

**GOVERNMENT OF INDIA  
DEPARTMENT OF SPACE**

**SCHEDULE – I  
CED/CMG/CMD TECHNICAL SPECIFICATION**

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# CIVIL ENGINEERING SPECIFICATION

**CIVIL ENGINEERING DIVISION  
SPECIFICATIONS FOR CIVIL WORKS**

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## CHAPTER – 0

### GENERAL

#### 0.1 GENERAL

These general specifications shall be applicable to all sections to the extent the context permits and are intended to supplement the provision in particular sections. In case of any discrepancy/deviation the provisions in the particular section shall take precedence.

#### 0.2 RATE

The rates for all items of work unless clearly specified otherwise shall include cost of all labour, materials and other inputs involved.

#### 0.3 INTERPRETATIONS:

- 0.3.1 The chief Engineer, Civil Engineering Division, Department of Space shall be the sole deciding authority as to the meaning, interpretations and implications for various provisions of the standard specifications. His decision in writing shall be final and binding on all concerned.

#### 0.4 GENERAL DEFINITIONS:

The following terms and expressions in the specifications shall have the meaning or implication hereby assigned to them unless mentioned otherwise elsewhere.

##### 0.4.1 CONTRACTOR:

The individual or firm or company whether incorporated or not, undertaking the works and shall include the legal personal representatives of such individual or the persons composing such firms or company, or the successors of such individual or firm or company and the permitted assignees of such individual or firm or company.

##### 0.4.2 ENGINEER IN-CHARGE/EIC:

The engineer officer who shall supervise and be in charge of the work and also who signs the contract on behalf of the President.

##### 0.4.3 SITE:

The "Site" shall mean the land / or other places on, in, into or through which the work is to be executed under the contract or any adjacent land, path or street which may be allotted or used for the purpose of carrying out the contract.

**0.4.4 DEPARTMENT:**

Shall mean Civil Engineering Division, Department of Space (CED-DOS).

**0.5 FOUNDATION:**

The work in foundations shall include:

- a) For building – All works below floor 1 level or upto 1.2m above ground level whichever is lower.
- b) For all abutments, piers, wall of reservoirs all works upto 1.2 meters above formed yard level.
- c) For retaining walls, upto 1.2 metres above ground level.
- d) For basement reservoirs etc. All works below floor 1 level or upto 1.2 metres above ground level which ever is lower.

**NOTE:-** Specific provision may be made for works in foundation below 3m from the plinth level in the estimates for all structures.

**0.6 FLOOR LEVEL:**

Means top level of structural slab except the floor 1 which shall be the top of finished floor.

**0.6.1** Floor 1 level is the level of the lowest floor above G.L. in the building unless otherwise specified in a particular case. Plinth level is first floor level (floor 1). The floor above floor 1 shall be numbered in sequence as floor 2, floor 3 and so on. The number shall increase upwards.

**0.6.2 PLINTH LEVEL:** Floor 1 level or 1.2m level above, the ground level which ever is lower shall be plinth level.

**0.6.3 IDENTIFICATION OF FLOOR:**

Floor height for structures where identification of floors can not be done as in case of structures like retaining walls, overhead reservoirs / tanks and other elevated structures, level at 1.2 m above ground level shall be floor 1 level as well as plinth level. Level at height of 3.5m above floor 1 level shall be reckoned as floor 2 level and for heights of every 3.5 m above shall be reckoned as floor 3, floor 4 and so on. The top most floor level shall be the next in sequence to the floor level just below, even if the height is less than 3.5m above the immediate floor level below.

**0.7 INDIAN STANDARDS (IS)**

**0.7.1** The Indian Standard means the standard issued by the Bureau of Indian Standards. Wherever any reference is made to IS in the specifications it shall be taken as reference to the latest edition with all amendments issued thereto. In the event of any variation between the CED DOS specifications and that in I.S the former shall take precedence over the latter.

**0.8 STORES:**

- 0.8.1 When used in connection with the materials included in the appropriate schedule of the contract for issue by department, the place of issue mentioned in that schedule.

**0.9 DIAMETER:**

- 0.9.1 Diameter for PVC pipes, brass tubes and steel conduits is the external diameter. In other cases it will be the nominal diameter of the bore.

**0.10 MATERIALS TO BE APPROVED**

- 0.10.1 All materials shall be in accordance with the specification and shall be got approved by the Engineer In-Charge well in time before use in the works. Where materials are specified to comply with IS, the contractor shall if required furnish the manufacturer's certificate that the materials satisfy the requirements of IS. Approved samples duly authenticated and sealed shall be kept in the custody of the Engineer In-Charge till the completion of work. All materials shall be brand new and as per approved samples.

**0.10.2 "STANDARD MARK OF IS FOR MATERIALS"**

Materials listed in Appendix 'A' to this booklet wherever used on work shall bear IS Mark invariably. For other materials also wherever brands with IS marks are available the same shall be used. The contractor shall ascertain the source where materials with IS mark is available and procure the same. Documentary proof for procurement of all materials conforming to above shall be submitted by contractor to EIC as and when brought to site of works. Materials procured shall bear IS mark and those for which IS mark is not available shall be of acceptable standard.

- 0.10.3 Engineer In-Charge may insist testing of samples of materials even with IS mark. Wherever materials with IS mark fail to meet specification requirement Engineer In-Charge may take up the matter with BIS for appropriate action against the defaulter.
- 0.10.4 Materials procured by contractors from the approved source are also to be subjected to mandatory tests and in the event they fail to meet the specification requirements Engineer In-Charge may pursue appropriate action on defaulters for which the contractors shall provide necessary documents in original to Engineer In-Charge in proof of payment relating to the procurement of materials from the approved source.
- 0.10.5 Materials supplied by the Department are supplied after requisite testing. They shall be deemed to be complying with the specification requirements.
- 0.10.6 Materials stored at site shall be properly protected against deterioration due to atmospheric effects or from any other harmful cause, fire hazard etc. The

contractors shall also ensure security of materials stored and their safety etc. The rate quoted by contractor shall include the expenditure towards the above.

- 0.10.7 Samples of materials, fittings etc shall be submitted by the contractor for approval of Engineer In-Charge before bulk supplies are brought on the site of works.
- 0.10.8 When required by Engineer In-Charge the contractors shall supply for the purpose of testing samples of any material proposed to be used in the works free of cost.
- 0.10.9 Samples whether submitted to govern bulk supplies or required for testing before use and suitable packages to contain them shall be provided free of charge by the contractor. All incidental expenditure to be incurred for testing of samples viz., packing, sealing, transporting, loading, unloading etc. interalia shall be borne by the contractor.

Materials rejected by Engineer In-Charge shall be removed forthwith by the contractor off the premises.

#### **0.11 TESTING OF MATERIALS, QUALITY CONTROL TESTS ETC.**

All arrangements required for taking samples, conveyance, packaging etc shall be made by the contractor. Testing charges if any shall be borne by the Department.

#### **0.12 MEASUREMENT**

- 0.12.1 All measurements shall be recorded as per methods of measurement in relevant IS 1200 except specifically stated otherwise in this booklet or in respective work order. For any item the mode of measurement is not mentioned in this book nor in IS nor in work order specifically, it shall be as per directions of the Engineer In-Charge. The method of measurement indicated in the work order and in this booklet shall have precedence in that order over that is stated elsewhere.
- 0.12.3 In recording measurements the order shall be consistent and in the sequence of length, width and height / depth / thickness.
- 0.12.4 Rounding off: Rounding off where required shall be done in accordance with IS. The number of significant places rounded in the round off value should be as specified.

#### **0.13 SAFETY CODE**

Safety pertaining to construction works such as excavation, trenching, blasting, demolition, provision of scaffolds, ladder, working platforms, gangways, mixing of asphaltic materials, electric arc and gas welding, use of hoisting and construction machinery shall be governed by the relevant provision of the CED, DOS safety code (indicated in agreement) and also construction safety manual,



DOS:ISRO:TR105, as in appendix B at the end of this booklet and also as directed by the Engineer In-Charge.

#### 0.14 SCHEDULE / SCOPE OF WORK

- 0.14.0 The specifications furnished hereunder cover the general requirements of items of work as per the details shown on drawings. These specifications shall be read in conjunction with the drawings which the Engineer In-charge will be furnishing for execution and to complete the works in all respects within the intent and purpose of items of works indicated.
- 0.14.1 The rates to be quoted against the items in the schedule, unless otherwise stated shall include all relevant details in these specifications and also shall include all minor details of construction which are obviously and fairly intended and which may not have been referred to in the works schedule but which are essential for the completion of work in all respects in accordance with standard engineering practice and the rate shall include the cost of all materials, labour involved in all the operations described in the item, including all leads, lifts incidental expenditure, contingencies etc for execution of work in a workman like manner and complete the same.
- 0.15 No extra payment will be admissible for **staging** in all centering and form work at all heights and levels, i.e., above finished floor level / ground level upto top most member of the structure and also for works below ground level at all depths and levels. Rates for items shall include cost towards above component irrespective of whether a specific mention is made or not in any item.
- 0.16 Rates for the item shall include cost towards **scaffolding**. No extra payment shall be admissible for scaffolding and lift charges wherever applicable from finished floor level / ground level upto top most level of the structure.
- 0.17 The contractor entrusted with the execution of a work shall be required to work in **co-ordination with contractors** of civil engineering, public health, electrical and air-conditioning or other contractors who may also be entrusted work at the site and give them all reasonable assistance and co-operation for the execution of the entire work all as directed by the Engineer In-Charge.
- 0.18 **Water supply and power supply** for construction purposes will be as indicated in the relevant contract documents.
- 0.19 The **centering** for all RCC work shall be of steel tubes with or without extension pieces or built up sections of rolled steel irrespective of specific mention of the same in item description. However for minor RCC elements like lintel, chajjas etc and slabs at height less than 3 meters from the support approved bullies may be used. The rate for form work shall be inclusive of providing steel props/ bracings / ballies as the case may be.

- 0.20 Unless otherwise stated **design mix** shall be adopted for cement concrete works M 20 grade and above, irrespective of mention of it in item specification. The contractor should furnish design mix details to Engineer In-Charge well in advance of the time the design mix has to be adopted and it should be got approved. Contractor should ensure that at least two weeks time is available for the Engineer In-Charge from the date of receipt of details of design mix in full, for approval. It is the responsibility of contractor to furnish the design mix in time for approval by Engineer In-Charge.
- 0.21 Wherever **brand names** of materials or equivalent are stipulated, the materials of brand names only shall be incorporated in the work. The equivalent material shall be permitted only on production of documentary evidence to the satisfaction of Engineer In-Charge that the material of stipulated brand is not under production.

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## CHAPTER 1

### CARRIAGE AND STORAGE / STACKOF MATERIALS

#### 1.0 GENERAL

The carriage and stacking of materials shall be done as directed by Engineer In-Charge. any tools and plants required for the work shall be arranged by the contractor. The carriage of materials include loading within a lead of 50 metres, unloading and stacking within a lead of 50 metres.

#### 1.1 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 rate of the materials are not available then the recovery shall be effected at twice the prevailing market rates as determined by the Engineer In-Charge.

#### 1.2 MODE OF CARRIAGE

Depending upon the feasibility and economy, the Engineer In-Charge (EIC) shall determine the mode of carriage viz., whether by mechanical or animal transport or manual labour. Contractor may carry the material by any desired mode. But payment shall be restricted to mode determined and approved by the Engineer In-Charge.

#### 1.3 LEAD

- 1.3.1 All distances shall be measured over the shortest practical route and not necessary the rout actually taken.
- 1.3.2 Carriage by manual labour shall be reckoned in units of 50 meters. Distance of 25m or more shall be taken as 50m and distance less than 25m shall be ignored.
- 1.3.3 Carriage by animal and mechanical transport shall be reckoned in one KM unit. Distances of 0.5KM or more shall be taken as 1KM and distance of less than 0.5 KM shall be ignored but paid for separately in successive stages of 50m 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.

#### **1.4 STACKING**

Material shall be stacked in such a manner as to ensure the preservation of their quality and fitness for the work. Different types of materials shall be stacked separately and in such a way counting measurements can be done without disturbing the stacks.

- 1.4.1 Earth, dismantled materials, and other similar materials shall be stacked as directed by the Engineer In-Charge.
- 1.4.2 Cement bags, steel bars, structural steel sections, bricks and timber and other similar materials shall be stacked in regular tiers.
- 1.4.3 Pipes of RCC, SW, Gl. Cl, etc shall be stacked in rows.
- 1.4.4 Lime stone, metal, sand and such similar materials shall be stacked as directed by Engineer In-Charge.

#### **1.5 TIMBER**

The stacks shall not be exposed to direct sun rays, rains or hot dry winds. To prevent warping or distortion of timber, it is proposed that heavy weights like rails or large sections of wood are placed on the top of stack. When the timber is to be stored for a long period the ends of all members shall be coated with coal tar, aluminium leaf paints (hardened gloss oil) microcrystalline wax, etc. to prevent the cracking of ends.

Timber should not be stacked directly on the ground. The same should be stacked over even surfaced beam sleepers or brick pillars to maintain minimum 150mm clearance. The different types of members should be stored separately in different lengths.

While arranging a stack longer pieces should be placed at bottom layers. A gap of minimum 25mm (air space) is to be provided between adjacent members. The two layers are separated by wooden battens or say crosses. In case no separate crosses area available, smaller sections of available timber may be employed as crosses.

The one end of the stack and the cross in different layers shall be in vertical alignment. The most suitable height of stack should be between 1.5m to 2.00 m and the distance between the adjacent stacks should be 450mm minimum.

#### **1.6 ROOFING SHEETS**

Roofing sheets especially AC sheets should be stacked and handled very carefully. AC sheets (plain or corrugated) shall be stacked horizontally up to a height of not

more than 1.00mm on a firm and level ground. The sheets should not be stacked directly on the ground but on timber or any other packing pieces. If the sheets are stored in open space they should be covered preferably by water proofing sheets.

AC sheets should be sorted out and all damaged sheets should be salvaged as quickly as possible and only good sheets should be stacked taking care that the sheets of different sizes should be stacked separately.

Corrugated galvanized iron sheets and aluminium sheets also should be stacked in the same way as AC sheets except that the height of stack should not be more than 500mm.

Plastic sheets or glass reinforced plastic sheets (GRP) shall not be stacked in open and stacked to a height of not more than 500mm.

The sheets should be stacked horizontally on level ground with timber support at bottom.

## **1.7 BOARDS**

Gypsum boards, plywoods fibre board, particle board, block boards etc.

The boards of different sizes and type shall be stacked separately.

