximum tension induced by the safe working load.
- 6) The crane hook shall be of high-grade forged steel trapezoidal section in accordance with BS 2903/ IS 15560, 'C' type. The hook shall be supported on a ball thrust bearing to allow free swiveling under full loads and shall also be

fitted with a safety catch. The safe working load shall be marked in the hook in accordance with BS 2903/ IS 15560.

- 7) All the hoist functions shall be controlled from a single pendant push button station. The pendant unit shall be suspended from a special track spanning the bridge length using a non-metallic cord and not the control cable. The pendant shall operate on a low voltages (typically 110 volts AC) source, incorporated with a key operated switch to prevent unauthorized operation and indicators to indicate all crane or hoist movements including start and stop. The hook shall have a safety latch to prevent rope coming off the hook.
- 8) The electric hoist shall be fitted with right and left handed spiral grooved seamless pipe with a rope hoist arrangement with spring loaded rope bands and guards to ensure accurate rope guidance and location. Hoist rope shall be extra flexible, improved plough steel rope with well lubricated hemp core and having six stands of 37 wires per strand with an ultimate tensile strength of 160/180 kg/sq.mm Electromagnetic brake shall be provided to hold suspended load instantly, securely and automatically in the event of the electric current being cut off whether intentionally, accidentally or due to power failure.
- 9) Power feed to the crane shall be from a shrouded conductor rail system and that to the hoist shall be through close looped flexible cable suspension system with carriers sliding along a wire across the full span of the crane. Flood lights of an approved design shall be fitted to the end carriages and arranged to illuminate the entire area under the crane.
- 10) The sheaves of the hook block shall be guarded to prevent a hand or fingers from being trapped between the sheaves and the in-running rope.
- 11) A limit switch shall be fitted to prevent over hoisting. This shall be self-resetting, closing automatically when the hoist motor is put in reverse.
- 12) Brakes shall be well protected from oil and grease leakage or spillage, and from adverse effects of atmospheric condensation or dust. A simple and easily accessible means of carrying out adjustment for wear of the shoes or linings shall be provided for all brakes.
- 13) Automatic brakes, operating when the drive motor stops shall be supplied for the long and cross travel motions.
- 14) Long-travel, cross-travel and slow and normal speed hoist motors of each crane shall be controlled from the lowest level by a pendant push button station.

Lifting speed	Low	0.9 m/min
	High	2.5 m/min
L.T. speed		10 m/min
C.T. speed		2.5 m/min

## **5.4 Factory Inspection and Testing**

- 1) The Contractor shall secure from the lifting equipment manufacturer certification that the following inspections and tests have been conducted on each crane or hoist system at the factory, and submit to the Engineer prior to shipment.
- 2) Cranes shall be inspected and tested in accordance with the requirements of BS 466/ IS 3177/ IS 3938/ IS 3822/ IS 2266 and shall also be carried out in the manufacturer's works and witnessed by the Engineer.
- 3) The works tests shall include overload tests during which a 25 percent overload shall be lifted by the hoist at the middle of the crane span and sustained under full control whilst it is moved up and down at both normal and creep hoist speeds. Whilst still under overload the crab unit of each crane shall be operated from end to end of its travel and in both directions.
- 4) The mechanism and controls for the long travel motions shall be tested under light running conditions without moving the crane.

## **5.5 Execution**

### **5.5.1 Installation**

Lifting equipment shall be installed in accordance with the requirements and instructions of the manufacturer. The lifting equipment manufacturer shall provide a representative to supervise the installation and testing.

### **5.5.2 Site Tests**

After erection cranes and hoists shall be inspected, tested and certification provided by a qualified independent crane-testing specialist in accordance with the requirements of BS 466 and the tests witnessed by the Engineer. Site tests shall be done by the Contractor who shall supply the necessary materials for the test loads. The test loads shall be removed from Site by the Contractor after successful tests have been completed.

## **6. EXHAUST FANS**

Exhaust fans of appropriate rating shall be provided for pump houses and switchgear rooms, for the ventilation of pumping stations. Contractor shall submit the fan selection details for approval.

Exhaust Fan should comply with IS 2312/ IS3588.

The blades shall be of mild steel and properly balanced so as to avoid noise and vibration. The blade and blade carriers shall be securely fixed so that they do not loosen in operation. The means provided for securing the fan mounting or fan casing to the wall, partition or window shall be such as to provide a secure fixing without damage to the fan or wall.

Suitably designed guards shall be fitted to the inlet and the outlet side to prevent accidental contact. No flammable material shall be used in the construction of fan. Moulded parts, if used, shall be of such materials as to withstand the maximum temperature attained in the adjacent

component parts.

The fan shall have protective insulation or be capable of being earthed. A fan with protective insulation may be of all insulated construction or have either double insulation or reinforced insulation. Each fan should be provided with a 10 sq.mm mesh bird screen. The sheet used for the cowl should be 14 G.

## **7. FIRE EXTINGUISHERS**

The type, rating and quantity of fire extinguishers as required and as applicable for the various rooms shall be provided in accordance with relevant codal stipulations and shall be of ISI mark and as per Tariff Advisory Committee's recommendations. ABC type extinguishers shall be provided



**6.2.1.3**  
**STANDARD SPECIFICATIONS:**  
**(ELECTRICAL WORKS)**





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## 1. ELECTRICAL SCOPE OF WORK

- a) The scope of work includes design, manufacture, inspection, supply, installation (including storing, unloading and transferring the material / equipment to Contractor's storage area, maintaining equipment / material in safe custody and assembling the elements of the equipment and installing at the place of work), testing & commissioning of the plant equipment/ system for Pumping Station (PS) as per the SLD and specifications enclosed. The major electrical equipment and systems of these pumping station under this contract are briefly listed below:
  - i. 11kV HT Switchgear
  - ii. 11kV/433V Transformers
  - iii. LV Bus duct
  - iv. LV indoor switchboards
  - v. Energy Efficient (IE-2 or better) LV motors
  - vi. LV Soft Starter
  - vii. 11KV HV and LV Cables (Power & Control)
  - viii. DC system consisting of 110 V batteries, battery chargers and DC distribution board
  - ix. Uninterrupted Power Supply
  - x. Cabling system
  - xi. Outdoor and indoor lighting system (comprising energy efficient fixtures and accessories, lighting panels, receptacles, wiring, cabling, welding receptacles, emergency lighting, etc.)
  - xii. Earthing and lightning protection system
- b) Bidders shall completely acquaint themselves with the requirements of the specifications. They shall ensure that their bids are complete and are prepared as required. Incomplete tenders will be rejected. Deviations, if any, from any of the clauses of the specification shall be categorically stated. Otherwise it will be construed that the bid is in full conformity with the specification.
- c) The Bidders should visit the site before quoting for the bid and acquaint themselves with the system at their own cost.
- d) All equipment offered shall comply with the requirements specified in the latest editions of applicable Indian Standards and shall also comply with the good Engineering practices. Where these standards are in conflict with the requirements of the specification, this specification shall supersede them.
- e) The SLDs and drawings enclosed with the specification form the part of the specification.
- f) The SLDs and drawings enclosed with the specification are indicative and for bidding purpose only.
- g) All type (as applicable), routine and acceptance tests shall be conducted in the presence of Employer / Consultant/ Third Party on all the equipment as per latest applicable IS code without any extra cost. Typical type test reports for other equipment shall be submitted by the Bidder for approval by Employer / Consultant.
- h) Liaison with NDPL/BSES and other Government organization/Statutory bodies for obtaining Power supply/ other clearance shall be Contractor's scope. The electrical installation has to be got cleared from Chief Electrical Inspector for obtaining electrical power connection from NDPL/BSES and all necessary documents have to be furnished to the department without any extra charges.

- i) All commissioning tests shall be carried out in the presence of Employer's representative and approval for the same shall be obtained before commissioning and installation. All instrument and accessories required for testing and commissioning of the equipment specified herein shall be provided by the Contractor.
- j) The Contractor shall possess the valid electrical contractor's license of appropriate class from the concerned statutory bodies governing the area of work place. The Contractor shall fully comply with the relevant statutory rules and regulations.
- k) After completion of installation work, the Contractor shall arrange for inspection and obtain approval from the concerned statutory bodies. Any fees that are to be paid to such statutory bodies for testing, inspection or calibration shall be paid by the Contractor and later stage shall be reimburse by Employer. Any modification / revision in the equipment / installation of equipment as required by the statutory bodies shall be carried out by the Contractor. All such costs / fees for revisions / modifications shall be deemed to be included in the prices of supply, installation, testing and commissioning of equipment as quoted by the Bidder.
- l) All test reports shall be properly maintained by the Contractor duly approved by the statutory bodies and shall be handed over to the Employer after completion of the job.
- m) The necessary dismantling of equipment and transportation of dismantled equipment from the store of the dismantled site to the store of DJB shall be in the scope of contractor . All the dismantled equipments and materials shall be the property of DJB.
- n) The contractor shall dismantle all the equipment and materials in such a way that there shall be no disruption in normal operation of the pump house and water supply during dismantling and carrying out of the modification work .
- o) The contractor shall remove the existing equipment and new equipment shall be installed suitably without disturbing the existing water supply. The contractor shall also submit the electric load shifting plan for approval.
- p) The contractor shall undertake all the necessary civil works required for Electrical system.
- q) In case 11 KV Cables are required to be laid by contractor, necessary right of way and approval from statutory shall be in the scope of contractor.
- r) Preparation of drawings, Layouts and detail working drawings shall be in the scope of contractor.
- s) The contractor shall prepare the equipment layout drawings, Earthing and lightning protection Layout drawings, Cable routing drawings.
- t) Contractor shall submit all the sizing and calculations for approval.

## 2. GENERAL INFORMATION

- The design basis of electrical system as a whole is based on providing safe, reliable & stable power and efficient performance of electrical system.
- All electrical installations should conform to Central Electricity Authority' 2010 (CEA) regulations and rules and regulation laid down by NDPL/BSES
- All indoor electrical equipment has been designed based on ambient temperature of 50 °C.
- Incoming power supply is available at 11kV, 3 phase, 50Hz, solidly earthed system from Power Company(NDPL/BSES). 415V system is 3 phase, 4 wire, solidly earthed

system.

- Short time rating of 11kV Switchgear shall be 18.1 kA for 1 sec. and for 415V Switchgear shall be 50kA for 1 sec.
- Permissible voltage drops of motors during starting are limited to 15% and during running are limited to 3%.
- Voltage variation for HT and LT system is +10% to -10% and frequency variation is +5% to -5%.
- All equipment/components and accessories should be designed, manufactured and tested in accordance with the latest Indian international codes and standards.
- Electrical Resistivity Test Results: . The contractor has to carry out his own studies before starting works and if any discrepancy is found, and if any modifications are required to suite the modified output, the contractor has to carry out the modifications and get it approved from Engineer-in-charge nothing extra will be paid on this account.

### 3. GENERAL REQUIREMENTS

#### 3.1 Electrical Drawings

a) Following documents / drawings shall be enclosed with the bid by the bidder:

(i) The work programme in the form of a bar chart/ PERT chart covering entire scope of the work showing all activities, their duration, start and finish dates and their inter-relationships.

(ii) Dimensional general arrangement drawings showing plan, elevation and sections together with identification of parts / accessories, etc. for all equipment along with manufacturer's catalogues / literature, etc.

b) Following drawings shall be submitted by Contractor after award of Contract:

(i) HT Switchgear:-

Detailed design calculations for busbar sizes and temperature rise. Fully dimensional general arrangement drawings complete with plan, elevation and sectional views, location of cable and / or bus duct entry for incoming and outgoing feeders, complete bill of material, foundation drawing and cable entry details, switchgear sizing calculation, protection relay setting calculation and setting table. Schematic diagrams for all power, control, protection and indication circuits. Manufacturer's catalogues / literature, etc. for numerical relays and other brought-out items.

(ii) Power Transformer:-

Dimensional general arrangement drawings comprising plan, elevation and sectional views, dimensions, weights, foundation details, etc.  
Marshalling box wiring diagram, Name plate diagram etc.

(iii) LV Busduct:-

Dimensional general arrangement drawings, elevation and sectional views, dimensions, weights, support details, etc.

(iv) LV switchboard:-

Detailed design calculations for busbar sizes and temperature rise. Fully dimensional general

arrangement drawings complete with plan, elevation and sectional views, location of cable and / or bus duct entry for incoming and outgoing feeders, complete bill of material, foundation drawing and cable entry details, switchgear sizing calculation, protection relay setting calculation and setting table.

Schematic diagrams for all power, control, protection and indication circuits. Manufacturer's catalogues / literature, etc. for numerical relays and other brought-out items.

(v) Motors

Dimensional general arrangement drawings comprising plan, elevation and sectional views, dimensions, weights, foundation details, etc.

Details of frame size, bearings, starting and stalling times, motor efficiency and power factor at full, 3/4th and ½ load, type of enclosure, cooling, terminal box, space heater, etc.

(vi) -Soft Starter

Dimensional general arrangement drawings, elevation and sectional views, dimensions, weights, etc.

Schematic diagrams for all power, & control circuits.

Cable termination details with dimensions.

Detailed bill of material together with rating, makes, etc. Motor curves

Manufacturer's catalogues / literature, etc. of equipment and accessories being supplied.

(vii) Battery and battery chargers:

Dimensional general arrangement, drawings of battery and battery chargers comprising plan, elevation and sectional views, foundation details, etc. Complete schematic and wiring diagrams for battery chargers

Detailed bill of material together with rating, makes, etc. Manufacturer's catalogues / literature.

(viii) Uninterrupted Power Supply

Dimensional general arrangement, drawings of UPS comprising plan, elevation and sectional views, foundation details, etc. Complete schematic and wiring diagrams for UPS

Detailed bill of material together with rating, makes, etc. Manufacturer's catalogues / literature.

(ix) Cabling System

Layout drawings showing cable route, laying method, trench, tray and pipe /conduit layout, clamping, etc. including installation details.

(x) Lighting system

Lighting layout drawings for indoor and outdoor areas showing layout of lighting fixtures, conduit / cables, lighting circuit distribution scheme, complete bill of material, locations of control switches, receptacles, etc. and mounting details for fixtures, switches and receptacles.

Manufacturer's catalogues / literature showing dimensions, weights, ballast losses, lumen output, light distribution diagrams (zonal and isocandela), etc.

(xi) Earthing / Lightning Protection system

Layout drawings for earthing/ lightning protection system showing earthing grid, locations of



earth electrodes, routes of conductors, interconnections, earth leads to various equipment, bill of material, etc.

#### **4. ELECTRICAL EQUIPMENT GENERAL REQUIREMENTS**

##### **4.1 HT SWITCHGEAR**

HT switchgear and its components shall comply with the following standards, including those referred to therein. IEC 60265, 62271, 60529, 60044 and IS 3427, 13118, 5578, 5082, 2705 etc.

##### **4.1.1 Circuit Breaker**

- i. Circuit breakers shall vacuum type. Circuit breaker along with its operating mechanism shall be mounted on a wheeled carriage moving on guides, designed to align correctly and allow easy movement. Plugs and sockets for power circuits shall be silver faced and shall be insulated with suitable insulating material shrouds. All corresponding components of circuit breaker cubicles of same rating shall be interchangeable with one another.
- ii. There shall be 'Service', 'Test' 'Fully withdrawn' positions for the breakers. In the 'Test' position the circuit breaker shall be capable of being tested for operation without energizing the power circuits, i.e. the control circuits shall remain undisturbed while the power contacts shall remain disconnected. Separate limit switches, each having a minimum of 2 'NO' + 2 'NC' contacts, shall be provided for both 'Service' and 'Test' positions of the circuit breakers for future SCADA.
- iii. Electrical tripping shall be performed by shunt trip coils. "Local / Remote" selector switch lockable in "Local" position shall be provided on the cubicle door. 'Red' and 'Green' indicating lamps shall be provided on cubicle door to indicate breaker close and open positions. Breaker "Service" and "Test" positions shall be indicated by separate indicating lamps on the cubicle door, in case mechanical indication of "Service" and "Test" positions are not available on the cubicle door.
- iv. Connection of the control / interlocking circuits between the fixed portion of the cubicle and the breaker carriage shall be preferably by means of plug socket arrangement.
- v. Operating Mechanism Control
  - a) Circuit breakers shall be operated by a motor spring charging type of mechanism. The mechanism shall be complete with motor, opening spring, closing spring and all accessories to make the mechanism a complete operating unit
  - b) Operating mechanism shall normally be operated from the breaker cubicle itself.
  - c) The tripping spring shall be charged by the closing action, to enable quick tripping. Closing of the circuit breaker shall automatically initiate recharging of the springs to enable the mechanism to be ready for the next closing stroke. Charging time for the springs shall not exceed 30 seconds. It shall be possible to manually charge the springs in an emergency. Transfer from motor to manual charging shall automatically disconnect the charging motor. All operating mechanisms shall be provided with "ON" - "OFF" mechanical indication. The charging mechanism shall be provided with mechanical indicators to show "charged" and "discharged" conditions of the spring. Failure of any spring, vibration or mechanical shock shall not cause tripping or closing of the circuit breaker.
  - d) Only one closing operation of the circuit breaker shall result from each closing impulse (manual or electrical), even if the breaker trips while the control device (manual or electrical) is being held in the "close" position.
  - e) The circuit breaker mechanism shall make one complete closing operation, once the

push button (PB) or control switch has been operated and the first device in the control scheme has responded, even though the PB or control switch is released before the closing operation is complete, subject to the condition that there is no counter-impulse for tripping.

- f) Means shall be provided to manually open and close the breakers slowly, when the operating power is not available, for maintenance and adjustments. A local manual trip device shall also be provided on the operating mechanism.
- g) Circuit breaker control shall be on 110 V DC. Closing coils and other auxiliary devices shall operate satisfactorily at all voltages between 85-110 % of the control voltage. Trip coils shall operate satisfactorily between 70 -110 % the rated control voltage.
- h) Provision for remote control shall be provided .

vi. Safety Interlocks and Features

- a) Withdrawal or engagement of a circuit breaker / switch disconnecter shall not be possible unless it is in the open position.
- b) Operation of a circuit breaker / switch disconnecter shall not be possible unless it is in service position, withdrawn to test position or fully drawn out. It shall not be possible to close the circuit breaker electrically in the service position, without completing the auxiliary circuit between the fixed and moving portions.
- c) Circuit breaker / switch disconnecter cubicles shall be provided with safety shutters operated automatically by the movement of the circuit breaker / switch disconnecter carriage to cover the stationary isolated contacts when the breaker / switch disconnecter is withdrawn. Padlocking facilities shall be provided for locking the shutters positively in the closed position. It shall, however, be possible to open the shutters intentionally against spring pressure for testing purposes.
- d) The circuit breaker / switch disconnecter carriage shall be earthed before the circuit breaker / switch disconnecter reaches the test position from fully withdrawn position. In case of breakers / switch disconnecter with automatic disconnecting type of auxiliary disconnects, the carriage shall be earthed before the auxiliary disconnects are made and the carriage earthing shall break only after the auxiliary disconnects break.
- e) Caution nameplate, "Caution Live Terminals" shall be provided at all points where the terminals are likely to remain live and isolation is possible only at remote end, i.e. incomer to the switchboard. Suitable interlock shall be wired for the purpose.

vii. Current and Voltage Transformers

CTs and VTs shall have polarity marks indelibly marked on each transformer and at the associated terminal block. Facility shall be provided for short-circuiting and earthing the CT secondary at the terminal blocks.

CT shall be able to withstand the thermal and mechanical stresses resulting from the maximum short circuit current. Core laminations shall be of high grade silicon steel.

VTs shall be of the single phase type and mounted on a draw out trolley. VTs shall be protected on their primary and secondary sides by current limiting fuses with interrupting ratings corresponding to breaker rating. It shall be possible to replace the secondary fuses safely when the switchboard is energized. Alternatively, MCB having auxiliary contact shall be provided. Primary side fuses shall be replaceable only in the de-energized position.

Secondary winding of voltage transformer (VT) shall be rated for a three phase line to line voltage of 110 V.

Identification labels giving type, ratio, output and serial numbers shall be provided for CTs and VTs.

viii. Relays

Protection relays shall be Numerical (microprocessor based) type. Relays shall have interfacing facilities to communicate data to SCADA system.

All relays shall be enclosed in rectangular shaped, dustproof cases and shall be suitable for flush mounting.

All relays shall be accessible from the front for setting and resetting. Access to setting devices shall be possible only after the front covers of the relays are removed.

All protective relays shall be of the draw-out type and shall be provided with operation indicators visible from the front.

ix. Over Current / Earth Fault Protection

- a) This relay shall be of the multi-characteristics type which has a flexible mode selection facility so that it is possible to select one mode for the over current elements and another for the earth fault element.
- b) Phase current range shall cover at least 50-300% of 'In' in steps of not more than 10% while the earth current range shall cover at least 5-100% of 'In' in steps of not more than 5%.
- c) The time setting range of the definite time mode shall not be less than 5 seconds in steps of 0.1 second each.
- d) The time multiplier setting for the inverse time-current characteristic modes shall have a range not less than 0.05- 1.6 in steps of 0.05.
- e) Over current and earth fault relays shall have separate timers and operation indicators.
- f) The high set element shall have a range of 2 - 15 times the nominal current in steps of 'In' and shall be of low transient overreach, with a tripping time of less than 25 ms and possible to be selected on "blocked" position. Reset time shall be not more than 50 ms for both elements.
- g) The relays that are installed on the transformer neutral side shall be of single phase version, but they shall have the same characteristics as the phase side relays.

x. Restricted Earth Fault Protection

- a) The restricted earth fault relay shall be operated from a completely separate core of line and neutral current transformers. The dedicated CTs shall be of class PS and have the same magnetization characteristics with a knee 'emf' value higher than the highest possible setting of the relay. Intermediate CTs for ratio correction are not acceptable. CT sizing shall be matched with the requirements of the relay.
- b) For this protection, 1-phase high impedance relay shall be provided and all the aspects regarding stability of the protection, dimensioning of current transformer, considering the peak short circuit current, etc. and all the auxiliary equipment such as non-linear VDR resistor for voltage limiting, filter for harmonics and DC component suppression and variable shunt resistor for sensitivity adjustment, if required, shall be provided. The total fault clearing time shall not exceed 20 m sec. at  $3 \times I_n$ .
- c) The stability of this protection against out-zone faults shall be confirmed. A calculation to show the proper selection of the relay up to the maximum short circuit of the switchboard shall be submitted.

xi. Under Voltage Relays

- a) Suitable voltage operated relays for sensing loss of voltage shall be provided. The relay shall have a drop off to pick up ratio of the order 90%. The relays shall be fast operating type and shall be fitted with operation indication. The indication shall come on drop off or loss of voltage.
- b) Additional potential free contacts for all the relay outputs i.e. trip as well as alarm signals shall be provided for connection to future SCADA.

xii. Auxiliary Relays and Timers

- a) Following auxiliary relays shall be provided on each breaker cubicle:
  - i. Trip circuit supervision relay
  - ii. Anti- pumping relay
- b) Hand reset type lockout (tripping) relays and timers shall be provided as required in addition to the protection relays given in the single line diagram.
- c) Auxiliary relays and timers shall be rated to operate satisfactorily between 70 % and

- 110 % of the rated voltage.
- d) Voltage operated relays with sufficient contacts to initiate tripping, alarm, annunciation for various trip functions like Buchholz relay operation. Each relay shall have four (4) pairs of self-reset contacts except for Buchholz and "PRD" trip which shall have hand-reset contact. The relays shall have hand-reset operation indicators.
- e) Voltage operated relays with sufficient contacts to initiate alarm and data logging for various alarm functions for transformers, etc. shall be provided. Each relay shall have four (4) normally open self-reset contacts. The auxiliary relay for Buchholz alarm shall be slugged to have delay on drop off at 100 ms. The relays shall have hand reset operation indicator.

## 4.2 TRANSFORMER

Transformers and its accessories shall comply with the following Standards, including those referred to therein and any Gazette notifications by GOI.

IEC 60076, 60214, 60296 / IS 2026, IS 335 / BS 148, 171/IS 1180

Transformers should also comply to "Bureau of Energy Efficiency Notification No. 2/11(5)/03-BEE-3 issued by Ministry of Power " and the IS: 1180 Level 2.

### 4.2.1 Design Features

- a) Transformers shall be suitable for indoor duty and shall be installed inside closed room. It shall be rated for satisfactory operation at 50°C design ambient temperature. Transformers shall be designed for over-fluxing withstand capability of 110% continuous, 125% for at least 1 minute and 140% for 5 seconds.
- b) The individual Transformer KVA rating shall be designed considering maximum 80% loading on the transformer at full load with a power factor of 0.8. Both the transformers should be suitable for parallel operation.
- c) Voltage regulation of Transformer should be  $\leq 5\%$  at starting of largest motor at 0.8 power factor.

### 4.2.2 Accessories and Fittings

Each main power transformer shall have the following fittings and accessories including but not limited to:

- a) A conservator of sufficient volume with
  - i. oil level gauge with potential free contacts for initiating alarm for low oil level
  - ii. weather-proof dehydrating breathers for both compartments with activated alumina or silica gel as the dehydrating breather
  - iii. shut off valves
  - iv. filling plug and drain valves

The conservator shall be designed to maintain an oil seal up to a temperature of 100°C.
- b) Gas and oil actuated Buchholz relay with
  - i. necessary shut off valves
  - ii. test cock with pipe connections for sampling
  - iii. potential free contacts for initiation of alarm in case of slow gas formation and trip in case of fast oil and gas surges

- c) Dial type thermometer with
  - i. maximum temperature indicator and its resetting device
  - ii. potential free contacts for initiating alarm on high temperature and trip on very high temperature
- d) Winding temperature indicator with
  - i. necessary sensing, compensating and calibrating devices
  - ii. potential free contacts for initiating alarm on high temperature and trip on very high temperature
  - iii. WTI transmitter for remote indication on remote tap changing panel if required
- f) Detachable type of radiators including but not limited to:
  - i. Shut-off valves and blanking plates on transformer tank at each point of connection of inlet and outlet header
  - ii. Top and bottom shut-off valves and blanking plate on each radiator
  - iii. Lifting lugs
  - iv. Top oil filling plug, 19 mm size
  - v. Air release plug at top
  - vi. Oil drain plug at bottom, 19 mm size
  - vii. Earthing terminals
- g) Pressure relief device for transformer tank
- h) Weather - proof marshaling box mounted on transformer tank
- i) Name plate, rating plate and Diagram plate
- j) Valves and plugs as below:
  - i. Drain valve
  - ii. Filter valve
  - iii. Oil sampling valves at top and bottom
  - iv. Valves between radiators and tank (in case of detachable radiators)
  - v. Air release plug
  - vi. Twin outlets (with plug) for applying vacuum with attachments.
- k) Earthing pads of copper or non-corrodible material for transformer tank (2 places) and radiator banks
- l) Inspection manholes as required
- m) Lifting arrangement for
  - i. fully assembled transformer
  - ii. core and coil
  - iii. tank
- n) Hauling eyes on each face of the transformer
- o) Bi-directional flanged wheels
- p) Anti-earthquake clamping devices
- q) Jacking pads

Each auxiliary transformer shall have the following fittings and accessories including, but not limited to:

- a) Conservator with oil level gauge

- b) Dehydrating silica gel breather
- c) Oil temperature indicator
- d) Thermometer pocket
- e) Explosion vent diaphragm / pressure relief valve
- f) Sampling and drainage valves
- g) A plug or blank flange at the top for connecting valve for filtration
- h) Two earthing terminals
- i) Rating plate (Name plate and diagram plate)
- j) Lifting lugs
- k) Removable plain rollers
- l) Adequate number of air vents for relieving trapped air during oil filling and during maintenance.
- m) Accessories for clamping the wheel to the foundation channel in order to withstand earthquake forces.

#### **4.2.3 Windings**

The windings shall be of electrical grade copper.

Materials used in insulation and assembly shall be insoluble, non-catalytic and chemically inactive in the hot transformer oil and shall not soften or otherwise be affected under operating conditions. Windings and insulation shall be so arranged that free circulation of oil is possible between coils, between windings, and between winding and core.

Leads from winding to the terminal board and bushings shall be rigidly supported to prevent injury from vibration. Guide tubes shall be used where practicable.

Windings shall be subjected to shrinking and seasoning processes so that no further shrinkage occurs during service. Adjustable devices shall be provided to take up possible shrinkage in service. High voltage end - windings shall be suitably braced to withstand short circuit stresses.

#### **4.2.4 Core**

The magnetic circuit shall be constructed from high grade, cold rolled, non-ageing, grain oriented silicon steel laminations. Each sheet shall have an insulating coating resistant to the action of hot oil. Each lamination shall be coated with insulation which is unaffected by the temperature attained by the transformer during service.

The insulation structure for the core to bolts and core to clamp plates shall be such as to withstand appropriate dielectric test. All steel sections used for supporting the core shall be thoroughly shot or sand blasted after cutting, drilling and welding. Core laminations shall be annealed and burrs removed after cutting. Cut edges shall be insulated. The framework and clamping arrangements of core and coil shall be securely earthed inside the tank by a copper strap connected to the tank. The core clamping structure shall be designed to minimize eddy current loss. The core shall be provided with lugs suitable for lifting the complete core and coil assembly. The framework and clamping arrangements shall be securely earthed.

The core and coil assembly shall be dried out and impregnated under vacuum.

#### **4.2.5 Tank**

The transformer tank shall be made from high-grade sheet steel, suitably reinforced by stiffeners made of structural steel sections. All seams, flanges, lifting lugs, braces, and other parts attached to the tank shall be welded. The interior of the tank shall be cleaned by shot blasting and painted with two coats

of heat resistant, oil insoluble paint. Adequately sized manholes shall be provided for ease of inspection and maintenance. Steel bolts and nuts exposed to atmosphere, shall be galvanized. Tank together with radiators, conservator, bushings and other fittings shall be designed to withstand without permanent distortion the following conditions:

- a) Full vacuum of 760 mm of Hg for filling with oil under vacuum
- b) Internal gas pressure of 0.35 kg/cm<sup>2</sup> with oil at operating level

Tank shall be provided with a pressure release device, which shall operate at a pressure below the test pressure for the tank and radiators. The device shall be provided with a device visible from ground to indicate operation. An equalizer pipe connecting the pressure relief device to the conservator shall be supplied. The device shall be provided with potential free contacts for alarm and tripping. Alternatively, a separate pressure relay shall be provided for this purpose.

The tank cover shall be bolted type and not welded, sealed type. The tank cover shall be removable and shall be suitably sloped so that it does not retain rainwater.

#### **4.2.6 Radiators**

Radiators shall be designed to withstand the vacuum pressure conditions specified for the tank. They shall be so designed as to completely drain oil into the soak pit and to prevent formation of gas pockets when the tank is being filled.

Transformers of rating above 1500 kVA shall be equipped with detachable or separately mounted radiator banks. Radiators for the main transformers shall be with bolted and gasket flange connections. Transformers of rating 1500 kVA and below shall be provided with fixed type radiators. Fins of the radiators shall not have sharp edges and shall be rounded in shape.

When transformers are provided with separately mounted radiators, flexible joints shall be provided on the main oil pipes connecting the transformer tank to the radiator banks, to reduce vibration and facilitate erection and dismantling. The interconnecting pipes shall be provided with drain plug and air release vents.

#### Off-circuit tap changer

Off circuit tap changer shall be provided for auxiliary transformers. It shall comprise

- a) Operating handle or wheel accessible from ground level
- b) Tap position indicator
- c) Padlocking arrangement with padlock.

#### **4.2.7 Marshalling Box**

The marshalling box shall be tank mounted, weather proof, vermin proof, dust proof, sheet steel (2 mm thick), enclosed and with hinged door having padlock. Door and gland plate shall be fitted with neoprene gaskets. Bottom shall be at least 600 mm from grade level. Top surface shall be sloped. The degree of protection shall be IP65.

Contacts / terminals of electrical devices / relays, etc. mounted on the transformer shall be wired to the marshalling box. Interconnecting wires between the marshalling box and the accessories / devices shall be either PVC insulated wires in GI conduits or PVC insulated, armoured cables together with provision of double compression type, brass cable glands at the marshalling box. The above mentioned cables as well as terminating the cables shall be the Contractor's responsibility.

All contacts for alarm, trip and indication circuits shall each be electrically free, designed for the

auxiliary DC supply of 110 V and brought out to separate terminals in the marshalling box. Terminals shall be rated for 10 A. Disconnecting / shorting type terminal block shall be used for CT circuits.

In case of main transformers, provision for remote annunciation shall be provided with two changeover contacts for alarm condition and two changeover contacts for trip condition for each of the following conditions including but not limited to:

- a) Buchholz alarm
- b) Buchholz Trip
- c) Oil Temperature high
- d) Oil Temperature very high
- e) Oil level low
- f) Pressure relief device operated
- g) Winding temperature high
- h) Winding temperature very high
- i) Conservator oil level low

#### **4.2.8 Cable Terminations**

Cable boxes shall have sufficient space for segregating the cable cores and for adequate clearance in air between bare conductors at the terminals. Cable boxes shall be complete with necessary glands, lugs and armour grips.

Air filled cable boxes shall be of adequate dimensions and designed in such a manner that they can be opened for inspection without disturbing the gland plate or incoming cable. Disconnecting chamber shall be provided for disconnecting and moving away the main transformer, without removing the cables or the cable box. Provision shall be made for earthing the body of each cable box.

#### **4.2.9 Tests**

All tests required by the specification including repeated tests and inspection that may be necessary owing to the failure to meet any tests specified, shall be carried out at the Contractor's expense.

The following tests shall be carried out on the assembled transformer during inspection at the manufacturer's works.

- a) Temperature rise test on one transformer
- b) Measurement of resistance of windings at principal and extreme taps
- c) Ratio at each tap, polarity and phase relationships
- d) Measurement of impedance voltage at principal and extreme taps
- e) Measurement of no load current and no load losses at rated frequency and at both the rated voltage and 110 % rated voltage
- f) Measurement of efficiency and regulation at  $\frac{1}{2}$ ,  $\frac{3}{4}$  and full load
- g) Measurement of insulation resistance
- h) Induced over voltage withstand test
- i) Separate source voltage withstand test
- j) Magnetic balance test
- k) Test on OLTC

Type test certificates shall be provided for verification. Whenever two nos. or more identical transformers are being offered, type tests on one of them shall be carried out, including heat run test.