To stack the boards, a wooden frame of almost the size of the board with timber of size 50mm x 25mm battens has to be made. The frame is placed on a neat and level platform. The sheets are as arranged over the frame such that all corners and sides rest on the frame. In the centre portion of the frame also timber pieces are provided so that support is available in the centre portion of the board as well.

The board shall be placed strictly in vertical alignment. The top sheet of each stack should be weighted down to avoid any wrapages.

The board should be unloaded very carefully without damaging the corners and surface. In case of decorative boards where the surface may get damaged due to dragging of one sheet over the other, the sheets should be lifted in pairs facing each other.

## **1.8 GLASS SHEETS**

The most important factor in storage of glass sheets is that the same should be stored in a covered shed and should always be kept dry, even if they are packed in crates. The glass sheets shall be stored on their long edges against vertical

wall or any other support in such a manner that proper inclination is provided to the first sheet so that subsequent sheets rest on it without falling out.

Not more than 25 panes shall be stacked in one stack. The stack shall be supported at two places by wooden fillets 300mm away from each end, taking care that the whole stack is as close and upright as possible. The glass sheets of different size and of different thickness shall be stored in separate lots. The distance between the two stocks should not be more than 400mm. Great care should be taken while removing the glass sheets from crates, to avoid damages.

#### **1.9 CAST IRON, GALVANIZED IRON AND ASBESTOS CEMENT PIPES AND FITTINGS**

The pipes shall be brought to the site only when the trenches are ready to receive them and shall be stacked on clear and level ground. The stacks can be of pyramid shape especially for small diameter pipes or stacked horizontally length wise, cross wise in alternate layers, taking care that the height of the stack does not exceed 1.50m and wedges should be provided at the bottom layer to keep the stacks stable.

The stack should be arranged as per class and size of pipe, and as far as possible marked with consignment number and particulars of suppliers.

C.I. detachable joints and fittings shall be stored under cover separately from asbestos cement pipes and fittings. Rubber rings shall be kept clean and away from grease, oil, heat and light.

#### **1.10 POLYETHYLENE PIPES**

These pipes should not be stored in heated areas exceeding 27° centigrade, and should be stored in covered space thus protected from direct sunlight, however, black pipes may be stored in open.

The pipes in coils may be stacked on edge or stacked flat one coil over the other but should be kept away from the hot surfaces and should not be allowed to come in contact with hot water or steam pipes.

The straight pipes should be stored in horizontal racks to avoid the pipes getting permanent sets due to lack of continuous support.

#### **1.11 UNPLASTICIZED PVC PIPES**

These pipes should not be stacked in racks but on clean level surface free from stones and sharp projections. It should be seen that the pipe is supported

throughout its length. Stacking in large piles should be avoided especially under warm temperature as due to large piles the bottom pipe may get distorted, thus, causing difficulty in joining.

Pipes especially socket and spigot pipes should be stored with sockets placed at alternate ends to avoid uneven stacking one pipe should not be stored inside another pipe.

The pipe should not be stored near any source of heat nor stored in bent or stressed condition. Pipes of different sizes and class should be stored separately and no stock should exceed more than 1.5m in height.

During winter the impact strength of PVC is reduced making it brittle, hence more care should be taken in handling during that period. In tropical conditions the pipes should be stored in shade.

The ends of the pipes should be protected from damage specially prepared for jointing either spigot or socket solvent welded joints or shouldered for use with couplings. Sometimes thin pipes get kinked due to unsatisfactory storage or handling, in such cases the damaged portion should be cut out completely.

#### **1.12 BITUMEN, ROAD TAR, ASPHALT ETC.**

The drums of all types of bitumen, road tar or asphalt shall be stacked vertically upon 3 tiers on their bottom. Leaky drum shall be kept separately. Empty drums should be stored in rows preferably in pyramidal shape.

Water for construction should be stored in a proper storage tank to prevent any organic impurities mixed.

#### **1.13 OIL PAINTS**

A separate room with good ventilation, free from direct rays of sun, excessive heat, sparks of flame is the main requirement for storage of all containers of paints, thinners and allied materials. The above containers shall be stored on floor with sand cushion. The containers shall be opened only while using and should be fitted with lid immediately and shall not be kept open. The date of expiry marked on the container should be highlighted and efforts should be made to use the paint before the date of expiry.

#### **1.14 INFLAMMABLE MATERIALS AND EXPLOSIVES**

The manner of storage of explosive as given in "Explosive Acts and Rules" shall be followed.

### **1.15 CEMENT**

Cement on site should be stored in a shed or godown which should be adequately moisture proof, and heat proof. It should be dry in all seasons. The shed where cement is to be stored should have minimum number of windows and doors which should be close fitting one and should always be kept closed.

Cement bags should not be stacked directly on the floor, but about 150mm to 200mm above floor on wooden planks so that the bags will not come in contact with any dampness or moisture.

The floor may be of lean concrete or two layers of dry bricks laid on well consolidated layer of 150mm thick earth. Minimum space of 600mm should be left between two stacks and around walls.

To reduce the circulation of air the cement bags should be kept as close as possible. Some times the bags in the bottom most layer gets so much pressed that one may mistake the same as hardened one, but on rolling the bag when taken out, the bags will be usable. However, by chance, if any, bag is hardened, the same should be removed and disposed off.

The height of stack shall not be more than 10bags to avoid the possibility of lumping under pressure. The width of stack will be more than 3.00m (four bags). Where more than 8 bags are stacked in height it is advisable to arrange the stack of cement bags length wise and cross wise alternately. This method will tie the stack together and prevent any topping.

Cement bags should be so stacked that it facilitates their removal and use in the order they were received. The date of receipt of cement in a particular stack should be prominently displayed so as to know the age of cement.

In case the cement is to be stored for longer time that too in monsoon, it is advisable to cover the stacks completely by a waterproofing membrane such as polyethylene etc. and to ensure that the water proofing membrane is not damaged during use.

Different types of cement should be stored separately. Also cement in gunny bags, paper bags and polyethylene bag should be stored separately.

If the cement is received in drums the same should be stored near concrete mixing place on a plain and level ground., When required the quantity of cement is taken out from the drum the lid should be fixed properly to prevent entering of moisture.

### **1.16 QUICK LIME BEFORE STACKING**

Quick Lime subject to exposure takes moisture and carbon dioxide from atmosphere and deteriorates rapidly. Hence it should be slaked as soon as



possible. If immediate slaking is not possible the same can be stored in compact heaps having minimum exposed area.

The heap shall be stored on a level platform and covered completely with water proof membrane such as polyethylene sheet. So that any damage due to rain or wind is prevented. If the quick lime is stored in a shed, a space of minimum 300mm should be left around.

#### **1.17 HYDRATED LIME**

To prevent deterioration due to dampness etc. the hydrated lime should be stored in a building with a concrete floor, having least ventilation to eliminate draughts through the walls and roofs.

The cement godown described earlier under "Cement" will be suitable to store the hydrated lime as well. Hydrated lime can be stored upto three months if the air movement is practically reduced to a minimum.

#### **1.18 DRY SLAKED LIME**

In case the slaked lime is to be used after 2 months or so the same should be stored in a dry and closed godown on the other hand if the same is to be used within a few days the same can be stored on a platform suitably covered to protect the same from rain and wind.

#### **1.19 STONES**

Stones shall be stacked on dry and firm ground in a heap of not more than 1 m height and stones of different size classification should be stacked in separate stacks.

Veneering stones shall be stacked in tiers up to 1.2m height on a dry firm ground in vertical position. A minimum 800 mm distance should be maintained between two stacks.

#### **1.20 BRICKS**

There are many types of bricks such as clay bricks, clay fly ash bricks, fly ash lime bricks, sand lime (Calcium silicate bricks) solid bricks, hollow bricks and perforated bricks. Again there is a difference like conventional & modular bricks. Hence care must be taken to stack different bricks in different stacks.

The bricks should be stacked as near the site of work as possible on a firm & level ground. A recommended stack shall be length wise 50 bricks, nor more than 4 bricks in width and 10 bricks in height. However, one truck load shall be

put in one stock taking care that the distance between two stacks should not be less than 800 mm and the stacks should be so arranged that the inspection and counting the bricks and removal for use should be easy.

The loading or unloading of bricks shall be done in pairs at a time and unloading in any other way may damage the corners or edges of bricks. The wooden pallets may also be used to load or unload the bricks.

The bricks under no circumstances shall be dumped at site, when unloaded, they must be stacked in regular tiers. Some times bricks made from clay, containing lime Kankar, are to be stacked and if stacked dry lime bursting may take place. Hence the bricks in stack should be thoroughly drenched in water.

### **1.21 BLOCKS**

Blocks also are of different types like hollow concrete blocks, solid concrete blocks, hollow and solid light weight concrete blocks, auto claved concrete blocks, concrete stone masonry blocks and soil based blocks. The blocks are manufactured on site or in factory.

Only blocks that are cured for 28 days should be taken for use. The blocks should be water cured for 14 days and air cured for another 14 days. Blocks cured for less than above period should be rejected. The date of manufacture of each block must be suitably marked in each block, and the stack in turn, to be marked the date of manufacture of blocks.

The blocks shall be unloaded near the site so that least efforts is required to transport the same. The block should not be dumped but, stacked neatly in tiers. The block should be unloaded one at a time to minimize breakages. The stack should be length wise 3.00 m maximum, and the width shall be two or three blocks. The height of stack should not exceed 1.2m.

### **1.22 FLOOR, WALL AND ROOF TILES**

Tiles of different variety, size, thickness should be stacked separately to enable easy removal and usage.

The floor, wall and roof tiles are of different type like, cement concrete tiles (plain, coloured and terrazzo) ceramic tiles or unglazed, Mangalore tiles etc.

The tiles shall be stacked on a good platform, possibly under cover. They shall not be dumped in a heap but stacked neatly in tiers and layers. The height of stacks should not exceed 1.00m.

Care should be taken while stacking tiles that the mould surface of one tile be placed on the mould surface of other tile. The unloading should be done very carefully to avoid breakages.

The tiles that are supplied in cartons like ceramic tiles should be handled with great care and should be transported at site on platform trolleys.

#### 1.23 COARSE AGGREGATE (STONE AGGREGATE OR STONE METAL)

The contamination of stone aggregates, with clay, dust, vegetable and other foreign matter must be prevented and for this the stone aggregates should be stored on a hard, dry and level ground. If such ground is not available a platform with lean concrete, or old iron sheets, or floor of dry bricks should be provided.

#### 1.24 FINE AGGREGATES (SAND)

The fine aggregates also should be stored on a platform as explained for coarse aggregate but sufficient gap should be maintained to separate coarse and fine aggregates intermixing with each other. In major works, it is advisable to construct a dividing wall between the two types of aggregates. However, care should be taken to stack fine aggregate in a place where loss due to wind effect is minimum.

A rough guide for making stacks of different materials is given below in  
**Annexure 1.1**

Sl. No.	Material	Size of Stack (In M)		
		Length	Breadth	Depth
1	Soling Stone	5.00	2.00	0.50
		or 5.00	1.00	0.50
2	Coarse Aggregates or Stone Aggregates or Stone Metal	2.00	2.00	0.50
		or 5.00	5.00	1.00
		or 5.00	1.00	0.50
3	Fine Aggregate or Sand	2.00	2.00	0.50
		or 5.00	5.00	1.00
		or 5.00	1.00	0.50

#### 1.25 FLY ASH

Fly ash if supplied in bags should be stored in stacks as cement and the height of stack should not be more than 10 bags. If in loose state the same may be stored similarly as fine aggregate. The storing shall be such that it should permit easy access for proper inspection and identification.

#### 1.26 STEEL

Steel reinforcement shall be stored to avoid deterioration and corrosion. Hence before the steel is stacked it may be coated with cement wash to prevent corrosion.

Also to identify the different types of reinforcement the ends of bars should be painted in separate colours.

The bars of different size and length should be stored separately so as to facilitate issue in required size and length thus minimizing the wastage in cutting. When the steel is to be stored for longer period the same shall be stacked at least 150mm above ground.

In case of structural steel the same should be stored atleast 150mm above ground level on a platform. The different sizes, classification and length shall be stored separately. In case of long storage and in coastal areas it is preferable to apply a protective coating of primer paint to prevent scaling or rusting.

#### **1.27 ALUMINIUM SECTION**

The aluminium section should be stored under cover. The different classification of sizes and lengths shall be stored separately. The aluminium sections shall not be pulled or pushed or slid on each other while removing from stack, this will damage the anodizing layer.

#### **1.28 DOORS, WINDOWS AND VENTILATORS**

During unloading, handling, shifting timber or other lignocelulosic material based, metal and plastic door and window frames and shutters, one should be careful not to drag one over the other, thus causing damage to the surface of the material especially the decorative shutters. The material should be lifted and carried flat without damaging the sides and corners.

Doors, windows and ventilators made of metal or plastic shall be stacked up right (on their sills) on level ground preferably on battens. Proper care should be taken to see that the materials do not come in contact with dirt and ashes.

In case the above materials are received in crates they should be stored as per the manufacture instructions and the crates to be opened only when the material is required for the work.

The frames of doors, windows and ventilators made of metal or plastic should be stored upside down with thick plates at top. However these shall not be stacked for a long periods as the door frames may go out of shape and the hinges will get strained. When the doors, windows, ventilator made of metal are stored in site, utmost care should be taken to prevent falling of loose cement, mortar on the above materials. The best course would be to cover the above items with a tarpaulin fixed on a temporary frame work so that the circulation of air is not affected.

The frames and shutters manufactured out of timber or lignocellulosic material based ones, should be stored in a covered place which is clean and dry and without any dampness. The storage rooms shall be well ventilated and dry.

The door frames should be staked in vertical stacks one over the other with cross battens of same size at regular distance to keep the stacks truly vertical and straight.

In case of door shutters they should be stacked minimum 80mm above ground on pallets or suitable beams or rafters. The shutters shall be stacked in vertical form one over the other. In both cases the stacks should rest on hard and level ground. The top of the stack shall be covered by tarpaulin and weighed down suitably.

During transit, if the above frames or shutters become wet, the same should be kept out separately from undamaged material. The wet materials can be dried in shade by keeping battens in between adjacent boards so that the free access is available for air. The guidelines in this cases may be obtained from IS:1141. In case due to want of space different sizes of frames and shutters are to be stacked together, the bigger size materials should be stacked first and smaller size on top separating the two sizes with the help of suitable pallets or separating battens. Otherwise separate stack should be made for each size, grade and type of materials.

#### **1.29 PLASTIC AND RUBBER FLOORING SHEETS AND TILES**

The plastic and rubber sheets should be stored in coolest possible room which is well ventilated. Particular care should be taken to see that the direct sun light does not fall on the materials. The plastic and rubber materials have a tendency to brake down during storage. Hence, the manufacturers instructions about storage should be strictly followed.

The rubber and plastic sheets should not be stored near electric generator, electric motors, switch gears and any such electrical equipments. Also the above tiles should be prevented from contamination with vegetable and mineral oils, greases, organic solvents, acids and their fumes, alkalies, dust and grit. In case any greasy contamination occurs, this shall be washed immediately with petrol, wiped dry and dusted with chalk powder.

In case of long storage, the sheets should be turned over periodically and if necessary treated with chalk powder. Due care should be taken to avoid undue stretch and strain, kink, sharp bends or folds in the tiles.

#### **1.30 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, worked out be reduced by percentages as shown against each at para 1.30.1 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.

### **1.30.1 EARTH**

- 1.30.1.1 In loose stacks such as cart loads, lorry loads, etc. – 20%
- 1.30.1.2 In fills consolidated by light mechanical machinery – 10%
- 1.30.1.3 In fills consolidated by heavy mechanical machinery but not under OMC (Optimum Moisture Content) – 5%
- 1.30.1.4 In fills consolidated by heavy mechanical machinery at OMC – Nil
- 1.30.1.5 Consolidated fills in confined situation such as under floors, etc. – Nil
- 1.30.1.6 Manure or sludge – 8%
- 1.30.1.7 Moorum, building rubbish Lime and sand – Nil
- 1.30.1.8 Stone metal, 40mm nominal size and above – 7.5%
- 1.30.1.9 Coarse aggregate / stone metal below 40mm nominal size – Nil
- 1.30.1.10 Soling stone / boulder 100mm and above – 15%
- 1.30.1.11 Excavated rocks – 50%

### **1.31 RATE**

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

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## CHAPTER 2

### EARTH WORK

#### 2.0 DEFINITIONS

- 2.0.1 **DEADMAN OR TELL TALES:** Mounds of earth left undisturbed in pits dug out for borrowing earth.
- 2.0.2 **BURJIS:** Short pillars of brick / stone having top surface finished with cement plaster for marking etc.
- 2.0.3 **FORMATION OR PROFILE:** Final shape of ground after excavation or filling up.
- 2.0.4 **FOUL POSITION:** Filthy and unhygienic condition where physical movements are hampered such as soil mixed with sewage or night soil etc.
- 2.0.5 **LEAD:** The distance for removal measured over the shortest practicable route and not necessarily the route actually taken.
- 2.0.6 **LIQUID MUD:** Mud in liquid form or in highly plastic state.
- 2.0.7 **LILFT:** The vertical distance for removal with reference to the ground level. The excavation upto 1.5m depth below the ground level and depositing the excavated materials upto 1.5 metres above the ground level are included in the rate of earthwork. Lifts inherent in the lead due to ground slope shall not be paid.
- 2.0.8 **SAFETY RULES:** Safety rules indicated in the relevant documents and those laid down by the statutory authorities.

#### 2.1 EARTH WORK AND CLASSIFICATION OF SOILS

- 2.1.0 The earth work excavation shall include the following:
- i) Excavation and depositioning
  - ii) Setting out works
  - iii) Site clearance
  - iv) Forming deadman in borrow pits and removal after measurements
  - v) Bailing out water in excavation from rains, seepages, ravages etc which shall be bailed out or pumped out from work at contractors own expenses.

- vi) Protection and supporting of existing services i.e, pipes, water mains, cables etc met within the course of excavation. Care shall be taken not to disturb electric and communication cables, removal of which, if necessary shall be arranged by the Engineer-in-charge.
- vii) Forming steps in sides of deep trenches and their removal after measurements and removing slips or falls in excavation.
- viii) Fencing and protection against risk of accidents due to open excavation,
- ix) Excavation for insertion of planking and strutting including arrangements for shoring and strutting.

2.1.1 Earthwork shall be classified under following categories and measured separately for each category.

- a) **ALL KINDS OF SOIL:** Generally any strata such as sand, gravel, loam, clay, mud, black, cotton, moorum, shigle, river or nallah bed boulders, soling of roads, paths etc and hard core macadam surface of any description (water bound, grouted tarmac etc.) lime concrete, mud concrete, and their mixers which for excavation yields to the application of picks showels, jumper, scarifies, ripper and other manual digging implements.
- b) **ORDINARY ROCKS:** Generally any rock which can be excavated by splitting by crow bars or picks and does not require blasting wedging or similar means for excavation such as lime stone, sand stone, hard laterite, hard conglomerate and unreinforced cement concrete, below ground level. (If required light blasting may be resorted to for loosening the materials but this will not in any way entitle the materials to be classified as "Hand rock"
- c) **HARD ROCK:** Generally any rock or boulder for the excavation of which blasting is required such as guartzite, granite, basalt, reinforced cement concrete (reinforcement to be cut through but not separated from concrete) below ground level and the like.
- d) **HARD ROCK (BLASTING PROHIBITED):** Hard rock requiring blasting as described under (c) above but where the blasting is prohibited for any reason and excavation has to be carried out by chiseling, wedging or any other agreed method.

#### 2.1.2 DISCRETE CLASSIFICATION OF SOIL

- a) **Ordinary soil comprising any of the following**
  - i) Organic soil, turf, sand, gravel, clay, mud, peat, black cotton soil, soft shale, and loose murum.



- ii) Any mixed soil of above.
- iii) Generally any material which yields to the ordinary application of picks, shovel, rack or other ordinary digging equipment and not affording resistance to digging greater than hardest of any soil mentioned above.

**b) Hard soil comprising of the following**

- i) Heavy clay, hard shale or compact murum requiring grafting tool and / or pick and shovel closely applied.
- ii) Shingle and river or nalah bed boulders
- iii) Soling of roads, paths and hardcore.
- iv) Macadam surface of any description (water bound, grouted, tar mac etc.)
- v) Lime concrete, stone masonry in lime mortar, brick work in lime or cement mortar below ground level.
- vi) Soft conglomerate where the stones can be detached from the matrix with picks.
- vii) Any materials which requires close application of picks or sacrifiers to loosen and not affording resistance to digging greater than hardest of any soil mentioned above.

**c) Ordinary rock comprising of the following:**

- i) Lime stone, sand stone, laterite hard conglomerate or other soft or disintegrated rock which can be quarried or split with crow bars or wedges.
- ii) Unreinforced Portland cement concrete which can be broken up with crow bars or picks and stone masonry in cement mortar below ground level.

**d) Hard rock (requiring blasting) comprising any of the following:**

- i) Any rock or Portland cement concrete the excavation of which use of mechanical plant or blasting is required; reinforced cement concrete; (reinforcement cut through but not separated from concrete) below ground level.
- ii) Hard rock requiring blasting but blasting prohibited for any reason and excavation has to be carried out by chiseling, wedging, or any other agreed method.

## **2.2 ANTIQUITIES AND USEFUL MATERIALS**

- 2.2.1 Any finds of archaeological interest such as relics of antiquity, coins, fossils or other articles of value shall be delivered to the Engineer-in-charge and shall be the property of Government.
- 2.2.2 Any material obtained from the excavation which in the opinion of EIC is useful shall be stacked separately in regular stacks as directed by the EIC and shall be the property of Government.

## **2.3 PROTECTIONS**

- 2.3.1 Excavation where directed by the EIC shall be securely fenced and provided with proper caution signs, conspicuously displayed during the day and properly illuminated with red lights during the night to avoid accidents.
- 2.3.2 The contractors shall take adequate protective measures to see that the excavation operations do not damage the adjoining structures or dislocate the services. Water supply pipes, sluice valve chambers, sewerage pipes, manholes, drainage pipes and chambers, communication cables, power supply cables etc met within the course of excavation shall be properly supported and adequately protected so that these services remain functional.
- 2.3.3 Excavation shall not be carried out below the foundation level of adjacent buildings until under pinning, shoring etc is done as per the directions of the EIC for which payment shall be made separately, if specifically provided for in the relevant item, otherwise this should be absorbed with in quoted that.

## **2.4 SITE CLEARANCE**

- 2.4.1 Before earth work is started, the area coming under cutting and filling shall be cleared of shrubs, rank vegetation, grass, brush wood trees and saplings of girth upto 300 mm, measured at a height of 1 metre above ground level and rubbish removed upto a distance of 50 Mtrs. Outside the periphery of the area under clearance. The roots of the trees and sapling shall be removed to a minimum depth of 60 cms below ground level or a minimum of 30 cms below formation level or 15cm below sub grade level whichever is lower and the holes or hollows filled up with earth.
- 2.4.2 Existing structures and services such as old buildings culverts, fencing water supply pipe lines, sewers, power cables communication cables, drainage pipe etc with in or adjacent to the area if required to be diverted / removed, shall be diverted / dismantled as per the directions of EIC and payment for such diversion / dismantling works shall be made separately.

### **2.4.3 JUNGLE CLEARANCE /CUTTING AND CLEARING SITE**

Jungle cutting includes uprooting of rank vegetation, grass, brushwood, trees and sapling of girth upto 30 cms measured at a height of 1M above ground level. Where clearance of grass only is involved, no payment shall be made under this item:

Payments for cutting and removing of roots of trees of girth above 30 cms, at a height of 1M above ground level shall be made separately as per stipulation in the work order.

In uprooting of vegetation the roots of trees shall be dug at least upto 60 cms below ground level or 30 cms below formation level 15 cm below such grade level. Which ever is lower. All holes or hollows formed by digging up roots shall be carefully filled up with earth well rammed and leveled. Tree, shrubs, poles, fences, signs, monuments, pipelines cable etc with in or adjacent to area which are not required to be disturbed during jungle clearance shall be properly protected by the contractor at his own cost and nothing extra shall be payable.

Useful materials from the site cleared shall be stacked at site as directed by the Engineer-in-charge. The unserviceable materials shall be disposed off as directed by the EIC. All serviceable materials shall be the property of the Government. All unserviceable materials which in the opinion of the EIC can not be used or auctioned shall be removed upto a distance of 50 m outside the periphery of area under clearance. Contractor shall ensure that unserviceable materials are disposed off in such a manner that there is not likelihood of getting mixed up with the materials meant for construction.

The area over which the jungle clearance has been done shall be measured and paid for. The rate includes cost of all operations mentioned above.

### **2.4.4 FELLING OF TREES**

Trees above 30 cms girth (measured at a height of 1 Mtrs above ground level) to be cut shall be approved by the Engineer-in-charge. Felling of trees shall include taking out roots upto 60 cm below ground level or 15 cms below the formation level whichever is lower. After the tree is cut and roots removed, holes and hollows formed shall be filled up with good earth in 15cm layer and well rammed. The trunk and branches shall be cut into suitable pieces as directed by the EIC. All holes or hollows formed due to removal of roots shall be filled up with earth rammed and leveled. Trees, shrubs, poles, fences, signs monuments, pipe lines, cable etc within or adjacent to the area which are not required to be disturbed during jungle clearance shall be properly protected by the contractor at his own cost and nothing extra shall be payable.

The rate shall include cost involved in all the operations described above unless otherwise specified.

#### **2.4.5 STACKING AND DISPOSAL**

All useful materials obtained from clearing and grubbing operation shall be stacked in the manner as directed by the Engineer-in-charge. Trunks and branches of trees shall be cleared of limbs and tops and stacked neatly at places indicated by the Engineer-in-Charge. The material shall be the property of the Government. All unserviceable materials which in the opinion of the Engineer-in-Charge cannot be used or auctioned shall be removed up to a distance of 50m outside the periphery of the area under clearance. It shall be ensured by the contractor that unserviceable materials are disposed of in such a manner that there is no likelihood of getting mixed up with the materials meant for construction.

#### **2.4.6 CLEARANCE OF GRASS**

Unless otherwise specified clearing and grubbing operations involving only the clearance of grass shall be measured and paid for separately and shall include removal of rubbish upto a distance of 50 m outside the periphery of the area under clearance.

#### **2.5 SETTING OUT AND MAKING PROFILES**

Masonry pillars will be erected at suitable points in the area to serve as bench marks which is visible from large area for the execution of the work. These bench marks shall be constructed as direction of EIC and shall be connected with GTS or any other permanent bench marks/standard bench mark approved by the EIC. Necessary profiles with strings stretched on pegs, bamboos, etc and strings shall be made to show the correct formation level before the work is started. The contractor shall supply labour and materials for bench mark, setting out and making profiles for the work at his own cost. The bench mark profile etc shall be maintained by the contractor during the execution of work at his cost for checking the profiles .

Ground levels shall be taken at intervals of 5 to 15 meters intervals as directed by EIC in an uniformly sloping ground and at closer intervals where local mounds, pitches or undulations are met, with, as directed by EIC. The ground levels shall be recorded in field books and also plotted on plans. It shall be signed by Contractor and EIC before the work is started. The ground level plans shall be drawn to a scale 5m to one cm or any other suitable scale as decided by the EIC. North direction line and position of bench mark shall invariably shown on the plans. These plans shall be signed by both contractor and EIC or their representatives before earthwork is commenced. The labour required for

taking levels shall be supplied by the contractor at his own cost. It is the responsibility of contractor comply with the above requirement failing which the records prepared for the above by EIC shall be the acceptable record for both parties.

## **2.6 TYPES OF EXCAVATION**

### **2.6.1 Excavation in all kinds of soil.**

- 2.6.1.1 All excavated operation shall include excavation and "getting out" the excavated materials. In case of excavated for trenches, basements, water tanks etc. "getting out" shall include throwing the excavated material atleast one meter or half the depth of excavation which ever is more. Clear off the edge of the excavation. In all other cases "getting out" shall include depositing the excavated materials as specified. Subsequent disposal of excavated material shall be either state as a separate item or included with the items of excavation stating lead.
- 2.6.1.2 During the excavation the natural drainage of the area shall be maintained. Excavation shall be done from top to bottom under mining or under cutting shall not be done.
- 2.6.1.3 In firm soils, the sides of the trenches shall be kept vertical upto a depth of 2 m from the bottom. For greater depths, the excavation profile shall be wider by allowing steps of 50 cms on either side after every 2 m from the bottom. Alternatively excavation can be done so as to give slope of 1:4 (1 horizontal:4 vertical) where the soil is soft, loose or slushy, the width of step shall be suitably increased or sides sloped or the soil shored up as directed by the Engineer in charge. It shall be the responsibility of the contractor to take complete instructions in writing from the EIC regarding the stepping, sloping or shoring to be done from excavation deeper than 2 metres.
- 2.6.1.4 The excavation shall be done true to level, slope, shape, depth and pattern indicated by EIC. For width of excavation only the excavation shown on the foundation drawings i.e. only to the outer dimensions of the lowest structural element of foundation shall be measured for payment purpose and will be paid unless stated otherwise in the contract. However the excavation for the foundation shall have to be done as per the requirements of working spaces said above as per IS stipulations for foundation excavation, as required by site condition, as directed by the EIC for execution of for foundation in a safe manner, to meet structural requirements and also it has to be done in a workman like manner.
- 2.6.1.5 In case of excavation for foundation in trenches or over areas the bed of excavation shall be to the correct level or slope and consolidated by watering and ramming. If excavation for foundation is done to a depth greater than that shown in the

drawings or more than directed by EIC, the excess depth shall be made good by contractor at his own cost with concrete of the mix used for leveling / bed concrete for foundations. Soft / defective spots at the bed of the foundations shall be dug out and filled with concrete (to be paid separately) as directed by EIC.