All auxiliaries and accessories such as temperature indicators, Buchholz and pressure relays shall be tested as per the applicable standards and test certificates shall be furnished to the Employer's Representative for approval.



### 4.3 LV Busduct

LV Busduct and its components shall comply with the following standards, including those referred to therein. IEC 60105, IS 8084, 5082, 816, 2629 etc.

#### 4.3.1 Bus Enclosure

##### i. Material

Phase busbars shall be enclosed in a weather proof, dust tight, non magnetic metal (for NSPBD the same shall be of mild steel or Aluminium) preferably rectangular in shape. The minimum enclosure thickness shall be 3mm. Degree of protection of enclosure shall meet the requirements of Appendix-F of IS-8084.

Circumferential neoprene rubber gaskets (Joint less type) shall be provided for dust tight joints with adjacent enclosures sections.

Busduct shall be self cooled without any forced ventilation.

##### ii. Construction

The entire bus duct shall be designed for indoor installation, with a dust and vermin-proof construction.

##### iii. Painting

The inside of the bus enclosure shall be treated with a matt paint of dark colour, preferably black to facilitate efficient heat dissipation. The bare enclosure with above painting shall be designed so as not to exceed the temperature specified in IS:8084. BIDDER shall submit supporting test certificates.

##### iv. Bellow Joints

Joints consisting of metallic or rubber expansion bellows shall be provided on the bus enclosure at following points :

- (a) At terminations at transformers
- (b) At terminations at switchgear cubicles

##### v. Flexible Expansion Joints

Flexible expansion joints for the enclosure shall be provided wherever deemed necessary by the VENDOR. The flexible joints shall take care of expansion and contraction due to temperature variations and fault conditions.

##### vi. Bonding

Necessary bonding shall be provided at the above expansion joints if joints are made of insulating material.

##### vii. Terminal Enclosures and Flanges

- (a) Three-phase terminal enclosures shall be provided with flanged ends with drilling dimensions to suit the flange at equipment terminals.
- (b) The flanges shall be provided with gaskets, nuts, bolts etc.
- (c) It shall be the responsibility of the VENDOR of the bus duct to coordinate with various equipment (by OTHERS) to which his bus duct has to be terminated to ensure proper alignment of the bus duct with these equipment.

##### viii. Inspection Covers

Suitable inspection openings shall be provided for access to support insulators, bus joints transformer, switchgear terminals etc. The inspection covers shall be provided at the bottom with quick-acting stainless steel clamps and shall have reliable sealing arrangement with neoprene gaskets. There shall be no joints or fixing bolts on the top surface through which water could seep through.

ix. Drain Plugs and Vents

The drain plugs shall be easily removable for cleaning purposes.

x. Gaskets

(a) The gasket material and thickness shall be so selected as to satisfy the operating conditions imposed by temperature, weathering, durability, etc. Care shall be exercised to ensure that covers fit easily, that the required compression of the gaskets can be obtained without damage to the inspection covers by bolts and that covers do not bend after this compression has been applied. Over-compression of the gaskets shall be avoided.

(b) The material of the gasket shall preferably be neoprene closed-cell sponge rubber or equivalent.

(c) Flange gaskets shall be provided at the equipment terminal connections.

xi. Miscellaneous Hardware

The bus duct shall not have any through bolts. All nuts and bolts shall be mild steel hot dip galvanised. GS spring washers shall be provided for making satisfactory joints. Clamps splice plates etc. shall be provided wherever necessary.

#### 4.3.2 Bus Conductor

i. Material

The material of the conductor shall be aluminium alloy or copper as specified in Data Sheet. The grade of aluminium alloy or copper shall be indicated by the BIDDER in his Bid and shall be subject to the PURCHASER'S approval.

ii. Rating

The temperature rise of conductor shall be as per IS: 8084. Also the temperature of the bus shall not exceed 250°C while carrying the specified short circuit current for one second when a fault occurs at the operating temperature.

iii. Painting

The bus conductor shall be given a coat of matt black paint to facilitate heat dissipation. The bare conductor with above painting shall be designed to carry the normal rated current without exceeding temperature rise as specified in IS: 8084.

(a) Neutral Conductor (Optional)

Fully rated, isolated and insulated neutral conductor shall be provided when specified.

iv. Joints

(a) The bus conductor shall be designed for bolted connections throughout the run (high grade stainless steels nuts bolts plain & belle-ville washers).

(b) All joint surfaces shall be silver-plated or tin-plated to ensure maximum conductivity through the joint. Aluminium / copper flexible connections shall be provided maximum at 10 meters interval between bus sections to allow for expansion & contraction of the conductor. Flexible connection shall also be provided at all equipment terminations.

(c) At all silver/tin plated joints, suitable jointing compound shall be used to prevent galvanic corrosion and deterioration of joint.

(d) Bimetallic connectors shall be used for connections where bus conductor material is different.

v. Clamps and Hardware

(a) The busbar clamps at insulators shall be designed to withstand the forces due to momentary short circuit current. They shall permit free longitudinal movement of the bus

bars during expansion and contraction. The material of the clamps shall be aluminium alloy. Suitable copper or aluminium spacers shall be provided wherever necessary.

(b) All bolts, nuts and lock washers used in the bus assembly shall be of high tensile steel, plated for corrosion resistance. Spring washers of “Beleville” type or equivalent shall be used.

(c) Suitable splice plates and bimetallic connectors shall be provided wherever necessary.

#### vi. Disconnecting Links

Disconnecting links with rating same as that of the main busbars shall be provided in the run of the bus duct at the points as specified in Data Sheet to facilitate disconnection of the busbars during testing and maintenance. The separation of the busbar sections with the bolted links removed shall be sufficient to withstand the rated voltage of the bus duct.

A minimum clearance of 300mm shall be provided between the disconnected bus sections with the link removed.

#### vii. Shorting Links

(a) Shorting jumpers, for the purpose of drying out the equipment before commissioning or for carrying out short circuit test on the equipment, rated for the main bus current shall be supplied for shorting the bus duct at a location, adjacent to the disconnecting links or as specified in Data Sheet.

(b) The shorting links shall have drilling dimensions matching those of the main bus disconnecting links. Suitable supporting structures and support insulators for the shorting links if necessary shall also be offered.

### 4.3.3 Bus Support Insulators

Within the bus duct the bus shall be mounted and supported on insulators. The insulators shall be mounted on resilient pads provided in the bus enclosure.

#### Material

(a) The insulators shall be either fine glazed porcelain or resin cast.

(b) For bus ducts with voltage rating upto 1100 Volt, Fibre glass/FRP or equivalent type of non-hygroscopic insulating supports are acceptable. The bus support insulators shall be of for non-segregated phase bus ducts. Suitable space heater shall be provided preferably located near to each insulator to avoid moisture condensation within bus-duct.

### 4.3.4 Wall Frame Assembly and Seal-Off Bushings

#### i. Wall Frame Assembly

The wall frame shall be fabricated out of aluminium angles and sheet and shall be suitable for grouting in the wall. It shall be provided with flanges on both sides to receive the bus duct flanges.

Silica gel breather shall be provided on both indoor and outdoor portions of the bus duct.

#### ii. Seal-off Bushings

Seal of bushings shall be provided at each switchgear termination. Wherever busduct crosses internal wall of the building, wall frame assembly shall be provided. Seal-off bushings shall prevent interchange of air at different temperatures. The seal-off bushings shall be flanged type.

Seal off bushing shall be of Epoxy resin cast material or porcelain. The bushings shall be designed for thermal expansion/contraction due to temperature differential for outdoor/indoor use.

### iii.Phase Transposition

Phase transposition is normally provided within the switchgear equipment. However, when required, it can be provided within the bus run system to align phasing of terminal equipment at two ends.

## 4.3.5 Bus Duct Supports

### i.Material

The supporting structure shall be fabricated from standard steel sections and shall be hot dip galvanised after fabrication. The hot dip galvanising shall be in accordance with standards listed in Data Sheet.

### ii.Mechanical Strength

Calculations shall be furnished to substantiate the strength support structure to withstand the various static and dynamic loadings.

### iii.Accessories and Hardware

The supporting structures shall include supporting members, brackets, hangers, longitudinal beams, channels, nuts, bolts, washers and all other hardware which are necessary for the erection and support of the entire bus duct installation. All the accessories and hardware of ferrous material shall be hot dip galvanised.

### iv.Method of Support

The bus duct may be supported from the floor or ceiling beams.

### v.Earthing

A separately run 50 x 6 mm/ 25x6 mm G.I. flat suitably clamped along the enclosure shall be used as the ground bus. All parts of the bus enclosure, supporting structures and equipment frames shall be bonded to above ground bus.

Ground pad shall be bolted type to accommodate 50 x 6 mm/25 x 6 mm galvanized steel flats. Complete with suitable tapped holes, bolts and washers.

## 4.3.6 Markings

All components of the bus duct along with the supporting structure shall be distinctly marked for erection in accordance with the erection drawings to be prepared and furnished by the VENDOR. These marks shall be made in a manner as not to be obliterated and erased in transit or to damage the galvanising of the bus duct or the supporting structure.

## 4.3.7 Miscellaneous

Studs, nuts, bolts and tapped holes shall conform to the relevant standards. Only hexagonal nuts shall be used. All bolt holes shall be spot faced for nuts.

Castings and forgings shall conform to respective material specifications and shall be free from flaws. They shall be machined true as per good workshop practice. Welding shall be performed in accordance with relevant recognized standards.

All threaded pipe connections and fittings, pipe flanges and tube fittings shall comply with relevant standards.

## 4.3.8 Design Requirements of Bus Duct

(i)The Bid shall contain design calculation in support of the bus duct design:

(a) Sizing of the busbars vis-à-vis thermal capability to withstand rated continuous current and one second short time current.

(b) Spacing of the insulators vis-à-vis mechanical strength to withstand forces due to momentary short circuit current.

(c) Heat loss and temperature rise calculations for conductor and enclosure. All formulae and other information from which the heat losses have been derived shall be enlisted.

#### **4.3.9 Space Heaters**

The bus duct shall be provided with adequate number of thermostatically controlled space heaters of adequate capacity to maintain the internal temperature above the dew point to prevent moisture condensation within the bus duct. The space heaters with thermostat shall be rated for 240 V single phase, 50 Hz, AC supply. The space heater shall be automatically controlled by differential thermometers. An ammeter of suitable range may be provided in series with space heater circuit of bus duct to monitor proper functioning of space heaters. The wiring inside busduct shall be done with high temperature resistant cable suitable for the bus maximum temperature specified. The conductor shall be stranded Al/copper. A separate ON-OFF switch with contactor shall be provided for controlling the space heated in a marshalling box located at convenient height adjacent to the busduct.

#### **4.3.10 Test Equipment**

Vendor shall ensure to use calibrated test equipment having valid calibration test certificates from standard laboratories traceable to National Standards.

#### **4.3.11 Spares**

Whether included in the BIDDER's recommendation or not, unit prices of the following items shall be quoted together with their suggested quantities and catalogue numbers:

- i. Bus support insulators
- ii. Flexible connector
- iii. Isolating link
- iv. Different type of gaskets
- v. Seal-off bushing

### **4.4 LV SWITCHBOARD**

LV indoor switchboard and its components shall comply with the following Standards, including those referred to therein. IEC 60269, 60947 & 61459, BS 5486 and IS 13947, 2705, 3156, 722, 10118, 5578 etc.

#### **4.4.1 Constructional Features**

The major parameters of the switchgear and other required features are given in data sheet of particular specifications. The bidder shall in his offer specifically conform compliance of these data in full. Deviation if any should be specifically brought out in the schedule of Technical Deviation.

The switchgear shall be indoor, metal enclosed, floor mounted of uniform height not more than 2450 mm, made up of the requisite vertical sections, dust and vermin proof construction with IP - 52 degree of protection, unless otherwise stated and the degree of protection provided by enclosures against external mechanical impacts shall be IK08 minimum. Panels shall be supplied with base channel (ISMC 75/ 100 or so) which will be an integral part of the panel.

Adjacent switchgear cubicles shall be provided with side sheets on either side to ensure complete isolation. The switchgear shall be easily extendable on both sides by the addition of vertical sections.

From internal isolation point of view, the switchgear shall be designated in the following form of separation.

Form 1: No internal separation

Form 2: Separation of busbars from the functional units

Form 2a: Terminals not separated from bus bars

Form 2b: Terminals separated from bus bars

Form 3: Separation of busbars from the functional units

Separation of all functional units from one another

Form 3a: Terminals not separated from bus bars

Form 3b: Terminals separated from bus bars

Form 4: Separation of busbars from the functional units

Separation of all functional units from one another

Separation of terminals from those of any other functional unit

The bottom of the switchgear shall be fully covered by sheet steel.

Removable gland plates shall be provided for power and control cables. The gland plates shall be 3mm thick for panel with breaker cubicles and 2mm thick for other cubicles. The gland plates for single core cables shall be of non-magnetic material.

All sheet steel work shall be thoroughly cleaned of rust, scale, oil, grease, dirt and swarf by pickling, emulsion cleaning etc. The sheet steel shall be phosphated and then painted with two coats of zinc rich primer paints. After application of the primer, two coats of finished synthetic enamel oven-baked / stoved, paint shall be applied or powder coated.

Each switchgear cubicle shall be fitted with a label in the front and back of the cubicle. Each switchgear shall also be fitted with label indicating the switchgear designation, rating and duty. Each relay, instrument, switch, fuse and other devices shall be provided with separate labels.

Operating devices shall be incorporated only in the front of the switchgear. No equipment needing manual operation shall be located less than 250 mm above ground level.

The switchgear shall be divided into distinct vertical sections comprising of

Individual feeder module which shall be integral multiples of basic module, containing all associated equipment, enclosed in sheet steel enclosure on all sides and the rear except cable alley side and provided with hinged door on the front.

A completely metal enclosed, busbar compartment running horizontally, and a vertical busbar compartment serving all modules in vertical section

A vertical cable alley covering the entire height, except horizontal busbar compartment with minimum 250 mm width for MCC modules at right hand side and minimum 200 mm for circuit breaker controlled modules, with adequate number of slotted cable support arms.

A horizontal separate enclosure or enclosures separated by phylum/FRP sheets for power and control buses with tap off connections to each vertical section.

The circuit breakers shall be fully draw out type. The circuit breakers shall have distinct service, test, isolated and maintenance positions. In the test position the circuit breakers shall be capable of being tested for operation without energising the power circuits. Four normally open auxiliary contacts shall be provided for each of the services and test limit positions switches.

The test position should preferably be obtained without the need to disconnect normal control connections and use extension cords for testing.

The current transformers shall be mounted on the fixed portion of the switchgear but not directly on buses or the breaker truck.

The withdraw able chassis housing feeder for motor control equipment except circuit breakers/common control transformers of big size, shall be of the fully draw-out, semi-draw-out, or fixed type as specified in the Data Sheet.

i. Fully Drawout Type Withdrawable Chassis

In this type of construction it shall be possible to drawout the withdrawable chassis without having to unscrew or unbolt any connections to the equipment mounted on the withdrawable chassis. The power and control drawout type connections shall be of the stab-in or sliding type. All drawout contacts, including for auxiliary and control wiring shall be of self aligning type.

ii. Semi-Draw-out Type Withdrawable Chassis

In this type of construction, it shall be possible to draw-out the withdrawable chassis after manually unplugging at the terminal blocks the control circuit connections of the equipment mounted on the withdrawable chassis, without having to unbolt any power connections of the equipment. The power connections shall be of the stab-in or sliding type and shall be disconnected when the chassis is withdrawn.

iii. Fixed Type Withdrawable Chassis

In this type of construction all power connections to the equipment mounted on the withdrawable chassis shall be of the bolted type. All control circuit connections to equipment mounted on the withdrawable chassis shall be carried out through conventional terminal blocks mounted in the respective chassis. It shall be possible to draw-out the chassis after unbolting/ unscrewing all the power and control circuit connections to the equipment mounted on the withdrawable chassis.

All identical equipment and corresponding parts including chassis of drawout modules of the same size shall be fully interchangeable, without having to carry out modifications.

The draw-out contacts shall be made of copper/ copper alloy/aluminium faces, which shall be silver or tinned.

If ventilating louvers are provided they shall be provided with fine-screened brass or GI meshes from inside to prevent entry of vermin and dust.

**4.4.2 Main and Auxiliary Buses**

Busbars shall be of uniform cross section throughout the length of the switchgear, and up to the incoming terminals of the incoming feeder circuit breaker/ switch.

All busbars shall be provided with heat shrinkable type PVC sleeves, all bus taps, joints shall be insulated with molded caps. If insulating sleeve is not colored, busbars shall be color coded with colored bands at suitable intervals.

Busbars shall be adequately supported on insulators. These shall withstand dynamic stresses due to short circuit currents specified.

All bus joint connections shall be made with a minimum of two grade 5 bolts and secured by lock washers and washers to withstand mechanical forces exerted during short circuits

**Auxiliary Buses**

Auxiliary buses for control power supply, space heater power supply or any other specified service shall be provided. These buses shall be insulated, adequately supported and sized to suit specific requirements. The material of control power supply buses shall be electrolytic copper. The material for space heater power supply buses shall be same as that for the main power buses. Supply transformer(s), auxiliary busbars and necessary connections to the supply transformers and associated circuits shall be in the VENDOR'S scope.

**4.4.3 Safety Interlocks and Features**

Withdrawal or engagement of circuit breakers or switch (isolator) shall not be possible unless it is in the open position.

Operation of circuit breaker shall not be possible unless it is fully in service positions or in test position or is fully drawn out.

Circuit breaker cubicles shall be provided with safety shutters operated automatically by the movement of the circuit breaker carriage, to cover the exposed live parts when the breaker is withdrawn.

Caution name plate with inscription "Caution - Live Terminals" shall be provided at all points where the terminals are likely to remain live and isolation is possible only at remote end, e.g. incoming terminals.

A breaker of given rating shall be prevented from engaging with a stationery element of higher rating.

Padlocking provisions shall permit locking the circuit breaker in either the "test" or "disconnected" position.

**4.4.4 Circuit Breakers**

Circuit breakers shall be provided with following accessories.

Mechanically operated targets to show 'Open', 'Closed', 'Service' and 'Test' positions of the circuit breaker. Padlock devices shall be provided in order to control opening/closing and racking in/out of the circuit breaker



Mechanically operated, red 'trip' push button, shrouded to prevent accidental operation. Circuit breaker main contacts should be separate from arcing contacts

Locking facilities in the 'Service', 'Test', and 'Isolated', positions. In test position the breaker will be tested without energizing the power circuits. The breaker shall remain fully housed inside the compartment in the test position. Complete operation of the circuit breaker and trip unit must be accessible without opening the circuit breaker door

Minimum 6 NO and 6 NC potential free auxiliary contacts, rated 10 A at 240V A.C. and 1A (inductive breaking at 220 V D.C.)

'Red', 'green' and 'amber' indicating lamps to show 'Closed' 'Open', and 'Auto-trip' conditions of the circuit breaker when breaker operation is controlled by a control switch.

Closing and trip coil shall operate satisfactorily under the following conditions of supply voltage variation:

- (a) Closing coils - 85% to 110% of rated voltage.
- (b) Trip coils - 70% to 110% of rated voltage.

When series trip circuit breakers are specified the following releases with adjustable settings shall be provided: (Oil dash-pot type release is not acceptable):

- (a) Overload
- (b) Short circuit
- (c) Under voltage

In addition to the adjustable current setting range specified in the Data Sheet short circuit releases shall be provided with at least four adjustable time delay settings, If it is not possible to provide the specified adjustable current.

setting range for the short circuit releases, shunt trip circuit breakers together with necessary protective relays shall be offered and shall be indicated in Data Sheet.

Facilities shall be provided for blocking the under-voltage release, if so required at Site.

Each of the foregoing releases shall be provided with a single pole, double throw, potential free alarm contact rated for 0.5A, 220V D.C / 10A, 240V AC.

#### **4.4.5 Spring Operated Mechanism**

The operating mechanism shall be manually operated spring charging stored energy type or with motor, opening and closing springs, limit switches for automatic charging and all necessary accessories. Facility for manual charging of the closing spring shall be provided. The operating mechanism shall be trip-free and non-pumping electrically. An antipumping relay to achieve electrical anti-pumping feature even if the breaker has provision for anti-pumping by mechanical arrangement.

Power operated mechanism shall be:

Provided with facilities for remote panel closing and opening operations whenever specified in Data Sheet as per breaker module designation and respective enclosed control scheme drawing.

The control scheme will be as follows for remote control:

Sl. No.	Breaker Position	Service		Test	
		Local	Remote	Local	Remote
(a)	Switchgear Protection Tripping	Yes	Yes	Yes	Yes
(b)	Remote Interlock Tripping	Yes	Yes	-	-
(c)	Switchgear Manual Closing	-	-	Yes	-
(d)	Remote and Auto Closing through Interlocks	-	Yes	-	Yes
(e)	Switchgear Manual Tripping	Yes	-	Yes	-
(f)	Remote Manual Tripping	Yes	Yes	-	Yes
(g)	Local P.B. Station of Motor (For breaker Operated motors)				
(i)	Closing for trial run	Yes	-	-	-
(ii)	Tripping	Yes	Yes	Yes	Yes

Power operating mechanisms shall be provided with the following additional features:

Closing of the circuit breaker shall automatically initiate recharging of the spring ready for the next closing stroke.

The motor shall be mechanically decoupled as soon as the emergency manual charging handle is coupled.

#### 4.4.6 Protection Coordination

It shall be the responsibility of the Vendor to fully coordinate the overload and short circuit tripping of the circuit breakers with the upstream and downstream circuit breakers/fuses/motor starters, to provide satisfactory discrimination.

#### **4.4.7 Air Break Switches**

Air break switches shall be of the heavy duty, group operated load-break, fault-make type, complying with the requirements of applicable standards mentioned in Data Sheet.

Continuous current rating of switches shall be as specified in Data Sheet or single line diagram enclosed with specification.

Whenever solid link are used for the connections between switches and fuses, such links shall be fitted with insulated sleeves. Whenever the links are of less than 100 mm length where sleeves cannot be fitted, taping is acceptable.

All live parts of the switch shall be shrouded.

Switch operating handle shall be suitable for padlocking in 'OFF' position.

It shall be possible to open the door only when the switch is in the 'off' position.

Suitable means shall be provided to intentionally release the interlocks specified in the preceding clause 6.6 for making trip setting adjustments and operation tests.

#### **4.4.8 Fuses**

Fuses generally shall be of the HRC cartridge fuse-link type having a certified rupturing capacity of not less than 80 kA at 440V.

Fuses shall be provided with visible indication to show that they have operated.

Fuse ratings chosen by the VENDOR for application in various circuits shall be subject to the PURCHASER'S approval.

Fuses shall preferably be mounted in moulded plastic carriers and shall be complete with fuse bases.

Wherever it is not possible to mount fuses on carriers, fuses shall be directly mounted on plug-in type of bases. In such cases an insulated fuse pulling handle shall be provided for each size of fuse for each switchboard.

Current time characteristics of fuses shall be furnished along with bid.

#### **4.4.9 Motor Starters**

##### **i. Contactors**

Motor starter contactor shall be of the electromagnetic type rated for uninterrupted duty as defined in applicable standards unless otherwise specified in Data Sheet.

Operating coils of contactors shall be suitable for operation from the control supply system specified in Section-B or as per enclosed control schemes.

Class of coordination for starter module shall be class '2'.

##### **ii. Direct-On-Line Starters**

Direct-on-line starters shall be suitable for Class AC 3 utilization category as specified in applicable standards, unless otherwise mentioned in Data Sheet.

##### **iii. Reversing Starters**

Reversing starters shall comprise forward and reverse contactors, electrically interlocked with each other.

Reversing starters shall be suitable for Class AC 4 duty as specified in applicable standards, unless otherwise mentioned in Data Sheet.

#### **4.4.10 Thermal Overload Relays**

Starters shall be complete with a three element, positive acting, ambient temperature compensated, time lagged thermal overload relay with adjustable settings and built in single phasing preventer. The setting range shall be properly selected in accordance with the rating of the motor.

Thermal overload relays shall be hand reset type, unless otherwise specified in Data Sheet.

'Stop' push button of the starter and hand reset device shall be separate from each other.

Overload relay hand reset push button shall be brought out on the front of the compartment door.

#### **4.4.11 Switch and Contactor Ratings**

Switch and contactor rating for various motor starter modules shall be selected by the bidder and indicated in the bid. BIDDER shall also select appropriate ratings for HRC fuses and ranges for thermal overload relays and indicate the same in the bid. These details shall be subject to the PURCHASER'S approval.

##### **Molded Case Circuit Breakers**

Molded case circuit breakers (MCCBs) shall be provided when called for in Data Sheet for use in lieu of switch-fuse for the motor controls. The MCCBs shall conform to the latest applicable standards.

MCCBs in AC circuits shall be of triple/four pole construction arranged for simultaneous three/four pole manual closing and opening. If indicated in Data Sheet, power closing device for remote operation shall be provided. Operating mechanism shall be quick-make, quick-break and trip-free type. The ON, OFF and TRIP positions of the MCCB shall be clearly indicated and visible to the operator. Operating handle for operating MCCBs from door of board shall be provided.

The instantaneous short circuit release shall be so chosen by the VENDOR as to operate at a current in excess of the peak motor inrush current and a range of settings shall be provided for the PURCHASER'S selection.

MCCB terminals shall be shrouded and designed to receive cable lugs for cable sizes relevant to circuit ratings.

##### **Miniature Circuit Breakers**

Miniature circuit breakers for use on motor space heater control circuits shall comply with the requirements of applicable standards, unless otherwise mentioned in Data Sheet.

**4.4.12 Earthing**

An earthing bus shall be provided at the bottom and extended throughout the length of the switchgear. It shall be bolted / welded to the frame work of each unit and each breaker earthing bar.

All non-current carrying metal work of the switchgear shall be effectively bonded to the earth bus. Hinged doors shall be earthed through flexible earthing braid.

Positive earthing of the circuit breaker frame shall be maintained both in service and test position.

**4.4.13 Instrument Transformers**

The ratings of instrument transformers specified in Data Sheet are approximate. The BIDDER shall ensure that the specified ratings are adequate for the relays and meters furnished by him. If specified ratings are not adequate the BIDDER shall offer instrument transformers of required rating.

The CTs and VTs shall be dry type and withstand momentary and short time current ratings of the associated switchgear. For feeders with fuse, CTs shall have withstand capacity equal to let-through current of associated fuse.

Unless otherwise specified minimum performance requirements of CT's & VTs shall be as follows.

Current Transformers:

(a) Measuring CTs - 10VA, accuracy Class 1.0 and ISF of 5 Protective CTs - 10 VA, accuracy class of 5P-10

(b) CTs shall be provided with test links in both secondary leads for carrying out current and phase angle measurement.

Voltage Transformer

(a) Measuring VT's - 50 VA per phase with accuracy class of 1.0

(b) Protective VT - 50 VA per phase with accuracy class of 3.0.

(c) Dual purpose VT - 100 VA per phase and dual accuracy of 1.0/3.0 for metering and protection respectively

(d) Voltage transformer shall have continuous over voltage factor of 1.2 and short time over voltage factor of 1.5 for 30 seconds for effectively earthed system and 1.9 for 8 hours for non-effectively earthed system.

(e) Voltage transformers shall be complete with suitable rated primary, secondary and tertiary fuses. Primary fuses shall have a rupturing capacity equal to the rupturing capacity rating of the associated switchgear. Fuses shall be provided on each sub circuit.

(f) It shall be possible to replace voltage transformers without having to de-energise the main bus bars.

(g) The terminals of V.T. secondary and tertiary windings which are required to be connected to earth shall be earthed by an isolating link without a fuse.

#### **4.4.14 Switchgear Accessories and Wiring**

Switchgear shall be supplied completely wired internally upto terminal blocks ready for the PURCHASER's external cable connections at the terminal blocks. Inter panel wiring between cubicles of same switchgear shall be routed inside by the VENDOR.

All auxiliary wiring shall be carried out with 1100 volts grade, single core, stranded copper conductor with PVC insulation. The sizes of wire shall be not less than 2.5 mm<sup>2</sup> per lead of CT circuits and 1.5 mm<sup>2</sup> per lead of other circuits.

Terminal blocks shall be of stud type, 1100 volts grade, 10 amps. rated complete with insulated barriers. Terminal blocks for CTs and VTs shall be provided with test links and isolating facilities and CT terminals shall have short circuiting and earthing facility.

All spare contacts and terminals of cubicle mounted equipment and devices shall be wired to terminal blocks.

Accuracy class for indicating instruments shall be 2.0 or better. Instruments shall be 96 mm square 90° scale for semi-flush mounting with only flanges projecting.

Relays shall be suitable for semi-flush mounting with only flanges projecting.

All protective relays shall be in draw-out cases with built-in test facilities. Necessary test plugs shall be supplied loose and shall be included in the VENDOR'S scope of supply. All auxiliary relays and timers shall be supplied in non-draw-out cases. All relays shall be of self reset type except lockout relay unless otherwise specified. Externally operated hand reset flag indicators shall be provided on all relays and timers. Timers shall be of electromagnetic or electronic type only.

Control and instrument switches shall be rotary type provided with escutcheon plates clearly marked to show operating position and suitable for semi flush mounting with only switch front plate and operating handle projecting out.

Breaker control switches shall be pistol grip black and selector switches shall be oval or knob, black. Breaker control switches shall be 3 position spring return to neutral. Instruments selector switches shall be of the maintained stay-put type. Contacts of the switches shall be spring assisted and contact faces shall be with rivets of pure silver. The contact ratings shall be adequate to meet the requirements of circuit capacity in which they are used. If specified in data sheets, control switches with built-in flashing type discrepancy lamp shall be provided to control circuit breaker.

Push buttons shall be provided wherever specified. They shall be provided with inscription plates engraved with their functions. Push buttons shall be rated for 10A at 240 AC and 1A at 220 VDC, with 2 No and 2NC contacts. Start PB shall be green in color and stop PB shall be red colored stay put type.

Indicating lamps shall be Cluster type LEDS.

Space heaters of adequate capacity shall be provided inside each panel. They shall be suitable for 240 V, 1 ph, 50 cycles supply. They shall be complete with MCB or HRC fuses, isolating switches and adjustable thermostat.

Each switchgear panel shall be provided with 240 Volts, 1 phase. 50 cycles, 5 amps. 3 pin receptacle with switch located in a convenient position.

The single phasing preventer relay shall be provided when called for in data sheet and shall have following characteristics.

Operate for supply voltage unbalance of more than + 5% and when relay internal wiring is open circuited.

Not operate for 3 ph supply failure.

Instantaneous hand reset type

Visual indication for operation

Suitable for reversible and non-reversible motors

#### **4.4.15 Transformers for Control, Space Heating and Annunciator Supplies**

Adequately rated single phase, two winding, dry type transformers shall be provided for providing supply to the switchgear control and alarm circuits, space heaters provided in plant equipment and space heaters in the switchgear and motor winding heating circuits.

As specified in the enclosed module control wiring drawing/bill of material either duplicate common transformer with one as stand by shall be provided in each switchgear or a separate control transformer shall be provided in each module to cater for that particular module. Common control transformer rating shall be adequate to cater for all the control equipment connected across it. For control transformers in each module, the minimum rating shall be as follows:-

Motor rating (kW)	Control type	Control transformer rating (kVA)
Upto and including 30	K-11 or K-21 or R21	75
	L-11 or L-21	100
Above 31	All types	300

All transformers of 500 VA and above shall be controlled by MCBs/ switches and fuses on the primary and secondary side.

Common control transformer shall have fuses on all line leads of each winding and control transformer in individual module shall have fuse in the line lead of only secondary winding. The fuses shall be of proper rating to protect the control transformers against over loads and short circuits. the neutral or the earth lead shall have earth link instead of fuses.

#### **4.4.16 Window Type Alarm Annunciator**

The alarm annunciator if called for in Data Sheet shall consist of flush mounted facia and shall have following features:-

(a) Fault indication by steady lit window

- (b) Audible alarm on fault occurrence
- (c) Acknowledgement, resetting and test
- (d) Suitable for NC/NO initiating contacts
- (e) Facility for separate audio visual alarm on control supply failure

The alarm annunciator scheme operation shall be as follows:

		Visual Alarm	Audible Alarm
a)	Normal	OFF	OFF
b)	On occurrence of fault		
	i. First fault	Flashing	On
	ii. Subsequent Faults	Flashing	On
c)	Accept fault		
	i. First fault	Steady	Off
	ii. Subsequent Faults	Steady	Off
d)	Reset – faults cleared	Off	Off
e)	Faults not cleared	Steady	Off
f)	Lamp test	Steady	Off

#### 4.4.17 Arc Resistance

The switchgear assembly shall be certified as Arc Resistant. The minimum arcing duration used for testing shall be 500ms.

Rear venting flaps in the panel shall be provided for added air flow under normal operating conditions but automatically close during and arc event to prevent pressure and gasses from escaping.

The panel top shall be provided with roof flaps for pressure relief created by an internal arcing event.

#### 4.4.18 Cable Termination

If asked for in Data Sheet necessary number of cable glands and lugs shall be supplied for terminating power and control cables. Glands shall be of heavy duty brass castings, machine finished and complete with check nut, washers, neoprene compression ring etc. The lugs shall be tinned copper/aluminium depending on cable conductor and of solder-less crimping type.

#### 4.4.19 Local Push Button Stations

The local P.B. stations shall be metal enclosed, provided with IP-55 protection, made up of die-cast aluminum or 2 mm thick sheet metal.



The P.B. station shall be suitable for wall or structure mounting, provided with labels, earthing terminals, suitable lugs glands.

Push buttons shall be fitted with 2 NO and 2NC contacts (1A at 220V DC and 10A at 240V AC) with stop PB of stop put type and red in color. Other PB's shall be green in color.

PB station shall be of one of the following types

Type A - Three PB's forward-reverse-Stop for reversible motors

Type B - Two PB's start-stop for non-reversible motors

Type C - One PB STOP for emergency

#### **4.4.20 Spare Parts**

The BIDDER shall furnish a list of recommended spare parts for five years operation along with unit prices.

#### **4.4.21 Tests and Reports**

Type test reports for the switchgear and circuit breakers shall be furnished along with the tender and subsequently.

The switchgear, circuit breakers and all associated equipment shall be tested in accordance with relevant standards. All routine tests shall be carried out. Type tests shall also be carried out if not tested previously.

Type and routine test report shall be submitted for the PURCHASER's approval before the equipment is dispatched. Bound copies of test reports shall be furnished along with the switchgear.

All meters and other reference devices used for testing shall have valid calibration from reputed national laboratories/institutes. Inspection by Purchaser/ Engineer will not be carried out unless the vendor confirms that calibrated equipment are ready for proceeding with the tests.

Equipment shall not be dispatched unless the test certificates are duly approved by Employer.

#### **4.4.22 Drawings and Data**

The following shall be furnished as part of the tender:

- i. General arrangement showing plan, elevation and typical sectional views.
- ii. Foundation plan showing location of fixing channels, floor openings etc.
- iii. Schematic wiring drawings for each cubicle.
- iv. Technical literature on the equipment offered.
- v. All drawings and data sheets shall be annotated in English.
- vi. Quality Assurance Plan.

**4.5 CABLES**

The following aspects are applicable for all the types of cables covered in this specification.

**4.5.1 Construction and Performance**

Construction and Performance of the Cable shall conform to the relevant

Standards IEC 60183, 60227, 60502, 60885 and IS 1554, 7098, 8130, 5831.

**4.5.2 Conductor**

Aluminium conductor, stranded, grade H4, Class 2 as per IS code.

Annealed, stranded Copper Conductor, Class 2 as per IS code.

**4.5.3 Insulation**

Insulation for cables shall be as per the applicable standards.

**4.5.4 Core Identification**

Colour coding shall be acceptable for all cables upto 5 cores. Cables with more than 5 cores shall have printed numerals on each core.

**4.5.5 Inner Sheath**

Inner sheath shall be extruded type and shall be compatible with the insulation provided for the cables.

**4.5.6 Armour**

Armouring for the cables shall comprise galvanised steel or hard drawn aluminium in the form of round wires or strips.

**4.5.7 Outer Sheath**

The outer sheath shall be of an extruded layer of suitable synthetic material compatible with the specified ambient and operating temperature of the cables. The sheath shall be resistant to water, ultra violet radiation, fungus, termite and rodent attacks. The colour of the outer sheath shall be black unless otherwise specified.

**4.5.8 Cable Drum**

Cables shall be supplied in non-returnable wooden and steel drums as applicable. The wood used for construction of the drum shall be properly seasoned and free from defects and wood preservative shall be applied to the entire drum. All ferrous parts shall be treated with a suitable rust preventive coating to avoid rusting during transit or storage. Cable drums shall conform to IS 10418 (Specification for drums of electric cables).

The BIDDER shall indicate in the offer, the maximum length for each size of cable, which can be supplied on one drum. The actual length supplied on each drum shall be within tolerance limit of 5 % with an overall ceiling of +5% on total ordered quantity of each size of cable unless otherwise indicated in Data Sheet. However, before winding the cables on drums, VENDOR shall obtain PURCHASER's approval for the drum lengths so as to minimize the number of joints to the extent possible. Cable ends shall be sealed by non-hygroscopic sealing caps.

Cable drums shall carry following details in printed form :

(a) Manufacturer's name and trade mark

(b) Type of cable and voltage grade

- (c) Year of manufacture
- (d) Type of insulation
- (e) No. of cores and size of cables
- (f) Cable code
- (g) Length of cable on drum
- (h) Inner Diameter and Outer Diameter of Drum

#### **4.5.9 Tests and Test Equipment**

Cables shall be subjected to routine and acceptance tests as per relevant standards. Tenderer shall ensure use of calibrated test equipment having valid calibration test certificates from standard laboratory traceable to National Standards.

#### **4.5.10 Power & Control Cables, 1100 V Grade XLPE Insulated**

The cable shall be extruded XLPE insulated. The inner sheath over laid up cores and outer sheath over the armour shall be extruded PVC compound type ST-2. Core identification shall be by printed numerals.

Cables for low and medium voltage , industrial heavy application shall be of Al conductor, XLPE insulated, armoured, suitable for 1100 V earthed system while 2.5 sq.mm & below the same shall be of Cu conductor, XLPE insulated, XLPE sheathed and armoured, of voltage grade 1100 V.

The following abbreviations are applicable to these cables

A	Aluminium conductor, stranded, grade H4, class 2 as per IS code
C	Copper conductor, stranded, class 2 as per IS 8130
W	Galvanised single steel wire
F	Galvanised single steel strip
AW/AS	Hard drawn aluminium single wire/strip

The construction, performance and testing of cable shall comply with relevant IS code.

#### **4.5.11 1100 V Grade Lighting / Misc. / Light duty armoured cables**

Cables shall be insulated with extruded PVC type-A. Outer sheath shall be extruded black PVC type ST-1.

The following abbreviations are applicable to these cables.

- A - Aluminum conductor, stranded, grade H2, class 2 as per IS code.
- C - Copper conductor, stranded, class 2 as per IS code.

The construction, performance and testing of cable shall comply with relevant IS code.

## 4.6 INDUCTION MOTORS

### 4.6.1 Performance and Characteristics

All motors shall comply with IEC 60034, 60072 and IS-325, 4029, 4722 including standards referred to therein.

Motors shall be capable of giving rated output without reduction in the expected life span when operated continuously under the following supply conditions as per the specifications.

Variation in supply voltage from rated voltage :  $\pm 10\%$   
 frequency from rated frequency :  $\pm 5\%$

Combined voltage and frequency variation :  $\pm 10\%$

Motors shall be energy efficient (IE-2 or better) squirrel cage induction motors (TEFC type) with degree of protection for enclosure of IP 55. They shall be capable of starting and accelerating the load for the method of starting, as per SLD without exceeding acceptable winding temperatures, when the supply voltage is 80% of the rated voltage. Main conductor and insulation shall be non-hygroscopic and in accordance with Class F of IEC 60085/to be as per new IS code for motors.

The power rating of the motor shall be larger of the following:

115% of the power input to the pump at duty point at rated speed and frequency.

105% of the power input to the pump between 110% to 75% head.

Motors shall be capable of starting and accelerating the load with the applicable method of starting, without exceeding permissible winding temperatures, when the supply voltage is 80% of the rated voltage. Motors shall be capable of satisfactory operation at full load at a supply voltage of 80% of the rated voltage for 5 minutes, commencing from hot condition.

Motors shall withstand the voltage and torque stresses developed due to the vector difference between the motor residual voltage and the incoming supply voltage equal to 150% of the rated voltage, during fast changeover of buses. The duration of this condition is envisaged for a period of one second.

The locked rotor withstand time under hot conditions at 110% rated voltage shall be more than the starting time at minimum permissible voltage by at least two seconds or 15% of the accelerating time, whichever is greater. The locked rotor current of motors shall not exceed 700% of full load current of motor which is inclusive of 20% tolerance.

The motors shall be provided with class F insulation with temperature rise limited to that of class B insulation.

Motors when started with the drive imposing its full starting torque under the specified supply voltage variations shall be capable of withstanding at least two successive starts from cold conditions and one start from hot condition without injurious heating of windings. The motors shall also be suitable for three equally spread starts per hour under the above referred supply conditions.

RTD shall be provided in all Main Motors.

**4.6.2 Constructional Features**

All bearings shall be fitted with oil or grease lubricators. Motor bearings shall not be subjected to any external thrust load. Unless otherwise specified, motor bearings shall have an estimated life of atleast 40,000 hrs. It shall be possible to lubricate the bearings without dismantling any part of the motor.

All terminals shall be of the stud type of adequate size for the particular duty, marked in accordance with an approved standard and enclosed in a weatherproof box.

Two independent earthing points shall be provided on opposite sides of the motor for bolted connections. These earthing points shall be in addition to earthing stud provided in the terminal box.

**4.6.3 Specific Requirements of Motors**

- a) The motor shall be suitable for the current waveforms produced by the power supply..
- b) The Motor shall be designed for continuous duty (S1) operation. The permitted voltage variation should take into account the steady state voltage drop across the Soft Starter and all other system components upstream of the motor.
- c) The driven equipment manufacturer shall be solely responsible for proper selection of the motor for the given load application and the output characteristics of the driven equipment.

**4.6.4 Insulation**

The insulation shall be given tropical and fungicidal treatment for successful operation of the motor in hot, humid and tropical climate.

The insulation shall be of double coat winding wires which having superior electric strength and thermal capability..

Winding shall be insulated as VPI (Vacuum Pressure Impregnation) of winding with suitable resin

**4.6.5 Temperature Rise**

The temperature rises shall not exceed the values given in IS 12802. Under extremes of supply condition (clause 4.1 above), the temperature rise shall not exceed the value indicated in IS code by 10oC.

For motors specified for outdoor installation heating due to direct exposure to solar radiation shall be considered.

**4.6.6 Bearings**

Unless otherwise specified in data sheet, motor bearings shall not be subjected to any external thrust load.

Unless otherwise specified, motor bearings shall have an estimated life of atleast 40,000 hrs.

The bearings shall permit running of the motor in either direction of rotation.

When forced oil lubrication or water cooling is required, prior approval from the purchaser shall be obtained.

It shall be possible to lubricate the bearings without dismantling any part of the motor.

**4.6.7 Terminal Box**

Terminal boxes shall have a degree of protection of at least IP 55 for outdoor applicable.

Unless otherwise approved, the terminal box shall be capable of being turned through 360° in steps of 90°.

Terminals shall be of stud type & the terminal box shall be complete with necessary lugs, nuts, washers.

When single core cables are to be used the gland plates shall be of non-magnetic material.

Sizes of terminal boxes and lugs shall be as given in Table-I, unless specified otherwise in data sheet .

**4.6.8 Paint and Finish**

All motor parts exposed directly to atmosphere shall be finished and painted to produce a neat and durable surface which would prevent rusting and corrosion. The equipment shall be thoroughly degreased, all rust, sharp edges and scale removed and treated with one coat of primer and finished with two coats of grey enamel paint.

**4.6.9 Heating during Idle Periods**

Motors rated above 30 kW shall have space heaters suitable for 240V, single phase, 50 Hz, AC supply. Space heaters shall have adequate capacity to maintain motor internal temperature above dew point to prevent moisture condensation during idle period. The space heaters shall be placed in easily accessible positions in the lowest part of the motor frame.

**4.6.10 Accessories****i. Drain Plugs**

Motors shall be provided with drain plugs, so located to drain water, resulting from condensation or due to other causes, from all pockets in the motor casing.

**ii. Heating during Idle Period**

For motors rated below 30 kW, during idle periods, the stator winding will be connected to required single phase, 50 Hz, AC supply for heating and elimination of moisture. The supply will be connected between any two terminals.

Motors rated 30kW and above shall have space heaters suitable for 230V, single phase, 50 Hz, AC supply. Space heaters shall have adequate capacity to maintain motor internal temperature above dew point to prevent moisture condensation during idle period. The space heaters shall be placed in easily accessible positions in the lowest part of the motor frame.

**iii. Terminal Box**

Terminal boxes shall be of weather proof and PSTB construction. To eliminate entry of dust and water, gaskets of neoprene or equivalent approved shall be provided at cover joints and between box and motor frame. It shall be suitable for bottom entry of cables. It shall be suitable of being turned through 360° in steps of 90°.

The terminals shall be of stud type with necessary plain washers, spring washers and check nuts. They shall be designed for rated current carrying capacity and shall ensure ample

phase to phase and phase to earth clearances. Suitable cable glands and lugs shall be supplied.

Separate terminal boxes shall be provided for each of the following:

Stator Leads

Space Heaters

Temperature Detectors

#### iv. Earthing Pad

The earthing pads shall be of non-corrodible metal welded or brazed at two locations on opposite sides complete with suitable bolt and washers for earthing.

#### v. Rating Plate

The following details, in addition to those specified in applicable standards shall be included on the rating plate.

- a) Rated voltage, kW rating, frequency, efficiency, power factor, temperature rise of windings in degree centigrade at rated load, and ambient conditions.
- b) Type of bearings, recommended lubricant, lubricating interval & re-lubricating quantity.

### 4.6.11 Tests

Motor shall be subjected to all the type test and routine tests as per applicable standard in the presence of the Employer's representative. Copies of test certificates for all brought out items shall be furnished at the time of inspection for the Employer's approval. The Contractor shall ensure to use calibrated test equipment / instruments having valid calibration test certificates from standard laboratories traceable to National / International standards.

## 4.7 SOFT STARTER

The soft starters shall comply with the requirements of the following International Standards including those standards referred to therein.

The Soft starter shall comply with the requirements of the following International standards including those standards referred to therein.

- IEC 60034,
- IEC 60947
- IS 325

### 4.7.1 Constructional and Performance Features

Motor Starters shall be of the switched reactance type, flux compensated type or electronic type. Soft starter Panels shall be indoor rated, metal clad with separate enclosed compartments for:

- i. Control, metering and current transformers for differential protection
- ii. Shorting (Bypass) arrangement
- iii. Bus Bars
- iv. Power cable terminations
- v. Push buttons with indicating lamps

Soft starters shall achieve smooth starting by torque control for gradual acceleration

of the drive thus preventing jerking and extending the life of the equipment being started.

The starting current shall be limited to 2.5 to 3 times the rated current of the motor. The soft starter manufacturer shall co-ordinate with motor manufacturer for this purpose. Separate removable gland plates shall be provided for power and control cables.

Each cubicle shall be fitted with a label in the front and rear of the cubicle, indicating the panel designation, rating and duty. Each relay, instrument, switch, fuse and other device shall be provided with separate labels.

A detailed wiring diagram shall be provided showing the starting interlock, trip circuit, starting and running mode signals. It shall be possible to manually start the motor locally from the starter panel or in 'Auto' mode through the PLC.

#### **4.7.2 Main Bus Bars**

Bus bars shall be fully insulated by encapsulation in epoxy resin, with molded caps protecting all joints.

Bus bars shall be supported on insulators capable of withstanding dynamic stresses due to short circuiting.

Bus bars shall be made of hard drawn copper conductor and be of high conductivity, EC grade copper of 99.7% minimum purity shall be used

#### **4.7.3 Earthing**

A copper earthing bus shall be provided at the bottom and extended throughout the length of the panel. It shall be bolted or welded to the framework. All non-current carrying metal work of the panel shall be effectively bonded to the earth bus. Hinged doors shall be earthed through a flexible earthing braid

#### **4.7.4 Panel Accessories and Wiring**

Panels shall be supplied completely wired internally up to any equipment and terminal blocks and shall be ready to accept the external cable connections at the terminal blocks. Inter-panel wiring between compartments of the same panel shall be provided.

All auxiliary wiring shall be done with 1,100V grade, single core, stranded copper conductor with PVC insulation. The size of each wire shall be not less than 1.5 mm<sup>2</sup>.

Terminal blocks shall be of the stud type, 10 A rated, complete with insulated barriers.

Terminal blocks for CTs shall be provided with test links and isolating facilities.

All spare contacts and terminals of cubicle mounted equipment and devices shall be wired to terminal blocks.

Accuracy class for indicating instruments shall be 1.0 or better. Instruments shall be 110 mm square, with a 240o scale for flush mounting with only flanges projecting.

Push buttons shall be provided with inscription plates engraved with their functions.

Indicating lamps shall be of the clustered LED type.

Space heaters of adequate capacity shall be provided inside each panel. They shall be suitable for 230V, 1 Ph, 50 Hz supply. They shall be complete with a MCB and a thermostat.

Each panel shall be provided with a 230V, 1 phase, 50 Hz, 5A, 3 pin receptacles with a MCB located in a convenient position. An interior illuminating lamp together with the operating door switch and protective MCBs shall be provided.

The DC and AC auxiliary power supplies shall be distributed inside the panel with necessary isolating arrangements at the point of entry and with sub-circuit MCBs as required.

#### **4.7.5 Testing**

Each soft starter unit shall be tested at the manufacturer's works. Test result must satisfy all of the characteristics during starting and acceleration against their quoted values listed in the design submittal



## **4.8 BATTERY**

### **4.8.1 Sealed Ni-Cd Battery**

The sealed batteries shall be Ni-Cd SMF type. The batteries shall conform to IEC: 60896-2 or equivalent standard. It shall conform to the safety requirements of UL 924 or equivalent safety standard. The battery shall have maximum recharge time of 8 hours. Each cell shall be marked in a permanent manner in accordance with relevant standards. Tenderer shall quote in his offer the guaranteed life of the battery when operating under the conditions specified.

### **4.8.2 Connectors And Terminal Posts**

Inter-cell and inter-tier connectors and terminal posts shall be of copper.

### **4.8.3 Accessories**

The battery shall be complete with accessories and devices, including but not limited to the following:

- i. Battery racks
- ii. Porcelain insulators, rubber pads, etc.
- iii. Set of inter-cell, inter-tier and inter-bank connectors as required for the complete installation.
- iv. Other accessories e.g. cell tester, thermometer, rubber apron, rubber gloves, etc.

### **4.8.4 Battery Rack**

Battery racks shall be constructed from good quality teak wood and painted with two coats of approved alkali resisting paint. The racks shall be rigid, mechanically strong, free standing type and free from warp and twist. The completed racks shall be suitable for being bolted end to end to form a continuous row. Insulators shall be provided below the legs of the stands.

### **4.8.5 Tests**

All tests shall be conducted as per the relevant standards. Tests shall include following Type & Acceptance tests.

Type & Routine Tests : Performed at Manufacturer's works

Acceptance Tests : Performed at site after installation and commissioning of the battery.

Type tests (min.) shall comprise of the following in accordance with IS/IEC:

Visual inspection Dimensional check Capacity

Retention of charge test

Ampere-hour and watt-hour efficiency test

Endurance test

Life cycle test

Short circuit current and Internal resistance measurement test

Acceptance tests shall be conducted at site on completion of installation and commissioning and immediately prior to putting the battery in service. These tests shall comprise of:

Visual inspection Dimensional check Capacity test

Test for voltage during charging/ discharging

Storage test

Insulation resistance

#### **4.9 Battery Charger**

##### **4.9.1 Type**

The float and boost battery charger shall be static type composed of silicon controlled rectifiers (SCRs) and diodes connected in three phase full wave bridge circuit along with electronic controllers.

Each battery charger shall be suitable for float charging the battery under normal conditions and boost charging the battery when it has discharged during service conditions. The change-over from float to boost mode and vice versa shall be automatic.

The rectifier transformers for float and boost chargers shall be indoor dry type, double wound with required number of taps.

##### **4.9.2 Rating**

The float charger shall be designed for supplying:

The DC loads i.e. continuous load of control, indication and annunciation circuits that remain energised during normal operation and the momentary closing and trip coil loads of circuit breakers, etc.

The float charging current of the battery - 25% margin over the above loads

The boost charger shall be designed for supplying the boost charging current of the battery. The float and boost chargers shall be designed for 415V, 3 phase, 4 wire, 50 Hz input.

If the battery and charger are to be supplied by separate Contractors, the Contractor for charger shall co-ordinate with the Contractor for battery regarding the float / trickle and boost charging current and voltages required by the battery.

##### **4.9.3 Performance**

###### **i.Float Charger**

The DC output voltage during float charging shall be stabilized within + 1% of the set DC bus voltage for AC input voltage variation of +10%, frequency variation of + 5% and DC load variation from 0 - 100%. The voltage regulation shall be achieved by a constant voltage regulator having fast response SCR control. The ripple content shall be within 1% of DC output nominal voltage with battery disconnected and shall be designed to have voltage regulation of 1%. Also in any mode of operation, the maximum harmonics in the charger output shall not exceed 5%.

The setting of the output DC bus voltage shall be adjustable between + 10% of nominal rated voltage. There shall be provision for manual control if auto mode fails. Line surge suppressers shall be provided.

###### **ii.Boost Charger**

For boost charging the discharged battery after a mains failure, the rectifier shall charge the battery at high rate limited to the maximum boost charging voltage. The boost charging shall come on only when selected for boost mode manually. In auto control, the DC output current shall be stabilised within +2% for AC input voltage & frequency variation of + 10% and + 5% respectively. There shall be provision for manual control if auto-mode fails. Boost charging time for charging the battery to full capacity from fully discharged condition shall not exceed 8 hours.

The boost charge voltage and current settings shall be adjustable between 70 to 100% of maximum boost charge voltage and between 30 to 100% of maximum boost charging current.

During boost charging following emergency measures shall be provided:

If the AC mains supply fails, an arrangement shall be made to automatically connect the battery directly across the load in case of charger with separate float & boost units.

Line surge suppressers shall be provided.

#### **4.9.4 Charger Cubicle**

Boost and float chargers shall have separate sections. Indications, controls and output voltage setting adjustments shall be on front panel. The components shall be liberally rated and housed in a well ventilated sheet metal cubicle complete with input and output terminals. Sheet steel used for construction shall be 2 mm thick. Louvers shall be provided for ventilation backed up by fine wire mesh so that the degree of protection shall be equal to or better than IP-42.

All printed circuit cards shall be plug-in type, interlocked to prevent insertion in a wrong slot. Each card shall have LED indication on its front plate to indicate normal condition and readily marked test pins.

All power & control wiring within the cubicle shall be done with stranded copper wires. The power wiring shall be adequately sized for the required rating. The minimum sizes for control wiring shall be 1.5 mm<sup>2</sup> and for power wiring shall be 4 mm<sup>2</sup>. Ground terminals with isolating links shall be provided.

#### **4.9.5 Components / Accessories For Battery Charger**

The Contractor shall submit a scheme for alarm and trip indication, lamps on the cabinet and provide suitably rated 3 pole MCCBs (micro-processor type) with over load, short circuit and earth fault protections and auxiliary contacts.

##### **i. Float / Boost Charging**

Charger unit shall essentially comprise of following:

Three phase full wave bridge rectifier circuit comprising silicon controlled rectifiers and silicon diodes complete with resistor / capacitor network for surge protection. The diodes / SCRs shall be individually protected by fuses and fuse failure indication. The fuses shall be of fast acting semiconductor type.

Double wound, dry type, three phase suitably rated mains transformer with fuse protection and with one set of power factor correction capacitors to maintain a power factor of 0.85 (lag).

DC contactor with suitably rated coil, to be interlocked with incoming AC contactor such that during boost charging, the load will be fed from battery through the blocking diodes connected to battery tapped cell when float charger fails. When battery is in boost charging

mode the diodes will prevent the voltage of float charger appearing on battery tap. If AC mains supply fails the full battery gets connected across the load through contacts of the DC contactor.

Silicon diodes (blocking diodes) two in series for connection between the end cell tap on the battery and the positive bus of charger output.

DC undervoltage relay to annunciate fully discharged condition of the battery. Suitably rated control transformers for electronic controller.

Electronic controller comprising of power supply card, soft start cum current limit card, auto trickle mode card with facility for setting trickle charge current and monitoring battery current, error amplifier cards and pulse generating cards for achieving the DC output voltage stabilisation of + 1% and also for achieving current limiting feature. The electronic controller shall have protection features with indications for under-voltage, over-voltage, earth fault, set output voltage and phase failure or voltage unbalance.

Adequately sized necessary built-in accessories shall be provided such that on failure of the controller in auto mode, the voltage can be effectively controlled manually.

Filter circuit comprising of smoothing choke and condensers complete with HRC fuse with trip indication for filter condenser circuit.

Auto / Manual selector switch for selecting the mode of operation of the controller.

Front panel mounted potentiometer for set point adjustment of output voltage in auto mode.

Front panel mounted potentiometer for manual adjustment of voltage in manual mode.

Selector switch for mode of charging i.e. float charging / boost charging

Double pole ON / OFF DC switch for boost charger DC output

AC ON / OFF switch for float/boost charger incoming.

HRC fuses complete with fuse fittings for AC/DC input with suitable ratings and with trip indication.

Pilot lamps for indications.

AC contactor with suitably rated coil with three main contacts and 2 NO + 2 NC auxiliary contacts, suitably rated thermal overload relay and ON / OFF control switch.

HRC fuses complete with fuse fittings for the DC output and with trip indication. DC voltmeter with fuses and a three position selector switch.

DC ammeter of suitable range to read the float charger output current. Double pole DC ON / OFF rotary switch for float charger output.

Blocking diodes in series to block backfeed from battery to float charger. AC ammeter with selector switch for incoming AC power.

AC voltmeter with selector switch for incoming AC power

MCB for incoming AC supply along with surge suppressers

AC / DC switching relays for alarm and indication circuits including buzzer

## ii.Common Accessories

The chargers shall essentially comprise of following common items.

DC voltmeter suitable range with a four (4) position selector switch to read the voltage of 'FLOAT CHARGER', 'BOOST CHARGER', and 'BATTERY TAP' with 'OFF' position for separate float and boost charger.

Ammeter to read output current.

Centre zero ammeter to read discharge / charger currents of the battery, with suitable range.

Cubicle space heater suitable for 230 V AC 50 Hz, single phase supply.

230 V AC lamp for cubicle internal lighting. MCB for space heater and internal lighting.

The charger cubicle / DC board shall have one I/C MCCB and eight (8) O/Gs controlled through MCB for supplying Auxiliary DC Power to breaker closing & tripping, indication & annunciation for HV and LV switchgear.

Fault indicating lamps shall be provided on the charger cubicle and initiating contacts shall be provided for alarm for each of the following faults :

Mains AC failure

Float charger AC input fuse blown / MCCB tripped Boost charger AC input fuse blown / MCCB tripped AVR Defective.

Float charger DC output fuse blown

Float charger U/V and current limiter protection

Boost charger over current protection Float charger over voltage protection Boost charger DC output DC fuse blown.

Float or float-cum-boost charger filter condenser fuse blown. Boost charger filter condenser fuse blown.

Float charger rectifier fuse blown Boost charger rectifier fuse blown. Battery earth fault

### iii. Power Electronic Components

Diode and thyristors shall be of monocrystalline type silicon, capable of providing continuous output at specified voltages. It shall have high power efficiency. The diodes or thyristor banks shall be natural air cooled.

If many diode or thyristor assemblies are connected in parallel, care shall be taken to ensure that each rectifier or thyristor operates within its rating and shares the load uniformly.

Each diode or thyristor built in a multi-built assembly shall be provided with a short circuit protection to avoid complete shut-down of the equipment because of a fault on single unit. Suitable fuses shall be provided for such protection.

The diodes or thyristors shall be protected against overvoltage due to chopping surges with the aid of snubbers (i.e. resistor-capacitor combination and Metal oxide varistor).

#### 4.9.6 Co-ordination with Battery Vendor

When battery is procured separately, the VENDOR shall coordinate with battery VENDOR with regard to layout, connections, charging voltage requirements, etc.

If Battery health monitoring system is supplied through Battery charger vendor, Battery charger vendor shall coordinate with battery vendor and ensure the performance of the system.

BHMS controller shall be preferably located as part of the Battery charger panel.

#### **4.9.7 Tests & Tests Reports**

All routine and type tests shall be conducted as per the relevant standards.

Contractor shall ensure use of calibrated test equipment having valid calibration test certificates from standard laboratories traceable to National Standards.

#### **4.10 UNINTERRUPTED POWER SUPPLY (UPS)**

The UPS shall meet the requirements of this specification and latest edition of all applicable standards.

##### **4.10.1 System Requirement**

The UPS system shall be true on line static type and the components of UPS shall isolate power line transients, frequency and voltage variations. The UPS shall provide no-break power supply to the critical loads under normal conditions, during outages in the input power and during failure / mal operation of the main components of the UPS by switching the alternate supply.

UPS system shall be working in Parallel Redundant configuration having two sets of 100% rectifiers, batteries, static transfer switch and inverters and shall share the load. Under normal conditions, when AC mains power is available, both the rectifiers shall operate independently and supply DC power for float / boost charging the batteries and simultaneously to inverters. In case of failure in any one rectifier, the faulty rectifier unit shall automatically get disconnected and the entire load shall be fed from the other UPS. Each rectifier shall be designed for feeding inverter load and float / boost charging of the battery to its rated capacity within 10 hours.

Normally both inverters will be synchronized with each other and with bypass supply. The two inverters shall operate in parallel and share the load equally. When a disturbance / fault occur in any one of the inverters, the faulty unit shall automatically get disconnected and the entire load shall be fed from the other inverter. In case, both inverters develop a fault, the complete load shall be transferred to bypass supply through static transfer switches and retransfer of load from bypass to inverter supply shall be automatic.

A manually operated make before break changeover switch/MCCB shall be provided to bypass the UPS power circuits (inverters and static switches) for maintenance and repair purposes.

##### **4.10.2 Design Requirement**

All UPS components, i.e., rectifier, inverter, static switch, by-pass switch, isolation transformer associated controls shall be mounted in floor mounted, sheet steel panel. In case of 3ph output UPS, its shall be transformer less design. The panels shall be designed for continuous operation for the ambient conditions defined in Section-B & Data sheet. The battery shall be separately installed in a battery room. In case fans are required for cooling, N+1 Redundancy shall be provided to ensure rated output of the UPS.

##### **i. Battery**

The battery backup time, number and type of batteries shall be as specified in Data Sheet. The BIDDER shall choose the required voltage of the battery. The AH capacity of battery shall be chosen by BIDDER, based on the battery backup time / duty cycle, and minimum

ambient temp. specified in Data Sheet and the guaranteed DC/AC efficiency of the UPS system offered.

BIDDER shall furnish calculation for sizing of the battery based on the requirements.

#### ii.Rectifier

The rectifier shall essentially be IGBT type for all ratings of three phase UPS. For single phase UPS full controlled full wave type Thyristors rectifier shall be used. The Thyristor type rectifier shall be 6 pulse design (minimum) with input isolation transformer. For Redundant UPS design the two rectifier input isolation transformers shall have vector grouping and connections to ensure 12 pulse operation seen from the source side. The rectifier shall be provided with soft start feature. The rectifier shall have features for temperature compensation charging of the batteries

The rectifier shall be capable of supplying the inverter full load, in addition to charging the fully discharged batteries in 8 to 10 hours or as recommended by battery manufacturer and then maintain the battery on trickle charge mode. The rectifiers shall automatically share the load during parallel operation in case of common battery, as specified in Data Sheet.

#### iii.Inverters

The inverter shall be of IGBT type. The same shall be of PWM (Pulse Width Modulation) type. The inverter system shall be complete with necessary filters to limit the harmonic distortions to the load. The system shall have features to prevent deep discharge of battery.

#### iv.Static Switch

The static switch shall comprise thyristors connected in anti parallel configuration, enabling loads on each branch circuit to be connected to the inverter of the other branch circuit or to the stand-by regulated AC supply.

The current rating of the static switch shall be not less than the continuous full load rating of the branch circuit and short time rating of 1000% for 10 milliseconds.

Automatic initiation of the transfer from a faulty branch circuit to either a healthy branch circuit or the stand-by regulated source shall be accomplished during following conditions:

- (a) Inverter failure.
- (b) Loss of inverter AC output.
- (c) Load over current (in case of non-redundant UPS with static by pass to regulated supply).

#### v.Regulated Stand-by AC Supply

Regulated stand-by AC supply shall be derived from stand-by source through a 3 ph servo controlled voltage stabiliser (SCVS) and a 3 ph/3ph-1ph Delta-Vee connected adequately rated isolation transformer.

The voltage regulation and transient response shall be as specified in Data Sheet

#### vi.Circuit Protection

The following devices shall be provided to protect the UPS system:

- (a) AC input circuit breaker to Rectifier unit.

- (b) AC input circuit breaker to supply stand-by transformer / voltage stabiliser.
- (c) DC circuit breaker for battery output.
- (d) Fast acting semiconductor fuses.

#### **4.10.3 Indications & Annunciation**

The UPS system shall be provided with necessary meters, mimic diagram, local indication / alarm conditions.

Multi line alpha numeric text display unit shall be provided for continuous monitoring of the UPS operation. The UPS control system shall be fully compatible for remote operation via communication link. BIDDER to indicate the type of communication protocol supported by the system along with the details of links provided in the system. The control system shall operate on Windows or eqvt. Platform. The following operating conditions shall be annunciated.

Alarm Indication:

System fault

Rectifier charger failure

Inverter failure /faulty

Battery under voltage

UPS over temperature

Over load

Static transfer to stand-by

Transfer inhibited

Over load shutdown

Emergency shutdown

Battery circuit breaker / switch open

AC Main failure

AC stand-by source mains failure

Manual bypass ON

Fan failure

Asynchronous condition

Control power failure

Status Indication on Mimic:

Mains on



Rectifier on

Battery on load

Inverter on

AC Stand-by source on

Inverter on –load

Manual by-pass on

Load on static by pass.

Display of measurements:

(a) Inverter output phase-to-phase voltages

(b) Inverter output currents

(c) Inverter output frequency

(d) Voltage across battery terminals

(e) Rectifier input phase-to-phase voltages

(f) Rectifier input currents

(g) Crest factor

(h) Active and apparent power

(i) DC voltage & Current

#### **4.10.4 Harmonics**

Necessary input and output filters shall be provided or the Rectifier and Inverter design shall be such that the harmonics injected back to the source and to the load shall be within limits specified in IEEE-519 at the point of coupling of the UPS to the system. The fault level of the system at the point of common coupling shall be as specified in data sheet.

#### **4.10.5 Tests**

Type and routine tests certificates for all components made use in the UPS system shall be furnished. Tests for components shall be as per relevant standard specifications indicated in Data Sheet.

BIDDER shall furnish his quality assurance plan for the equipment offered. The quality assurance plan shall include bought out components and assemblies used in the UPS system.

Routine tests on the complete UPS system shall be carried out as per relevant standards for each major sub-system in the UPS, viz., Rectifier, Inverters, batteries, stand-by supply etc.

System tests shall be performed on the completely assembled UPS system. System tests shall include frequency regulations, Voltage regulation, current limiting feature and harmonic content tests in addition to the tests to prove the functional requirements such as

synchronisation with range of adjustments, transfer of static switches for conditions of loss of square wave, overload and under voltage conditions.

Type, routine and optional tests covered under clause 6 of IEC-62040-3 shall be conducted on the UPS system in addition to the system tests.

Endurance test on static switches shall be performed for not less than 10 transfer / retransfer cycles at full load.

Heat run test shall be carried out on each branch of UPS including bypass (if provided) and on overall UPS system at rated load under relevant ambient conditions for a period of 8 hours. This test shall be conducted as a routine test on all UPS being supplied.

#### **4.11 ELECTRICAL INSTALLATION WORK**

The requirements specified herein are part and parcel of the complete scope of work of installation, testing and commissioning of various installations including storing, transferring the material & equipment to the place of work, assembling (if required), installing, testing and commissioning as per single line diagram (enclosed) and as per the approved drawings.