- 2.6.1.6 While carrying out excavation for drain work, care shall be taken to cut the sides and bottom to the required shape, scope and gradient. The surface shall then be properly dressed. If excavation is done to a depth greater than that shown on the drawing or greater than directed by the EIC, the excess depth shall be made good by the contractor at his own cost with stiff clay puddle at places where the drains are not required to be pitched.
- 2.6.1.7 In case the excavation is done wider than that shown on the drawings or wider than directed by EIC, additional filling wherever required on this account shall be done by the contractor at his own cost.

## **2.6.2 EXCAVATION IN ORDINARY ROCK / HARD ROCK**

- 2.6.2.1 The details at para 2.6.1.1, 2.6.1.2, 2.6.1.4., 2.6.1.5, 2.6.1.6 & 2.6.1.7 with respect to excavation in all kinds of soil holds good for excavation in ordinary rock / hard rock.
- 2.6.2.2 Where hard rock is met with and blasting operations are considered necessary the contractor shall obtain the approval of EIC in writing for resorting to the blasting operations. Blasting operations should be done as specified under "blasting" and "chiscelling" and shall be done to obtain correct levels, depth slopes, shape and pattern of excavation as per the drawings or as required by the Engineer-in-charge and nothing extra shall be payable for chiseling. Unless otherwise specified in the work order.
- 2.6.2.3 Where blasting operations are prohibited or are not practicable excavation in hard rock shall be done by chiseling
- 2.6.2.4 In ordinary rock excavation shall be carried out by crow bars, pick axes, or pneumatic drills and blasting operations shall not be generally adopted. Where blasting operation are not prohibited and it is practicable to resort to blasting for excavation in ordinary rock, the contractor may do so with the permission of EIC in writing but nothing extra shall be paid for this blasting. Blasting shall be done as detailed under "Blasting" specification below.
- 2.6.2.5 Where blasting operation is resorted to, excavation shall be measured to the actuals provided the EIC is satisfied that the contractor has not gone deeper than that was unavoidable. The measurement for refilling / making good the unavoidable blasting done also may be considered subject to the condition that the EIC is satisfied that it is unavoidable.

### **2.6.3 SURFACE EXCAVATION**

- 2.6.3.1 Surface excavation shall comprise excavation greater than 1.5m in width as well as 10 Sqm on plan but exceeding 30 cm in depth in any type of soils and rocks.

### **2.6.4 ROUGH EXCAVATION**

- 2.6.4.1 Rough excavation shall comprise excavation not requiring dressing of sides and bottom and reduction to exact level such as excavation for earth from borrow pits and excavation for cutting hill side. The position and depth of borrow pits and also the extent of hill side cutting shall be indicated by EIC. Where practicable the borrow pits shall be drained to prevent water stagnating in them.

### **2.6.5 BLASTING**

Where hard rock is met with and blasting operations are considered necessary, the contractor will obtain the approval of Engineer-in-charge in writing for resorting to blasting operation. In ordinary rock blasting operation shall not be generally adopted. However the contractor may resort to blasting with the permission of EIC. But nothing extra shall be paid for such blasting operations of ordinary rock.

The contractor shall obtain licence from the competent authority for under taking blasting work as well as containing and storing the explosives as per the explosive Act 1884 as amended upto date and the explosive rules 1983. The contractor shall purchase explosive fuses, detonators etc., only from a licenced dealer. Transportation and storage of explosives at site shall conform to the aforesaid Explosive Act and Explosive Rules. The contractor shall be responsible for the safe custody and proper accounting of the explosive materials. Fuses and detonators shall be stored separately and away from explosives. The EIC or his authorized representative shall have the right to check the contractors store and account of explosives. The contractor shall provide the necessary facilities for this.

The contractor shall be responsible for any damage arising out of accident to workmen, public or private property due to storage, transportation and use of explosive during blasting operation.

- 2.6.5.1 Blasting operation shall be carried out under the supervision of a responsible authorized agent of the contractor (herein after be referred as agent on duty) during specified hours as approved in writing by the EIC. The agent shall be conversant with the rules of blasting. In case of blasting with dynamite or any other high explosive, the position of all the bore holes to be drilled shall be marked in circles with white paint. These shall be inspected by the contractors agent. Bore holes shall be of size that cartridge can easily pass down. The contractors' agent once after satisfying himself that bores have been made at

correct locations shall then prepare the necessary charge separately for each bore hole. The bore holes shall be thoroughly cleared before a cartridge is inserted. Only cylindrical wooden tamping rods shall be used for tamping. Metal rods or rods having pointed ends shall never be used for tamping. One cartridge shall be placed in the borehole gently pressed but not rammed down. Other cartridges shall then be added as may be required to make up the necessary charge for the borehole. The top most cartridge shall be connected to the detonator which shall in turn be connected to the safety fuses of required length. All fuses shall be cut to the required length before being inserted to the holes. Joints in the fuses shall be avoided. Where joints are unavoidable, a semi circular notch shall be cut in one piece of fuse about 2 cm deep from the end and end of the other piece inserted into the notch. The two pieces shall then be wrapped together with string. All joints exposed to dampness shall be wrapped with rubber tape.

Maximum of eight bore holes shall be loaded and fired at one occasion. The charges shall be fired successively and not simultaneously. Immediately before firing warning shall be given and the agent shall see that all persons have retired to a place of safety. The safety fuses of the charged holes shall be ignited in the presence of agent; who shall see that all the fuses are properly ignited,

Careful count shall be kept by agent and others of each blast as it explodes in case all the charged holes are exploded, the agent shall inspect the site soon after the blast but in case of mis fire the agent shall inspect the site after half an hour and mark red crosses (X) over the holes which have not exploded. During this interval of half an hour, nobody shall approach the misfired holes. No driller shall work near such bore until either of the following operations have been done by the agent for the misfired boreholes.

- a) The contractors' agent shall very carefully (when the tamping is of damp day) extract the tamping with a wooden scraper and with draw the fuse, primer and detonator. After this a fresh detonator, primer, and fuse shall be placed in the misfired holes and fired or.
- b) The hole shall be cleaned for 30 cms of tamping, and its direction ascertained by placing a stick in the hole. Another hole shall then be drilled 15 cms away and parallel to it. This hole shall be charged and fired. The misfired hole shall also explode along with the new one.

Before leaving the site of work, the agent of one shift shall inform another agent relieving him for the next shift, of any case of misfire and each such location shall be jointly inspected and the action to be taken in the matter shall be explained to the relieving agent.

The Engineer-in-charge shall also be informed by the agent of all cases of mis fires, their causes and step taken in that connection.



### **2.6.5.2 GENERAL PRECAUTIONS**

For safety of persons red flags shall be prominently displayed around the area where blasting operations are to be carried out. All the workers at site, except those who actually ignite the fuse shall withdraw to a safety distance of at least 200 mtrs. From the blasting site. Audio warning by blowing whistles shall be given before igniting the fuse.

Blasting work shall be done under careful supervision and trained personnel shall be employed. Blasting shall not be done within 200 metres of an existing structure, unless specifically permitted by the EIC in writing.

All procedures and safety precautions for use of explosives, drilling and loading of explosives etc shall be as detailed in IS 4081, safety code for blasting and related drilling operations.

### **2.6.5.3 PRECAUTIONS AGAINST MISFIRE**

- a) The safety fuse shall be cut in an oblique direction with a knife. All saw dust shall be cleared from inside of the detonator. This can be done by blowing down the detonator and tapping the open end. No tools shall be inserted into the detonator for this purpose.
- b) If there is water present or if the bore hole is damp the junction of the fuse and detonator shall be made water tight by means of tough grease or any other suitable material
- c) The detonator shall be inserted into the cartridge so that about one third of copper tube is left exposed outside the explosive. The safety fuse just above the detonator shall be securely tied in position in the cartridge water proof fuse only shall be used in the damp bore hole or when water is present in the bore hole.
- d) If a misfire has been found due to defective fuse, detonator, dynamite, the entire consignment from which the fuse, detonator or dynamite was taken shall be got inspected by the EIC or his authorized representative before resuming the blasting or returning the consignment .

### **2.6.6 EXCAVATION OVER AREAS IN ALL KINDS OF SOIL / ORDINARY ROCK / HARD ROCK**

#### **2.6.6.1 EXCAVATION OVER AREAS SHALL COMPRISE**

- a) Excavation exceeding 1.5m l width as well as 10sqm in a plan and exceeding 30 cm in depth.
- b) Excavation for basements, water tank etc., which may require the bottoms to be trimmed to levels or slopes.

- c) Excavation in treches for foundation exceeding 1.5m width at bottom and exceeding 10 sqm on plan
- d) Excavation for shafts, wells, pits, etc exceeding 10 sqm on plan.

Excavation over areas shall be carried out to required depths and profiles.

**2.6.7 EXCAVATION FOR TRENCHES FOR FOUNDATIONS, SHAFTS, WELLS ETC IN ALL KINDS OF SOIL, ORDINARY ROCK, HARD ROCK ETC SHALL COMPRISE:**

- a) Excavation in trenches not exceeding 1.5m width at bottom and 10 sq m on planary depth in trench excluding trench for pipes, cables, conducts etc.
- b) Excavation for shafts, well, cess pits and the like not exceeding 10 sqm on plan (other than post holes). Excavation shall be restricted to the net quantity required to enable the necessary foundations etc to be put in.

2.6.7.1 Excavation in ordinary rocks shall be carried out by crow bars, pick axes or pneumatic drills. Blasting operations are not generally successful in this case and if the contractor resorts to blasting, he can do so with the permission of Engineer-in-charge but nothing extra will be paid to him.

**2.6.8 EXCAVATION FOR TRENCHES FOR PIPES AND HOLES FOR POSTS:**

2.6.8.1 Excavation to trenches for pipes, cables etc shall comprise excavation of trenches of authorized widths. In trench excavation for pipes etc, grips shall be dug if required to take sockets, collars and joint of pipes and shall not exceed 1.5m in width or 10 sq m In plan and to any depth. The rate shall include returning the excavated material to fill the trenches after pipes, cables etc laid their joints tested and passed including disposing surplus excavated material upto 50m lead.

**2.6.8.2 EXCAVATION IN POST HOLES**

Shall comprise excavation of independent post holes or similar holes each not exceeding 0.5 cum.

**2.6.8.3 WIDTH OF TRENCH**

- a) Upto one metre depth, the authorized width of trench for excavation shall be arrived by adding 25 cm to the external diameter of pipe (not socket / collar) cable, conduit, etc. Where a pipe is laid on concrete bed/cushioning layer, the authorized width shall be the external diameter of the pipe (not socket/ collar) plus 25 cm or the width of concrete bed / cushioning layer whichever is more.

- b) For depths exceeding one metre an allowance of 5 cm per metre of depth for each side of the trench shall be added to the authorized width (that is external diameter of pipe plus 25 cm) for excavation. This allowance shall apply to the entire depth of the trench. In firm soils the sides of the trenches shall be kept vertical upto a depth of 2 metres from the bottom. For depths greater than 2 metres the excavation profiles shall be widened by allowing steps of 50 cm on either side after every two metres from bottom.
- c) Where more than one pipe, cable, conduit etc are laid, the diameter shall be reckoned as the horizontal distance from outside to outside of the outermost pipes, cable, conduit, etc
- d) Where the soil is soft, loose or slushy, width of trench shall be suitably increased or side slopped or the soil shored up as directed by the Engineer-in-charge. It shall be the responsibility of the contractor to take complete instructions in writing from the Engineer-in-charge regarding increase in the width of the trench, sloping or shoring to be done for excavation in soft, loose or slushy soils.

#### **2.6.9 EXCAVATION FOR FOUNDATION IN HARD ROCK**

- 2.6.9.1 All rocks occurring in foundations are to be removed either by chiseling or muffle blasting. No other blasting shall be allowed.
- 2.6.9.2 The contractor shall obtain licence from the concerned authority for undertaking the blasting work as well as for obtaining and storing explosive as per explosive Rule 1940 corrected up to date.
- 2.6.9.3 Excavation in hard rock shall be done by chiseling only where blasting operations are prohibited and are not practicable.
- 2.6.9.4 In trenches and drains where blasting is not otherwise prohibited excavation in hard rock shall be carried out by blasting in the first instance and finally chiseling so as to obtain correct section of the trench as per drawing.

#### **2.6.10 EXCAVATION FOR CUTTING AND FILLING**

Cutting shall be done true to levels, slope, shapes and pattern and from top to bottom avoiding undermining or undercutting. The sides shall be neatly dressed or trimmed and bottoms shall be levelled and rammed. The earth from cutting shall directly be used for filling and no claim for double handling of earth shall be entertained. Filling shall be done in regular horizontal layers each not exceeding 20 cms in depth.

The earth shall be free from all roots, grass and rubbish, all lumps and clods exceeding 8 cms in any direction shall be broken, each layer shall be consolidated

by breaking clod and ramming. Watering shall be done if so stipulated. Finally, finished area shall be neatly dressed. The finished formation levels in case of filling shall be kept higher than the required levels making allowance of 10% of depth of filling for future settlement in case of ordinary consolidated fills and 5% in case where consolidation is done by heavy mechanical machinery. During execution of work, the natural drainage of the area shall be maintained by the Contractors.

Where excavation is in trenches or in borrow pits in a generally uniform ground, the measurements for cutting in trenches or borrow pits shall be made. In case of borrow pits, diagonal ridges, cross ridges etc deadman at appropriate position shall be left by the contractor for each pit and dead man position shall be fixed by the Engineer-in-charge to permit accurate measurements being taken on the completion of the work. Nothing extra will be paid for removal of deadman as subsequent operation and if this is not required to be removed deduction shall be made from the measurement.