##### **4.11.1 Codes and Standards**

The electrical installation work shall comply with the latest applicable Standards, Regulations, Electricity Rules and Safety Codes of the locality where the installation is carried out. Nothing in this specification shall be construed to relieve the Contractor of this responsibility.

##### **4.11.2 General Scope**

It will be the Contractor's responsibility to obtain approval / clearance from local statutory authorities including Electrical Inspector, wherever applicable for conducting of any work or for installation carried out which comes under the purview of such authorities.

The Contractor shall be responsible if any installation materials are lost or damaged during installation. All damages and thefts of equipment / component parts, shall be made good by the Contractor.

Chipping and punching holes / openings in concrete floors / walls and brick / RCC walls and finishing them and providing channels and embedments wherever required, provision of chequered plates to close floor openings left around switchgear / panels, etc. together with supply of materials.

It shall be the responsibility of the Contractor to obtain necessary License / Authorization / Permit for work from the Licensing Boards of the Locality / State where the work is to be carried out. The persons deputed by the Contractor's firm should also hold valid permits issued or recognised by the Licensing Board of the Locality / State where the work is to be carried out.

##### **4.11.3 Equipment Installation Work**

Foundation work for all major equipment will be carried out by the Civil Contractor. However minor civil work wherever found necessary for proper installation shall be carried out by the Contractor under this specification. Base frames for switchgear / MCC / control panel are included in the scope of this Contractor.

- i. Transformers

As and when applicable, CONTRACTOR shall

- (a) assemble the transformer with all the fittings such as radiators, bushings, cooler banks, conservator, valves, piping's, marshalling boxes etc.
- (b) arrange for oil filtration before oil filling
- (c) providing wedges/clamps for rigidly stationing transformers on rail
- (d) connect up the transformer's terminals
- (e) lay and terminate the OWNER's cables.

Due care shall be taken by CONTRACTOR to avoid any ingress of moisture or foreign matter during handling of insulation oil.

When lifting a transformer by the lifting lugs or shackles provided for the purpose, simultaneous use should be made of all such lugs and shackles in order to avoid any unbalance while lifting. The lifting chain should never interfere, with any part of the transformer. Before lifting complete transformer, it should be ensured that all cover bolts are tightened fully. In case where it is necessary to use jacks for lifting, jacking shall not be under valve or cooling tubes. For transporting transformers from stores to site, the transformers shall be loaded on a suitable capacity truck or trailer. The transformers shall be properly supported by steel ropes and stoppers on the trailer to avoid tilting of the transformers in transit due to jerks and vibrations. At no instance a transformer shall be kept on bare ground. Where it is not possible to unload the transformer directly on a foundation, these shall be unloaded on a properly built wooden sleeper platform. A transformer shall never be left without putting stoppers to the wheels.

Except large power transformers, all the lighting and small distribution transformers shall be placed on the prepared concrete bed. Large power transformers shall be placed after grouting channels or rails, over concrete foundations. The transformers shall be leveled, aligned and checked for free movement on the rails. Stoppers shall be clamped to the transformers immediately to prevent any movement. All the accessories where supplied loose, like radiators, cooling fans, valves, conservator tanks, explosion-vent pipe, bushings and other devices should be cleaned tested before fixing on the transformer. All the connections for C.T.s, bushings and other wiring shall be checked for tightness and correctness before replacing the lid or tightening all the bolts.

For LT Dry type transformer, the Contractor shall transport the transformers from store/railway siding to site and place them on their foundations, assemble different parts and accessories, fabricate and erect all the supporting structures for detachable cable boxes, complete all conduit erection and wiring connections.

Where assemblies are supplied in more than one section/package, Bidder shall make all necessary mechanical and electrical connections. All insulators and bushings shall be protected against any damage due to negligence or carelessness of Bidder during installation. Insulators/Bushings, chipped/cracked due to negligence or carelessness of the Bidder shall be replaced by bidder at its own expense.

- ii. Switch gear, Control/Relay Panels

The switchgear shall be handled with care, avoiding impact to the equipment; by the skilled manpower under the guidance of a competent supervisor. Dragging of the panels shall be avoided and use of a crane and trailer shall be made for the handling purposes while transporting to various sites. The switchboard shall be properly supported on the truck or trailer by means of ropes to avoid any chances of damage or tilting due to heavy vibration. The switchboards should be lifted by making use of lifting eyebolts only, fully tightened after ensuring that panel supports, nuts and bolts are all intact and tightened. When panels are to be lifted in packed conditions, utmost care shall be taken to avoid any damage to insulators, bushings, metering and protective equipment. The panels shall preferably be kept inside the packing cases till foundations are ready.

Base channels shall be grouted, leveled, in cement concrete pad for low voltage switchgear panels and other cubicle panels. A level benchmark shall be given by the owner as reference level, and further all levels shall be checked and kept with theodolite by the Contractor. Pedestal type panels and MCCs shall be erected by grouting base channels by bolts. A proper bonding surface should be made by chipping the floor while making cement concreting. All foundations, grouted bolts shall be cured for a minimum period of 48 hours.

The switchboard panels should be taken out from the packed cases and moved one by one to the proper place. All the panels should be assembled aligned leveled and it should be ensured that panel to panel coupling bolts, bus bars links fit properly without any strain on any part. It should also be checked up that lowering, lifting, racking in and out operation of the breaker and all other motions are free from any obstruction. The fixing bolts should be grouted only after satisfying all these requirements. The panels shall be checked for correct vertical position using pendulum weight and spirit levels. L.T. switchgear panels can be tack welded at suitable intervals for each shipping section.

After completion of the panel erection, all the cubicles switches, starters, C.T. and P.T. chambers, bus bars chamber should be cleaned and checked for tightness of all the components. All loosely supplied items shall be fitted up. All the wiring connections should also be checked with drawings and tightened. Metering and protective C.Ts, alarm, indications and protective relays should be fitted up. Phase sequence & polarity of PTs and CTs should be checked. Contact resistance of all bus bar joints and contactors should be checked up. Every part or insulator should be checked for any possible damage. All the starters, switches, contacts should be cleaned with C.T.C. Silver tipped contacts should be checked for easy and free movement. Hinges of panel doors should be lightly lubricated to give free and noiseless movement. All openings shall be kept completely closed to avoid ingress of any foreign particles inside the panel.

Switch gear and control/relay panels/desks shall be installed on finished surfaces or concrete or steel sills. Proper aligning, joining of various vertical shipping sections, bus bar connections, inter panel wiring etc. will be the responsibility of CONTRACTOR.

The CONTRACTOR shall take utmost care in handling instruments, relays and other delicate mechanisms. Wherever the instruments and relays are supplied separately, they shall be installed only after erection of switch gear/relay panels is complete.

iii. Bus ducts

If specified in section-C, bus ducts supplied by others will have to be erected by the CONTRACTOR. The CONTRACTOR shall provide suitable support structure for bus

ducts. Indoor portion of the bus duct may be supported from the floor or ceiling beams and outdoor portion of the bus duct shall be supported from ground below on suitable foundation (foundation by civil CONTRACTOR). Wherever called for, the wall frame assembly shall also be made good as per bus duct vendor drawings.

The bus duct will be supplied in parts and all the parts shall be assembled and the bus bar connections shall be made at site. The insulator in bus ducts shall be inspected for any possible damage during transit and the defective ones shall be replaced. The insulators shall be cleaned with carbon tetrachloride. Contact surface of bus bars, bus-bar bolts and nuts shall be thoroughly cleaned with petrol and wiped. Petroleum jelly shall then be applied and bolted connection made. The bus duct enclosure shall be checked for earth continuity and then earthed at two places. The bus duct shall be duly supported between switchgear and transformer. The opening in the wall where the bus duct enters the switchgear room shall be completely sealed to avoid rainwater entry. Expansion joints, flexible connections etc. supplied by the manufacturer of the bus duct shall be properly connected. The bus duct leveling shall be checked with spirit level and pendulum weight. Location of flexible joints shall be marked for identification.

iv. Motors

Unless otherwise specified all the motors will be installed by other agencies. However, pre-commissioning checks and testing of the motors will be by the CONTRACTOR.

Insulation resistance of the motors shall be measured between the winding of the machine and its frame by means of a 500/1000V megger in case of LT motors. A minimum value of 1 mega-ohm for 415V motors shall be considered a safe value.

Insulation resistance of MV motors shall be by 2500V megger and its value shall not be less than 20 mega-ohms at 60 deg. C

v. Battery and Chargers

Battery shall be set up on the racks. Contact surfaces of battery terminals and inter cell connectors shall be cleaned and coated with protective grease and assembled. Each cell shall be inspected for breakage and condition of cover seals as soon as it is received at site. Each cell shall be filled with electrolyte in accordance with the MANUFACTURER's instructions. The cells shall not be lifted by the terminals. Each cell shall be tested with hydrometer and thermometer and results logged. Freshening charge, if required, shall be added. The battery shall be fully charged and electrolyte shall be at full level and of specified specific gravity at the time of handing over to the OWNER.

vi. Welding Receptacles

The welding receptacles shall be erected on steel structures/concrete as per the drawings. In isolated places a separate support shall be fabricated and installed.

Erection of welding receptacle shall be done by fixing the socket with screws using rawl plug or by anchor fasteners. IR/HV test values shall be taken. Interlocks if any and switch operation shall be checked. Power cable shall be terminated properly and the receptacles shall be grounded at two separate points.

## vii. 240/24V Transformer and Flame proof sockets (24V)

The 240/24V transformers shall be an integral part of 24V flameproof hand lamp socket. Necessary supporting structures shall be fabricated out of mild steel and the same shall be painted. Only galvanized steel bolts, nuts & washers shall be used. Power cable shall be properly terminated and switch operation and mechanical/electrical interlock shall be checked. Socket shall be properly grounded.

## viii. Miscellaneous Items

Communication equipment, space heater and ventilation distribution boards, local starters, capacitors, exhaust fans with starters and with louvers assembly and any other electrical equipment within the plant premises shall be installed, tested and commissioned as per respective VENDOR's instructions and the drawings furnished by OWNER.

Suitable brackets, angle/channel section for support of wall mounted equipment shall be provided by the CONTRACTOR

**4.11.4 Cabling System Installation Work**

## Scope of Supply

Following equipment as required shall be supplied by the Contractor.

- Galvanized steel or MS with Aluminium Alkyd paint (ladder and perforated types), cable tray covers and vertical raceway covers.
- Cables glands, lugs and trefoil clamps.
- GI rigid and flexible conduits / pipes.
- Cable termination kits.
- Miscellaneous items like junction boxes / marshalling boxes, push button stations, power receptacles, space heater / auxiliary supply distribution boards.

## i. Cable Trays and Accessories

The cable trays shall be complete with all necessary coupler plates, elbows, tees, bends, reducers, stiffeners and other accessories and hardware. Cable trays and accessories such as tees, elbows, reducer, etc. shall be fabricated out of minimum 2 mm thick sheet of hot dip galvanised sheet except for trays of width 300 mm and lower for which 16 G GS sheet is acceptable. Bends, tees, etc. shall be supplied, as required. Cable tray supports such as angles, channels, etc. shall be of galvanised steel.

## ii. Cable Glands &amp; Lugs

Cable glands shall be of robust construction and of double compression type. Cables lugs shall be of tinned copper, solderless crimping type suitable for aluminium or copper conductors.

## iii. Conduits and Pipes

The Contractor shall supply galvanized steel/coated conduits, heavy duty, GS pipes and flexible conduits as required for the cabling work.

## iv. Power Receptacles

The power receptacles shall be industrial heavy duty type with switches for 3 - phase, AC supply with 3 pin and earth connections. The sockets and switch shall have suitable interlock facility for safety. The receptacles shall be provided with matching plugs. Each unit shall be complete with gasket, cable glands, cable lugs and earthing terminals with washers and nuts.

#### v. Junction Boxes / Marshalling Boxes

Junction boxes/ marshalling boxes shall be hot-dip galvanized, weather proof with IP 55 degree of protection. The terminals shall be suitable for terminating suitable cables. All the terminals shall be complete with insulated barriers, terminal studs, washers, nuts, etc.

#### vi. Local Push Button Stations.

The local push button stations shall be metal enclosed, weather-proof, dust and vermin proof, suitable for mounting on wall or steel structures. The enclosure shall be die cast aluminium or sheet steel of 2 mm thickness and provide a degree of protection of not less than IP:55. The enclosure shall be painted with one coat of epoxy primer and two coats of light gray epoxy paint.

The open / close / start push buttons shall be of momentary contact push to actuate type and stop push buttons shall be stay put type with mushroom knob. The stop push button shall be of lockable type in 'OFF' position. All push buttons shall be fitted with two (2) normally open and two (2) normally closed contacts.

#### vii. Space heater and auxiliary supply distribution boards

These distribution boards shall be sheet steel enclosed indoor, dust and vermin proof and wall mounting type. The enclosure shall be of 2.0 mm thick cold rolled sheet steel and provide degree of protection of not less than IP:52. All doors, removable covers and plates shall be gasketed all around with neoprene gaskets. The boards shall be complete with cable glands, lugs, removable gland plates, two nos. earthing terminals and other necessary accessories.

#### viii. Civil Works

Major civil works are excluded from the scope of this specification. These include construction of cable trenches, foundations, etc. Normally the required embedment plates will be provided by others at the time of civil construction.

Wherever the embedment plates are not provided by others, the Electrical Contractor shall provide the embedment plates by using anchor fasteners. However, minor civil works such as making holes / grooves in floor slab / wall and patching up in an approved manner any holes made in the walls / floors including painting by the Contractor, embedment of short lengths of conduits, plates in floors, walls, etc., if not already done by Civil Contractor shall be deemed to be included in the scope of Electrical Contractor.

#### ix. Cable laying and installation.

The Contractor shall install test and commission cables. The cables shall be laid in built-up trenches, directly buried in ground, or on cable trays, vertical raceways, clamped on structures / walls / ceiling, pulled through pipes and conduits, etc. The scope of cable installation shall include excavation and backfilling (in case of buried cable trench), laying, pulling of cables, proper dressing of cables on cable trays, racks, vertical raceways and supply and installation of cable tags, saddles, spacers and nylon chord for tying as required. The cost of supplying covers for cable route / joint markers, supply of sand and cover plates are included in the scope of the Contractor.

After pulling the cable, the Contractor shall record cable identification with date pulled neatly with waterproof ink in linen tags / aluminium tags and shall securely attach such identification tags. Identification tags shall be attached to each end of each cable with non-corrosive wire. The said wire must be non-ferrous material on single conductor power cable. Tags may further be required at intervals on long runs of cables on cable trays and in pull boxes. Cable and joint markers and RCC warning covers shall be provided wherever required. Sharp bends and kinks in cables shall be avoided. The bending radii for various types of cables shall not be less than 15 times the overall diameter of the cable. Cables laid in ground shall be laid on a 75 mm riddled earth bed. The cables shall then be covered on top and at their sides with fine sand of depth of about 150 mm. This should be then filled upto a depth of about 100 mm above the top of uppermost cable to provide bedding for the protective cable covers which shall be placed centrally over the cables. The RCC covers shall have one hole at each end, to tie them to each other with GI wires to prevent displacement. The trench should be then backfilled with the excavated soil and well rammed in successive layers of not more than 300 mm thick, with the trenches being watered to improve consolidation wherever necessary. To allow for subsidence, a crown of earth not less than 50 mm in the center and tapering towards the sides of the trench should be provided. Removal of surplus earth (if necessary) shall be in the Contractor's scope.

Provision of GI pipe sleeves for crossing roads, water / sewage pipe lines, etc. shall be the Contractor's responsibility. The Contractor shall provide rows of 150 mm diameter GI pipes in a concrete block for passage of cables. Contractor shall also lay spare pipes for future use. LV cables shall be buried at a depth of minimum 750 mm while HV & MV cables shall be buried at a depth of minimum 1000 mm. For road crossings, the pipe for the cables shall be buried at not less than one metre depth.

In each cable run, some extra length shall be kept at a suitable point to enable one or two 'straight through joints' to be made, should the cable develop a fault at a latter date.

#### x. Cable Termination.

All cables shall be connected at both ends. The scope of work shall include making the requisite holes in the gland plate, fixing the glands, terminating the cables in the glands, mounting of core balance CT if required, earthing the cable armour, crimping the cable lugs on each core, neatly clamping the cables in cable alleys / wiring troughs and connecting to the terminals. The cable and core identification tags shall be supplied and installed by the Contractor.

Cable termination of HV and MV cables shall be generally as described above and shall include cable termination kit.

#### xi. Cable Tray and Tray Covers Installation.

All cable racks, vertical raceways and supporting steel shall be installed. The sizes of ladder / perforated cable trays to be supplied shall be as per the requirement as approved by the Employer. Ladder type cable tray shall be used for Power cables. Perforated cable tray shall be used for control and instrumentation cables.

All vertical raceways / trays and outdoor trays shall be covered by 16 gauge galvanized MS sheet covers. The scope of work shall include the installation of these covers including necessary screws when required for fixing to vertical raceways/trays.

#### xii. Cable Trays / Vertical Raceways Mounting Arrangements and Cable Carrier

Structures.

The Contractor shall fabricate, install and paint the following as per the requirement:-



Mounting arrangements for cable trays. Any cable tray junction bends which are non-standard shall be fabricated as racks to suit the site requirements.

Vertical cable raceways and steel accessories (angles and plates) required to seal the floor openings in the case of indoor raceways.

Cables carrier structures (racks) for cable trenches.

Supporting steel for junction / marshalling boxes, push-button stations, vertical structures for clamping cables, etc., as required.

The steel members shall be welded to the floor beams, columns, plates embedded in RC floors or grouted in walls as the case may be to suit the installation. The cable racks and supports shall be painted after installation with one coat of red lead primer, one coat of oil primer followed by two coats of aluminium paint.

The above mounting structures / cable racks shall be fabricated from standard structural steel members (channels, plates, angles and flats).

It shall include fabrication of support, erection, welding grouting, painting including supply and installation of all hardware including anchor fastener to make the installation complete in all respects.

#### xiii. Conduits / Pipes Installation

Contractor shall install all conduits / pipes required for the cabling work. Conduits / pipes shall be laid buried in ground, laid along the walls / structural members along floors and ceilings. Conduit and pipe sleeves are required to be embedded in walls, roof slabs, floors and trench. All conduits / pipes shall have their ends closed by caps until cables are pulled.

Water-proof sealing shall be done for all outdoor to indoor conduit / pipe inserts by means of bell mouth termination pieces and bitumen based cold set water-proof compound.

The scope of installation of conduits / pipes shall include supply and installation of all accessories like tees, elbows, pull-boxes, conduits end plugs, bell-mouths, GI wire for cable pulling, GI saddles, spacers, screws, nuts and bolts. The scope for directly buried pipes / conduits shall include excavation and back filling as required.

#### xiv. Cable Joints

Jointing of cables shall be made in accordance with relevant codes of practice and Manufacturer's special instructions. Cables shall be firmly clamped and supported within 300mm from the joint to avoid mechanical stresses on the joint.

Joints shall not be permitted in control cables. However, in long runs of power cables, joints shall be permitted at an accessible location, which shall be chosen in consultation with Employer before work is taken up. A record of all joints giving cable number, type of cable, type of joint, location and date of jointing shall be kept by the Contractor.

Jointing kits shall be suitable for the type of cable and for underground buried installation. The Contractor shall offer Heat shrinkable jointing kits / cast resin type or tapex type jointing kits, complete with insulating materials, stress grading / relieving materials, plastic mould, resin, tinned copper lugs, plumbing materials and all other accessories to make the joint complete in all respects.

Miscellaneous items like Junction / Marshalling Boxes / Push Button Stations, etc.

The Contractor shall install, junction / marshalling boxes / push button stations. The scope of installation shall be mounting on walls, columns, structures, including necessary bolts, nuts, screws and welding work as necessary.

xv. Cable Trays and Markers.

Each cable shall be tagged with numbers. The tag shall be of aluminum with the number punched on it and securely attached to the cable / conduits by not less than two turns of 20 SWG GI wire. Cable tags shall be of rectangular shape for power cables and of circular shape for control cables. Cable tags shall be provided on all cables at each end, on both sides of wall / floor crossings, on each duct / conduit entry, at each bend/ corner and at every thirty (30) metres in cables trench / tray racks on straight run.

Location of cables laid directly underground shall be clearly indicated with cable marker made of galvanized iron plate. Location of underground cable joints shall be indicated with cable marker with an additional inscription "Cable Joint". The marker shall project 150mm above ground and shall be spaced at an interval of 30 meters, and at every change in direction. They shall be located on both sides of road and drain crossings.

xvi. Sealing of Floor Openings.

All floor openings for vertical cable trays / raceways shall be sealed. The scope of work shall include preparing and laying of the compound.

## **4.12 LIGHTING SYSTEM**

### **4.12.1 Codes & Standards**

Electrical installation work shall comply with all currently applicable standards i.e. IEC 60083, 60598, 60669, 60884, 60906, 60947 and IS 3646, 6665, 10322, 1534, 1913, 732 statutes, regulations and safety codes in the locality / country where the installation is to be carried out.

### **4.12.2 General Requirement**

Luminaires shall be designed for continuous trouble-free operation under atmospheric conditions as specified in Sections B & C of project information without reduction in lamp life or without deterioration of materials and internal wiring. Outdoor fittings shall be weather-proof and water-proof type.

For each type of luminaire the VENDOR shall furnish the utilization factor tables to indicate the proportion of the light emitted by the bare lamps which falls on the working plane.

All luminaires shall be supplied complete with lamps suitable for operation on a supply voltage and the variation in supply voltage and frequency indicated in Data Sheet.

Fluorescent type, incandescent type, mercury vapour, sodium vapour, LED and metal halide type luminaires shall be complete with accessories like lamps, ballasts, Driver, power factor improvement capacitors, starters etc. These shall be mounted as far as possible in the luminaire housing only. If these cannot be accommodated integral with the luminaire then a separate metal enclosed control gear box shall be included to accommodate the control accessories together with a terminal block suitable for loop-in, loop-out connections.

Outdoor type fixtures shall be provided with outdoor type weather-proof box with IP 54 or better.

Each luminaire shall have a terminal block suitable for loop-in, loop-out and T-off connection by 1100 V, 1 core, PVC insulated copper / aluminium conductor wires upto 4 sq.mm in size. In outdoor, corrosive and hazardous areas the termination at the luminaire shall be suitable for 1100 V, PVC insulated, copper / aluminium conductor, armoured cables of sizes upto 6 sq.mm conductor. Terminals shall be of stud or clamp type. The internal wiring should be completed by the MANUFACTURER by means of stranded copper wire of minimum 1 sq.mm size and terminated on the terminal block. Terminal blocks shall be mounted with minimum two fixing screws.

Mounting facility and conduit knock-outs for the luminaries shall be provided.

All hardware used in the luminaire shall be suitably plated or anodised and passivated for use in chemical, industrial and power plants.

#### EARTHING

Each luminaire and control gear box shall be provided with an earthing terminal suitable for connection to the PURCHASER's earthing conductor of 12SWG GI wire unless otherwise specified in Data Sheet . All metal or metal enclosed parts of the luminaire / control gear box shall be bonded and connected to the earthing terminal so as to ensure satisfactory earthing continuity.

#### PAINTING / FINISH

All surfaces of the luminaire / control gear box housing accessories shall be thoroughly cleaned and degreased. It shall be free from scale, rust, sharp edges and burrs.

The luminaire housing shall be stove-enamelled / epoxy stove-enamelled/vitreous enamelled or anodised as indicated under various types of fittings. Aluminium paint on flame proof fittings is prohibited.

The finish of the luminaire shall be such that no bright spots are produced either by direct light source or by reflection.

#### GENERAL REQUIREMENT FOR LED LIGHT FIXTURES

All LED luminaires shall be provided with toughened glass and shall have thickness of sufficient strength and high efficiency prismatic diffuser under the LED chamber to protect the LED and luminaries.

Suitable reflector / lenses may also be provided to increase the illumination uniformity and distribution for LED

The fixture shall be designed so as to have lumen maintenance of at least 70% at the end of 50,000 hours (L70) at design temperature of 35 degree C.

Adequate heat sink with proper thermal management shall be provided.

Minimum view angle of the LED shall not be less than 120 degree.

Power factor of complete fitting shall be more than 0.95 at full load 240V and THD<8%.

The LED luminaire shall be free of glare.

The luminaire should be an inbuilt surge protection of not less than 4 KV to prevent in damage to the driver in case of sudden voltage surge.

#### **4.12.3 Fluorescent Luminaires:**

The luminaire shall be provided with CRCA MS sheet in epoxy powder coat with anodised aluminium reflector and complete with all control accessories mounted on it. The finish shall be stove enamelled for general industrial application or vitreous enamelled where the atmosphere is humid such as textile mills, sugar mills, and thermal projects.

For dusty / moisture prevalent atmosphere (mill area / air washer rooms) the luminaire shall be totally enclosed in CRCA sheet steel enclosure with a heat resistant toughened glass cover or clear acrylic sheet fixed with EPDM gaskets for sealing. The luminaire shall be dust tight / vapour proof epoxy, stove enamelled (with IP 54 or better).

For atmospheres where chemically corrosive fumes or vapours are present (battery rooms, chlorine cylinder rooms, W.T. plant) the material of the housing / mounting, reflectors, end plates shall be cast aluminium / aluminium sheet and finished with epoxy stove enamel to resist corrosion. The control gear housing and lamp holder assembly shall be provided with EPDM gaskets to make it proof against entry of corrosive vapours with minimum degree of protection with IP 65 or better.

(a) The housing shall be Die-cast aluminium alloy (LM6) with heat resistant toughened flat glass, control gear chamber, with reflector and painted MS wire guard, earthing terminal, three way cable entry etc.

(b) The surface temperature rise of the luminaire shall comply with the temperature rise limits specified in relevant standards.

LED Luminaire:

(a) The housing shall be extruded aluminium natural anodized finish with high efficiency diffuser and LED mounted on PCB with integral electronic driver.

#### **4.12.4 Incandescent / Mercury Vapour / Sodium Vapour / MII Blended / Metal Halide Luminaires:**

##### **i. Bulk head Luminaire:**

The luminaire shall be of robust construction, die cast aluminium / vitreous enamelled housing, heat and shock resistant prismatic or clear glass cover fixed with EPDM neoprene gaskets for sealing. For mechanical protection to the glass cover, round MS wire guard with vitreous enamelled finish shall be provided.

##### **ii. High, Medium and Low Bay Luminaires:**

High and medium bay luminaires shall be cast aluminium / stove enamelled with anodised aluminium mirror polished reflector, canopy with eye bolt for suspension and cooling fins.

Glass cover shall be provided if specified. The glass cover housing shall be toughened and heat resistant.

Low bay luminaires shall be with CRCA MS sheet steel / cast aluminium enclosure, wide angle distribution type polished anodized aluminum reflector, housing covered with toughened heat resistant glass cover and wire guard complete with EPDM gaskets, mounting bracket etc.

All luminaires used with metal halide lamps shall be of enclosed type.

#### **4.12.5 LED Luminarie**

Low/Medium/Highbay LED Luminarie housing shall be die cast aluminium and anodized aluminum reflector with polyester powder coat finish or polyester white paint finish. and diffuser shall be made of Polycarbonate material and shall have heat sink for better thermal dissipation

Bulkhead LED Luminaries housing shall be die cast aluminum with front cover of polycarbonate diffuser.

#### **4.12.6 Flood Light Luminaire**

General purpose flood light luminaire:

Flood light luminaires shall be of weather proof construction with die-cast aluminium housing, anodised aluminium mirror polished reflector, heat resistant, toughened glass cover and necessary EPDM gaskets to prevent ingress of dust, moisture and insect.

The housing shall be supported on a cast iron / aluminium base and capable of being swivelled in both horizontal and vertical directions and locked in any desired position.

For focussing purposes, knobs shall be provided along with sector plate indicating the angle in degrees between 0 and 90 deg. in vertical direction.

When mercury vapour, sodium vapour or metal halide lamps are specified, the same shall be mounted in a separate sheet metal enclosed / cast aluminium weather proof control gear box.

The luminaire shall be complete with stove enamelled anodized aluminum reflector, porcelain lamp holder, heat resistant toughened glass cover, cast iron mounting base, cable gland, earthing terminal etc.

The Flood light LED luminaire shall house in die cast aluminium and corrosion resistant powder finish. And shall have toughened glass diffuser with integral driver.

#### **4.12.7 Street Lighting Luminaires**

##### **i. Fluorescent Luminaires**

Street lighting fluorescent luminaire shall be outdoor weather proof type for illumination of secondary roads, walkways, peripheral lighting of buildings etc.

The luminaire shall be of semi-cut off or non-cut off type, with CRCA sheet steel die cast aluminium housing body, vitreous/stove enamelled, plain or corrugated clear acrylic cover,

complete with integral mounted control gear, EPDM gaskets, side pipe entry or top suspension type.

The luminaire shall be suitable for required fluorescent tubes.

ii. Mercury Vapour and Sodium Vapour Luminaires

Street light mercury / sodium vapour luminaires shall be outdoor weather proof type for illumination of main roads, traffic islands etc.

The luminaire shall be of semi-cut off or cut-off type, with die-cast aluminium housing, acrylic or prismatic cover, polished high purity aluminium anodized reflectors with heat resistant toughened flat glass, complete with integral mounted control gear, EPDM gaskets and with rear pipe entry.

For LED Lighting, the street Light fixture shall be made up of high pressure die-cast aluminium alloy with toughened diffuser with anodised aluminium reflector. The Driver shall be of integral. The fixture shall have excellent heat dissipation through cooling fins on housing. The housing shall be complete with LED, driver and accessories pre-wired-up to terminal block in connector compartment. The degree of protection shall be IP65 or better.

#### **4.12.8 Accessories for Luminaires**

i. Reflectors

The reflectors shall be made of CRCA sheet steel / aluminium / silvered glass/ chromium plated sheet copper as indicated for above mentioned luminaires.

Aluminium used for reflectors shall be anodized / epoxy stove enamelled / mirror polished. The finish for the reflector shall be as indicated for above mentioned fittings and or in Data Sheet.

Aluminium paint on the reflectors of flame proof lighting fittings is prohibited.

Reflectors shall be free from scratches or blisters and shall have a smooth and glossy surface having an optimum light reflecting coefficient such as to ensure the overall light output specified by the MANUFACTURER.

Reflectors shall be readily removable from the housing for cleaning and maintenance without disturbing the lamps and without the use of tools. They shall be securely fixed to the housing by means of positive fastening device of captive type.

ii. Lamp / Starter Holders

Lamp holders shall comply with relevant standards specified in Data Sheet. They shall have low contact resistance, shall be resistant to wear and shall be suitable for operation at the specified temperature without deterioration in insulation value. They shall hold the lamps in position under normal condition of shock and vibration met with under normal installation and use.

Lamp holders for the fluorescent lamps shall be of the spring loaded bi-pin rotor type. Live parts of the lamp holder shall not be exposed during insertion or removal of lamp or after

the lamp, has been taken out. The lamp holder contacts shall provide adequate pressure on the lamp cap pins when the lamp is in working position.

Lamp holders for incandescent, MLL blended, metal halide, mercury vapour and sodium vapour lamps shall be of Edison Screw (E.S.) type.

Starter holders for fluorescent lamps shall conform to the standards specified in Data Sheet. All material used in the construction of the holder shall be suitable for tropical use.

The starter holders shall be so designed that they are mechanically robust and free from any operational difficulties. They shall be capable of withstanding the shocks met within normal transit, installation and use.

iii. Ballasts

The ballasts shall be designed, manufactured and supplied in accordance with the relevant standards specified in Data Sheet. The ballasts shall be designed to have a long service life and low power loss.

Ballasts shall be mounted using self locking, anti-vibration fixings and shall be easy to remove without demounting the fittings. They shall be in dust tight, non combustible enclosures.

Separate ballast for each lamp shall be provided in case of multi lamp luminaires, except in the case of 2 x 20 watts luminaires.

iv. Electronic Ballast

Electronic ballast shall be suitable for required fluorescent lamp and shall be energy saving, warm start type having a power factor better than 0.96, having an optimum wattage delivery to the lamp. The choke shall be suitable for 180 – 270 V AC for operation at ambient temperature range of -15°C to +50°C. The choke shall have low radiated and conducted EMI / RFI.

v. Starters

Starters shall have bimetal electrodes and high mechanical strength. Starters shall be replaceable without disturbing the reflector or lamps and without the use of any tool. Starters shall have brass contacts and radio interference capacitors. The choke shall be suitable for ambient temperature range of -20°C to 100°C

The starters shall generally conform to the relevant standards specified in Data Sheet.

vi. Capacitors

The capacitors shall have a constant value of capacitance and shall be connected across the supply of individual lamp circuits.

The capacitors shall be suitable for operation at supply voltage as specified in Data Sheet and shall have a value of capacitance so as to correct the power factor of its corresponding lamp circuit to the extent of 0.95 lag or better.

The capacitors shall be hermetically sealed preferably in a metal enclosure to prevent seepage of impregnant and ingress of moisture.

vii. Lamps

Lamps shall be capable of withstanding small vibrations and the connections at lead in wires and filaments / electrodes shall not break under such circumstances.

Lamps / tubes shall conform to relevant standards specified in Data Sheet and shall be suitable for supply voltage and frequency specified in Data Sheet

Incandescent lamps

(a) General lighting service (GLS) lamps shall be tungsten filament incandescent type. The filament shall be coiled coil type rated for 230 / 250 volts, single phase AC.

(b) Lamps shall be with Edison Screw metal lamp caps to prevent pilferage.

(c) Lamps shall be milky white for diffused, soft, glare free lighting and rated upto 100 watts.

(d) Lamps for special application with high intensity local lighting such as for lathes, carrom boards, show windows, reading tables etc. shall have surface coating.

(e) Lamps with internal mirror reflector and coated / silvered bowl shall be provided for bed focus lights, show window focus lights, restaurants and hotels, lamps shall be rated upto 150 watts.

Halogen Lamps

(a) Halogen lamps shall be tungsten halogen type suitable for fitment in flood light luminaires.

(b) Lamps shall be rated 250 volts single phase AC upto 1000 watts.

(c) Halogen LED shall have Extruded aluminum heat sink fixed on housing for better cooling.

Gas Discharge Lamps

Fluorescent Lamps

(a) Fluorescent lamps shall be low pressure mercury vapour type with low wattage consumption and high efficiency and longer burning life (above 5000 hours).

(b) Lamps shall be of warm white or cool day light type with triband phosphor coated, type suitable for operation on 240V, single phase AC in standard lengths of 2 and 4 feet.

Compact Fluorescent Lamps

(a) These compact fluorescent lamps shall be of low pressure, low wattage type with integral glow switch starter with separate/inbuilt ballast. Suitable for operation on 240 V, single phase AC with burning life (above 5000 hours).



#### Triband Phosphor Colour 80 Series of Fluorescent Lamps

- (a) These lamps shall be of the low pressure mercury vapour type with low wattage consumption and a high luminous efficiency of 90 Lumen / W or better and a longer burning life.
- (b) Lamps shall be cool day light type suitable for operation with 240 V single phase AC and ratings upto 36 W.
- (c) Lamps shall have a colour Rendering Index (Ra) of 85 or better.

#### High Intensity Discharge Lamps

These lamps include the high pressure mercury vapour blended lamp, high pressure mercury vapour lamp and the high pressure sodium vapour lamp.

- (a) High pressure mercury vapour blended lamps shall be direct replacement for incandescent lamps of higher wattages and shall be with in built control gear and burning life about 10000 hours.
- (b) High pressure mercury vapour lamps shall be with quartz discharge tube, internal coated shell, quick restrike time (of within 5 minutes) and with burning life (about 5000 hours) in standard ratings upto 1000 watts.
- (c) High pressure sodium vapour lamps shall be with polycrystalline translucent, coated discharge tube, coated shell, quick restrike time (of within 5 minutes) and with burning life (about 24,000 hours) in standard ratings upto 1000 watts.
- (d) Metal halide lamps shall be single ended or double ended as required. The lamps shall be with quartz discharge tube and transparent / internal coated shell, quick restrike time (of within 5 minutes) with burning life (upto 24000 hours) in standard ratings upto 1000 W. The colour rendering index of these lamps shall be very high. These lamps shall be used only in enclosed luminaires (lamps without protective coating) and can be used only in open luminaires in lamps with Teflon or other coating to hold the shell in case of non-passive end of lamp life.

#### Low Pressure Sodium Lamps

These lamps are high efficiency discharge lamps, with restrike time (of within 11 minutes) and with burning life (about 18,000 hours) in standard ratings of 18 W and 35,55,90,135 and 180Watts.

#### 4.12.9 Tests and Test Reports

Type tests, acceptance tests and routine tests for the lighting fixtures and accessories covered by this specification shall be carried out as per the relevant standard for the respective fixtures and their accessories.

The MANUFACTURER's type and routine test certificates shall be submitted for tests conducted as per relevant standards for the fixtures and accessories. The BIDDER shall submit with his proposal copies of available test certificates of the luminaires offered.

**4.12.10 Drawings and Data**

As part of proposal, the BIDDER shall furnish relevant descriptive and illustrative literature on lighting fixtures and accessories and the following drawings / data for the respective lighting fixtures.

Dimensioned drawings with manufacturer's catalogue numbers.

Table showing manufacturer's catalogue number for luminaires with corresponding TCE designation number.

Information called for in Data Sheet for each group of luminaires.

**4.13 EARTHING**

All the non-current carrying metal parts of the electrical installation and mechanical equipments shall be earthed properly. The metal conduits, trunking, cables armour and sheath, electric panels boards, lighting fixtures, ceiling fan, exhaust fan, receptacle and all other parts made of metal shall be bonded together and connected by means of specified earthing system. An earth continuity conductor shall be installed with all the feeders and circuits and shall be connected from the earth bar of the panel boards to the conduit system, earth stud of the switch box, lighting fixture, earth pin of the socket outlets and to any metallic wall plates used. All the enclosures of motors shall be also connected to the earthing system.

**4.13.1 Scope**

The scope of work shall cover supply, laying, installation, connecting, testing and commissioning of:

Earthing station

- Earthing Aluminum/copper strips from earthing station to equipotential bar.
- Earthing Aluminum/copper strips/wires from equipotential bar to lay feeder mains and circuit to connect power panels, switchboards etc.
- Bonding of Non-current carrying parts, and metallic parts of the electrical installation.

**4.13.2 Standards**

The following standards and rules shall be applicable.

- Indian Standard Code of practices for Earthing
- Indian Electricity Act and Rules

All codes and standards mean the latest. Where not specified otherwise the installation shall generally follow the Indian Standard Code of Practice or the British Standard Codes of Practice in absence of Indian Standard.

Type of Earthing Station

Total resistance of earth grid system should not exceed 1 ohms. Conductor directly buried in soil shall be MS rod of approved size & quality. Following earthing arrangement shall be done-

Plate Earthing

The station earthing arrangement shall be carried out as mentioned below:

HT panel, LT panel, Transformer body & neutral earthing shall be done by separate Plate earthing electrode.

The earth lead shall be connected to the earth plate through hot dip galvanised iron bolts.

The earthing grid and the earthing conductors shall be hot dip galvanised iron/ steel strip of size as specified.

G.I. pipe with funnel of approved quality shall be used for watering the earthing electrodes/stations.

The block masonry chamber with Cast Iron hinged cover shall be provided for housing the funnel and the pipe for watering the earthing electrodes/stations.

The hardware and other consumables for earthing installation shall be of copper/brass in case of copper Earth plate shall be hot dip galvanised iron material in case of G.I. earth plate.

Minimum size of plate electrode shall be 1200mm x 1200mm in case of GI & 600mm x 600mm in case of copper electrode. Minimum thickness shall be as per IS code.

#### Pipe Earthing

The earth electrode shall be 3 M long 50 mm dia class “A”, Galvanised steel pipe.

The earth lead shall be fixed to the pipe with a nut and safety set screws. The clamp shall be permanently accessible.

The earthing grid and the earthing conductor shall be hot dip galvanised iron strips of the size.

G.I. pipe with funnel of approved quality shall be used for watering the earth electrode\station.

The block masonry chamber with Cast Iron hinged cover shall be provided for housing the above referred funnel and pipe.

The hardware and other consumables for earthing installation shall be hot dip galvanised iron material as shown on the drawing.

#### **4.13.3 Installation and Connection**

The plate/pipe electrode, as far as practicable, shall be buried below permanent moisture level but in no case, less than 2.5m below finished ground level.

The plate/pipe electrode shall be kept clear of the building foundation and in no case, it shall be nearer by less than 2 m from outer face of the respective building wall/column.

The plate electrode shall be installed vertically and shall be surrounded with 150 mm thick layers of Charcoal dust, Salt and sand mixture.

20 mm dia G.I. pipe for watering, shall run from top edge of the plate/pipe electrode to the mid level of block masonry chamber.

Top of the pipe shall be provided with G.I. funnel and screen for watering the earth/ground through the pipe.

The funnel with screen over the G.I. pipe for watering to the earth shall be housed in a block masonry chamber.

The masonry chamber shall be provided with a Cast Iron hinged cover resting over the Cast Iron frame which shall be embedded in the block masonry.

Construction of the earthing station shall conform to the requirement on earth electrodes mentioned in the latest edition of Indian Standard (IS: 3043).

The earth conductors (Strips/Wires copper/Hot dip G.I.) inside the building shall properly be clamped/supported on the wall with galvanised clamps and Mild Steel Zinc Passivated screws / bolts. The conductors outside the building shall be laid atleast 600 mm below the finished ground level.

The earth conductors shall either terminate on earthing socket provided on the equipment or shall be fastened to the foundation bolt and / or on frames of the equipment. The earthing connection to equipment body shall be done after removing paint and other oily substances from the body and then properly finished.

Over lapping of earth conductors during straight through joints, where required, shall be of minimum 75 mm long.

The earth conductors shall be in one length between the earthing grid and the equipment to be earthed.

#### **4.13.4 Earth Leads and Connections**

Earth lead shall be bare copper or galvanised steel as specified. Copper lead shall have a phosphor content of not over 0.15%. Galvanised steel buried in the ground shall be protected with bitumen and Hessian wrap or polythene faced Hessian and bitumen coating. At road crossing necessary hume pipes shall be laid. Earth lead run on surface of wall or ceiling shall be fixed on saddles so that strip is at least 8 mm away from the wall surface.

The complete earthing system shall be mechanically and electrically bonded to provide an independent return path to the earth source.

#### **4.13.5 Equipment Earthing**

All apparatus and equipment transmitting or utilising power shall be earthed in the following manner. Copper /G.I. earth strips/wires shall be used unless otherwise indicated.

#### **4.13.6 Power Transmission Apparatus**

Metallic conduit shall not be accepted as an earth continuity conductor. A separate insulated/bar earth continuity conductor of size 50% of the phase conductor subject to the minimum shall be provided.

Non metallic conduit shall have an insulated earth continuity conductor of the same size for metallic conduit. All metal junction and switch boxes shall have an inside earth stud to which the earth conductor shall be connected. The earth conductor shall be distinctly colored (Green or Green / Yellow) for easy identification.

Three phase power panel and distribution boards shall have two distinct earth connections of the size correlated to the incoming cable size. In case of single phase DB's a single earth connection is adequate.

The body of the HT panel, Transformer body & neutral, LT panels, capacitor panels, 3 phase motors etc will be provided with two distinct earthing paths.

All earthing System of LT Panel & Starter panel in same room are to be looped together in trenches.

#### 4.13.7 Utilizing Equipment

Three phase motors and other three phase apparatus shall have two distinct earth connections of the size equal to 50% of the connecting cable subject to the following.

For single phase motors and apparatus, the single earth connection shall be provided of the above size. For all light fittings and fans a single earth connection with 1.5 sq. mm. Copper or equivalent size shall be provided.

In equipment earthing grid shall be established. All earth connections to all panels, DB's and equipment shall be connected to the nearest point of the earthing grid.

Test

The entire earthing installation shall be tested as per requirements of Indian Standard Specification.

#### 4.13.8 Conductor size of Equipment Earthing

Sl. No.	Equipment description	Conductor size
1	LT Motors above 37kW, LT Motors below 37kW,	50X6 mm GI Flat 25 X 3 mm GI Flat
2	HT Panel ,LT Panel, APFC Panel, Transformer body & neutral	50X6 mm GI Flat
3	Local control station, Welding receptacles	8 SWG wire
4	Main Earth Grid	50X6 mm GI Flat
5	Cable Tray, Crane, PDB, LDB	25X6 mm GI Flat

#### 4.13.9 Inspection

Energy efficient motor

Following test shall be carried out as per BIS/ IEC by the manufacturers on each motor:

- Dimensions
- Insulation resistance test
- • Measurement of resistance of winding of stator
- No load test at rated voltage to determine input current, power and speed

- Locked rotor readings of voltage, current and power input at a suitable reduced voltage
- Reduced voltage running up test
- High voltage test
- Full load test at duty point to determine efficiency, power factor and slip
- Temperature rise test (one on each rating)
- Momentary overload test
- Test for noise level of motor
- Test for vibration severity of motor
- Over speed test

Type test certificate (as per BIS/ IEC) for each similar rating motor shall be furnished at the time of inspection.

#### Power Cable & Control Cable

Acceptance test shall be carried out as per BIS/ IEC by the manufacturers on each cable. The following are recommended as acceptance tests:

- Tensile strength
- Wrapping test
- Conductor resistance test
- Test for thickness of insulation and sheath
- Hot set test for insulation
- Tensile strength and elongation at break test for insulation and sheath
- High voltage test
- Insulation resistance (volume resistivity) test

#### HV & LV Switchboard

Routine test shall be carried out as per BIS/ IEC by the manufacturers on HV & LV Switchboard. The following are recommended as routine tests:

- Dimensional check
- Bill of Quantity check
- Operational check
- Relay operation through primary/ secondary injection
- Insulation resistance test

- High voltage test

Type test certificate (as per BIS/ IEC) for similar rating switchboard shall be furnished at the time of inspection.

Transformer

All routine tests shall be conducted as per relevant standards. Type test certificate (as per BIS/ IEC) for similar rating of transformer shall be submitted.

LV Bus duct & miscellaneous electrical equipments

All routine tests shall be conducted as per relevant standards. Type test certificate (as per BIS/ IEC) for similar rating of equipment shall be submitted.

In case type test certificates for similar equipment is not available, the same shall be conducted in presence of Owner/Consultant/EPC Contractor or his representative if Owner/Consultant/EPC Contractor so desires.





**6.2.1.4**  
**Standard Specification**  
**(Instrumentation, Control & Automation, SCADA)**



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## **1.1 Introduction**

This part covers the general requirements for the design, supply, installation, inspection and testing of the Instrumentation, Control and Automation and associated plant and materials.

## **1.2 Reference Standards**

Unless otherwise approved, all equipment shall comply with relevant quality standards test procedures and codes of practice collectively referred to as Reference Standards including those listed below in accordance with the requirements detailed elsewhere in this specification.

Generally, the following latest edition of codes and standards prevailing at the time of award of contract shall be applicable.

### **1.2.1 Temperature Measurement**

- a) Instrument and apparatus for temperature measurement - ASME PTC 19.3 (1974).
- b) Temperature Measurement - Thermocouples - ANSI - MC 96.1 - 1982.
- c) Temperature Measurement by electrical resistance thermometers – IS : 2806
- d) Thermometer-element-Platinum resistance - IS: 2848 / DIN 43760

### **1.2.2 Pressure Measurement**

- a) Instrument and apparatus for pressure measurement - ASME PTC 19.2 (1964).
- b) Bourdon tube pressure and vacuum gauges - IS: 3624/1996.

### **1.2.3 Flow Measurement**

- a) Instruments and apparatus for flow measurement - ASME PTC 19.5 (1972) Interim supplement, Part-II
- b) Measurements of fluid flow in closed conduit - BS 1042.

### **1.2.4 Electronic Measuring Instruments and Control Hardware**

- a) Automatic null balancing electrical measuring instruments -ANSI C 39.4 (Rev. 1973), IS 9319
- b) Safety requirements for electrical and electronic measuring and controlling instrumentation - ANSI C 39.5 / 1974.
- c) Compatibility of analog signals for electronic industrial process instruments - ISA-S 50.1: ANSI MC 12.1 / 1975.
- d) Dynamic response testing of process control instrumentation - ANSI MC 4.1 (1975) - ISA -S26 (1968).
- e) Surge withstand capability (SWC) tests - ANSI C 37.90A (1989), IEC-255.4.

### **1.2.5 Printed circuit boards - IPC TM-650, IEC 326C.**

- a) General requirements and tests for printed wiring boards - IS-7405 (Part-I)/1973.
- b) Edge socket connectors - IEC 130-11.
- c) Requirements and methods of testing of wire wrap terminations--DIN 41611 Part-2.
- d) Dimensions of attachment plugs and receptacles- ANSI C73-1973.(Supplement ANSI C73a – 1980)

#### **1.2.6 Instrument Switches and Contacts**

- a) Contact Rating - AC services NEMA ICS Part-2 125, A-600
- b) Contact Rating - DC services NEMA ICS Part-2 125, N-600

#### **1.2.7 Enclosures**

- a) Enclosures for Industrial Controls and Systems–NEMA ICS-6-110.15 through 110.22
- b) Racks, panels and associated equipment -EIA: RS-310-B-1983 (ANSI C83.9 - 1972).

#### **1.2.8 Apparatus, Enclosures and Installation Practices in Hazardous Area**

- a) Classification of hazardous area - NEMA Article 500, Volume-6, 1978.
- b) Electrical Instruments in hazardous dust locations - ISA-RP 12.11.
- c) Intrinsically safe apparatus - NFPA Article 493 Volume-4 1978.
- d) Purged and pressurized enclosure for electrical equipment in hazardous location - NFPA Article 496 Volume-4, 1978.

#### **1.2.9 Sampling System**

- a) Stainless Steel material of tubing and valves, for sampling system - ASTM A 269-79 GRTO-316.
- b) Submerged helical coil heat exchangers for sample coolers -- ASTM D11 98.

#### **1.2.10 Annunciators**

- a) Specifications and guides for the use of general-purpose annunciators - ISA RP 18.1.
- b) Surge withstand capability tests -ANSI C37.90 a -1971 and IEEE Standard 472-1974.

#### **1.2.11 Interlocks, Protections**

- a) Relays and relay system associated with electric power apparatus - IEEE Standards 3.13.
- b) Surge withstand capability tests - ANSI C37.90 a - 1971 and IEEE Standard 472-1974.
- c) General requirements and tests for switching devices for control and auxiliary circuits including contactor relays - IS-6875 (Part-I)/1973.

#### **1.2.12 UPS System**

- a) Practice and requirements for semi-conductor power rectifiers - ANSI C34.2.
- b) Relays and relay systems associated with electrical power apparatus IEEE Standard - 3.13.
- c) Surge withstand capability tests - ANSI C 70.90 A/1971, IEC-255.4.
- d) Recommended practice for sizing large lead storage batteries for generating stations and sub-stations - -IEEE-485.
- e) Ni-Cd Battery – IEEE Std. 1106 /IS 10918

### 1.2.13 Instrument Tubing

- a) Seamless Carbon Steel Pipe - ASTM-A-106.
- b) Forged carbon steel fittings - ASTM-A-105.
- c) Dimensions of fittings - ANSI-B16.11.
- d) Code for pressure piping, welding, hydrostatic testing - ANSI-B 31.1.
- e) Nomenclature for instrument tube fittings - ISA-RP 42.1 / 1982.
- f) Seamless Stainless Steel Tube ASTM A-213 TP 316 / ASTM A-269 TP 316
- g) Seamless Alloy Steel Pipe ASTM A 335 P22
- h) Seamless Stainless Steel Pipe ASTM A-312 TP 316

### 1.2.14 Cables

- a) Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy-IPCEA S-61-402
- b) Guide for design and installation of cable system in power generating station (insulation, jacket materials) -IEEE Standard 422.
- c) Requirements of vertical tray flame test - IEEE 383
- d) Standard specification for tinned soft or annealed copper wire for electrical purpose - ASTM B33.

### 1.2.15 Electronic Cards, Subassemblies and Components

- a) Unpackaged
  - i) Vibration : IEC-68.2.6
  - ii) Shock : IEC-68.2.27
  - iii) Drop & Topple : IEC-68.2.31
- b) Packaged
  - Vibration, Drop & Static Compression - NSTA.
- c) Electromagnetic Compatibility
  - i) Electrical Fast Transient : IEC-801.4
  - ii) Surge Withstand : IEC-255.4
  - iii) Radiated Electromagnetic Field : IEC-801.3
  - iv) Electrostatic Discharge : IEC-801.2
  - v) Electromagnetic Emissions : VDE 0871, Class-B

### 1.2.16 Cable Trays, Conduits

- a) Guide for the design and installation of cable system in power generating station (cable trays, support systems, conduits)- IEEE Standard 422, NEMA VE-1, NEC-1981. Test Standards NEMA VE-1-1979.
- b) Galvanizing of carbon steel cable trays - ASTM A-386.

### 1.2.17 Reference Standards

- |                       |   |   |
|-----------------------|---|---|
| 1. ISO 9000 and 09004 | - | Quality Systems   |
| 2. IEEE 587           | - | Power Supply Surge Protection\  |
| 3. IEC 61158-2        | - | Communication Protocols   |
| 4. ISO 9075 (BS 6964) | - | Structured Query Language (SQL)   |
| 5. BS 5515            | - | Documentation of Computer Based Systems   |
| 6. BS 7165            | - | Recommendation for Achievement of Quality in Software                           |
| 7. BS EN 50081        | - | Electromagnetic Compatibility   |
| 8. ISO 3511           | - | Process measurement control functions – Instrumentation symbolic representation |
| 9. ISO-OSI            | - | 7 Layer Communication Model   |
| 10. IEEE 472-1974     | - | Surge protection.   |

## 1.3 Statement of Compliance

The Contractor shall provide a list of the reference standards used and shall provide a compliance/non-compliance statement during FDS submission and each datasheet for equipment approval.

**Note:** The contractor shall submit a deviation statement with each equipment datasheet and reference the contract clauses and state the deviation if any.

All standards which the Contractor intends to use but which are not part of the above Standards or other listed Reference Standards, shall be submitted to the Employer Representative for consent before any design against that standard proceeds.

### 1.3.1 Documents to be submitted during Bid Submission for Technical Qualification

Include a complete Table of Conformance to each and every reference standards or part of the specifications. Use a chart format with specification part identified, indicate whether each part is in compliance, a deviation or an exception to the specific part. If an exception or deviation, include a narrative description as to how the deviation or exception can benefit the end-user of the system over that item specified.

Provide a system configuration diagram of the proposed control system at the local control centers showing all major components and their interconnections and interrelationships. Label each diagram and indicate all external power and communications interfaces. Contractor shall ensure that the proposed block diagram developed by the Contractor shall be the proposed system offered by the Contractor and shall not merely submit the block diagram/system configuration representation as depicted in this tender as his proposed system.



Contractor shall provide a written overview of the proposed control & Instrumentation system at the local control center inclusive of SCADA software, Historian, control room architecture, necessary hardware and software modification, communication equipment and interface, instrumentation system, describing the principal functions and capabilities of the system's (servers, PLC's, system communications and general system capabilities (maximum number of network nodes, PLC's/RTU and I/O points, communication protocols available, etc. ).

Contractor shall list out the spares considered and to be supplied under this contract for each component Note: This is in addition to the mandatory spares which are listed in this document.

Contractor shall provide an operating system and software applications list with descriptive literature for the proposed system. Include all software items, supplier name, quantity, and model numbers. Indicate whether any proposed software is proprietary and would not be turned over to the Employer.

Information is also required for the following:

- 1) Name, version, product brochures, data sheets of the proposed centralized SCADA software, LCC SCADA software, historian software, PLC software, OPC software to achieve integration of data, MIS software etc.
- 2) Name, version, product brochures, data sheets of the proposed PLC system, I/O modules,
- 3) Name of version of all necessary software that shall be supplied and implemented under this contract.(All software's shall be the latest series version).
- 4) Name & version of the operating system software for operator & Employer Representative work station, Blade server software, networking software, etc.
- 5) Name & version of all IT hardware and software that shall be part of system.
- 6) Name and version of any required communications software, firmware, etc.
- 7) Name and version of the specified report application software,
- 8) Name and provide a description of any non-resident software required to program, troubleshoot or diagnose any devices in the system.
- 9) Describe the system supplier's provisions for service, technical assistance and replacement parts for the proposed system. Include the system supplier's 1-800-toll free number. Identify with resumes, all personnel who will be providing technical support services for the project after it is accepted.
- 10) Above documents shall be submitted in proper bounded form and indexed with page numbering for easy referencing. All catalogs and literature (including sub-suppliers' catalogs), datasheets, Instrument list, etc. shall be bounded together in indexed volumes. The Contractor shall submit all the documents with indexing with page numbering for easy reference.

#### **1.4 Project Requirements**

1. Contractor shall provide material, equipment & services specified or otherwise required within the scope boundary to fulfill the intent of specification and to integrate into a fully functional Instrumentation and Control system ensuring operability, maintainability and reliability and durability for comprehensive operation & maintenance period described in this specification.

2. Contractor shall furnish their offer based on the requirements as described in the specification.
3. Contractor shall include all associated instrumentation & control and automation equipment required for control and monitoring of the entire system (locally & remotely) under his scope of work
4. The scope of supply shall include but shall not be limited to the following within the scope boundary:
  - a) Field instruments and sensors for remote measurement, Primary flow elements along with branch pipes, root valves, nipples, flanges, nuts, bolts, gaskets and accessories.
  - b) Instrumentation pair, triad & core cable, instrumentation power cable, optical fiber cable, special cable etc. as required.
  - c) Control panel, panel instruments, accessories and furniture (system consoles), as required.
  - d) Required power supply
  - e) Supply of all start-up, commissioning and recommended spares in addition to the mandatory spares.
5. Contractor shall provide local panels for local start/stop monitoring of auxiliaries and equipments as per the requirements to be decided during detail Employer Representative stage. Ingress protection of panels shall be as per requirements mentioned in this document.
6. Local Panels, Gauge Boards and Transmitter Racks, stanchions, brackets etc. as required.
7. Process connection and piping materials including impulse pipes of different grades & stainless steel tubes, stub, bosses, root valves, isolation & drain valves, valve manifolds, gauge valves, condensate pot, fittings, stands, brackets etc. as applicable, for satisfactory installation of all field instruments and analyzers.
8. Pneumatic tubing along with fittings and isolating cocks for air consumers.
9. Erection hardware including junction boxes, canopies, structural steel items viz steel angles, channels, flats.
10. Complete cable accessories viz, flexible conduits, sub-trays/perforated trays, pull boxes, inspection covers, bends, elbows, mounting brackets, clamps, nuts and bolts, glands, lugs, ferrules, connectors, markers, tray supports, rigid conduits, tie wraps etc.
11. Complete optical fiber cable /special cables with accessories like optical fiber distribution box, patch cord / pigtail, converter, terminators, taps, heavy duty conduits etc. to make the system complete in all respect.
12. Rating plates, Nameplates and Labels.

13. Maintenance, calibration, commissioning, site testing and troubleshooting equipment.
14. Fiber optic cable and accessories including tray /conduit for system data network and for data collection through modbus, Ethernet or OPC connectivity, wherever required.
15. Arranging all performance test instruments and equipment.
16. Instrument control panels.
17. Performing tests on all equipment as per Quality Plan prior to shipment.
18. Contractor shall be responsible for software licensing, design, development, debugging, system Employer Representative, customizing, installation, site modification, tuning, adjustments, commissioning and furnishing manuals, documentation etc.
19. Drawings and Documents: Contractor shall furnish system description, operational write-up, bill of materials, drawings, data, information, technical catalogues, test certificates and other details to establish the provenness, capability and performance of the equipment and systems offered.
20. Final Drawings
  - a) Contractor shall secure approval on the design drawings from Employer for the drawings identified as “Approved”, in writing. Any manufacture done prior to approval of the drawings shall be rectified in accordance with the approved drawings by Contractor at his own cost and the equipment shall be supplied within the stipulated period.
  - b) Contractor shall furnish final drawings and documents in multiple ( 3 sets ) hard and soft copies. Contractor shall furnish instruction manuals containing various components, sub-assemblies, method of installation, check-ups and tests to be carried out during erection and commissioning of the equipment. The manual shall also include instruction for step checking, trouble shooting and fault rectification for different components and sub-assemblies.
  - c) Contractor shall incorporate all modifications in the drawings carried out at site during trial run, start-up performance and guarantee tests till hand over of the units to Employer and submit these final as-built drawings both in hard and soft copy.
  - d) Final documents shall be submitted in proper bounded form. All catalogs and literature (including sub-suppliers’ catalogs), datasheets, Instrument list, input output list, function control diagram, loop diagrams, configuration diagram etc. shall be bounded together in indexed volumes. All O&M manuals shall be in handy size and neatly bound for carrying it to the work place.
  - e) Contractor shall convert all drawings and documents, manuals under this contract in to PDF format and store it in operator work station at the LCC SCADA control room.

- f) Operation and maintenance instructions
  - (a) Composite manual describing the functional and operation of each piece of equipment.
  - (b) Composite manual for testing and servicing every system and individual item.
- g) Original manuals and CDs from OEMs.
- h) Training material shall be provided which shall include the presentations used for trainings and also the required relevant documents for the topics.  
The selected Contractor shall submit a complete set of  
Floor Layout Drawings,  
Single Line diagram.  
Complete cabling system layout (as installed), including cable routing.  
The layout shall detail locations of all components and indicate all wiring pathways.
- i) The Contractor shall be responsible for preparing process documentation related to the operation and maintenance of each and every component of the Instrumentation , control & Automation system.
- j) The prepared process document shall be formally signed off by end user before completion of final acceptance test.
- k) The Contractor shall document all the installation and commissioning procedures and provide the same to end user, within one week of the commissioning of project along with final configuration dumps and implemented solution details.
- l) The Contractor shall be responsible for documenting configuration of all devices and keeping back up of all configuration files, so as to enable quick recovery in case of failure of devices.

### **1.5 Submissions to be made by the contractor during the contract period:**

- 1) The Contractor shall make submissions to the Employer Representative of all design drawings, schedules and complete documentation on spare parts relating to instrumentation and control equipment and systems provided under this Contract.
- 2) These submissions shall include, the following:  
Functional design specification (FDS): The Contractor shall submit a complete functional design specification (FDS) for approval by the Employer Representative within three (3) months of the award of the Contract. The Contractor should take note of the importance of this obligation.

The functional design specification shall be submitted for the following:

#### **A. Instrumentation**

- a) The FDS shall include on a minimum, Instrument index, Instrument location layouts, Instrument datasheet, OEM product brochure, Instrument hook up diagrams and quality Assurance plan for inspection.
- b) General arrangement drawings of field-mounted instruments showing installation details.
- c) General arrangement drawings of instrument and control panels, fully dimensioned in plan and elevation views, showing foundation and fixing

details, access doors, clearances, cable-entry positions, weight and lifting arrangement.

- d) Layout drawings of panel fascias showing instruments, controls and details of all labels.
- e) Internal circuit and wiring diagrams for instrument and control panels.
- f) Schematic control diagrams.
- g) Instrument loop diagrams.
- h) Instrument wiring and piping diagrams.
- i) Interconnection wiring diagrams.
- j) Cable block diagrams, drawings and schedules.
- k) Instrument system and panel power distribution diagrams.
- l) The FDS shall describe control actions taken and monitoring functions which remain available during a power failure, and any automatic controls or sequencing which take place during system start-up and shut-down.
- m) The FDS shall be presented in a clear and precise manner and shall include figures or drawings where appropriate.
- n) Comprehensive testing schedules for all off-site, on-site, pre-commissioning and commissioning tests and take-over tests.

## **B. Control & Automation (SCADA)**

- 1) This document shall serve as the primary mechanism by which the Employer Representative may confirm that the Contractor possesses an accurate understanding of the system and its control requirements.
  - a) On a minimum, FDS shall comprise an overall description of the plant, its functioning and control, and a detailed description of each section of the control system covering modes of operation, manual overrides, set-point and parameter selection and adjustment. The detailed description shall include a step-by-step control description which defines the function of each piece of equipment and each control action and interlock, including details of the program in each programmable item. Flow charts shall be used to depict the control philosophy along with the write up for the same.
  - b) Proposed SCADA screens shall be an integral part of the submissions.
  - c) The FDS shall describe the 'fail-safe' features incorporated into the design for the event of failure of a plant item or system, or loss of an input signal.
  - d) The FDS shall describe control actions taken and monitoring functions which remain available during a power failure, and any automatic controls or sequencing which take place during system start-up and shut-down.
  - e) The FDS shall be presented in a clear and precise manner and shall include figures or drawings where appropriate.
- 2) Drawings and schedules as part of FDS (For both Instrumentation & Control & Automation):
  - (a) Process and instrumentation diagram shall be as per ISA 5.1 latest release. The P&ID shall contain the following on a minimum and in sequence:
    1. Legend sheet inclusive of process line abbreviations, line designation, process designation, symbols of all equipment, etc.
    2. Tag Identification system. (Note: The tagging philosophy shall be submitted before the submission of the P&ID for review and approval before the tag i.d is incorporated in the P&ID.)

3. Typical Signal interface sheet
  4. Process & Instrumentation sheets as per each process, which shall depict the interlock sequence for each equipment & process operation. The interlock sequence shall be depicted by using interlock numbering next to the equipment/process.
  5. Interlock sheet detailing every interlock for the system (Pumps, drives, valves, etc.). For Eg: Start, Stop, Trip, sub process sequence, etc.
  6. Each P&ID shall be submitted along with the control philosophy.
- (b) General arrangement drawings of field-mounted instruments showing installation details.
- (c) General arrangement drawings of instrument and control panels, fully dimensioned in plan and elevation views, showing foundation and fixing details, access doors, clearances, cable-entry positions, weight and lifting arrangement.
- (d) Layout drawings of panel fascias showing instruments, controls and details of all labels.
- (e) Layout drawings of panel interior showing equipment, terminal blocks and cable ways.
- (f) Annunciator arrangement and engraving details.
- (g) Internal circuit and wiring diagrams for instrument and control panels.
- (h) Schematic control diagrams.
- (j) Instrument loop diagrams.
- (k) Instrument wiring and piping diagrams.
- (l) Interconnection wiring diagrams.
- (m) Cable block diagrams, drawings and schedules.
- (n) Instrument system and panel power distribution diagrams.
- (p) Programmable-device functional design specifications which shall include hardware details, logic flow charts, ladder diagrams and program listings.
- (q) Schedules of inputs to and outputs from programmable controllers and telemetry outstations.
- (r) Labelling & tag schedules.
- (s) Comprehensive testing schedules for all off-site, on-site, pre-commissioning and Commissioning tests and take-over tests.

- 3) All other drawings necessary for the provision of ducts, openings, trenches, fixing holes for panels and the like and for the complete understanding of the operation, maintenance and extension of the system including any required for the Purchaser to dismantle, repair, maintain, modify or extend the Plant.
- 4) Control room, RIO Room interior design layouts, interior design diagrams, control room wiring layout, access control point's diagrams, etc...
- 5) Data and calculations
  - (a) Manufacturers' catalogues and data sheets.
  - (b) Calculations to support control system design.
  - (c) Specification for protective coatings and painting.
- 6) Certificates
  - (a) Manufacturers' works tests.
  - (b) Pre-installation checks.
  - (c) Pressure-testing schedules.
  - (d) Instrument loop test check sheets.
  - (e) Installed instrument performance tests.
  - (f) System tests.
  - (g) Statutory certificates of compliance (inclusive of hazardous area equipment).

**Note:** The Contractor shall submit and obtain approval of the FDS from the Employer Representative before beginning procurement. The contractor should take note of the importance of this obligation.

## **1.6 Design Requirements for Instrumentation, Control & Automation system**

### **Minimum Design Consideration**

The instrumentation, control & automation system shall fully comply with design standards, regulations and the material and workmanship requirements of the Specification.

The electrical plant installations associated instrumentation control and automation systems shall also comply with and be tested in accordance with the latest edition of BS 7671 or equivalent Indian standards.

All equipment and materials incorporated in the system shall be selected, designed and rated to operate under the defined performance duties and specified site conditions and to maintain a high level of operational reliability.

The instrumentation control and monitoring system equipment and materials shall have an operational life of not less than 15 years.