Where the ground is not uniform or where the site is required to be leveled, levels shall be taken before the starts and after the completion of the work and the quantity of excavation in cutting computed from these levels.

Where it not possible or convenient to taken measurements from cutting, the filling shall be measured and quantity of earth work computed from the cross sections of the filling or the embankment. The quantity of earthwork so computed shall be reduced from 10% to arrive at net cubical contents in case of ordinary consolidated fills and 5% in case where the consolidation is done by heavy mechanical machinery. Where earth work is measured from loose stacks, carts or lorries, 20% deduction will be made from actually measured quantity.

In case of excavated rock, the excavated materials shall be stacked separately, measured and each reduced by 50% to allow for voids to allow for quantity payable under the respective classification of rock.

#### **2.6.11 EXCAVATION IN WATER, MUD OR FOUL POSITION**

- a) **WORK IN OR UNDER WATER AND / OR LIQUID MUD:** Excavation, where water is met with from any of the sources specified in 2.20.1 shall fall in this category. Steady water level in the trial pits before the commencement of bailing or pumping operations shall be the sub-soil water level in that area.
- b) **WORK IN OR UNDER FOUL POSITION:** Excavation, where sewage, sewage gases or foul conditions are met with from any source, shall fall in this category. Decision of the Engineer-in-charge whether the work is in foul position or not, shall be final.

- 2.6.11.1 All water that may accumulate in excavation during the progress of work from springs, tidal or river water seepage, broken water mains or drains etc (not due to negligence of contractor) and seepages from sub soil aquifer shall be pumped out and removed. The contractor shall take adequate measures for pumping out water from excavation and construct diversion channel, bunds, sumps coffer dams etc as may be required. Pumping shall be done directly from the foundation trenches or form sump outside the excavation in such a manner as to preclude the possibility of movement of water any fresh concrete or masonry and washing away parts of concrete or mortar. During laying of concrete or masonry and for a period of 24 hours thereafter, pumping shall be done from a suitable sump separated from concrete or masonry by effective means.
- 2.6.11.2 Capacity and number of pumps, location at which the pumps are to be installed, pumping hours etc shall be decided from time to time in consultation with the Engineer-in-charge.
- 2.6.11.3 Pumping shall be done in such a way as not to cause damage to the work or adjoining property by subsidence etc. Disposal of water shall not cause inconvenience or nuisance in the area or cause damage to the property and structure near by.
- 2.6.11.4 To prevent slipping of sides, planking and strutting may also be done with the approval of the Engineer-in-charge.

#### **2.6.12 SURFACE DRESSING**

Surface dressing shall include cutting and filling up to a depth of 15 cm and clearing of shrubs rank vegetation, grass, brush wood, trees and saplings of girth upto 30cm measured at a height of one meter above the ground level and removal of rubbish and other excavated material upto a distance of 50 metres outside the periphery of the area under surface dressing. High portions of ground shall be cut down hollow depressions filled upto to the required level with excavated earth so as to give an even neat and tidy look.

#### **2.6.13 EARTH WORK EMBANKMENT, FLOODS BANKS, MARGINAL BANKS ETC.**

All areas to be excavated for obtaining the earth and the area coming under the embankment including the 3 Mtrs.wide strips measured beyond the lines of these areas shall be cleaned of all trees, vegetation and other objectionable materials. All stumps and roots of upto 60 cms below ground level or minimum 15 cms below formation level whichever is lower shall be removed. The cleared area shall be maintained free of vegetation growth during the execution of work. Trees of girth above 30 cms measured at a height of 1 mtr above ground level shall be cut as directed by EIC, payment of which shall be made separately. Unless specified otherwise.

The setting out and marking profiles shall be done as already specified. The foundation of embankment shall be ploughed to a depth of 15 to 25 cms. All clods shall be broken into fine earth and watered before the earth work is started.

The clear beam between the toe of the bank and inner edge of the borrow pits shall not be less than 2.5 mtr or as directed by EIC.

Earthwork shall be paid for the earth filled in 15 cms, layers and shall be continuous, parallel to the finished grade. The placing of earth fill shall be done in full width of the embankment including slopes and section of formation shall be cut slightly sloping away from the center to avoid pools of water formation due to rain. The height of filling in different sections shall be uniform as far as possible. All clods shall be broken while the earth is being placed. Organic matter of any kind shall be removed and disposed off as directed by Engineer-in-charge. Each layer of earth shall be adequately watered to aid compaction shall be rolled with roller of not less than 5 ton till it gets evenly and densely consolidated. Where specified the rolling shall be done, the earth filled is consolidated to atleast 95% of the consolidation obtainable at optimum moisture content under laboratory conditions. Where roller cannot work the earth shall be consolidated with wooden or steel rammer of 7 to 10 kgs. Having a base of 20 cm  $\times$  20 cm diameter. The labour for ramming shall be atleast one rammer for six diggers. Before placing the next layer, the surface of the under layer shall be moistened and scarified with pick axes or spades as to provide a satisfactory bond with the next layer.

## **2.7 PLANKING AND STRUTTING**

- 2.7.1 When the depth of trench is soft / loose soil exceeds 2 mtrs, stepping, sloping and / or planking and strutting of sides shall be done. In case of loose and slushy soils, the depths at which these precautions are to be taken shall be determined by the Engineer-in-charge according to the nature of soil.
- 2.7.2 Planning and strutting shall be 'close' or 'open' depending on the nature of soil and the depth of trench. The type of planking and strutting shall be determined by the EIC. IT shall be the responsibility of the contractor to take all necessary steps to prevent the sides of trenches from collapse. EIC and contractor should take guidance from IS:3764 for designing the shoring and strutting arrangements and specifying the profile of excavation.

## **2.7.3 CLOSE PLANKING AND STRUTTING**

Close planking and strutting shall be done by completely covering the sides of the trench generally with short upright, members called 'polling boards'. These shall be 250 x 38mm in section or as directed by the EIC.

The boards shall generally be placed in position vertically in pairs, one board on either side of cutting. These shall be kept apart by horizontal wallings of strong wood at a maximum spacing of 1.2 metres cross strutted with ballies, or as directed by Engineer-in-charge. The length and diameter of the ballie strut shall depend upon the width of the trench.

Where the soil is very soft and loose, the boards shall be placed horizontally against the sides of the excavation and supported by vertical 'wallings' which shall be strutted to similar timber pieces on the opposite face of the trench. The lowest boards supporting the sides shall be taken in the ground for a minimum depth of 75mm. No portion of the vertical side of the trench shall remain exposed.

The withdrawal of the timber members shall be done very carefully to prevent collapse of the trench. It shall be started at one end and proceed systematically to the other end. Concrete or masonry shall not be damaged while removing the planks. No claim shall be entertained for any timber which cannot be withdrawn and is lost or buried, unless required by the Engineer-in-charge to be left permanently in position.

#### **2.7.4 OPEN PLANKING AND STRUTTING**

In case of open planking and strutting, the entire surface of the side of the trench is not required to be covered. The vertical boards, 250mm wide and 38 mm thick shall be spaced sufficiently apart to leave unsupported strips of 50 cm average width. The detailed arrangement size of the timber and the distances apart shall be subject to the approval of the EIC. In all other respects specifications for close planking and strutting shall apply to open planking and strutting.

#### **2.8.0 REFILLING ETC.**

2.8.1 As soon as the work in foundation has been measured, the spaces around the foundation masonry trenches shall be cleared of all debris, brick bats, mortar etc and filled with earth in layers not exceeding 15 cms, each layer watered and rammed with steel rammer or half tonne roller and consolidated before the succeeding one is laid. Earth shall be rammed with rammers and where not possible by butt ends of crow bars. Where specified and practicable every third and top most layer shall also be consolidated with power roller of minimum 8 tones. The top and sides of the filling shall be neatly dressed. The contractor shall make good all subsidence and shrinkage in earth filling embankments, traverses etc during excavation and till the completion of work unless otherwise specified.

2.8.2 The plinth shall be similarly filled with earths in layer not exceeding 15 cms. Watered and consolidated by ramming the rammers with butt ends of crow bars.

When filling reaches the finished level, the surface shall be flooded with water for atleast 24 hrs. allowed to dry and then rammed and consolidated in order to avoid any settlement at a later stage. The finished level of filling shall be kept to slope intended to be given to the floor.

- 2.8.3 If approved by Engineer-in-charge, normally excavated earth from same area shall be used for filling which should be free from rank vegetation grass, brush wood, stone shingle, boulders larger than 75mm in any direction and organic or any other foreign matter. Earth containing deleterious materials, salt, peter earth etc shall not be used for filling. All clods and lumps of earth exceeding 8 cm in any direction shall be broken or removed before the earth is used for filling.
- 2.8.4 In case of foundation trench refilling the space around the foundation and trench side shall be clear of all debries, brick bats, etc. The filling shall be done in layers not exceeding 20 cms in depth. Each layer shall be watered, rammed and consolidated. Ramming shall be done with iron rammers where it is possible and with blunt end of crowbars where rammer cannot be used. Special care should be taken to ensure that no damage is caused to the pipes, drains, masonry or concrete in the trenches.
- 2.8.5 In case of filling under floors the finished level of filling shall be kept to the slope intended to be given to the floor.
- 2.8.6 Filling in trenches for pipes and drains shall be commenced as soon as the joints of the pipes and drain have been tested and passed. Where the trenches are excavated in soil, the filling shall be done with earth on the sides and top of the pipes in layers not exceeding 15 cms. Watered, rammed and consolidated taking care that no damage to the pipe of barrel shall be done with fine material such as earth moorum or pulverized decomposed rock according to the availability at site in the same manner as for plinth filing. The remaining filling shall be done with rock filling or boulders not exceeding 15 cms mixed with fines available to fill up voids, watered rammed and consolidated.

## **2.9 LEAD**

- 2.9.1 Lead will be measured over the shortest practical route, not necessarily the route actually taken for mechanical transport or carriage by animals.

## **2.10 CARRIAGE OF EARTH / SOIL**

- 2.10.1 **CARRIAGE BY MANUAL LABOUR SHALL BE RECKONED INUNITS OF 50 METRES**
- 2.10.2 Carriages by animals and mechanical transport shall be reckoned in one Km unit. Distance 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 metres



subject to the condition that the rate worked on this basis does not exceed the rate for initial lead of 1 Km by mechanical transport.

## 2.11 LIFTS

2.11.1 The lift shall be measured from ground level and only obvious lift shall be paid for i.e lifts inherent in the lead due to ground slope shall not be paid for.

## 2.12 ANTI TERMITE TREATMENT

### 2.12.1 PRECONSTRUCTION ANTI TERMITE TREATMENT

**CHEMICALS:** The chemicals used for the soil treatment shall be any one of the following with the concentration shown against each:

Sl. No.	CHEMICALS	CONCENTRATION BY VOLUME
1	Chloropyrifos emulsifiable Concentrate – 20 EC (conforming to IS8944)	1%
2	Lindane 20 EC (Conforming to IS 632)	1%

2.12.2 The preconstruction anti termite shall be provided using approved chemicals in water emulsion of specified concentration said above. A complete chemical barrier shall be provided on top surface of plinth filling, junction of wall and floor on top of damp proof course (DPC) or masonry at the plinth level as per IS 6313 (part II) The chemicals said above of specified concentration shall be spread at 5 lits per sq mtr on top surface of plinth filling, top of damp proof course and shall be applied at the rate of one litre per linear metre length along the junction of wall and floor.

2.12.3 The barrier shall be complete and continuous inside the whole of the structure to be protected. Each part of the area treated shall receive the prescribed dosage of chemical.

2.12.4 The treatment should start just prior to laying of concrete sub-base when the chemical emulsion has been absorbed by the filled up soil for plinth. Treatment should not be carried out when it is raining or when the soil barriers shall not be disturbed. If by chance treated soil barriers are disturbed. If by chance treated soil barriers are disturbed immediate steps shall be taken to restore the continuity and completeness of barrier system.

### 2.12.5 PRECAUTIONS

2.12.5.1 The chemicals used for antitermite treatment are poisonous and hazardous to health. Therefore necessary safety precautions shall be taken in handling and

use of the chemicals and emulsions. The containers should be stored carefully so that it is well away from children and pets. They should be kept securely closed. The chemicals used are highly inflammable due t the pressure avoided during mixing. Care should be taken during the application of chemicals to see that they are not allowed to contaminate wells or spring.

2.12.5.2 In view of the fact that the chemicals used are toxic and hazardous to health and that they may be carried to places of remote from the points of application by water, which is a very effective medium for their disposal, it is necessary to ensure that the treatment is not carried out where rainwater or sub soil water may gain access to it and leach out and transport the chemicals. The treatment should be restricted to be within the envelope created by the building walls and "doe not go below the highest expected ground water level.

#### **2.12.6 TERMITE PROOF COURSE IN DPC**

- a. Damp proof course in the form of concrete in level with sub-base concrete is proposed. Although this acts as an effective barrier impervious to termite entry, the top surface of DPC should be treated at 5 litres per M2 immediately after the course is laid and the concrete is green.
- b. If there is no provision for a DPC the top surface of the masonry course just below the level of plinth filling mentioned above should be soaked with the chemical emulsion at the rate of 5 litres per sqmtr., of the surface. This application should be carried out slowly to enable the masonry surface to absorb the emulsion properly. Both steps (a) and (b) above help in creating a barrier which is impervious to termite entry.

#### **2.12.7 TREATMENT AT JUNCITON OF WALLS AND FLOOR**

Roding shall be carried out along the junction of walls and earth filling at 15 cm intervals down to the bottom of plinth filling. Emulsion shall be sprayed along the wall junction at 1 litre per linear metre so that it mixes intimately with the broken up soil and seeps to the natural ground level. The disturbed earth is then tamped back in place.

#### **2.12.8 TREATMENT TO TOP SURFACE OF PLINTH FILLING**

- a. After the earth filling is completed in the plinth area and before the rubble packing or sub-grade is laid, the entire surface of the filled earth shall be treated with the chemical emulsion at the rate of 5 litres per sqm. Light rodding may be carried out in the soil surface to facilitate absorption saturation of the soil with chemical emulsion.
- b. For buildings where construction has advanced already, for facility of construction, the treatment could also be done effectively, over the case

concrete (lean mix) under the floor taking care that the emulsion at the rate of 5 litres per sqm. soaks fully into the concrete.