Instrumentation, Control, Automation system shall be designed, manufactured and installed to achieve the following basic requirements:

- to maintain the highest standards of availability, reliability and accuracy and to give clear warnings of any deterioration in performance;
- to suit the abilities of the staff who will:
  - use the systems;
  - service the systems;
- to measure, indicate, process, store and control the relevant parameters, as specified;

- to give clear warnings of dangerous and other abnormal conditions and to initiate plant safety procedures, shutdowns and corrective measures as specified to assure the safety of ‘operations and maintenance’ personnel and plant and to store and collate the data, as required;
- to derive, present and utilize, as required, such additional data as required to facilitate:
  - the most efficient operation of the plant;
  - the routine maintenance of the plant

Equipment and system shall be designed and constructed to perform accurately and safely under the environmental and operating conditions described or implied in this specification without undue heating, vibration, wear, corrosion.

Equipment and systems shall be supplied as per the vendor list indicated in specification elsewhere.

The equipment, systems and accessories furnished shall be designed and constructed to meet the performance specification during the continuous service life of the plant. Equipment or components that cannot meet this requirement shall be identified in the offer and their expected failure rate shall be indicated. Otherwise, it shall be deemed that the equipment or components are suitable for the service life of the entire plant.

Contractor shall indicate the year in which the offered models of the instruments and control system have been introduced and how long the commercial production of the same is expected to continue. In any case, Contractor shall ensure supply of spare parts for minimum period of 15 years. In case if it is felt by Contractor that certain equipment/ component is likely to become obsolete, Contractor shall clearly bring it to the notice of Employer and indicate step proposed to deal with such obsolescence like maintaining “bonded spares” with the manufacturer/s.

Any part/ module of the C&I system which are not listed under recommended spares shall be deemed as having life expectancy not less than 15 years.

Contractor shall supply proven latest version of hardware and software available at the time of system designing. In case of future up-gradation of software, Contractor shall remain committed to upgrade the supplied system at per with the new version within the warranty period and O&M period and ensure successful integration of the system.

For the sake of completeness of the system and in order to ensure desired performance & safety measures, any hardware or software item felt required, shall be in the scope of Contractor irrespective of their explicit or implicit inclusion in the accompanying document. Technical details furnished in the accompanying documents are subject to change in future within reasonable limits, which Contractor shall abide by.

## **1.7 General Technical Requirements**

### **1.7.1 Local Instruments**

Required local instruments including gauge boards, level –instruments, Pressure instruments, water quality Analyzers etc. shall be provided.



### **1.7.2 Cabling Concept**

Instrumentation cables shall be copper, overall screened unless manufacturer's recommendation dictates use of pair or triad shields apart from overall shield. All cables shall generally be armoured, other than short run cables which may be Un armoured. Un armoured cables shall run through conduits.

Binary and analog signals shall not run through the same cable. Signals of different voltage levels shall not be routed through the same cable. The screen shall be grounded at the control room end only.

Conductor cross section for single pair or triad signal cables shall not have individual conductor cross section below  $1.5 \text{ mm}^2$  and multi-pair or multi-triad cables shall not have individual conductor cross section below  $0.5 \text{ mm}^2$ . For solenoid valves, depending on pick-up VA, individual conductor cross section shall not be below  $2.5 \text{ mm}^2$ . For interposing relay drive connection individual conductor cross section shall not be below  $1.5 \text{ mm}^2$ .

### **1.7.3 Design Criteria**

This section lays down the general design criteria to be adapted in designing the instrumentation and control system

### **1.7.4 General Requirements**

Instrumentation and control devices and accessories shall be designed with the following considerations:

- a) Stable in spite of temperature fluctuations.
- b) Able to withstand high humidity.
- c) Weather proof.
- d) Dust proof.
- e) Corrosion resistant.
- f) Erosion resistant.
- g) Able to withstand high vibration.
- h) Entire control System for the plant shall be designed for complete auto mode of operation with all operational interlocks required.
- i) Easily accessible for operation & maintenance.

Parts subject to high pressure, temperature or other severe duty shall be of materials and construction suitable for the service conditions and long operating life.

### **Site Conditions**

- Temperature and Humidity Range. The equipment shall be installed in an environment having a temperature range of  $0^\circ\text{C}$  to  $55^\circ\text{C}$  and a maximum relative humidity of 100 % (non condensing). The Contractor shall use, where required, fans, heaters, and air conditioning units to maintain a correct working temperature for his equipment. All Parts of the equipment shall be constructed of materials or treated to prevent the formation of mould, fungus or any corrosion over the temperature and relative humidity ranges specified.

- EMI/RFI Noise Immunity. The equipment to be provided shall be adequately protected against interference from the use of radio transmitters, at any point external to the equipment housings and no malfunction of the equipment shall result from this cause. Responsibility for the correct and reliable operation of the equipment shall rest with the Contractor, who must ensure that the equipment is adequately protected against the ingress of radiated, mains-borne signal-borne interference.
- Generated Interference. The Contractor shall ensure that the computer, instrumentation and communications equipment conforms to BS EN 50081-1 or equivalent Indian Standard for noise emissions.
- Coordination. The Contractor shall check with other trades to ensure that equipment and material can be installed in space provided. Provide other trades with information necessary for them to execute their work. Details on Drawings, which are specific regarding dimensions and locations, are for information purposes. Coordinate with other trades to ensure work can be installed as indicated.
- Sequencing. The Contractor shall make applications to the local telecommunications Service Provider for provision of communications and coordinate with the sub-contractor responsible for installation of power supply services under this contract. Applications shall be made in time to ensure services are available for installation and commissioning of the telemetry equipment.

### **1.7.5 Instrument Accuracy, Standard Scales and Ranges**

#### **1.7.5.1 Instrument Accuracy**

Instruments shall meet the following general requirements.

- a) Pressure measurement shall be linear with respect to the measured pressure.
- b) Flow meter shall meet the specified accuracy criteria when operating between 25 and 100 % of full-scale flow. The accuracy shall include the effect of errors in the differential head measuring device, square root converter and signal generator.
- c) Level measurement shall be linear with respect to the measured level based on a water specific gravity of 1.00.

#### **1.7.5.2 Instrument Scale Displays**

- a) All displays shall be in Employer Representative units. Instrument scales displayed on screen will have graduations with scale divisions based on multiples of 10. The smallest division shall preferably be a whole number approximately 1% of the scale range if not otherwise impracticable.
- b) Pressure instrument shall have the unit suffixed with 'a' or 'g' to indicate absolute or gauge pressure, respectively.
- c) Scales and charts of all instruments shall have linear graduations

#### **1.7.5.3 Instrument Ranges**

Instrument range shall be selected to have the normal reading, preferably between 50% and 70% of full scale for linear parameters and 70% to 80% for flow measurements. Deviation indicators shall have the null position at mid scale. The normal operating parameter shall be identified with a clear green mark.

#### **1.7.6 Established Reliability & Availability of individual instrument system**

The target reliability of each component/module shall be established by taking into consideration its Mean time between failure (MTBF) and Mean time to repair (MTTR), so that availability of each system is assured for 99.7% of the time.

In order to establish the target reliability Contractor shall perform necessary availability tests. Surge protection for solid state systems, selection of proper materials, manufacturing processes, quality controlled components and parts, adequate derating of electronic components and parts shall be ensured to meet the reliability and life expectancy goals.

Continuous self-checking features shall be incorporated in system design with automatic transfer to healthy/redundant circuits to enhance the reliability of the complete system.

#### **1.7.7 Measurement & Channel Redundancy**

To meet the failure and self checking criteria for the control system, measurement redundancy shall be provided for all the critical parameters. Throughout the control system, the security and validity of signals are to be ensured based on the following design principles.

- a) Where a plant measurement is to be duplicated or triplicated such signals shall be separately fed to the different input modules.
- b) Signals, after due security and validity checking by means of voting, averaging, median, difference monitoring or similar technique shall be used for control functions.
- c) Where duplicated measurements are used, provision shall be there for selecting any one as the duty signal. Continuous monitoring of difference between the signals shall be made.
- d) Signals shall be verified against cable failure.

#### **1.7.8 Design Of Enclosures**

Design of outdoor enclosures shall be weather proof, dust-tight, drip-proof and shall take into account the environmental conditions. Enclosures shall be adequately sized so that the maximum permissible temperature rise above ambient is 10 °C (maximum). Enclosures design shall also take into account greatest possible personnel safety.

#### **1.7.9 Electrical Noise Control**

Equipment furnished by Contractor shall incorporate necessary techniques to eliminate problems caused by electrical noise interferences and power line borne surges encountered in power plant environment. Equipment, which is vulnerable to electrical noise interference or surge, shall be suitably immunized to eliminate possible problems.

#### **1.7.10 Surge-Protection for Solid State Equipment**

All solid-state equipment shall be able to withstand the surges inherent in a working environment. Equipment shall be designed to successfully withstand surges without damage to components and/or wiring on application of surge wave whose shape and characteristics are defined in ANSI publication C37.90-a (IEEE-472-1974) entitled "Guide for Surge Withstand Capability (SWC) Tests". To immunize the system against surge, coupling free wheeling diodes, surge suppressors, optical / galvanic isolators shall be used as required.

### **1.7.11 Panels, Cubicles and Enclosures**

#### **1.7.11.1 General**

- a) All panels, cubicles and enclosures shall be furnished complete with integral piping, internal wiring, convenience outlets, internal lighting, grounding, ventilation, space heating, vibration isolating pads and other accessories.
- b) Unless otherwise specified cable entry for panels / desks / cabinets shall be through bottom via glanding plate. Fireproof seal shall be used to seal the bottom to prevent entry of dust.
- c) Panels and cabinets shall be constructed from steel sheet reinforced as required to provide true surface and adequate support for devices mounted thereon. Thickness of the steel plate shall conform to the requirements of UL 50 or equivalent standard. Panels and cabinets shall be of adequate strength to support mounted components during shipment and to support a concentrated load of 100 Kilograms on their top after erection.
- d) Panel/ cabinet shall have eyebolt on top for lifting.

#### **1.7.11.2 Surface Preparation and Painting**

Sheet metal exterior steel surfaces shall be sand blasted, ground smooth and painted as specified below:

Suitable filler shall be applied to all pits, blemishes and voids in the surface. The filler shall be sanded so that surfaces are level and flat; corners are smooth and even. Exposed raw metal edges shall be ground burr-free. The entire surface shall be blast clean to remove rust and scale. Oil, grease and salts etc. shall be removed from by one or more solvent cleaning methods prior to blasting.

- a) Two spray coats of epoxy primer surfacer shall be applied to all exterior and interior surfaces, each coat of primer surfacer shall be of dry film thickness of 1.5 mil. A minimum of two spray coats of final finish color (Catalyzed epoxy or polyurethane) shall be applied to all surface of dry film thickness 2.0 Mil. The finish colors for exterior and interior surfaces shall conform to the following shades:
  - i) Exterior – RAL 7032
  - ii) Interior - Brilliant White.
- b) Paint films, which show sags, cheeks, blisters, teardrops, fat edges or other painting imperfections shall not be acceptable.

#### **1.7.11.3 Wiring**

Wiring within the panels shall conform to NEC standards and shall be factory installed and tested at the works. All interior wiring shall be installed neatly. Features shall not be limited to the following :

- a) All spare contacts of relays, switches and push buttons shall be wired up to the terminal blocks.
- b) Each wire shall be identified at both ends with wire designation as per approved wiring diagram. Heat shrinkable type ferrules with indelible computerized print shall be used with cross- identification.
- c) Wire termination shall be made with insulated sleeve and crimping type lugs. All external connections shall be made with one wire per terminal. Wire shall not be spliced or tapped between terminals. Open-ended terminal lugs shall not be used.
- d) Internal wiring should be terminated uniformly on one side of the terminal block leaving the other side available for termination of outgoing cables.
- e) Analyzer measuring lead wires, or any other lead wires carrying measuring signal of the order of low milli volt or micro volt shall be electrically and physically isolated from other AC and DC wiring.
- f) All low-level signal cables shall be separately bundled from control cable.
- g) Wires shall be dressed and run in troughs with clamp-on type covers. Wirings shall be neatly bunched in groups by non-metallic cleats or bands. Each group shall be adequately supported along its run to prevent sagging or strain on termination.
- h) Shield wires shall be terminated on separately.
- i) Common connections shall be limited to two wires per terminal.
- j) Wiring to door mounted devices shall be provided with multi-strand wires of (49 strands minimum) adequate loop lengths of hinge-wire so that multiple door openings will not cause fatigue to the conductor.
- k) Wiring shall be arranged to enable instruments or devices to be removed and/or serviced without disturbing the wiring. No wire shall be routed across the face or rear of any device in a manner, which will impede the opening of covers or obstruct access to leads, terminals or devices.
- l) Panel internal wiring shall follow distinct color-coding to segregate different voltage levels viz. 24V DC, 48V, 110V AC, 240V AC, 220V DC etc.
- m) Panels/ cabinets/ desks shall be provided with removable gasketed cable gland plates and cable glands. Split type grommets shall be used for prefab cables.
- n) Wire shall be multistranded annealed flexible high purity copper conductor with heat resistant FRLS PVC insulation and shall pass vertical flame test per IPCEAS-1981.
- o) Wire sizes used for internal wiring shall not be lower than the followings :
  - i) Control wiring : 1.5 Sq.mm  
(Switches, pushbuttons etc.)
  - ii) Power supply/ receptacle : 2.5 sq. mm or higher as per load.  
/ illumination wiring
  - iii) 4-20mA DC current : 0.5 Sq. mm  
and low voltage signal  
upto 48V DC
- p) Identification of conductors shall be done by insulation color-coding identified on drawings or by printed wiring lists.
- q) All cables terminated in the terminal block (both signal cables and power cables) shall be ferruled. Ferruling shall be double cross ferruling, i.e, source and destination addresses shall be marked on both sides of the tube ferruling.

#### 1.7.11.4 Grounding

- a) System cabinet AC and DC ground shall be electrically isolated from each other and also electrically isolated from the Instrumentation signal ground. All the above ground shall be individually connected to the single point on the ground pit. Dedicated redundant earth pit shall be provided which shall be away from the HV equipment. This earth pit shall not be shared with other electrical equipment ground and shall also be insulated from other electrical system ground to ensure single point grounding of the system. Grounding resistance shall be better than 1.0 ohm. IEEE guideline shall be followed while designing the grounding system.
- b) Panels and cabinets shall be provided with a continuous tinned copper ground bus bar of minimum 25 mm x 6 mm cross section, extending along the entire length of the panel / desk / cabinet assembly. The ground bus shall be bolted to the panel structure and effectively ground the entire structure.
- c) The panel/ desk/ enclosure/ JB ground shall have two (2) bolt drilling with GI bolts and nuts at each end to connect to GI/ copper flat ground riser by means of insulated copper ground cable of required cross section with lug.
- d) Circuits requiring grounding shall be individually and directly connected to the panel ground bus.
- e) For electronic system cabinets, the electronic system ground bus shall be similar but insulated from the cabinet and shall be separately connected to the system ground. Signal cable shields shall be grounded at the panel end only and shall not be left open. The ground in between panels of a shipping section shall be firmly looped.
- f) Electrical meters, relays, transmitters and switching devices, operating at a voltage less than 50V may be grounded through the steel structure.

#### 1.7.11.5 Panel / Cabinet/ Desk/ Enclosures Environmental Protections

- a) Panels, cabinets, desks, distribution boxes, terminal boxes and all other field mounted equipment / enclosures shall suit the environmental condition of the area and shall not be inferior to the requirement indicated in the following table:

LOCATION	ENCLOSURE TYPE
Indoor type non- ventilated enclosure in non-hazardous area	IP-54
Indoor type ventilated enclosure in non-hazardous area	IP-42
Enclosure in Air conditioned area	IP-22 with suitable canopy at top to prevent ingress of dripping water.
Outdoor type in non-hazardous areas	IP-65
Outdoor in hazardous areas	As per requirements of the NEC / IS Code for the location

- b) The construction of electrical enclosures located in areas subject to conditions classified in the National Electrical Code (NEC)/IS Code as hazardous shall be of a type designated suitable for the environment in which they are located.

### 1.7.11.6 Terminal Blocks

- a) Terminals shall be chromated galvanized DIN rail mounted screwless cage clamp type. Terminals shall have screwed connection for conductor cross-section above 2.5 mm<sup>2</sup>. Terminal blocks shall conform to IEC 947-7-1.
- b) The characteristics of the terminal blocks shall be as follows.
  - i) High contact force, independent of conductor cross-section and large contact surface area.
  - ii) Self-loosening protection.
  - iii) Resistant to thermal aging and vibration.
  - iv) Low and constant voltage drop
- c) Tension spring shall be made of high quality, non-rusting, acid-resistant steel. The current bar shall be of tin-lead plated copper or brass.
- d) Terminals shall be of non flammable suitable thermoplastic material such as polyamide.
- e) Terminal blocks shall be mounted vertically in panels and cubicles with clearance for at least 100 mm between two sets and between wall and terminal block.
- f) Terminal blocks shall be provided with white marking strips / self-adhesive marker cards. Power terminals shall have protection covers.
- g) At least 20 percent spare unwired terminals shall be provided for all panels /cabinets /desks /junction box etc. This shall be in addition to 20% spare wired terminals of spare IO channels and 10% wired spare modules.
- h) Bottom of the terminal block shall be at least 200 mm above the cable gland plate for bottom entry type panels.
- i) For extending 24 V DC supply to panels, the size of the terminals shall be decided based on voltage drop and not based on current.
- j) Other requirements of the terminal blocks are as follows:
  - 1. The last block in a rail-mounted assembly shall be closed with an end plate and end bracket.
  - 2. For visual and electrical separation of terminal groups, partition plates shall be provided, which can be push fitted after forming an assembly.
  - 3. Design shall permit testing of incoming and outgoing signals by using suitable test plug and socket without disconnecting the cable connections.
  - 4. It shall be possible to use jumper plugs through the test plug socket to connect adjacent terminals.
  - 5. Where more than one connection to a terminal block is required, two tier terminals shall be used.
  - 6. Terminal blocks shall be of different colors depending on voltage levels.

### 1.7.11.7 Nameplates and Labels

- a) Each item shall have permanently attached to it, in a prominent position, a rating plate of non-corrosive material upon which is to be engraved the equipment, type / model number, range, serial number, together with details

- of the loading conditions under which the item of plant in question has been designed to operate.
- b) Such nameplates or labels are to be of white non-hygroscopic material with engraved black lettering, or alternatively of transparent plastic material with suitably colored lettering engraved on the back.
  - c) The nameplates shall be held by self-tapping screws. The size of nameplate shall be approximately 20 mm x 75 mm for equipment and 40 mm x 150 mm for the panels.
  - d) Items of plant such as valves, which are subject to handling, are to be provided with an engraved chromium plated nameplate or label with engraving filled with enamel, suitably mounted or affixed with strong rustproof chain.
  - e) All such nameplates, instruction plates, lubrication charts etc. shall be with English inscriptions.

## 1.8 Metering Bases And Chart Units

The following system of units shall be followed for various displays and scales unless otherwise mentioned:

- |      |                   |   |                      |
|------|-------------------|---|----------------------|
| i)   | Pressure          | : | Kg/cm <sup>2</sup>   |
| ii)  | Temperature       | : | Degree Celsius (° C) |
| iii) | Flow              | : | M <sup>3</sup> /Hr   |
| iv)  | Level             | : | Mtrs & %             |
| v)   | Residual Chlorine | : | ppm                  |

## 1.9 Process Connection & Instrument Hook Up

Instrument connection to the process system (piping, vessel etc.) shall be according to the process & piping specification upto and including the root valves. Root valves shall be installed as close as possible to the piping or vessel.

Each instrument shall have its own independent connection to the process except for instruments located on standpipe. Each instrument shall be connected independently to the standpipe through isolation valve.

Isolation and drain valves adequate for duty and capable of withstanding continuous design condition of main process shall be provided. For process pressure equal or above 40 kg/sq.cm double blowdown valves shall be used connecting to blowdown header. Instrument manifold / gauge valve shall be installed close to the instrument

Process connection for instruments lines and vessels shall be in accordance to standards such as ASME or other recognized international standards. Table below indicates the type of connection generally to be used.

INSTRUMENTS	EQUIPMENT / PIPE SIDE	INSTRUMENT SIDE
<b>Level Instruments</b>		
Internal Displacer	4" - Flanged	4" - Flanged



INSTRUMENTS	EQUIPMENT / PIPE SIDE	INSTRUMENT SIDE
External Displacer	2" - Flanged	2" - Flanged
Level gauge	¾" - Flanged	¾" - Flanged
DP Type	½" (min.)-welded	½"- NPT
External cage Level switch	1"- welded	1"- welded
<b>Pressure Instruments</b>		
Conventional	½" (min.)-welded	½" - NPT
Diaphragm type- Fuel Oil application	3"- Flanged	3"- Flanged
<b>Temperature Instruments</b>		
Thermowell	Generally - M 33 X2 (M)	½" NPT
	1½" Flanged- For air path application	
<b>Analyzer</b>		
Liquid analyzer	½"- 1" - welded	½"

Separate stubs and take-off points with thermo well / root valves shall be provided for performance guarantee test.

Impulse pipes shall be clamped at suitable interval not exceeding 1.5 meter. Process pipe shall not be used for supporting the impulse pipe.

Fittings shall conform to ANSI B 16.11. Threads of piping component shall be of tapered construction.

Instrument blowdown header shall in no case be lower than the material grade ASTM A 106 Gr. C.

Impulse pipe shall be laid at least with slope of gradient 1:10 to avoid any air pocket or water accumulation.

Expansion loop shall be provided at least at every 2.5 meter interval without affecting the gradient of slope in long run impulse pipe to avoid stress on the piping.

Orientation of tappings shall be as follows :

- a) For liquid service within 45° at lower half of the pipe horizontal plane.
- b) For air service within 90° at upper half of the pipe horizontal plane.

As a rule tap orientation of high and low pressure side should be parallel and symmetrical.

Pressure & Differential pressure instruments in liquid services shall be located below the taps and the piping shall be sloped to avoid formation of air pocket.

Pressure & Differential pressure instruments in air service shall be located above the taps and the piping shall be sloped back to process to avoid formation of any liquid.

Material of impulse pipe for the instruments mounted on rack and enclosure shall be same as that of main process pipe except stainless steel tube of Gr. 316H or better shall be provided for connection in between impulse pipe (from tee connection on impulse pipe) and instrument manifold valve & instruments. Impulse pipe, tubes, fittings and accessories shall have the same design pressure and temperature applicable for the related main pipe.

## **A. Panel Details**

### **I. Enclosures and mounting boards**

Enclosures shall be any form of board, cabinet, panel, desk, box or case used to protect, contain or group instrumentation, telemetry or control equipment.

All equipment in or on enclosures shall be arranged logically and, as far as possible, symmetrically, with projections kept to a minimum. Each enclosure and board shall be designed on ergonomic principles and shall permit in-situ and safe access for any normal adjustment, maintenance and servicing. The tops of plant-mounted enclosures shall be sloped downwards from front to rear.

Enclosures mounted inside buildings shall have a minimum rating of protection to IP 54.

Enclosures for use outside buildings or in places where splashing may occur shall have a minimum rating of protection to IP 65 and have tops which project sufficiently to protect the vertical faces of the enclosure and any component mounted thereon from splashing, inclement weather and direct sunlight. Also, when enclosures for use outside buildings are located where exposure to direct sunlight will give rise to high top-panel surface temperatures such that the internal temperature rises above the manufacturer's recommendation (normally 40°C), the enclosure shall include a sun shield fitted to the top of the enclosure. The sun shield shall prevent direct sunlight from reaching the instrumentation for the full day throughout the year, and shall have louvered ventilation.

Fixing arrangements for surface-mounting enclosures shall be external to the enclosure and shall ensure that the rear face of the enclosure is not in contact with the surface to which it is fixed.

Enclosures shall have hinged access doors, fitted with recessed lockable handles.

Doors shall be of rigid construction and provided with close-fitting flexible seals in recesses to prevent the ingress of liquids, moisture, dust and vermin. Hinges shall be of the lift-off pattern and one hinge shall engage before the other for ease of fitting. Wherever necessary, removable access covers secured by quick-release fasteners shall be provided to ensure ease of maintenance for all installed apparatus.

Mounting plates, brackets and racks shall be provided for all other internal equipment which shall be hinged or otherwise arranged with quick-release fasteners or captive screws to give quick and easy access to equipment, securing screws, terminals and wiring.

Enclosures for two or more devices with electrical circuits shall have gland plates and terminal blocks as specified elsewhere.

Each enclosure shall be designed for the safe testing and servicing of equipment with the power on. Each part which may be live under any circumstances shall be so covered or shielded as to prevent inadvertent contact.

## **II. Panel design and construction**

Unless otherwise specified, all instrument panels, instrument cubicles, control panels, control consoles and desks, associated equipment and terminal racks, telemetry and electronic equipment racks and the like shall be free-standing, floor mounted units and shall conform to the requirements of this part and will hereafter be referred to as panels.

The design and dimensions of control consoles and desks shall be determined according to their intended function and shall be in accordance with the requirements of the Specification. The height shall not exceed 1400mm above the finished floor level.

Unless otherwise specified the height of panels shall be not greater than 2130mm overall (excluding lifting devices) above finished floor level.

The width of control panels (PLC Relay, etc) shall be minimum 900mm.

Controls, switches and push-buttons shall be positioned below or adjacent to any associated reading instrument. Panels for use in locations such as pumping stations and machinery rooms shall have anti-vibration mountings.

The clearance between the extremities of apparatus mounted on the internal walls shall allow safe and unobstructed access to all terminals and to parts requiring maintenance.

Panel layout drawings shall normally include a list of all instruments, accessories and components contained therein. If the drawings have insufficient space for the list, a separate schedule of instruments, accessories and components shall be provided and the panel drawing shall contain a cross reference to the contents list and an indication of the panel location of each item on the list.

## **III. Panels - Major**

Panels shall be constructed generally as specified in the preceding clause. Panel material shall be prime-quality, cold-rolled and annealed mild steel or zinc-coated mild steel sheet, suitably braced and stiffened as necessary with flat bar or angle to form a rigid structure.

Panel fronts shall be flat and free from bow or ripple. Exterior corners and edges shall be rounded or welded and ground to give a smooth overall appearance.

Flanged edges shall be straight and smooth.

Materials shall be chosen with due regard to the panel size, number of cut-outs, instrument weight and position of center of gravity and method of fabrication, with the following minimum thickness:

- instrument bearing surfaces, gland plates and pneumatic distribution plates, 3mm;
- internal mounting plates, 3mm;
- doors, covers and filler panels, 2mm.

No design involving the use of externally-visible assembly or fixing bolts and screws or any design resulting in dust or water-collecting crevices will be accepted.

When a panel is constructed in sections, the sections shall be designed for ease of assembly during installation and, in any case, shall not exceed 2m in length. All necessary nuts, bolts, washers and the like shall be supplied and included in the same shipment as the relevant sections. Sections exceeding 1m in length shall be provided with double doors.

The width of control panels (PLC Relay, etc) shall be minimum 900mm.

Each panel shall be mounted on a self-draining base frame fabricated from 150mm deep, steel channel section which shall be drilled or provided with clamps for bolting to the floor. The base frame shall be set back from the panel front face to give a toe space of not less than 25mm. The outside of the base frame shall be covered with an approved kicking strip.

Ceiling and other filler panels shall be fabricated from sheet steel and adequately stiffened. Each section shall have 50mm returned edges along all four sides and shall be braced to the main steelwork of the panel.

A chequered plate floor shall be provided inside and above the level of the base frame, having openings suitable for the bottom entry of cables when applicable.

Sufficient removable un-drilled gland plates, in sections convenient for handling, shall be fitted close to the appropriate terminal blocks and not less than 230mm above the panel floor or not less than 230mm below the panel top. The gland plates shall have removable side covers giving access to both sides of the gland plate and ensuring vermin-proof and dust-proof construction. Gland plates of a surface mounted enclosure may form a part of the base or top.

Panels containing instruments using a fluid as the transmission medium shall have distribution plates with bulkhead unions for the termination of internal and external pipework.

All doors shall open outwards and all doors in one panel assembly shall use the same lock and key combination.

Panel design shall ensure adequate ventilation and air circulation without permitting the entry of vermin or dust. Panels installed in control rooms or other clean condition areas shall have louvres to allow air circulation. Temporary closures shall be provided to prevent the entry of dust and vermin during transit and installation. After commissioning has been completed, all entries except air circulation louvres shall be sealed.

No equipment other than front-of-panel items shall be mounted on panel wall surfaces.

If electrical and non-electrical instruments are mounted in the same panel, the panel shall be subdivided internally to separate the electrical and non-electrical sections.

All connections shall be arranged to ensure that no accidental damage to cabling or electrical components can occur in the event of failure of any non-electrical component or connection.

Provision shall be made for safe and easy handling during transit and installation.

If lifting eyes are provided, they shall be reversible and panel tops shall be reinforced where necessary.

Where equipment is specified to be installed at a future date, space shall be allocated, and cut-outs with removable masking plates, brackets, supports, wiring, terminals and piping and the like shall be provided.

Panels shall be finish-coated at the place of manufacture before commencing the installation of apparatus and other fittings.

#### **IV. Panels - Minor**

Panels for installation on the Plant which contain relatively few items of equipment, or where so specified elsewhere, shall be classed as minor panels and shall be constructed generally as specified in the preceding clause and comply with this Clause.

Panels shall be fabricated from sheet steel or other approved material less than 2.5mm thick suitably braced to form a robust and rigid structure. Exterior corners and edges shall be rounded to give a smooth overall appearance and assembly bolts, screws or rivets shall not be visible on the front face.

The design shall be such as to ensure adequate ventilation and air circulation where required, without permitting the entry of vermin. Openings for cables shall be made vermin-proof. Doors shall be hinged and shall be provided with close-fitting flexible seals in recesses to prevent the ingress of liquids, moisture, dust and vermin. Unless otherwise specified, panels shall be suitable for floor mounting and shall not exceed 2130mm in height. Where surface-mounted panels are provided, the fixing shall prevent the ingress of moisture and the rear of the enclosure shall be not less than 10mm from the wall.

Lifting eyebolts shall be removed, issued to the Purchaser and subsequently replaced with bolts after installation.

Panels shall be extensible, and symmetrically arranged as far as possible with projections kept to a minimum. Where two or more panels are fitted together, they shall form a flush-fronted continuous panel of uniform height. Front door and top cover dimensions shall match. Instruments, relays, and control devices shall be mounted at a height not more than 2000mm and not less than 300mm from floor level.

The arrangement of equipment within each enclosure shall be such as to permit easy access for installation and maintenance. No instruments, relays or other components shall be mounted on rear access doors or removable covers.

#### **V. Panels - Composite**

In situations where space limitations preclude the use of separate instrumentation, control and automation (ICA) and switchgear panels and, at the sole discretion of the Employer Representative, ICA equipment may be combined within a single enclosure subject to the following conditions:

- The observance of all other clauses herein relating to enclosures, mounting boards and minor panels;
- The written assurance of each supplier of ICA equipment that the proximity of the switchgear will have no detrimental effect on the life or performance of any ICA component;
- The total segregation of ICA equipment and switchgear including the glanding and termination facilities;
- The absence of any voltage exceeding 250vac or 50vdc from any compartment containing ICA equipment;
- The use of the full height of the panel (excluding the bus bar chamber and Cable space) for any ICA equipment compartment.

## **VI. Panel protection**

Adequate facilities for isolation and protection by miniature circuit breaker or fuse for each instrumentation and control circuit and sub-circuit shall be provided and shall be so arranged that any interruption causes minimum disruption of plant, operates the appropriate alarm and cannot result in any unsafe operating condition.

All fuses shall be of the cartridge pattern and main fuses shall be of the high rupturing capacity type. Fuse and solid-link carriers and bases shall be of plastic molded insulating material of an approved make. Ceramic materials will not be accepted. Live connections shall be efficiently shrouded and it shall be possible to change fuses with power on without danger of contact with live metal. The fuses shall be rated to give maximum protection to the equipment in circuit and the rating shall be permanently inscribed on the fuse label and on the fuse carrier. Unless necessary for the protection of particular equipment, miniature circuit breakers used for individual circuits in a panel or control desk shall not trip on over-voltage or under-voltage.

Bases for solid links shall not be interchangeable with those for fuses. Fuses and links in the same circuit shall be mounted opposite each other in separate adjacent rows and shall not alternate in the same row. At least 10% and not less than two unallocated miniature circuit breakers or fuses and links shall be provided in each panel distribution board. Miniature circuit breakers and fuses of similar size and rating shall be of the same make and type.

At least 10%, and not less than two, spare fuses and links of each rating shall be provided and fitted in clips inside the panel.

Each instrument requiring a power supply shall be individually wired and protected so that, in the event of a failure in one circuit, the remainders are unaffected. Power supply circuits shall be of sufficient rating that any protective device may operate without reducing the voltage at the terminals of any other component to an unacceptable level.

## **VII. Panel isolation**

Clearly-labelled isolating circuit breakers shall be provided for each incoming power supply. Switches shall be of the quick make-and-break type with spring loaded contacts that close fully without requiring full operation of the handle. The handle and cover shall be interlocked so that the handle cannot be operated when the cover is open and the cover cannot be opened unless the switch is in the 'off' position. The 'on' and 'off' positions of each switch shall be indicated clearly.

Circuit breakers for panel power supplies shall be mounted near an access point and in positions where they may be operated easily from a standing position.

Plug-in isolating links or devices of an approved type shall be provided in any circuit that may still be live when the power supply isolators are in the 'off' position, as, for example, in circuits controlling equipment whose power supply is independent of the panel. Such links or devices shall be properly screened and, if not incorporated in or adjacent to their associated outgoing terminals, shall be labeled with suitable warning notices.

Any item of panel equipment to which panel internal wiring is connected with a plug and socket instead of terminals shall be wired in flexible cable of adequate rating between the 'free' plug and a socket mounted adjacent to the device.  
The power supply connector shall be a socket.

#### **VIII. Panel terminal blocks**

External wiring for panel power supplies shall be terminated on the appropriate isolator. Signal cables from strain gauges, analysers, resistance thermometers, retransmitting slide-wires and thermocouples may be terminated at their appropriate instruments.

A terminal block shall be provided as the interface between the corresponding conductors of each internal and external wire and each internal and external connection except those listed above. The terminal blocks shall be mounted vertically where possible and not nearer than 230mm to the floor or less than 230mm from an incoming cable gland.

Terminal block rows shall be spaced apart by not less than 150mm and arranged to permit convenient access to wires and terminals and to enable ferrule numbers to be read without difficulty.