#### **2.12.9 SPRAYING EQUIPMENT**

A pressure pump shall be used to carry out spraying operations to facilitate uniform spraying and penetration of chemicals into the earth. The chemical, concentration and dosage for horizontal and vertical surfaces are based on the IS code of practice for Anti-termite measures in building. (IS:6313 (part II))

#### **2.12.10 MOUNT TREATMENT**

If termite mounds are found within the plinth area, these should be destroyed by means of insecticides in the form of water suspension or emulsion which should be poured into the mounds at several places after breaking open the earthen, structure and making holes with crowbars. The quantity to be used will depend upon the size of the mound. For a mound volume of about 1 cum, 4 litres of an emulsion in water of one of the above chemicals may be used in the specified concentration.

#### **2.12.11 TREATMENT FOR EXPANSION JOINTS**

Expansion joints at ground floor level are one of the biggest hazardous for termite infestation. The soil beneath these joints should receive special attention when the treatment is carried out. This treatment should be supplemented by treating through the expansion joint after the sub – grade has been laid at the rate of 2 litres per linear meter.

#### **2.12.12 MESUREMENT FOR PAYMENT**

2.12.12.1 In case of chemical application of DPC plinth filling below concrete sub-bases of floors, plinth area covered by the building at ground level shall be the basis for payments.

#### **2.12.13 FREE SERVICE GUARANTEE**

The contractor shall note that termite proofing work is subject to a free service guarantee from the date of completion of the treatment. The contractor shall give an under taking in writing to the effect that during the guarantee period any infestation of sub–terrain termites will be eradicated and necessary treatment carried out to prevent the infestation, free of cost to the owners. The guarantee shall allow a minimum period of:

- a) 10 (ten) years for pre-construction treatment.
- b) 5 (five) years for post construction treatment.

2.12.14 Tenderers must ensure that the work will be got done through Professional pest control operators. They should be member of National Pest Control Association of USA, or Indian Pest Control Association. Any other recognized professional body. They should furnish a list of termite. Control jobs carried out by them successfully for Government Department, Statutory bodies or larger private organizations to prove that they are capable of handling anti-termite work.

#### **2.12.15 B POST CONSTRUCTION ANTITERMITE TREATMENT**

The treatment shall generally carried out conforming to IS 6313 (part 3).

##### **2.12.15.1 INSPECTION**

The infested structure should be inspected by EIC and determine the extent of spread of termites, its routes of entry into building etc and decide mode of treatment.

#### **2.12.16 EXTERMINATION OF TERMITE IN BUILDING**

The operation shall be carried out in a thorough manner, seeking the termites in their hideouts such as ceilings, behind wooden panellings, inside electrical wiring battens, conduits switch boards and similar locations. Action should be taken to inject chemicals at the required location such as the soil around the building, treatment around outside foundation, soil under floors, voids in masonry, points of contact of wood work, treatment to wood work, treatment to electrical fixtures etc.

2.12.17 The chemicals, precautions, methodology of application etc shall be generally as described above under pre construction anti termite treatment.

#### **2.13 MEASUREMENTS OF EARTHWORK**

2.13.1 The length and breadth of excavation or filling shall be measured with a steel tape correct to the nearest cm. The depth of cutting or height of filling shall be measured, correct to 5mm, by recording levels before the start of the work and after the completion of the work. The cubical contents shall be worked out to the nearest two places of decimal in cubic metres.

2.13.2 In case the ground is fairly uniform and where the site is not required to be leveled, the Engineer-in-charge may permit the measurements of depth of cutting or height of filling with steel tape, correct to the nearest cm. In case of borrow pits, diagonal ridges, cross ridges or deadmen, the position of which shall be fixed by the Engineer-in-charge, shall be left by the contractor to permit accurate measurements being taken with steel tape on the completion of the work. Deduction of such ridges and deadmen shall be made from the measurements

unless the same are required to be removed later on and earth so removed is utilized in the work. In the later case nothing extra will be paid for their removal as subsequent operation.

- 2.13.3 Where ordinary rock and hard rock is mixed, the measurement of the excavation shall be made as specified. The two kinds of rock shall be stacked separately and measured in stacks. The net quantity of the two kinds of rocks shall be arrived at by applying deduction of 50% to allow for voids in stacks. If the sum of net quantity of two kinds of rocks exceeds the total quantity of the excavated material, then the quantity for each type of rock shall be worked out from the total quantity in the ratio of net quantities in stack measurements of the two types of rocks. If in the opinion of the Engineer-in-charge stacking is not feasible, the quantity of ordinary and hard rock shall be worked out by means of cross sectional measurements.
- 2.13.4 Where soil, ordinary rock and hard rock are mixed, the measurements for the entire excavation shall be made as specified. Excavated materials comprising hard rock and ordinary rock shall be stacked separately, measured, and each reduced by 50% to allow for voids to arrive at the quantity payable under hard rock and ordinary rock. The difference between the entire excavation and the sum of the quantities payable under hard rock and ordinary rock. The difference between the entire excavation and the sum of the quantities payable under hard rock and ordinary rock shall be paid for as excavation in ordinary soil or hard soil as the case may be.
- 2.13.5 Where it is not possible or convenient to measure the depth of cutting by recording levels as specified, quantity of excavation shall be worked out from filling. The actual measurements of the fill shall be calculated by taking levels of the original ground before start of the work after site clearance and after compaction of the fill as specified and the quantity of earth work so computed shall be reduced by 10% in case of consolidated fills and by 5% in case the consolidation is done by heavy mechanical machinery to arrive at the net quantity of excavation for payment. No such deduction shall, however, be made in case of consolidation heavy mechanical machinery at optimum moisture content or when the consolidated filling is in confined situations such as under floors.
- 2.13.6 Cutting of trees above 30 cm girth (measured at a height of 1m above ground level) shall be measured in numbers according to the sizes given below.

Beyond 30 cm girth upto and including 60cm girth

Beyond 69cm girth upto and including 120 cm girth

Beyond 120 cm girth upto and including 240 cm girth

Above 240 cm girth

- 2.13.7 The measurement for earth work in foundation shall be done as stipulated above. The excavation for foundation shall be done to meet working space requirements including battering, benching, stepping etc as per the codal requirements and as detailed above based on site conditions. However for the measurement for payment of earth work in building foundation trenches, the width of foundation trench shall be restricted to that of foundation concrete, leveling concrete and actual depth shall be considered. Accordingly the contractor shall consider the cost of excavation of working space requirements and refilling of the same in the rate quoted by him for the restricted quantity of earth work said above duly loading the rate appropriately. No extra shall be measured or paid on account of working space/ battering / benching etc in excavation for foundation in trenches and refilling of the same.
- 2.13.8 Trenches for pipes, cables conduits shall be measured in running metres correct to the nearest cm in stages of 1.5m depth and described separately as under.
- Pipes, cables, conducts etc not exceeding 75mm dia
  - Pipes cables, conducts etc exceeding 75mm dia but not exceeding 300 mm dia.
  - Pipes, cables, conducts etc exceeding 300 mm dia.

Unless otherwise specified differently.

- 2.13.8.1 Where two or more categories of each work are involved due to different classification of soil within the same stage of trench depth or where the soil is soft loose or slushy requiring increase in the width of trench or sloping sides or showing trenches of pipes, cable conduits etc shall be measured in cubic meter. Extra excavation if any on account of collar / socket of pipes shall neither be measured nor paid for separately.

- 2.13.8.1.1 In case of planking and shuttering following shall be measured separately
- Depth not exceeding 1.5m.
  - Depth exceeding 1.5m in stages of 1.5m.
  - Works in trenches.
  - Areas- the description shall include use and waste of racking shores, Shafts, walls, cess pits, manholes and the like.
  - Tightly driven close butt jointed sheeting as in the case of running sand (description of item shall include packing of cavities behind sheeting.
  - Planking and shutting required to be left permanently in position.

## **2.14 RATES**

- 2.14.1 Rates for earth work shall include the following unless specified other wise
- a) Excavation and depositing excavated materials as specified.
  - b) Handling of antiquities and useful materials.
  - c) Protection as specified .
  - d) Site clearance as specified .
  - e) Setting out and making profiles as specified.
  - f) Forming (or leaving) deadmen or 'Tell Tales' in borrow pits and other removal after measurements.
  - g) Bailing out or pumping of rain water from excavations unless otherwise specified.
  - h) Initial lead of 50m and lift of 1.5m
  - i) Blasting operations for hard rock as specified.
- 2.14.2 No deductions shall be made from the rate if in the opinion of the Engineer-in-charge, operations like handling of antiquities and useful materials protective display and caution signs site clearance setting out and marking profiles, leaving / removing tell tales, bailing out water, initial lead and lift less than 50m and 1.5m respectively etc are not required to be carried out on any account whatsoever.
- 2.14.3 Rates for excavation in trenches for pipes, cables and like items if not specified otherwise shall also include the cost of refilling and all other activities described in the detailed specifications.
- 2.14.4 In case of planking and shuttering rates shall include use and waste of all timbers including fixing and subsequent removal.
- 2.14.5 RATE FOR WORK UNDER WATER IN MUD OR FOUL POSITION:**
- 2.14.5.1 The unit, namely, metre depth shall be the depth measured from the level of foul position/sub soil water level and upto the center of gravity of the cross sectional area of excavation actually done in the conditions classified so. Meter depth shall be reckoned correct to 0.1m, 0.05 or more shall be taken as 0.1m and less than 0.05m ignored. The extra percentage rate is applicable in respect of each item but the measurements shall be limited only to the quantities of earth work actually executed in the conditions classified as earth work excavation in foul condition / position or excavation in water as the case may be.

- 2.14.5.2 In case earthwork in or under foul position is also in or under water and / or liquid mud, extra payment shall be admissible only for the earthwork actually executed in or under foul position. The excavation under such condition be either of the two as per the pred.
- 2.14.5.3 Pumping or bailing out water met within excavations where envisaged and specifically ordered in writing by the EIC for which provision for payment not catered in earth work shall be measured separately and paid quantity of water shall be recorded in kilolitres correct to two places of decimal. This payment shall be in addition to the payment under respective items of earth work and shall be admissible only when pumping or bailing out water has been specifically ordered by the EIC in writing.
- 2.14.5.4 Unless otherwise specified planking and strutting or any other protection work done with the approval of the EIC to keep the trenches dry and / or to save the foundations against damage by erosion or rise in water level shall be measured and paid for separately.
- 2.14.5.5 Bailing or pumping out water accumulated in excavation, due to rains is included under respective items of earthwork and is not to be paid separately.

10-10-10-10-10-10



## CHAPTER 3

### MORTARS

#### 3.1 MATERIALS

##### 3.1.1 WATER

3.1.1.1 Water used for mixing and curing shall be clean and free from injurious. Quantities of alkalies, acid, oils, salts, sugar, organic materials, vegetables growth or other substances that may be deleterious to bricks stones, concrete or steel. Potable water is generally considered satisfactory for mixing. The Ph value of water shall be not less than 6. The following concentrations represent the maximum permissible values (of deleterious materials in water).

- a) **Limits of Acidity:** To neutralise 100 ml sample of water using phenolphthalein as an indicator. It should not require more than 5 ml of 0.02 normal NaOH. The details of test shall be given in IS:3025 (part 22)
- b) **Limits of Alkalinity:** To neutralise 100 ml sample of water, using mixed indicator, it should not require more than 25 ml of 0.02 normal  $H_2SO_4$ . The details of tests shall be given in IS:3025 (part 23).
- c) **Percentage of Solids:** Maximum permissible limits of solids when tested in accordance with IS:3025 shall be as under.

Organic	←	200 mg/litre
Inorganic	←	3000 mg/litre
Sulphates	←	400 mg/litre
Chlorides	←	500 mg/litre for RCC work and 2000 mg/ltr for Concrete not containing embedded steel.
Suspended Matter	←	2000 mg/litre

The physical and chemical properties of ground water shall be tested along with soil investigation and if the water is not found conforming to the requirements of IS:456:2000 it shall not be used on work. The tender documents shall clearly specify that the contractor has to arrange good quality water conforming to IS 456:2000 for construction indicating the source.

3.1.1.2 Water found satisfactory for mixing is also suitable for curing. However, water used for curing shall not produce any objectionable stain or unsightly deposit on the surface. The presence of tannic acid or iron compounds in the water meant for curing is objectionable.

3.1.1.3 Sea water shall not be used for mixing or curing.

3.1.1.4 Water from each source shall be tested before the commencement of the work and thereafter once in every three months till the completion of the work. In case of ground water, testing shall also be done for different points of draw down. Water from each source shall be got tested during the dry season before monsoon and again after monsoon.

### 3.1.2 CEMENT

3.1.2.1 The cement used shall be any of the following and the type selected should be appropriate for the intended use.

- a) 33 grade ordinary Portland cement conforming to IS:269
- b) 43 grade ordinary Portland cement conforming to IS:8112
- c) 53 grade ordinary Portland cement conforming to IS:12269
- d) Rapid hardening Portland cement conforming to IS:8401
- e) Portland Slag cement conforming to IS:455
- f) Portland pozzolona cement (Flyash based) conforming to IS:1489 (part 1)
- g) Portland pozzalona cement (Calcined clay based) conforming to IS:1489 (part 2)
- h) Hydrophobic cement conforming to IS:8403
- i) Low heat Portland cement conforming to IS:12600
- j) Sulphate resisting Portland cement conforming to IS:12330

Different types of cement shall not be mixed together. In case more than one type of cements is used in any work, a record shall be kept showing the location and the types of cement used.

**3.1.2.2 CAUTION IN USE OF CEMENT GRADE 53 IN CONSTRUCTION:** In case of grade 33 cement, the gain strength will continue beyond 28<sup>th</sup> day because of early gain, gain of strength of other cements do not increase much beyond 28<sup>th</sup> day. In addition, because of the faster hydration process, the concrete also releases heat of hydration at a much faster rate initially and release of heat is the highest in case of grade 53. The heat of hydration being higher, the chances of Micro – cracking of concrete is much greater. Thus, during initial setting period of concrete, the higher heat of hydration can lead to damaging

micro-cracking within the concrete which may not be visible at surface. This cracking is different from shrinkage conditions.

The situation can be worse when we tend to increase the quantity of the cement in concrete with a belief that such increases are better for both strength and durability of concrete. Thus, it is very essential to be forewarned that the higher grade cement specially grade 53 should be used only where such use is warranted for making higher strength concrete and also where good Quality Assurance measures are in place, by which proper precautions are taken to relieve the higher heat of hydration through chilling of aggregates or by proper curing of concrete. Instances have come to notice where higher grade cement is being used even for low strength concrete, as mortar or even for plastering. This can lead to unnecessary cracking of concrete / surfaces.

Another issue to be cautioned against is the tendency of the manufacturers to project grade 53 cement as a stronger cement, whereas grade 33 or 43 are enough to produce the concrete of desired characteristic strength. The scenario of method production of cement by various manufacturers should also be kept in mind while ordering various grades of cement. The ability to produce cements of various fineness get fixed by the machinery installed by the manufacturers, and thus the ability to produce various grades of cement by a particular manufacturer also get limited. Whereas tendency today is to supply the consumer what he orders for by the manufacturers by simply stamping such grades on the bags. Thus, it is often observed that cement bags marked as grade 33 or 43 may really be containing cements of much higher grade.

### 3.1.2.3 COMPRESSIVE STRENGTH

Compressive strength requirement of each type of cement for various grades when tested in accordance with IS:4031 (part 6) shall be as under:

SAMPLE	STRENGTH IN N/mm <sup>2</sup> – NOT LESS THAN FOR		
	Gr.33	Gr.43	Gr.53
Age @ test			
72± 1 hrs	16	23	27
168 ±2 hrs	22	33	37
672 ±4 hrs	33	43	53

**3.1.2.4 SETTING TIME:** Setting time of cement of any type or any grade when tested by Vicat apparatus method described in IS:4031 shall conform to the following requirement.

- Initial setting time: Not less than 30 Minutes.
- Final setting time: Not more than 600 Minutes.

**3.1.2.5 SUPPLY:** The cement shall be packed in jute sacking bags conforming to IS:2580, double hessian bituminised (CRI Type) or woven HDPE conforming to IS:11652. Woven polypropylene conforming to IS:11653, jute synthetic union conforming to IS:12174, or any other approved composite bags bearing the manufacturers name or his registered trade mark if any, and grade and type of cement.

Even delivery of cement shall be accompanied by a producer's certificate confirming that the supplied cement conforms to relevant specifications. These certificates shall be endorsed to the Engineer In-charge for his records.

Every consignment of cement must have identification marks on packages indicating date of manufacture and grade and type of cement.

**3.1.2.6 STACKING AND STORAGE:** Cement in bags be stored and stacked in a shed which is dry, leakproof and as moisture proof as possible. Flooring of the shed shall consist of two layers of dry brick laid on well consolidated earth to avoid contact of cement bags with the floor. Stacking shall be done about 150 to 200 mm clear above the floor using wooden planks. Cement bags shall be stacked atleast 450mm clear off the walls and in rows of two bags leaving a space of atleast 600mm between two consecutive rows. In each row the cement bags shall be kept close together so as to reduce air circulation. Stacking shall not be more than 10 bags high to avoid lumping under pressure. In stacks more than 8 bags high, the cement bags shall be arranged in header and stretcher fashion i.e alternately lengthwise and crosswise so as to tie the stacks together and minimize the danger of toppling over.

Different types of cement shall be stacked and stored separately.

Cement bags shall be stacked in a manner to facilitate their removal and use in the order in which they are received.

Storage of cement at work site shall be at contractors' expense and risks. Any damages occurring to cement due to faulty storage in contractors' shed or on account of negligence on his part shall be the liability to the contractor.

### **3.1.2.7 STRENGTH ALTERATION DUE TO STORAGE**

Cement stored for long periods, loose strength. Hence storing of cement for long periods shall be avoided. It is always advisable to get the sample of stored cement tested in recognized laboratory to ascertain whether the setting properties and strength have been seriously affected?

### **3.1.2.8 PRECAUTIONS TO BE TAKEN WHILE STORING CEMENT**

- \* Do not put godown into use immediately after construction. Allow a reasonable time for the interior to dry completely.

- Cement bags should not be piled against walls. A space of atleast 450mm should be left.
- Even in the godown with concrete floor cement should be stocked free from floor over wooden plank or like arrangement to ensure gap of atleast 200 mm between cement bags and floor top.
- While stacking cement extra care should be taken not to leave much gap between the bags to avoid scope for free air circulation between bags.
- In case of pile stacking, the cement bags shall be arranged in header and stretcher fashion so that pile remains tied together. Maximum height of the pile should not be more than 10 bags. Maximum width should not be more than 3m.

### 3.1.3 LIME

3.1.3.1 Lime used shall conform to IS:712 Building limes are classified as follows:

- Class A ➤ Eminently hydraulic lime used for structural purposes.
- Class B ➤ Semi Hydraulic lime used for masonry mortars
- Class C ➤ Fat lime used for finishing coat in plastering, white washing etc, and addition of pozzolanic material for Masonry Mortar
- Class D ➤ Magnesium lime used for finishing coat in plastering, white washing etc.
- Class E ➤ Kankar lime used for masonry mortars.

**3.1.3.2 QUICK LIME:** Quick lime shall be supplied in the form of lumps and not in powder. Soon after delivery lump lime shall be separated from powder and all under burnt / over burnt lumps and the powder removed. Quick lime shall not be used directly in the work and shall invariably be slaked and converted to lime putty before use.

**3.1.3.3 HYDRATED LIME:** Hydrated lime shall be in the form of a fine powder. It shall be supplied in suitable containers such as jute bags lined with water proofing membrane. The bags shall bear marking indicating the class of lime, net weight, date of manufacture and the brand name. It shall be used within 4 months of its date of manufacture.

**STORAGE:** Lime shall be stored in weather 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.

**TESTING:** Chemical and physical requirements of building limes are as per relevant IS. Laboratory tests shall be carried out to check the quality of lime to be used.

### 3.1.4 FINE AGGREGATE

Aggregate most of which passes through 4.75 mm IS sieve is known as fine aggregate. Fine aggregate shall consist of natural sand, crushed stone sand or crushed gravel sand stone dust or marble dust, fly ash and surkhi (crushed brick and cinder) conforming to IS:2686. It shall be hard, durable, chemically inert, clean and free from adherent coatings, organic matter etc, and shall not contain any appreciable amount of clay balls or pellets and harmful impurities eg. Iron pyrites, alkalies, salts, coal, mica, shale or similar laminated materials in such form or in such quantities as to cause corrosion of metal or affect adversely the hardening, the strength, the durability or the appearance of mortar, plaster or concrete. The sum of the percentages of all deleterious materials shall not exceed 5%. Fine aggregate must be checked for organic impurities such as decayed vegetation humps, coal dust etc in accordance with the procedure prescribed in Appendix A of Chapter 3.

**3.1.4.1 SILT CONTENT:** The maximum quantity of silt in sand as determined by the method prescribed in appendix D of Chapter 3 shall not exceed 8%.

3.1.4.2 Fine aggregate containing more than allowable percentage of silt shall be washed so as to bring the silt content within allowable limits for which nothing extra shall be paid.

#### 3.1.4.3 GRADING

On the basis of particle size, fine aggregate is graded into four zones. The grading when determined in accordance with the procedure prescribed in Appendix B of chapter 3 shall be within the limits given in Table 1 below. Where the grading falls outside the limits of any particular grading zone of sieves, other than 600 micron IS sieve, by a total amount not exceeding 5 percent, it shall be regarded as falling within that grading zone.

TABLE 1

IS SIEVE	PERCENTAGE PASSING FOR			
	GRADING ZONE 1	GRADING ZONE -II	GRADING ZONE III	GRADING ZONE IV
10mm	100	100	100	100
4.75mm	90-100	90-100	90-100	95-100
2.36mm	60-95	75-100	85-100	95-100
1.18mm	30-70	55-90	75-100	90-100
600 microns	15-34	35-59	60-79	80-100
300 microns	5-20	8-30	12-40	15-50
150 microns	0-10	0-10	0-10	0-15

- Note 1 :** For crushed stones sands, the permissible limit on 150 micron sieve is increased to 20 percent. This does not affect the 5 percent allowance permitted in 3.1.4.4(e) (1) applying to other sieves.
- Note 2 :** Allowance of 5% permitted in 3.1.4.4 (e) (1) can be split up, for example it could be 1% on each of three sieves and 2% on another or 4% on one sieve and 1% on another.
- Note 3 :** Fine aggregate conforming to Grading Zone IV shall not be used in reinforced cement concrete unless tests have been made to ascertain the suitability of proposed mix proportions.
- Note 4 :** Sand requiring use for mortar for plaster work shall conform to IS:1542 and for masonry work shall conform to IS:2116.

3.1.4.4 Type and grading of fine aggregate to be used shall be specified. It shall be coarse sand, fine sand, stone dust, or marble dust, fly ash and surkhi. Use of sea sand shall not be allowed, unless otherwise specified.

- a) Coarse sand shall be generally river sand. It shall be clean, sharp, angular, gritty to touch and composed of hard silicious material. Its grading shall fall within the limits of grading zone I, II, III of Table 1.
- b) Fine sand shall be either river sand or pit sand or a combination of the two. Its grading shall fall within the limits of Grading Zone IV of Table 1.
- c) Stone dust shall be obtained by crushing hard stones or gravel. Its grading shall fall within the limits of grading zone I, II, III or Table 1.
- d) Marble dust shall be obtained by crushing marble. Its grading shall fall within the limits of grading zone IV of Table 1.
- e) Sand for Masonry Mortar and for Plaster: Sand shall consist of natural sand, crushed stone sand or crushed gravel sand or a combination of any of these. Sand shall be hard, durable, clean and free from adherent coatings and organic matter and shall not contain the amount of clay, silt and fine dust more than specified as under.

**3.1.4.5 DELETERIOUS MATERIALS:** Sand shall not contain any harmful impurities such as iron, pyrites, alkalis, salts, coal or other organic impurities, mica, shale or similar laminated materials, soft fragments, sea shale in such form or in such quantities as to affect adversely the hardening, strength or durability of the mortar.

The maximum quantities of clay, fine silt, fine dust and organic impurities in the sand shall not exceed the following limits:

- 1 Clay, fine silt and fine dust when determined in accordance with IS:23286 (part II) in natural sand or crushed gravel sand and crushed stone sand
  - ← Not more than 5% by mass
  
- 2 Organic impurities when determined in accordance with IS:2386 (part II)
  - ← Colour of the liquid shall be lighter than indicated by the standard specified in IS:2386 (part II).

Grading of sand for use in masonry mortar shall be conforming to IS:2116 (Table 2 below) Grading of sand for use in plaster shall be conforming to IS:1542 (Table 3 below):

**TABLE 2**

**GRADING OF SAND FOR USE IN MASONRY MORTAR AS PER IS:2116-1980**

IS SIEVE DESIGNATION	PERCENTAGE PASSING BY MASS	REF TO METHOD OF TEST
4.75MM	100	IS:2386 (PART I)
2.36 MM	90-100	
1.18 MM	70-100	
600 MICRON	40-100	
300 MICRON	5-70	
150 MICRON	0-15	

**TABLE 3**

**GRADING OF SAND FOR USE IN PLASTER AS PER IS:1542**

IS SIEVE DESIGNATION	PERCENTAGE PASSING
10 MM	100
4.75 MM	95-100
2.36MM	95-100
1.18MM	90-100
600 MICRON	80-100
300 MICRON	20-65
150 MICRON	0-15



**Note :** For crushed stone sands, the permissible limit on 150 micron IS Sieve is increased to 20%. This does not affect the 5% allowance IS:2386 (part 1-1963).

**3.1.4.6 BULKING:** Fine aggregate, when dry or saturated, has almost the same volume but dampness causes increase in volume. In case fine aggregate is damp at the time of proportioning the ingredients for mortars or concrete, its quantity shall be increased suitably to allow for bulking, which shall be determined by the method prescribed in Appendix 'D' of Chapter 3. Table 4 gives the relation between moisture content and percentage of bulking for guidance only.

**TABLE 4**

MOISTURE CONTENT % AGE	BULKING %AGE [BY VOLUME]
2	15
3	20
4	25
5	30

**3.1.4.7 STACKING:** Fine aggregate shall be so stacked as to prevent dust and foreign matter getting mixed up with it as far as practically possible.

**3.1.4.8 MEASUREMENTS:** As the fine aggregate bulks to a substantial extent when partially wet, measurement shall be taken when the stacks are dry or appropriate allowance made for bulking.

**3.1.5 FLY ASH:** Fly ash is a finely divided residue resulting from the combustion of pulverized coal in boilers. Fly ash used shall be as per IS:3812. It shall be clean and free from any contamination of bottom ash, grit or small pieces of pebbles. Fly ash covered in this part is meant for use as a part replacement of fine aggregate in mortar with a view to improve grading and to make uses of its pozzolanic properties.

Fly ash shall be supplied in the following grades corresponding to the properties specified.

Sl.#	GRADE DESIGNATION		GENERAL USE
1	Grade I	➤	For incorporation in cement mortar and concrete and in lime pozzolana mixtures, and for manufacture of Portland pozzolana cement.
2	Grade II	➤	For incorporation in cement mortar and concrete and lime pozzolana mixture.

**Note :** It is obligatory on the part of supplier / manufacture that the fly ash conforms to the requirement mutually agreed upon and shall furnish a certificate to this effect to the purchaser or his representative.

**3.1.5.1 STACKING:** Fly ash shall be protected from dirt collecting on it.

**3.1.5.2 MEASUREMENTS:** Fly ash shall be measured in regular stacks in cubic meters. Alternatively it may also be measured by weight when supplied in bags.

### **3.1.5.3 PREPARATION OF MORTARS AND ITS GRADE**

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

- The grade of masonry mortar will be defined by its compressive strength in  $N/mm^2$  at the age of 28 days as determined by the standard procedure detailed in IS:2250.
- For detail of grades and criteria for selection on masonry mortar, see Appendix E of Chapter 3.

**3.1.5.4** For proportioning the ingredients by volume, the conversion of weight into volume shall be made on the following basis.

a	Dry hydrated lime	⇒	700 kg/cum
b	Burnt clay pozzolane	⇒	860 Kg/cum
c	Lime Pozzolana mixture	⇒	770 Kg/cum
d	Coarse sand (dry)	⇒	1280 kg/cum
e	Fine sand (dry)	⇒	1600 kg/cum
f	Fly ash	⇒	590 Kg/cum

For details of grades and criteria for selection of Masonry Mortars see Appendix 'E' of Chapter 3.

### **3.1.6 M SAND**

The sand manufactured by mechanically crushing granite rock at factory is known as M sand (Manufactured Sand) It shall be clean, hard, durable, chemically inert, free from any coating, organic matter, harmful impurities, deleterious materials, excess fines etc and shall be similar to river / pit sand in all aspects including shape, gradation, strength etc and shall pass relevant laboratory tests. This may be used in concrete and mortar subject to conforming to relevant requirements of IS stipulations for fine aggregate in all aspects as at para 3.1.4 and its sub paras above.