Other circuits shall be grouped on the terminal blocks according to the classification given in the clause for 'Panel internal wiring' which shall be clearly marked along the corresponding section of each terminal board. Groups of different voltages on the same board shall be separated by insulated barriers.

All connections shall be made from the front of terminal blocks and no live metal shall be exposed at the back. All terminal blocks shall be of the type which clamps the wire securely and without damage between two plates by means of a captive screw and which permits removal of any terminal without disturbance to adjacent terminals. Pinch-screw type terminal blocks will not be accepted. Terminal moldings shall be in melamine to BS 1322, polyamide or equivalent. Terminal rails shall be hot-dip galvanized. Current bars between the two connection points of each terminal block shall be of copper or brass with tin/lead alloy plating. All steel parts shall be zinc-plated and passivated with a yellow chromate layer. Terminal blocks for input and output analogue signals and for circuits containing volt-free

contacts internal or external to the cabinet shall be of the Clip-on type SAKC or equivalent which permit the connection of a test milliammeter or continuity meter without disconnecting any wiring. Terminal blocks for power supplies for equipment external to the panel shall permit the isolation of the item of external equipment without affecting the operation of any other circuit within or outside the panel.

No more than one core of external cables or two internal wires shall be connected to any terminal. If terminal blocks are used as common points for two or more circuits, individual terminals with the appropriate number of permanent cross connections shall be provided. The lengths of exposed cable cores shall be sufficient to reach any terminal in the appropriate row or rows. The cores shall be formed into a neat loom and a separate loom shall be provided for each cable.

Each row of terminal blocks shall contain at least 25% spare terminals over the number required for terminating all cores of external cables in that row. Unless otherwise specified, each external cable shall contain at least 20% spare circuits, with a minimum of one spare circuit.

Terminal blocks shall be numbered consecutively in a sequence different from that used for identifying wiring. The terminal numbers, voltage grouping and terminal board layout shall correspond precisely with wiring diagrams so that quick and accurate identification of wiring can be made.

All the terminal boards shall be provided with covers of transparent insulating material that does not sustain combustion and shall be sectionalized where possible to give access to groups of terminals without uncovering all boards. Terminals which may be live when the panel is isolated from its main supplies shall be suitably labelled to minimize the risk of accidental contact.

#### **IX. Panel internal wiring**

Panel circuits shall be segregated into the following categories:

##### **Group 1: Power control and very-high-level signal wiring (above 50V):**

- 1.1 ac power supplies;
- 1.2 dc power supplies;
- 1.3 ac current signals above 50mA (such as CT circuits);
- 1.4 ac voltage and control signals above 50V (such as PT circuits).

##### **Group 2: High-level signal wiring (6V to 50Vdc):**

- 2.1 signals from conventional electronic transmitters and controllers (such as digital or 4mA to 20mA);
- 2.2 circuits to alarm annunciators and other solid-state devices
- 2.3 digital signals;
- 2.4 emergency shut-down and tripping circuits;
- 2.5 on/off control circuits;
- 2.6 intrinsically safe circuits;

##### **Group 3: Low-level signal wiring (5V dc and below):**

- 3.1 signals from thermocouples;
- 3.2 signals from resistance thermometers and re-transmitting slide-wires;
- 3.3 signals from analytical equipment and strain gauges.



For Group 3 wiring, internal connections to the instruments shall be made by one of the following methods:

- (a) The twisted, screened conductors of the external cable shall be led direct to their appropriate instruments via ducting systems installed for this purpose during construction of the panel;
- (b) The conductors of the external cables shall be terminated on terminals segregated from all other categories and the connections to the appropriate instruments shall be made using twisted pairs with individual screening installed for this purpose during construction of the panel.

Internal wiring for all circuits in Group 2 except those sharing a common connection shall be multi-stranded, twisted pair, 0.75mm<sup>2</sup> minimum copper conductor with HPDE or PVC-insulated cable of adequate grade and rating.

Wiring for circuits in other Groups or sharing a common connection shall be run in stranded, 1.0mm<sup>2</sup> minimum copper conductor with 250V grade, PVC-insulated cable of adequate grade and rating.

Wiring sheath colors shall be black for ac circuits, and grey for dc circuits (excluding thermocouple circuits) and blue for Group 2.6 circuits. Circuits supplied at 240V, between 240V and 110V dc shall also be physically segregated from each other and from other circuits. Access to wiring and components of circuits having voltages exceeding 240V shall not be possible unless and until the circuit has been isolated.

Separate ducts, trunking, cable looms, tray work and the like shall be provided within the panel for each category with at least 150mm between parallel paths of Group 1 and those of any other Group. Intrinsically-safe circuits and their terminals shall be segregated from other circuits and terminals.

All wiring shall be neatly and securely fixed by insulated cleats, bunched and secured by approved plastic strapping or run in approved insulated wiring trunking or non-corrodible flexible tubing. Not more than **75%** of the capacity of trunking, ducts, looming, or tubing shall be used. Insulated earth wiring shall be so arranged that access to any equipment or connection point or the removal of any item of equipment is unimpeded.

Wiring for future equipment shall be secured and terminated on terminal blocks. Lacing for wiring looms shall be of rot-proof cord or plastic strips. Inter-section wiring in multi-section cabinets shall be via a terminal block in each section.

## **X. Panel wiring identification and termination**

Identification ferrules shall be fitted at both ends of each wire. The numbers or letters used shall correspond with the appropriate wiring diagram. The ferrules shall be of plastic insulating material with permanent black characters on a color coded background for numbers and on a white background for letters, unaffected by oil or water. They shall be so arranged that they can be read logically from left to right when viewed normally.

The system of wire identification shall be such that wires in the same circuit on opposite sides of a terminal shall have the same reference, and this system shall be continued through all external cabling.

Terminal ferrules (spade, tongue, crimped connections) shall be provided on each conductor.

## **XI. Panel Earthing**

A continuous copper earth bar of not less than 25mm x 6mm cross section shall run the full length of each panel and shall be securely fixed and bonded electrically to the main frame. The cable gland-plates and the earth bar shall be provided with suitable brass terminals of not less than 6mm diameter for connecting the metal cladding or armouring of all incoming and outgoing cables to the station earthing system.

A second continuous copper earth bar of not less than 25mm x 6mm cross section, electrically isolated from the steelwork of the panel and metal cladding and armouring of cables, shall be provided for earthing the signal earth connection of each instrumentation and control device and the screen(s) of each instrument cable not earthed elsewhere to the station instrumentation earth plate. The earth bar shall have sufficient brass terminals as specified above for each instrumentation and control device and the screen of every shielded cable plus 25% spare terminals.

In multi-section panels, each earth bar shall be electrically bonded to the corresponding bars in the adjacent section(s).

The earth pit for instrumentation system shall be separate. Electric earth pit shall not be used for earthing of instrumentation equipment. All signal cable screens (analogue and digital) shall be terminated onto the instrument earth bar. Signal cable screens shall be earthed at the control panel end only. Screens at the field end shall be tied back and insulated.

SPD s associated with the control and instrumentation system shall be earthed to the instrument earth in accordance with the SPD manufacturer's recommendations.

## **XII. Panel lighting**

Each panel shall be adequately illuminated internally, as evenly and as free from dazzle as possible, by fixed fluorescent lighting controlled from totally-enclosed light switches and by totally-enclosed door-operated switches positioned so as not to interfere with access. There shall also be one installed inspection lamp per three metres of panel length or part thereof with adequate flexible connection cable to reach any point in the panel. The control switch for an inspection lamp shall form part of the lamp assembly. Lighting circuits shall be fused independently of any instrumentation and control circuit and designed to allow lamps to be replaced safely and shall be fed from a distribution board and circuit breaker connected on the live side of the main panel ac supply circuit breaker.

## **XIII. Panel ventilation**

Each panel shall be provided with ventilation fans as required to ensure that equipment within the panel is maintained within manufacturer's recommendations, with due regard to the

environment in which the panel will be mounted. Fans shall be controlled by a suitably-labelled enclosed switch mounted internally in an accessible position.

Fans shall be mounted with their axes horizontal and shall be arranged to draw clean air into the panel. Air entries shall have filters which can be renewed from outside the panel and shall be designed to prevent the entry of rain, spray, injurious fluids, sand or dust.

#### **XIV. Panel labels**

All control gear shall be fully labelled, identifying the equipment designation/function, all external and internal components, all rating data, detailed equipment operating data and for danger and hazard warning.

Labels shall be provided for every panel to describe the duty or otherwise identify the panel and its sections and every instrument, component and item of equipment mounted internally and externally. Where applicable, front-of-panel labels shall be as detailed in the Specification. Wording shall be clear, concise and unambiguous and shall be subject to review by the Employer Representative before manufacture. Each label shall be permanently secured to the surface near the item to which it refers. Externally-fitted labels shall be of Perspex or other approved transparent plastic, with letters and numbers rear-engraved and filled with black.

The rear surface of each Perspex label shall be finished with a coat of paint of the same colour as the panel external finish. Instrument duty labels fitted externally shall be below the item to which they refer. Embossed tape or similar adhesive labels will not be approved.

Laminated materials or rear-engraved and filled plastic shall be used for internally fitted labels, which shall be white with engraved black letters.

Labels conforming to the requirements of the preceding paragraphs or other approved means shall be provided:

- To describe or identify circuits or circuit components;
- To identify dc polarity;
- To warn or remind about dangerous or potentially-dangerous circumstances;
- Wherever elsewhere specified.

Unless otherwise specified, all engraving shall be in plain block letters, 4mm high.

The minimum practicable number of different sizes shall be used.

Note: Contractor shall note that Manufacturers' nameplates shall not be fitted on panel external surfaces. Only equipment Tag I.D shall be located on the panel exterior surface.

#### **XV. Panel finish**

For control and instrument panels, desks and cubicles a hard, smooth, durable finish, free of blemishes, shall be provided. Before painting, all external welds and any rough areas shall be smoothed, and all surfaces shall be thoroughly cleaned and free from scale, contaminates, corrosion or grease. If rust-proof or Zintec steel has not been used in the construction, the panel shall be treated with a passivating agent such as phosphoric acid. All internal surfaces

shall have a minimum of three coats of paint of which the first shall be an approved anti-rusting priming coat and the final coat shall be an opaque gloss white enamel. All external surfaces shall have not less than five coats of paint of which the first shall be an approved etch-priming coat, and the second and third suitable undercoats, all of which shall be rubbed smooth when dry before application of the next coat. The undercoats shall be easily distinguished in shade or colour from the priming and finishing coats. The two final coats shall be of stove enamel paint, gloss or semi-matt finish, to a colour and finish to be advised by the Employer Representative. Stoving shall be carried out in accordance with the recommendation of the paint manufacturer.

The overall dry film thickness (DFT) shall be between 85 and 120 microns.

Nuts, bolts, washers and other fixing devices which may have to be removed for transit or maintenance purposes shall be galvanized or otherwise finished to an approved standard.

## **B. Instruments and ancillaries**

### **I. General**

All instruments, gauges and control equipment which perform similar duties shall be of uniform type and manufacture throughout the Works in order to facilitate maintenance and the stocking of spare parts.

All equipment shall be fully tropicalised and suitable for the worst environmental operating conditions. Panel-mounted instruments shall be of the electrically operated flush mounted type and shall have damp-proof and dust-proof cases.

Instruments mounted outside instrument panels shall have weatherproof and dustproof cases. Instrument cases shall be of corrosion-resistant material or finish.

Instrument screws (unless forming part of a magnetic circuit) shall be of brass or bronze. Access to terminal compartments of instruments mounted outside panels or other enclosures shall not expose any working part. Moving parts and contacts shall be adequately protected from the ingress of dust. Where applicable instruments shall be easily withdrawable from its housing for maintenance without interrupting its signal.

Unless otherwise specified, instruments shall be finished in the manufacturer's standard colour. Instrument dials shall be of such material that no peeling or discolouration will take place with age under tropical conditions.

Plant-mounted indicators and gauges shall be sized to give full legibility when viewed from a position with convenient and easy access or from the point at which any operation requiring observation of the gauge is performed. The minimum diameter for any gauge shall be 150mm except where forming part of standard instruments and accessories such as air-sets.

Dials and bezels shall be of bronze and internal components shall be of stainless steel, bronze or other corrosion-resistant material.

Unless otherwise specified, all functions shall be transmitted electrically and all analogue signal-transmission systems shall be in accordance with BS 5863: Part 1 or equivalent and

shall use a signal of digital or 4mA to 20mA dc. Where possible, measuring systems shall be designed so that any necessary power supply is taken from the appropriate instrument panel.

Transmitting devices shall have integral indicators to monitor the output signal or connections suitable for use with a portable test meter, and shall be capable of meeting the performance requirements specified in the appropriate part of BS EN 60770-1 or equivalent. For the important and critical processes the transmitting devices, such as pressure, temperature and level gauges, shall have a reference gauge installed locally for easy reference for the operation and maintenance staff.

The transmitters shall be provided with LED meters.

Equipment mounted in enclosures shall be suitable for continuous operation at the maximum internal temperature possible in service, due account being taken of internally-generated heat and heat dissipated by other plant. All components shall be rated adequately and circuits shall be designed so that change of component characteristics within the manufacturers' tolerances shall not affect the performance of plant. All equipment shall be designed to operate without forced (or fan) cooling.

Equipment provided with anti-condensation heaters shall be capable of operating without damage if the heaters are left on continuously. Unless provided with unalterable factory configured ranges, measuring instruments shall have zero and span adjustment.

Field mounted instruments shall be mounted such that they are easily viewable and easily accessible for maintenance.

Instruments not mounted in panels shall be supplied complete with all brackets, stands, supporting steelwork and weatherproof enclosures (separate from the instrument cases) necessary for securing them in their working positions and affording complete protection at all times including periods of servicing, adjustment, calibration and maintenance.

Each installation shall incorporate a valve and pipework for obtaining a sample representative of the fluid at the position of the permanent meter and drain. If the measuring and sampling points are remote from each other, the test and sample facilities shall be provided at both points.

In order that maintenance and inspection may be carried out safely and conveniently instruments mounted in elevated and open work areas shall be provided with safety ladders and a sufficiently sized working platform with sun shading.

## **II. Indicating Instruments and Meters**

All instruments and meters shall be flush mounted and generally of the same pattern and appearance throughout and those which perform similar duties shall be of uniform type and manufacture.

Indicating instruments shall be fitted with an externally accessible zero adjuster. They shall have no parallax error and their normal maximum reading shall be approximately 60% full scale deflection.

Ammeters in motor starter circuits shall be capable of withstanding the starting current and shall have a compressed overload scale. The ammeter shall have an adjustable and sealable red

pointer set to indicate normal full load current. The ammeter physical size shall be in keeping with the size of the starter concerned. The minimum size to be used is 0.25 DIN.

Indicating instruments shall comply with IS 1248, BS 89 or IEC 60051 and shall be of industrial grade accuracy.

#### **(a) Panel Mounted Digital Panel Indicators For Field Instruments**

Digital panel indicators shall be microprocessor based and modular in design. It shall accept 4-20 mA DC isolated input. The digital panel indicator shall provide an output of 4-20 mA DC proportional to input signal for retransmission. It shall have RS 485 communication port for connectivity to PLC.

#### **Technical Particulars**

Type	:	Microprocessor based.
Mounting	:	Front Facia of Instrument Control Panel(ICP)
Display	:	Back-lit LCD or LED
Digit height	:	12.5 mm or higher
No. of digits	:	4
Input	:	4-20 mA DC (isolated)
Zero & Span adjustment	:	Required
Weather protection class	:	IP-52 of IS 13947
Retransmission output	:	4-20 mA proportional to Process variables.
Relay outputs	:	Required 2NO+2NC for high level alarm and 2NO+2NC for low level alarm
Communication port	:	RS-485 (With Modbus protocol)

#### **(b) Kilowatt-hour meters.**

Kilowatt-hour meters shall comply fully with IS 722 or BS 5685 Class 2 and shall have industrial grade accuracy ( $\pm 2.5\%$ ). Three element units shall be used for 3 phase 4-wire systems. Two element units shall be used for 3 phase, 3-wire systems.

Quantity : 1 No. for each pump and incomers of -415 Volt (or more)  
Switchboard (200 KW & above motors)  
As per site conditions.

Purpose : Power and Energy Monitoring

It shall monitor voltage, current, kW, kVAr, kVA, power factor and frequency.

### III. Indicator Lights

Indicator lights shall be not less than 20 mm diameter and shall be panel mounted types with metal bodies adequately fastened so that the lamps shall be capable of replacement from the front of the apparatus without disturbance to the lamp holder or panel wiring. Lamp holders shall be keyed into panels to prevent rotation. Lens colours shall comply with BS EN 60037 as follows:

- power on - white\*
- running - green
- tripped/alarm - red
- status (open, closed, etc) - blue
- ready to start - blue
- warning (no imminent danger) - amber

Note: \*white may be used where doubt exists as to which other colour to use.

The lights shall be under-run to give long life either by use of a resistor to limit voltage to 90% normal value or by using higher voltage lamps.

The indicating lamps on control panel shall be cluster of LED's.

### IV. Pushbuttons

Colours of pushbuttons shall generally comply with IS 6875, BSEN 60947, 60037 or IEC 60073 and in particular shall be as follows:

- stop, emergency stop - red
- start - green
- jogging/inching - black
- reset (when not also acting as a stop) - blue
- lamp test - blue
- override/alarm accept - yellow

### C. Junction Boxes

#### I. Junction box (instrument)

1	Construction	-	3mm sheet steel hot
2	Protection	-	IP 65
3	Paint and shade	-	One coat of red oxide primer
			Powder coated light grey as per
			Dhade 631 of is:5

4	Terminal strip	-	Elmex type capable of Terminating 0.5 sqmm to 1.5 sqmm Cable din rail mounted
5	No of terminal strips	-	30/40/70 Rating:600v 10 a ac
6	Conduit & cable entry	-	Lower side
7	Gland plant thickness	-	3mm
8	Door of JB	-	Hinged with proper locking Arrangement to avoid entry of Dust & moisture the design of Fixing screws of the lids of the Junction box shall be such that They do not come out of the lids When completely unscrewed (captive screws)
9	Dimension	-	Vendor to provide most Economic dimension of JB based On the no of Terminal bases and cable Entry
10	Mounting	-	Frame mounted
11	Earthing	-	Two no of earthing bolts for JB Earthing separate instrument Earth bus on insulating clits to be provided
12	Name plates	-	To be provided material: white Engraved letters on black Anodized aluminum sheet Fixing: stainless steel screws Lettering:- black with white Engraved

## II. Junction box (power & control)

1	Construction	-	3mm sheet steel hot
2	Protection	-	IP 65
3	Paint and shade	-	Power coated light grey as per Shade 631 of is:5
4	Terminal strip	-	Elmex type capable of Terminating 0.5 sqmm to 1.5 sqmm Cable din rail mounted



5	No of terminal strips	-	30/40/70
6	Conduit & cable entry	-	Lower side
7	Gland plate thickness	-	3mm
8	Door of JB	-	Hinged with proper locking
			Arrangement to avoid entry of
			Dust & moisture the design of
			Fixing screws of the lids of the
			Junction box shall be such that
			They do not come out of the lid
			When completely unscrewed
			(captive screws)
9	Dimension	-	Vendor to provide most
			Economic dimension of JB based
			On the no of Terminal bases and cable
			Entry clearly specifying GA
			Drawing
10	Mounting	-	Frame mounted
11	Earthing	-	Two no of earthing bolts for JB
			Earthing
12	Name plates	-	To be provided material: white
			Engraved letters on black
			Anodized aluminum sheet
			Fixing: stainless steel screws
			Lettering:- black with white
			Engraved.

## D. Cabling

### I. Instrumentation cabling

Cables from conventional measuring transmitters and analogue process controllers, such as digital or 4mA to 20mA dc output from a constant-current source, (hereinafter referred to as high-level signals) shall be polyethylene or PVC insulated with stranded conductors and laid up as twisted pairs with one twist per 30mm approx. Each cable shall have an overall screen of braided copper or mylar backed aluminium foil giving a minimum coverage of 85%, a steel wire armouring insulated from the screen and from any ducting and an overall PVC sheath. For runs exceeding 30 metres or for all inputs to a data logger, computer or microprocessor, multi-core cables shall have an individual screen of braided copper or mylar-backed aluminium foil for each signal pair. The minimum conductor size shall be 24/0.2mm but shall be of greater cross-sectional area if required for the satisfactory operation of associated plant. Cables for intrinsically safe systems shall comply with BS 5308 and the relevant certificate.

Cables from strain gauges, analysers and the like, such as 0 to 100mV (hereinafter referred to as low-level signals — see also below) shall be as specified above and shall have an individual screen for each signal pair.

Cables from indicating devices to alarm or tripping circuits shall be as specified above for high-level signals but shall use cables, cable trays, ducts and conduit separate from those for other high-level circuits.

Cables for high-level signals, low-level signals, resistance thermometers and thermocouples shall be segregated from each other and each shall be separated from cables for power, communications and other electrical services. Other cables run in the vicinity of instrumentation cables shall be twisted at the rate of one twist per 50mm approximately and shall be separated from instrumentation cables by a distance of not less than 300mm.

Initiating devices for plant protection and personnel safety shall be connected by individual cables direct to the tripping or safety device and shall not be routed via any intermediate junction, marshalling box, cabinet, relay or similar. The outer sheaths of such cables shall be coloured orange.

## **II. Telemetry cabling**

Telemetry cabling between a master station and an outstation, unless otherwise specified, shall consist of a minimum of 6 signal pairs, of which two pairs shall be allocated to the telemetry system, one pair shall be allocated to a speech circuit and three pairs shall be spare. Each conductor shall be multi-stranded with an equivalent diameter of not less than 0.9mm. Conductors shall be laid up in starquad formation. The dc resistance of any pair of conductors shall not exceed 88 ohms per loop mile at 10°C and the difference between the resistances of the conductors of any pair shall not exceed 0.5% of the loop resistance of that pair.

Telemetry cables shall be designed for burying in water-logged ground.

Conductors shall be plain annealed copper with aluminium/polythene laminate sheath moisture barrier, copper or brass tape pest barrier, single galvanised steel wire armour and overall polythene sheath. The cable shall have a solid filling of petroleum jelly.

The characteristic impedance of each signal circuit shall have a nominal value of 600 ohms at 800Hz and the circuits shall be suitable for signal input levels of between –30dbm to +4dbm (0dbm = 1mW into a load of 600 ohms). The overall attenuation between the terminations of any circuit at the mean frequency of the band width specified elsewhere shall not exceed 20dbm and the attenuation at any two frequencies within this band width shall not differ by more than 6dbm. The transmission time for any two frequencies within the band width specified elsewhere shall not differ by more than  $1 / (4 \% B)$  seconds, where B is the transmission speed in bauds, as specified elsewhere.

The signal-to-noise ratio within the bandwidth specified elsewhere shall be better than 12db. The frequency of any received signal shall not differ from the frequency of the corresponding transmitted frequency by more than 1% of the transmission speed in bauds specified elsewhere.

Loading coils as necessary to meet the performance requirements detailed herein shall be supplied and installed at equally-spaced points.

### **III. Fiber optic cable**

To facilitate the proper and efficient co-ordination of the Works the Contractor shall sublet all Cabling Works to one Sub-Contractor who has proven and successful experience in fiber optic cable installations on projects similar to the one now proposed.

If cable sizes are not indicated on Drawings or in schedules, determine the correct size based on total end to end signal attenuation not to exceed 40 dB, including all splices and termination losses, and after taking into consideration.

- a) Type of fiber
- b) Ambient conditions
- c) Method of installation
- d) The disposition of each cable relative to others

All cables and wires shall be suitable for installation and continuous services in the ambient conditions described elsewhere in this document.

Shop Drawings and Product Data shall be submitted for the approval of the Employer Representatives as follows;

- Submit full technical details of each type of cable proposed.
- Submit copy of test certificates from the manufacturer or an independent testing authority confirming that cables comply with the specification.
- Submit exact route of the cable run and relevant Sections in the shop drawings.

Each drum length of cable shall be allotted a distinct and separate reference number. This number shall appear on the test certificate covering the respective length of cable and shall also be clearly marked on the cable drum.

The Contractor shall advise the Employer Representative upon delivery to site of each drum length, quoting the reference number, the test certificates shall be handed to the Employer Representative for examination and approval.

All cables shall be delivered to site with the manufacturer seals, labels or other proof of origin intact. These labels and seals shall not be removed until the cable is required for use and shall be retained for inspection by the Employer Representative.

The Contractor shall be responsible for the off-loading and handling of the cables on site, and shall ensure that cables are delivered to site on drums and properly protected against mechanical damages. Where lengths are cut from cables, the open ends shall be sealed.

The contractor shall be aware of the need to supply and install all cables for this Contract which are most suitable for the special environmental conditions prevailing in this project.

The cable shall comprise 8 fibers, loose tube, two fibers per tube with central 1.5 mm nominal steel central strength member, moisture barrier, steel tape armored in continuous lengths up to a maximum of 6.0 km or as dictated by cable joint chamber locations and route survey.

<b>Mode</b>
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Type of fiber	Single mode, doped silica
Core Diameter	9.0 ± 0.5 micro m
Cladding Dia	125 ± 2.0 micro m
Coating (outer) Diameter	250 ± 15 micro m Material UV curable acrylate
Numerical aperture	0.11 micro m
Attenuation	<0.4 dB/km @ 1300 nm <0.2 dB/km @ 1500 nm
Bandwidth	1000 MHz @ 1300 nm
Chromatic Dispersion	3.5 ps/nm x km @ 1300 nm 20 ps/nm x km @ 1500 nm
Operating temperature range	-30 to +80 deg. C
Crush resistance	>200N/cm
Weight	500 kg/km (maximum)
Tensile strength	2000 N (minimum)
<b>Multi mode</b>	
Type of fiber	Multi mode, doped silica
Core Diameter	62.5 ± 3.0 micro m
Cladding Diameter	125 ± 2.0 micro m
Coating (outer) Dia	250 ± 15 micro m Material UV curable acrylate
Numerical aperture	0.275 ± 0.15 micro m
Attenuation	<3.2 dB/km @ 1300 nm <0.9 dB/km @ 1500 nm
Bandwidth	500 Mhz x km @ 1300 nm
Operating temperature range	-30 to +80 deg. C
Crush resistance	>200N/cm
Weight	500 kg/km (maximum)
Tensile strength	2000 N (minimum)

#### IV. Cable termination boxes

Cable termination boxes shall have double-ended screw terminals with removable links to facilitate core isolation during testing. Each box shall contain sufficient terminals for every conductor plus 20% spare terminals. Cable termination boxes shall have cable sealing chambers and insulated glands with earthing terminals so that the armouring may be earthed or isolated from earth, as circumstances dictate.

Termination boxes for use within buildings shall be of sheet steel with hinged or removable front covers. All other termination boxes shall be cast steel or heavy gauge sheet steel construction giving protection to IP55. All termination boxes shall be hot-dip galvanised or approved equivalent finish. Each terminal box shall have a removable, un-drilled gland plate and the Contractor shall supply and fit the requisite number of cable glands.

At each cable termination box, each cable core (including spares) shall be identified by a numbered slip-over type collet. The numbering for a particular cable core shall be the same throughout its length.

Cable joints shall be at points approved by the Employer Representative.

Each cable joint shall be of the straight-through type. The conductors shall be ferrule-jointed with the insulation maintained by heat-shrink sleeving. Joint closure shall be made with epoxy resin and the completed joint shall be impervious to water if submerged or in waterlogged ground. If cast iron joint boxes be used, they shall be provided with cable glands

and, after installation and testing, shall be covered with Densomastic HD compound or equal; so that all sharp corners, bolts and projections are moulded to a smooth surface. Two lappings of Densopol grade ZN 50mm tape, or equal, shall then be applied overall. Jointing shall be carried out on each conductor, including any provided in excess of the minimum quantity specified. All materials and things of every kind required for the cabling jointing shall be provided by the Contractor.

## **V. Cable labelling**

At each end of each cable, in a uniform and visible position, a label shall be fixed on the cable to indicate the site cable number and route, and the number and size of conductors. Labels shall be made of brass, aluminium, lead or copper strip, engraved and retained by suitable non-rusting or non-corrodible binding wire passing through two fixing holes, one at either end of the label. If the cable gland is not normally visible, then the label shall be fixed inside the panel by means of screws.

Three-phase power cable cores shall be identified A, B, C or colour-coded red, yellow, blue so that the correct three-phase sequence is preserved throughout the system. Single-phase power cable cores shall be colour-coded red and black.

Control cables shall have individual cores identified by means of suitable permanent ferrules bearing the same number at both ends. Core identification shall occur at every point of termination using an approved system of colour-coded ferrule markers. The size of these ferrule markers shall be such as to match the overall diameter of conductor plus insulation. Numbering shall read from the termination upwards on all cores.

Each cable and core shall bear the same number at both ends of the cable and core respectively.

- (a) Power terminations — colour, number or letter.
- (b) Control terminations — letter or number or both.

## **VI. Cable terminations**

All PVCSWAPVC, PVCPVC and XLPESWAPVC cables shall be terminated with mechanical glands which shall comply with BS 6121. They shall seal the inner and outer cable sheaths against ingress of dirt and moisture and provide adequate mechanical support. Each cable gland shall be protected by corrosion-resistant molded PVC hoods, covering the entire assembly from the overall sheath to the gland neck.

Glands for armoured cables shall provide a positive armour clamp to the enclosure so that no tension is applied to the termination. The clamp shall also provide a high level of earth continuity and be of adequate size to withstand the full fault current of the system for one second.

All glands shall be provided with an earthing tag. For cables of 4mm<sup>2</sup> or less, a serrated washer may be used instead for earth continuity.

The cable termination and sealing equipment shall be obtained from the cable manufacturer, or other approved supplier, and shall be purpose-made for the type, size and grade of cable concerned. The application of these materials shall be strictly in accordance with the manufacturer's instructions.

Through joints shall be permitted only on long cable runs outside buildings. Where such joints are necessary; the cables shall be jointed with epoxy or acrylic resin Cold-setting compound which has been pre-measured and pre-packed ready for use.

The boxes shall be of a split moulded plastic type with filling vents for compound.

Bonding straps shall be fitted with armour clamps across the joint and inspected by the Employer Representative prior to filling the box with compound. Wrapped pressure type joints shall not be accepted.

Conductor cores shall be jointed number to number or color to color.

## **VII. Cable installation-general**

Cables which are to be run on walls, ceilings or other building structures shall, unless otherwise agreed by the Employer Representative, be secured on cable trays and ladders or enclosed in conduit or trunking.

Every cable shall be neatly run vertically or parallel to adjacent walls, beams or other structural members. Cables shall not be installed in areas of direct sunlight.

Where this is unavoidable, approved sun shields shall be supplied and installed.

Where the building structure incorporates purpose-built covered duct or trench systems for main cables, instrumentation cables shall be segregated and installed on tray work or otherwise secured to the sides of the duct or trench.

Where the structure incorporates general service ducts or trenches containing pipework, chemical lines and other services, all cabling shall be segregated from the other services and shall be run on the walls unless otherwise agreed by the Employer Representative.

Cables shall be spaced to prevent interference between power and signal cables, and to avoid unnecessary crossovers.

The spacing of clips, saddles and cleats shall prevent the sagging of the cables during their installed life. The method of fixing clips and the like shall be by means of non-corrodible screws inserted into approved wall fixings, such as rawlplugs.

Cable hangers, cleats, saddles, brackets and similar supporting devices shall be of an approved type and of adequate strength for the cables they are supporting. They shall be treated to withstand Site conditions without corroding. Self-locking plastic buckle clips and strapping shall not be used. The arrangement and fixing of each cable shall permit the removal and replacement of any cable without disturbance to any other cable or the fixings thereof.

When cables are terminated in any particular item of equipment, special care shall be taken to ensure that the cables finally approach the equipment from a common direction and are individually terminated in an orderly and symmetrical fashion.

Submissions which the Contractor shall submit the following in relation to cable installations in addition to submissions detailed elsewhere in the Specification.

### **VIII. Drawings and schedules:**

- Block diagrams to show control cabling systems with each cable and terminal equipment being identified as in the cable schedules.
- Cable route and layout drawings. For those items which are underground, these drawings shall include the following:
  - Route plans and sectional views for all cable runs, cable trays, cable ducts and cable trenches;
  - The position of all marker posts, joints, draw pits and the like.
- Cable schedules shall detail the cable number, type, voltage, size, route length and number of cores or pairs. Control-cable schedules shall detail the connected and spare core numbers, diagram number for connected equipment, core ferrule and terminal reference number.

### **IX. Data and calculations:**

Manufacturers' catalogues and data sheets for all cables and fittings. Cable sizing Calculations.

### **X. Test certificates:**

Test certificates for all witnessed and routine tests carried out at the manufacturer's works and at Site (calibration).

### **XI. Cable trays and ladders**

Cable tray and cable-support ladders shall be of heavy-gauge galvanised steel and with an overall PVC coating when required to the approval of the Employer Representative.

Cable tray and ladder systems shall be installed using factory-made supports, joints and junction/bend pieces. Wherever tray and ladder sections are cut and shaped on Site, cut edges shall be dressed and painted with at least two coats of cold galvanising compound or lead-based anti-corrosive paint.

Ladder systems shall be secured to walls and ceilings by pre-formed galvanized interlocking channel.

### **XII. Flexible conduits**

Flexible conduit shall be of the waterproof galvanised type of PVC wire-wound type with cadmium-plated mild steel couplings. Lengths of flexible conduit shall be sufficient to permit withdrawal, adjustment or movement of the equipment to which it is attached and shall have a minimum length of 300mm. Flexible conduit shall not be used as a means of providing earth continuity. A single earth conductor of adequate size shall be installed external to the conduit complete with earth terminations.

Where conversion from rigid conduit to flexible metallic conduit is to be made, the rigid conduit shall terminate in a trough-type box. The flexible conduit shall extend from this box to the equipment; the earth continuity cable shall be secured to the box and to the piece of equipment. The use of lid facing screws and the like will not be permitted. Adaptors shall incorporate a grub screw or a gland to prevent the flexible conduit becoming loose.

### **XIII. PVC conduit**

Where galvanized conduit would be liable to corrosion, PVC conduit shall be installed.

PVC conduit shall be of the oval or round high impact non-flame-propagating type as specified and self-extinguishing, to BS EN 61386-21. Surface and concealed installations shall be generally as described for steel conduit. PVC conduit fittings shall comply with BS 4607. They shall all be white unless specified otherwise.

Jointing shall be carried out using PVC solvent and socketed accessories.

Expansion couplers shall be fitted in straight surface runs every 12m. The free end shall be sealed with non-setting mastic to form a waterproof seal.

Purpose-made bends may be used providing that the cable bending radius is maintained. Cracked or crinkled conduit will be rejected.

The conduit shall be suitable for use in ambient temperatures of between  $-5^{\circ}\text{C}$  and  $+60^{\circ}\text{C}$  and shall not be installed in areas that receive direct sunlight. A separate protective conductor (earth-continuity conductor) shall be installed.

Adaptable boxes and accessories shall be made from heat-resistant insulating material. The minimum wall thickness of boxes having a nominal internal depth of 16mm or less shall be 1.5mm. For deeper boxes, the minimum wall thickness shall be 2mm. All boxes which are intended to support luminaires or other heat sources shall have either external fixing lugs riveted to the metal inserts or utilize steel insert clips.

### **E. Cable installation methods General**

All cabling installation methods shall be subject to the approval of the Employer Representative.

#### **I. Installation directly into the ground**

Where cables are buried in the earth, the bottom of the excavated trenches shall be freed of sharp stones and other projections and covered with sand to a depth of 50mm.

Cables shall be unrolled from drums without loops and kinks, and care shall be taken when laying to avoid damage to the outer sheath by drawing over sharp projections.



Cables shall be snaked into the trenches to avoid tension in the cables during backfilling or from subsequent settlement. After laying, cables shall be covered to a minimum depth of 100mm of compacted sand and shall have a layer of protective interlocking concrete cable tiles. The tiles shall be overlaid with marker tape.

When cables of different voltages are laid together at the same depth, vertical cable tiles shall be used to segregate the cables.

ICA and communication cables shall be laid not closer than 1000mm to high voltage cables.

A sufficient number of rollers shall be provided so that the cable does not touch the ground or twist during pulling.

## **II. Installation in underground ducts**

Underground ducts shall be constructed of impact-resistant uPVC and laid at a minimum depth of 500mm (to the duct centre), surrounded by at least 75mm of sieved sand. At road crossings, uPVC ducts of minimum diameter 100mm shall be laid at a minimum depth of 1000mm (to the duct centre). The ducts shall be encased by 150mm concrete on all sides.

When installing cables in ducts, the following measures shall be observed:

- Cables shall be pulled in a straight line;
- Rollers shall be positioned at the edges of drawpits both at the drawing-in and drawing-out points over which the cables shall be drawn;
- uPVC pipes and cable sheaths shall be coated with an approved lubricant;
- Sufficient draw-in points shall be provided and adequate room allowed for installation of cables;
- The pulling rope shall be guided by rollers.

Only one power cable shall be drawn into each duct.

Whenever a duct is laid in the ground, a draw-wire shall be pulled through with at least 1000mm excess at each end and the draw-wire left in position if the duct is not to be used immediately.

## **III. Sealing cable entries into buildings**

Whenever cables pass through walls below ground level, the point of entry shall be sealed against the ingress of water. This shall be achieved with silicone foam or similar.

All cable entries into a building shall be in ducts and where the cables pass in or out of ducts, together with any spare ducts, the ducts shall be sealed against the ingress of moisture by means of duct stoppers and bituminous compounds or by any other method approved by the Employer Representative. The stopper shall have a fire resistance of at least 30 minutes.

## **IV. Marking of underground cables**

The location of all underground cables shall be identified by:

- Brass plates fixed to the exterior surface of all walls of buildings 300mm above ground level and directly above the point where cables pass through the wall;

- Marker posts in road verges and the like at intervals of not more than 100m and at all junctions and changes of direction along the route;
- Marker posts at 10m intervals within an enclosed site and at all junctions and changes of direction along the route.

Marker posts shall be of concrete, not less than 200mm high above ground with an inscribed brass or enamel metal plate. The inscription shall indicate the presence of a cable below, the depth, classification and voltage rating.

A drawing or sample of a typical marker post shall be submitted for the approval of the Employer Representative.

## **V. Installation in cable trunking**

Cable trunking shall be manufactured from mild steel of not less than 1.25mm and shall be hot-dip galvanized. The Contractor shall ensure that the size of the trunking is adequate for the number of cables to be installed together with 50% spare capacity. Trunking shall have minimum dimensions of 50mm x 50mm.

Segregation of cables shall be carried out if required using continuous sheet steel barriers with the bottom edge welded to the trunking. The trunking shall have two return flanges for rigidity. Where necessary, additional strengthening straps shall be fitted internally. The cover shall overlap the trunking and be made of the same gauge. Fixing screws for covers shall be recessed and be of the self-retaining quick-fix type. All bends, tees and intersections shall be of the gusset type and shall, wherever possible, be purpose-made by the manufacturer and of a matching design to the main trunking.

Cables shall be retained in the trunking when the cover is removed by means of straps. Internal connecting sleeves shall be fitted across joints in the trunking and earth continuity ensured by bonding each section of trunking to a continuous earth wire.

Non-flammable fire barriers shall be inserted where the trunking passes through walls or floors. Conduit connections to trunking shall be made by flanged couplings and male bushes.

Trunking shall be supported at intervals not greater than 2m horizontally or 2.5m vertically.

Crossings over expansion joints shall be made in flexible conduit.

Should it be necessary to cut or drill a section of trunking, the bared ends shall immediately be given a coat of zinc-rich cold galvanizing paint.

Cable and trunking runs shall be determined by the Contractor and agreed by the Employer Representative before any work is started. The run shall be at least 150mm clear of plumbing and mechanical services.

Trunking systems erected outside a building shall be weatherproof.

## **VI. Installation in troughs and trenches**

Where the building structure incorporates purpose-built covered trench systems, power distribution cables may be laid on the floor of the trench. Control and instrumentation cables

shall be segregated and installed on supporting steelwork or cable trays secured to the walls of the trench.

Where the building structure incorporates general service trenches containing pipework, chemical lines and other services, all cabling shall be segregated from other services and run on the trench walls. Crossovers shall be kept to a minimum and cabling shall be taken above wet service pipework.

Cable trays shall be of perforated steel with formed flanges and of minimum thickness not less than 1mm for trays up to 100mm width, not less than 1.25mm for trays from 100mm to 150mm width and not less than 1.5mm thickness for trays from 150mm to 300mm width.

Cable-tray supports shall be of sufficient strength to maintain rigid support to the fully-laden cable tray along its entire length. All brackets and tray work shall be suitable for withstanding a temporary weight of 125kg.

Wherever possible, cable trays shall be installed in full lengths without cutting.

Should it be necessary to cut or drill a length of tray, the bared ends shall be dressed and immediately be given a coat of zinc-rich cold galvanizing paint. Similarly for PVC-coated trays, the bared end shall be immediately sprayed using a PVC aerosol.

All cables shall be firmly secured to the tray using purpose-made saddles, as approved by the Employer Representative, together with proprietary cable cleats.

## **VII. Installation in buildings**

Cables required to be run on walls, ceilings, or other structures shall be carried on substantial cleats, either in groups or simply at spacings determined by rating requirements, supported on tray or ladder racks or enclosed in conduit or trunking.

All cables shall be neatly run vertically or parallel to adjacent walls, beams or other structural members.

The spacing of clips, saddles and cleats shall be such as to prevent the sagging of the cables during their installed life. The method of fixing clips and the like shall be by means of non-corrodible screws inserted into approved wall fixings.

Cable hangers, cleats, saddles, brackets and similar supporting devices shall be of an approved type and of adequate strength for the cables they are supporting. They shall be treated to withstand site conditions without corroding. Self-locking plastic buckle clips and strapping shall not be used.

Hangers shall be spaced according to recommendations in the IEE Wiring Regulations. Allowance shall be made for expansion and contraction of the cables.

Cables shall be located between 50mm pegs spaced at 40mm centres across a rung so that a 40mm or 80mm space is maintained between cable centres. Cleats shall be used where the ladder racking is vertical.

Cables shall be run at least 150mm clear of plumbing and below heating and hot water pipework.

### **VIII. Cable installation in conduits**

Conduits shall be either galvanized heavy-gauge steel screwed type or light-gauge steel non-screwed type, steel or PVC. Accessories shall either be malleable cast iron or pressed steel.

A space factor of 40% shall not be exceeded and, in any case, conduit shall have a minimum diameter of 20mm. The tubing is to be perfectly smooth inside and out and free from imperfections. Both ends of every length of tubing shall be reamed and all sharp edges removed before erection.

Where conduits converge, adaptor boxes shall be used. Conduits shall be connected by means of male brass bushes and couplings. Where conduits are greater than 25mm diameter, straight-through joint boxes shall be of the trough type. Where conduit or fittings are attached to equipment casings, the material of the casing shall be tapped for a depth of not less than 10mm or male bushes and flanged couplings may be used.

Hexagonal lock nuts shall be used at running joints. They shall seat firmly and evenly on to mating faces. All function boxes, draw-in boxes, and inspection fittings shall be placed so that the cables can be inspected, withdrawn and re-wired during the life of the installation.

Generally not more than two bends or offsets or one coupling will be permitted without a suitable inspection accessory. Fish wires shall not be left in conduits during erection. The whole of the installation shall be arranged for a loop-in type of system with joints being carried out at switches, isolators or appliance fittings.

Ends of conduits which are liable to be left open for any length of time during building operations shall be plugged to prevent the ingress of dirt and covers shall be fitted on all boxes.

Generally, conduits shall not cross expansion joints of buildings. Where they cannot be installed in any other manner, a galvanized flexible conduit shall be used across the expansion joint. A total of 150mm movement shall be allowed.

#### **F. Microprocessor based Alarm Annunciator**

- (1) Microprocessor based alarm annunciator shall be provided for generating audio-visual alarms for each abnormal condition. Alarms shall be initiated by the opening and closing of volt-free contacts which shall remain unchanged throughout the periods in which the alarm conditions exist. Alarm circuits shall be capable of conversion from open-healthy to open-alarm or vice versa by a simple configuration after installation requiring no additional parts or special equipment. Each alarm shall initiate the operation of both visual and audible devices. The sound intensity (adjustable) of each audible device shall be suitable for the maximum sound level of its environment
- (2) Each alarm shall initiate a visible and audible indication of the specified condition. Unless otherwise specified, alarm indicators shall be grouped together in annunciator units each having at least 20% spare windows. Each alarm window shall consist of minimum 2 nos. of bulbs having cluster of LEDs

and shall have screens engraved with legends approved by the Employer Representative's Representative.

- (3) When any alarm condition occurs, an audible device common to an alarm annunciator system shall sound and the appropriate indicator shall flash on and off. The flashing rate shall be selectable. Facility for selection of type of sequence shall be provided.
- (4) The operation or acceptance of one alarm shall not inhibit the operation of the audible device or the flashing of the appropriate alarm indicator if a future alarm condition occurs.
- (5) An integral 'test' pushbutton shall be provided to illuminate each lamp and to operate the audible device but shall not cause a spurious alarm condition.
- (6) Alarm circuitry shall be arranged so that spurious or transient alarm states persisting for less than 0.5 seconds adjustable do not initiate any action.
- (7) Isolation facility shall be provided for the hooters.
- (8) Alarm annunciator/indicator legends or labels shall be arranged with three lines of text as follows:

i.	top line	:	Location
ii.	middle line	:	Parameter
iii.	bottom line	:	Status
e.g.		:	LEVEL LOW

- (9) Alarm annunciator shall have RS-485 communication port (Modbus protocol) for interfacing with the PLC system.
- (10) A LED shall be provided to indicate the 'ON' status of the alarm annunciator.

### Technical Particulars

Alarm annunciator shall be provided for annunciation of alarms in control room. The technical particulars of alarm annunciator are as follows:

i.	Type	:	Microprocessor based, split type with alarm windows mounted on the front door and electronic modules inside the panel.
ii.	Mounting	:	Flush with panel
iii.	Construction	:	Modular

iv	Inputs	:	Potential free, NO/NC contacts
v	Size of windows	:	60 mm X 26 mm
vi	Operating sequences	:	First up (user selectable dip switch)
vii	Bulbs per channel	:	2 (Cluster LEDs)
viii	Push Buttons	:	For Test, Mute, Acknowledge & Reset
ix	Hooter	:	Required, electronic type
x	Power supply	:	24 V DC/240 V AC
xi	Power supply status Indication	:	Required
xii	Weather protection	:	IP-52 of IS 13947
xiii	No. of Windows	:	8 / 12 / 24, As required with 20 % Spare
xiv	Quantity	:	As per process requirement

## 1.10 Process Instrumentation

### 1.11 General

- Instrumentation system shall be designed, manufactured, installed and tested to ensure the high standards of operational reliability. All electronic components shall be adequately rated and circuits shall be designed so that change of component characteristics shall not affect plant operation.
- All instrumentation equipment shall be new, of proven design, reputed make, and shall be suitable for continuous operation. Unless otherwise specified, all instruments shall be tropicalized. The outdoor equipments shall be designed to withstand tropical rain. Wherever necessary space heaters, dust and water proof cabinets shall be provided. Instruments offered shall be complete with all the necessary mounting accessories.
- All instruments shall be from the country of origin as indicated in the preferred vendor list elsewhere in this specification.
- All instruments shall be offered for complete functional inspection & testing before dispatch, at Manufacturers Factory works where the instrument has been manufactured. No deviation from the same shall be accepted.
- Electronic instruments shall utilize solid state electronic components, integrated circuits, microprocessors, etc., and shall be of proven design.
- No custom made hybrid type integrated circuits shall be used.
- Unless otherwise stated, overall accuracy of all measurement systems shall be  $\pm 1\%$  of measured value, and repeatability shall be  $\pm 0.5\%$ .
- Unless otherwise specified, the normal working range of all indicating instruments shall be between 30% and 80% of the full scale range.
- On resumption of the supply following a power failure the instruments and associated equipment shall start working automatically.

- The instruments shall be designed to permit maximum interchangeability of parts and ease of access during inspection and maintenance.
- Unless otherwise stated, field mounted electrical and electronic instruments shall be weatherproof to IP-65. All outdoor instruments shall be fitted with canopy to shield the instruments against the weather.
- The instruments shall be designed to work at the ambient conditions of temperature, humidity, and chlorine contamination that may prevail but in any case not less stringent than those conditions detailed in the Project Requirements. Instruments shall be resistant to corrosion in the atmosphere in which they are expected to operate.
- Lockable enclosures shall be provided for all the field mounted instruments.
- All field instruments, and cabinets/panel mounted instruments shall have tag plates/name plates permanently attached to them. Details of proposed inscriptions shall be submitted to the Employer for approval before any labels are manufactured.
- All coated parts of sensors shall be made out of non corrosive material capable of working with chlorine content of 5 ppm.
- For all instruments installed in the field, surge protection devices (SPD s) shall be provided at both ends of the connecting cable for protection against static discharges / lightning and electromagnetic interference.
- Individual pair screened, overall screened, armoured cables shall be used for analogue signals and armoured, overall screened cable shall be used for digital signal cables.

#### **1.11.1 Flow Measuring Systems**

Flow measuring system shall consist of flow sensor / transducers, flow computer and flow transmitter.

Flow transducers shall be rugged in construction and shall be suitable for continuous operation. Flow transducers shall have waterproof construction and shall be suitable for installation in underground/above ground pipelines.

To avoid the effects of disturbances in the velocity profile, a straight and uninterrupted run, upstream as well as downstream from the location of the flow sensor shall be provided in accordance with the requirements of the flowmeter manufacturer.

The flow transmitter shall be suitable for field or panel mounting and shall accept an input from the flow sensor. It shall process the input signal and provide 4-20 mA dc output proportional to flow rate. The flow range shall be adjustable.

A zero span adjustment facility shall be provided for flow transmitter and indicator.

Flow measurement shall not be affected by physical properties of sewage/water viz., temperature, pressure, viscosity, density etc., within given limits. Contractor shall provide compensating electronic circuits if required. The overall accuracy of flow measuring systems shall be at least **-0.5%** of the measured value unless otherwise stated.

#### **1.11.2 Electromagnetic Flow Meter (Full Bore):**

The Electromagnetic Flow Meters shall be installed in RCC chambers / open pits or buried for indication of flow rate and total consumption of water in a transmission or distribution pipe work of system. The Electromagnetic Flow Meters shall withstand maximum working temperature and working pressure shall be as per process requirement.

Full bore electromagnetic flow meters shall be designed, manufactured and calibrated to ISO standard. The flow meter shall be capable of measuring bi-directional flow.

Electromagnetic Flow Meter shall be a velocity sensing electromagnetic type, microprocessor based signal converter, Flow Integrator and Totalizer sealed housing, flanged tube meter as per working pressure requirement. The meter shall be manufactured to highest standard available for mag-meters. The accuracy shall be inclusive of linearity, hysteresis, and repeatability, temperature and pressure effects. The meter assembly shall operate within a range of 0.3 m/sec to 5 m/sec and pressure rating shall be as per process requirement to be constructed as follows

Meter tube shall have a constant nominal inside diameter offering no obstruction to the flow.

Signal Converter shall be pulsed DC coil excitation type with auto zeroing. The signal converter shall be remotely mounted away from the meter. The converter shall indicate direction of flow and provide a flow rate indication and a total of flow volume for both forward and reverse directions.

The converter shall provide an isolated 4-20 mA output into minimum 600 ohm load and a frequency output of a maximum of 0-10 KHZ and a scaled pulse output.

The microprocessor based signal converter shall have a self-diagnostic test mode and backlit display that continuously displays 'Rate of Flow' and 'Total Volume'.

The converter shall be compatible with Microsoft Windows and other software programs with built in terminal communication capabilities of RS 485, HART or other protocols for interface.

The converter shall be remotely mounted maximum upto 200 m from the sensor, and shall be supplied with all calibration complete for desired requirements.

The converter cum transmitter shall be fully programmable from the front facia.

The programming shall be user friendly, self-prompting menu driven.



The length of the sensor shall be strictly as per ISO upto DN 600 mm and for other sizes it shall be as per the manufacturer's standard. Only, one manufacturer shall make all meter size and styles required for this contract.

All flow meters shall be offered for inspection & testing before dispatch at Manufacturers Factory where the instrument has been manufactured.

## **I. Level Measuring System**

### **A. Ultrasonic Level Meters**

Ultrasonic level measuring devices applied for liquid level measurement shall comprise a transducer, control unit and remote indicator.

The transducer shall be suitable for flange or bracket mounting as required and shall be environmentally protected to IP 65. It shall have ambient temperature compensation, adjustable datum setting facilities.

The accuracy of the sensor shall be  $\pm 0.25\%$  or better.

It shall be programmable with an integral programming keyboard and provide a digital display of the measured variable. It shall be provided with diagnosis facilities and shall provide an isolated 4 to 20 mA dc output signal proportional to the range of measurement.

The design and application of ultrasonic level meters shall take into account the vessel or channel construction, the material, size, shape, environment, process fluid or material, the presence of foam, granules, size etc.

The installation shall avoid any degradation of performance from spurious reflections, absorption, sound velocity variations, sensor detection area, temperature fluctuations, specific gravity changes and condensation. For applications where spurious reflections are unavoidable the control unit shall be provided with facilities for spurious reflection rejection.

If turbulence exists, shielding, stilling tubes or other measures shall be provided to avoid effects on the measurement.

### **B. Conductivity Level Switches**

The electrodes used for conductivity level switches shall be stainless steel. Single electrode systems (one electrode per holder) shall be used (except where their use is impractical) with insulated electrodes such that only the tip of each electrode is exposed to the liquid at the operating level.

Relay or control units operating with level electrodes shall have adjustable sensitivity. Electrodes for use in fluids of low or variable conductivity shall be fitted with conductivity discs.

Where relay or control units are not mounted in control panels, they shall be provided with surface mounting enclosures with a degree of protection to IP 52 for indoor locations or IP 65 for outdoor locations.

## II. Pressure gauges ,Switches and transmitters

Pressure gauges shall comply with BS EN 837- Parts 1, 2 and 3. Pressure gauges, transmitters and switches shall have over range protection up to 1.5 times the maximum anticipated line pressure and have concentric scales. For specially arduous duty where the gauge is subject to pressure pulsations and/or vibration, it shall be provided with a glycerine-filled dial and line snubbers shall be used. Bourdon-tube type differential-pressure gauges shall be capable of withstanding full line pressure on any side with the other side vented to atmosphere without damage to or effect on the calibration. No plastic material shall be used in their construction. Internal parts shall be of stainless steel, bronze or approved corrosion-resistant material.

The minimum diameter for round pressure gauges shall be 100mm unless specified otherwise or where the gauge forms part of a standard item of equipment.

Unless specified elsewhere the accuracy for pressure gauges shall be 1% of range, for diaphragm gauges 1% of range and for differential gauges 1.5% of range or better.

Where compensation of more than 2% of the instrument span is needed for the difference in level between the instrument and the tapping point, the reading shall be suitably adjusted and the amount of compensation shall be marked on the dial.

The zero and span of a pressure transmitter shall not change by more than 0.1% of the span per Celsius degree change in ambient temperature. After application for 10 minutes of pressure at 130% of maximum pressure, the change in zero and span shall not exceed 0.1% of the span.

Pressure transmitters/switches shall have an accuracy typically better than 0.1% of span, depending on the application and shall be protected to BS EN 60529: IP 65 standard or higher standard. For transmitters installed in meter chambers liable to flooding or underwater applications, they shall be to BS EN 60529: IP 68 standard and shall operate up to maximum submergence of 20 metres of water.

Pressure transmitters shall provide a digital or 4mA to 20mA dc output proportional to the pressure range.

Pressure gauges, switches and transmitters shall have primary isolating valves, 2 or 3 way valve manifold and vents, in such a way that it has the facility to calibrate the gauges or transmitters without removal.

Pressure and differential pressure switches shall have contacts with separate 'cut in' and 'cut out' pressure values.

The nominal pressure values at which pressure switches operate shall be fully adjustable over the whole range of the instrument and the set value(s) shall be clearly indicated by means of a scale and pointer.

Pressure monitoring shall be by a sensor suitable for the medium and pressure/level range.

The sensor shall be suitable for either free wire suspension in the medium or fitted remotely and provided with threaded sockets to permit connection of pressure pipework.

A transmitter shall be provided either integral with the transducer or separately mounted and converting the signals received from the transducer to a 4 to 20 mA signal proportional to the range specified.

The transmitter shall have provision for span and zero adjustment.

### **III. Strain-gauge pressure transducers and transmitters**

Strain-gauge pressure transducers shall use thin film sensors without bonding.

Each instrument housing shall be of all-welded Grade X 4 CrNiMo 17 12 2 stainless steel or equivalent and hermetically sealed. Non-interacting, zero and span adjustments shall be provided on each transducer. The measuring diaphragm shall be isolated from the process fluid by a non-corrodible barrier diaphragm. The mean time between failure for any model of strain-gauge transducer shall be not less than 15 years, and the performance of the measurement system shall be as given below, or higher performance:

- accuracy:  $\pm 0.1\%$  of calibrated span, including linearity hysteresis and repeatability;
- repeatability:  $\pm 0.05\%$  at maximum span;
- stability:  $\pm 0.1\%$  of upper range limit over 6-month period;
- over-pressure: sustain a 400% over-pressure without damage;
- RFI / EMI effect: less than 1% of span with 500MHz at 5W direct contact;
- power-supply variation effect: 0.01% per volt variation.
- load variation effect:  $\pm 0.0002\%$  per ohm of loop-resistance variation.
- temperature:  $-29^{\circ}\text{C}$  to  $+82^{\circ}\text{C}$  range; total thermal error of  $\pm 0.75\%$  of span over  $0^{\circ}\text{C}$  to  $50^{\circ}\text{C}$ ;
- protection: IP 65.

Strain-gauge transducers which do not have terminals for their cable connection, shall have integral sealed-cable assemblies, installed in conduit and terminated at weatherproof junction boxes, protected to IP 65 each mounted near to its associated process transmitter. A digital or 4mA to 20mA dc output signal proportional to the transducer range shall be provided.

Strain-gauge pressure transmitters shall be generally as the transducer except that it shall incorporate a waterproof pressure transmitter producing a digital or 4mA to 20mA output signal.

Provision for transducer venting shall be provided.

### **IV. Temperature Instrumentation**

- Resistance Thermometers

Platinum resistance (PT 100) elements shall be used for temperature sensing up to  $650^{\circ}\text{C}$ .

Each temperature sensor, used for process monitoring shall have a stainless steel pocket and extension assembly, non-corrodible metal sheath and waterproof terminal head. Pockets for steam, oil and pressurized water lines shall be welded; pockets for other duties shall be screwed. Temperature sensors incorporated within motor winding shall be inserted during the winding process to ensure intimacy of contact.

Platinum resistance thermometers shall be selected and used in accordance with BS 1041-3 and shall comply with BS EN 60751. Each element shall be artificially aged during manufacture. Terminal heads and amplifiers shall be designed for three-wire connections between head and amplifier.

Platinum resistance elements shall be fully encapsulated in ceramic, and element and high temperature resistant lead wires shall be hermetically sealed. The associated resistance-to-current converters shall have zero and span adjustments and input-output circuit isolation.

- Thermocouples

Thermocouples shall be of the mineral insulated type and, unless otherwise specified, shall be of the chromel-alumel (nickel chromium v nickel-aluminium) type. Wires shall not be smaller than 1.0 mm<sup>2</sup> and shall be selected and used in accordance with BS 1041-3 and shall comply with BS EN 60584.

## **1.12 Installation Requirements for Instruments**

### **1.12.1 General**

The contractor is responsible for coordinating the installation, testing and commissioning to assure proper interface and system integration. Services shall include, but not necessarily be limited to all labour, materials, tools, equipment, supplies and services and auxiliary devices including brackets and mounting hardware required to install the instrumentation.

### **1.12.2 The following general installation guidelines shall apply:**

- Transmitters and transducers shall be mounted as near as practical to the measurement point.
- Instruments shall be readily and safely accessible from grade, permanent platforms or fixed ladders to facilitate ease of maintenance for the equipment.
- Supply power to instrumentation from the control panel to which information is reported for remote monitoring. Provide a separate (independent) circuit for each analyzer (note that control panels are powered by online UPS and supplied from the sites critical emergency power circuit).
- Unless otherwise shown or specified, mount instruments 1.4 m above finished floors, grade or platforms. Allow for cabinet plinth/floor-pad heights when locating panel instruments.
- Do not mount direct reading or electrical transmitters on process piping. Mount on instrument racks or stands or in enclosures near the sensor at a level that permits viewing from ground elevation.
- Do not mount instruments on vibrating structures (e.g. handrails), or on piping or near equipment that may induce vibration.
- Do not mount instruments below or directly adjacent to lines conveying corrosive chemicals or near sources of leakage or spillage.
- Install the instrumentation and auxiliary devices (including sensors) such that they are accessible for maintenance. Provide space between instruments and other equipment and piping for ease of removal and servicing. Install to ensure accessibility from grade without requiring staff to enter confined spaces.

- Ensure that instrument displays are properly oriented for easy viewing.
- Any instrument that is not easily accessible for operation or maintenance, and any indicator that is not easily and readily visible, must be relocated as directed at no charge to the contract.
- Follow additional installation requirements as specified in the individual instrument sections and as recommended by the manufacturer.
- Follow the Manufacturer's recommendations for loading resistors on digital outputs to limit the effect of leakage currents through triac and relay outputs.
- Follow the Manufacturer's recommendations for surge suppression on inductive loads.
- Unless specifically instructed otherwise, ensure installations conform to the manufacturer's installation recommendations.

### **1.12.3 Analytical Instrumentation**

- Physically locate the sample point so it does not contribute unnecessary dead time in the analysis. Take care to ensure the sample point is clean, thoroughly mixed, and representative of the process stream.
- Locate the analyzer next to a floor drain. Provide shutoff (block) and bleed valves: size valve and select type and material for the application.
- Provide a table nearby with the necessary equipment and chemicals to perform calibration checks.
- Provide flushing facilities for cleaning probes

### **1.12.4 Surge Protection Devices**

Surge protection devices (SPDs) shall be suitable for withstanding the surge arising out of high energy static discharge / lightning strikes and protect the instrument to which it is connected against damage. SPDs shall provide protection through the use of quick acting semiconductors like Transorb, zener diodes, varistors and an automatic disconnect and reset circuit. SPDs shall be passive and shall require negligible power for operation. During the occurrence of a surge it shall clamp on the allowable voltage and pass the excess voltage to the ground. The SPD shall be self resetting to minimise the down time of the measurement loop.

SPDs shall be provided to protect devices transmitting and receiving analogue and digital signals derived from field devices located outdoors.

The surge protection device shall be rated for surge rating of 10 KA.

## **1.13 Control & Automation**

### **1.13.1 Programmable Logic Controllers**

Programmable Logic Controllers (PLC) shall be provided as a Hot Stand-by Controller to perform combinational and sequential logic functions, status monitoring, process control and reporting functions with counter and timer facilities.

In general the following configuration shall be applicable across the –Pumping station.

Main PLC: Hot standby PLC

PLC shall comprise of necessary processors, Simplex input/output (I/O) modules, communication interface modules and Human-Machine Interface (HMI) required performing the desired functions.

PLC shall have the following attributes as a Hot Stand-by Controller.

- carry out sequential logic implementation for operations of plant;
- carry out computation and interfacing for data acquisition, data storage and retrieval;
- it shall accept downloaded program from a programmer;
- it shall have different functional modules to perform the desired functions;
- it shall scan the inputs in time cycles and update the status of its outputs.

The PLC system shall be expandable, OPC Compatible and shall be modular in construction, so as to be capable of future expansion without hardware modifications.

PLC shall be microprocessor based. PLC shall use standard known protocols and structures for communication outside the system.

In case of system failure or power supply failure the outputs shall attain a predetermined fail safe condition (this shall normally be ‘off’).

PLC System & RIO systems should be housed in air conditioned environment.

The contractor shall submit the sizing calculations for the air conditioning system for review and approval.

The contractor shall refer the approved vendor list for the PLC system and hardware, elsewhere in this document.

#### **1.13.1.1 Remote input/output modules (RIO)**

The PLC system shall consist of field remote input/output modules (RIO) and panels. Each RIO panel shall consist of redundant communication modules, power supply modules, minimum 16” colour panel mounted HMI with touch screen functionality. It shall be possible to view and acknowledge the alarms and view setpoints for the particular process from the HMI etc.

#### **1.13.1.2 I/O Modules:**

Standard rack mounted plug in I/O modules shall be provided. I/O Modules should be of the same series as the PLC CPU. Refer the approved vendor list for the PLC system and hardware, elsewhere in this document. Deviation from this would be treated as a non-responsive bid. Contractor should take note on the importance of this obligation.

Field wiring shall be terminated in screwed terminal blocks and interconnected to the processor I/O system with prefabricated cables and plug in card type connectors. I/O Modules should be hot swappable.

20% extra modules of installed capacity for each type of module shall be provided as spare. Provision shall be made for future expansion of additional 20% extra I/O modules of the installed capacity in the panel.

**I/O modules shall be as follows:**

- a) Inputs shall be opto isolated;
- b) filters shall be provided for noise rejection;
- c) output status shall be indicated by an LED;
- d) all outputs shall be fuse protected and have fuse failure indication the fuses may be mounted externally from the output module;
- e) All the modules shall be of addressable type.
- f) Ethernet I/O modules shall be connected to the PLC by on board Ethernet 10/100 Base T connection port. Ethernet I/O modules shall support multiple communications including TCP/IP and Modbus ASCII and RTU allowing connection to any device supporting these protocols over standard Ethernet backplane.

### **1.13.2 Ethernet Switches**

The contractor shall only provide managed industrial grade Ethernet switches under this contract.

### **1.13.3 PLC Programming**

The Contractor shall supply, install, program and commission the PLC using the PLC manufacturers recommended windows based PLC coding and documentation software. The PLC code shall be structured in the manner of the best industry standard and have comprehensive subroutine and rung annotation.

PLC programming under this contract shall be implemented using functional block diagrams (FBD). The logic shall be prepared using proprietary programming software and shall be comprehensively annotated with subroutine and rung comments to assist further development and maintenance.

The system shall support a simple programming of the application software comply with IEC 61131-3.

The system shall support a structured, modular programming. At least the following standard operations shall be applicable:

- (1) Logic functions (such as AND/OR/AND NOT etc.);
- (2) Timer functions (externally adjustable);
- (3) Counter functions;
- (4) Skip functions;
- (5) Comparison functions;
- (6) Limit value functions;
- (7) Arithmetic functions;
- (8) Physical unit functions;
- (9) Closed-loop functions such as P/PI/PID/etc.

The Contractor shall submit the logic diagrams for review & approval as an integral part of FDS submissions.

The Contractor shall provide all required IT Hardware complete with PLC coding and documentation software as specified in the bid document & as agreed with the Employer representative based on the FDS submitted.

**1.13.3.1 Minimum I/O Requirements for Auto mode Control operation of the Plant:**

The contractor shall refer to the minimum I/O requirements which are described in the particular specifications. On a minimum, the control design shall incorporate the I/O requirements which are indicated in the table and sections of the particular specifications. All process & Instrumentation Diagrams (P&ID) shall incorporate & depict the minimum I/O requirements.

Design shall include complete auto mode of operation of the entire plant and associated plants/stations with all necessary interlocks.

**1.13.4 PLC based SCADA system - at Pump House**

Each -CRW and pump house shall be provided with a PLC based SCADA system to control and monitor the pump station and the CWR levels.

The contractor shall provide a hot standby PLC based SCADA System. The SCADA software and hardware shall be dual redundant. The PLC based SCADA system shall be housed in an air conditioned environment.

The PLC based SCADA system - shall control and monitor the status of pump operation at the pump house. -It also monitor- -CWR levels, flow and pressure, residual chlorine The contractor scope of work - for PLC based SCADA system for each pump house- shall include on a minimum but not limited to:

1. Monitoring of CWR level and flow
2. Control & monitoring of CWR pumps and all equipment
3. Monitoring & Control of delivery valve -of each -Pump .
4. Monitoring and logging of flow & pressure data at each pumping station.
5. Monitoring of residual chlorine levels at the CWR
6. Transmitting all the operational data from -CWR and Pump house - - to the centralized SCADA center at the command area WTP for monitoring and analysis.

Refer System configuration drawing