## **3.2 MORTAR**

### **3.2.1 CEMENT MORTAR**

**3.2.2** This shall be prepared by mixing cement and sand with or without the addition of pozzolana in specified proportions as per Appendix E.

**3.2.1.2 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.

**3.2.1.3 MIXING:** The mixing of mortar shall be done in mechanical mixers operated manually or by power as decided by Engineer-in-charge. The Engineer-in-charge 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 is not feasible. In cases, where mechanical mixers are not to be used, the contractor shall take permission of the Engineer-in-charge in writing before the commencement of work.

**3.2.1.4 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 paste of necessary working consistency.

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

### **3.2.2 CEMENT LIME MORTAR**

**3.2.2.1** This shall be prepared by mixing cement, lime putty / dehydrated lime powder and sand in specified proportions. Mixing shall be done in a mechanical mixer operated manually or by power as decided by Engineer-in-charge. The Engineer-in-charge 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 Engineer-in-charge in writing before the commencement of the work.

**3.2.2.2 PROPORTIONING:** Cement, lime putty / dehydrated 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 40,35, 25 cms. Sand shall be measured on the basis of its dry volume.

### **3.2.2.3 MIXING AND GRINDING**

**3.2.2.4 MECHANICAL MIXING:** Lime putty and sand shall be mixed and ground in the manner described before mixing the same with cement. In case where factory made dehydrated 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 the 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.

**3.2.2.5 HAND MIXING:** Cement and sand shall be mixed dry thoroughly on clean and water tight masonry platforms or 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 of workable consistency.

**3.2.2.6 PRECAUTIONS:** Mortar shall be used as soon as possible after mixing and maximum within two hours. Mortar unused for more than two hours shall be rejected and removed from the site of work. Mixture of lime putty and sand can be kept for 72 hours of 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.

### **3.2.3 CEMENT FLY ASH SAND MORTAR**

**3.2.3.1** This shall be prepared by mixing cement, flyash and sand in specified proportion as Appendix G. Mixing shall be done in a mechanical mixer (operated manually or by power) unless otherwise permitted by the Engineer-in-charge in writing. The Engineer-in-charge 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 mixer or where items involving small quantities are to be done or in his opinion the use of mechanical mixer is not feasible. In case, where mechanical mixer is not to be used, the contractor shall take permission of the Engineer-in-Charge in writing before the commencement of the work.

**3.2.3.2 PROPORTIONING:** Cement bag weighing 50 Kg shall be taken as 0.035 cubic metre. Other ingredients in the specified proportions shall be measured using boxes of suitable sizes. Sand and flyash shall be measured on the basis of their dry volume.

### 3.2.3.3 MIXING

**3.2.3.4 MECHANICAL MIXING:** sand and fly ash in the specified proportions shall be mixed dry in a mixer and then the specified quantity of cement shall be added and mixed dry thoroughly. Water shall then be added gradually and wet mixing continued for atleast one minute. Water shall be just sufficient to bring the mortar of the consistency of a workable paste. Only the quantity of mortar which can be used within 30 minutes of its mixing, shall be prepared at a time.

**3.2.3.5 HAND MIXING:** The measured quantity of sand and flyash shall be mixed dry on a clean masonry platform before adding specified quantity of cement to it.. The resulting mixture of cement, sand and flyash shall then be mixed thoroughly being turned over and over, backward 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 clean watertight masonry trough with just sufficient quantity of water, to bring the mortar to a stiff paste of necessary working consistency.

**3.2.3.6 PRECAUTIONS:** shall be same as specified in 3.2.2.6

## APPENDIX 'A'

### TEST FOR ORGANIC IMPURITIES

- \* The aggregate must also be checked for organic impurities such as decayed vegetation humus, coal dust etc.
- \* What is called the colour test is reliable indicator of the presence of harmful organic matter in aggregate, except in the area where there are deposits of lignite.
- \* Fill a 350 ml clear glass medicine bottle upto 70 ml mark with a 3% solution of caustic soda or sodium hydroxide. The sand is next added gradually until the volume measured by the sand layer is 125ml. The volume is then made upto 200 ml by addition of more of solution. The bottle is then stoppered and shaken vigorously and allowed to stand for 24 hours. At the end of this period, the colour of the liquid will indicate whether the sand contains a dangerous amount of organic matter. A colourless liquid indicates a clear sand free from organic matter. A straw coloured solution indicates some organic matter but not enough to be seriously objectionable. Darker colour means that the sand contains injurious amounts and should not be used unless it is washed, and a retest shows that it is satisfactory.
- \* Add 2.5ml of two percent solution of tannic acid in 10 percent alcohol, to 97.5 ml of three percent sodium hydroxide solution. Place in a 350 ml.

bottle, fix the stopper, shake vigorously and allow it to stand for 24 hours before comparison with the solution above the sand.

- \* **Note:** A three percent solution of caustic soda is made by dissolving 3 g of sodium hydroxide in 100 ml of water, preferably distilled. The solution should be kept in a glass of bottle tightly closed with a rubber stopper. Handling sodium hydroxide with moist hands may result in serious burns. Care should be taken not to spill the solution for its highly injurious to clothing, leather, and other materials.

## APPENDIX 'B'

### TEST FOR PARTICLE SIZE [SIEVE ANALYSIS]

**APPARATUS:** Perforated plate sieves of designation 10mm, 4.75mm and fine mesh sieve of designation 2.36 mm, 1.18mm, 600 micron 300 micron and 150 micron should be used.

The balance or scale shall be such that it is readable and accurate to 0.1 percent of the weight of the test sample.

**SAMPLE:** The weight of sample available shall not less than the weight given in the table below. The sample of sieving shall be prepared from the larger sample either by quartering or by means of sample divider:

**TABLE SHOWING MINIMUM WEIGHT FOR SAMPLING**

MAXIMUM SIZE PRESENT IN SUBSTANTIAL PROPORTIONS (MM)	MINIMUM WEIGHT OF SAMPLE FOR ..... (KG)
10	0.5
4.75	0.2
2.36	0.1

### TEST PROCEDURE

The sample shall be brought to an air-dry condition before weighing and sieving. This may be achieved either by drying it at room temperature or by heating at a temperature of 100 degree to 110 degree centigrade. The air dry sample shall be weighed and sieved successively on the appropriate sieves starting with the largest. Care shall be taken to ensure that the sieves are clean before use.

Each sieve shall be shaken separately over a clean tray until not more than a trace passes, but in any case for a period of not less than two minutes. The shaking shall be done with a varied motion, backward and forwards, left to right, circular clockwise and anti-clockwise, and with frequent jarring, so that the materials is kept moving over the sieve surfaces in frequently changing directions. Materials shall not be forced through the sieve by hand pressure, but on sieve coarser than 20mm, placing of particles is permitted. Lumps of fine materials, if present may be broken by gently pressure with fingers against the side of the sieve. Light brushing of under side of the sieve with a soft brush may be used to clear the sieve openings.

Light brushing with a fine camel hair brush may be used on the 150 microns IS sieve to prevent segregation of powder and blinging of apertures. Stiff or worn out brushed shall not be used for this purpose and pressure shall not be applied to the surface of the sieve to force particles through the mesh.

On completion of sieving the material retained on each sieve, together with any material cleaned from mesh, shall be weighed.

#### **REPORTING OF RESULTUS**

The results shall be calculated and reported as:

- a) The cumulative percentage by weight of the total sample passing each of the sieves, to the nearest whole number.

[OR]

- b) The percentage by weight of the total sample passing one sieve and retained on the next smaller sieve, to the nearest 0.1 percent.

**TEST FOR SILT CONTENT**

The sand shall not contain more than 8% of silt as determined by field test with measuring cylinder. The method of determining silt contents by field test is given below:

A sample of sand to be tested shall be placed without drying in a 200 ml measuring cylinder. The volume of the samples shall be such that it fills the cylinder upto 100ml mark.

Clean water shall be added upto 150 ml mark. Dissolve a little salt in the water in the proportion one teaspoon of half a litre. The mixture shall be shaken vigorously, the last few shakes being sidewise direction to level off the sand the contents allowed to settle for three hours.

The height of the silt visible as settled layer above the sand shall be expressed as a percentage of the height of sand below. The sand containing more than the above allowable percentage of silt, shall be washed so as to bring the silt contents within allowed limits.



**BULKING OF FINE AGGREGATE / SANDS [FIELD METHODS]**

Two methods are suggested for determining the bulking of sand / fine aggregate. The procedure may be suitably varied, if necessary. Both depend on the fact that the volume of inundated sand / fine aggregate is the same if the sand / fine aggregate were dry.

**METHOD 1 :** Put sufficient quantity of sand loosely into a container until it is about two – third full. Level the top of the sand and push a steel rule vertically down through the sand at the middle to bottom. Measure the height, suppose this is 'X' cm empty the sand out of the container into another container where none of it is lost. Half fill the first with water. Put back about half the sand and rod it with a steel rod, about 6mm in diameter so that the volume is reduced to a minimum. Then add the remainder and level the top surface of the inundated sand. Measure its depth at the middle with the steel rule, Suppose this is 'Y' cm. The percentage of bulking of the sand due to moisture shall be calculated from the formula.

Percentage bulking =  $(X/Y - 1) \times 100$ .

**METHOD 2 :** In a 250ml measuring cylinder, pour the damp sand consolidated it by stacking until it reaches the 200ml mark (x). Then fill the cylinder with the water and stir the sand well (the water shall be sufficient to submerge the sand completely) it will be seen that the sand surface is now below its original level. Suppose the surface is at the mark of Ycm. The percentage of bulking of sand due to moisture shall be calculated from the formula.

Percentage bulking =  $( X/Y - 1) \times 100$ .

**CRITERIA FOR SELECTION OF MASONRY MORTARS**

- a. The selection of masonry mortars from durability consideration will have to cover both the loading and exposure conditions of the masonry. The masonry mortar shall generally be as specified in (b) to (g).
- b. In case of masonry exposed frequently to rain and where there is further protection by way of plastering or rendering or other finishes, the grade of mortar shall not be less than MM 0.7 but preferably be of grade MM2. where no protection is provided. The grade of mortar for external walls shall not be less than MM2.
- c. In case of load bearing internal walls, the grade of mortar shall preferably by MM0.7 or more for high durability but in no case less than MM 0.5
- d. In case of masonry work in foundations laid below damp proof course, the grade of mortar for use in masonry shall be as specified below:
- e. Where soil has little moisture, masonry mortar of grade not less than MM 0.7 shall be used.
- f. Where soil is very damp, masonry mortar of grade preferably MM2 or more shall be used. But in no case shall the grade of mortar be less than MM2.
- g. For masonry in building subject to vibration of machinery, the grade of mortar shall not be less than MM3.
- h. For parapets, where the height is greater than thrice the thickness, the grade of masonry mortar shall not be less than MM3. In case of low parapets the grade of mortar shall be the same as used in the wall masonry.
- i. The grade of mortar for bedding joints in masonry with large concrete blocks shall not be less than MM3.

**GRADE OF MASONRY MORTARS**

SL.#	GRADE	MORTAR MIX (BY LOOSE VOLUME)					COMPRES- SIVE STRENGTH 28 DAYS
		CEMENT	LIME	LIME POZZOLANA MIXTURE	POZZOLANA	SAND	
1	2	3	4	5	6	7	8 N/mm2
1	MM 0-5	0	1B or E	0	0	3	0.5 to 0.7
2		0	0	0	1(LP-7)	1.25	
3		0	1C OR D	1	0	2	
4	MM 0-7	0	0	0	1(LP-20)	1.5	0.7 TO 1.5
5		0	0	0	1	2.25	
6		1	3C OR D	0	0	12	
7	MM1-5	1	0	0	0	8	1.5 TO 2
8		1	0	0	0	10	
9		0	0	0	1(LP 20)	1.25	
10	MM2	0	0	0	1(LP 40)	2	2 TO 3
11		1	0	0	0	7	
12		1	0	0.4*	0	8.75	
13	MM3	0	1A	0	0	3	3 TO 5
14		0	1A	0	0	2	
15		0	1C OR D	3	0	0	
16	MM4	1	2C OR D	0	0	9	5 TO 7.5
17		0	0	0	1(LP 20)	1	
18		0	0	0	1(LP 40)	1.75	
19	MM5	0	1C OR D	2*	0	0	7.5 AND ABOVE
		1	1C OR D	0	0	0	
		1	0	0	0	6	
	MM 7.5	0	1A	0	0	1	7.5 AND ABOVE
		11	0	0.21*	0	4.2	
		0	0	0	1(LP 40)	1.5	
	MM 7.5	1	0	0.4*	0	7.5	7.5 AND ABOVE
		1	0	0	2(LP 20)	12	
		1	0 TO ¼ B,C,D OR E	0	0	4	
	MM 7.5	1	0	0	0	5	7.5 AND ABOVE
		0	1	0	0	1	
		1	0	0.4	0	6.25	
	MM 7.5	1	0	0.4	0	5	7.5 AND ABOVE
		1	¼ C OR D	0	0	3	
		1	½ C OR D	0	0	4.5	
	MM 7.5	1	0	0	0	4	7.5 AND ABOVE
		11	0	0.2*	0	2.1	
		1	0	0	0	3	
	MM 7.5	1	0	0.4	0	3.75	7.5 AND ABOVE
		1	0	0	1(LP-20)	8	

**Note I** : A, B, C D & E denote the classes of limes to be used (See IS:712-1984 specification for building limes).

**Note II** : The strength values of lime mortar given in the table are after wet grinding of the mortar ingredients.

**Note III** : The compressive strength shall be determined in accordance with the procedure given in IS:2250-1981.

\* Pozzolana of minimum lime reactivity of 4N/mm<sup>2</sup>

The ratio by volume corresponds approximately to cement pozzolana ratio of 0:8:02 by weight. In this case, only ordinary Portland cement is to be used.

□ □ □ □ □ □ □ □ □ □

## CHAPTER 4

### CONCRETE WORK

#### 4.1 MATERIALS

4.1.1 Water, cement, lime, fine aggregate or sand, surkhi, cinder and fly ash shall be as specified in Chapter 3 Mortar.

#### 4.1.2 COARSE AGGREGATE

4.1.2.1 **General:** Aggregate most of which is retained on 4.75 mm. Sieve and contains only as much fine material as is permitted in IS:383 for various sizes and grading is known as coarse aggregate. Coarse aggregate shall be specified as stone aggregate, gravel or brick aggregate and it shall be obtained from approved / authorized sources.

- a) **STONE AGGREGATE:** It shall consist of naturally occurring (uncrushed, crushed or broken stones. It shall be hard, strong, dense, durable and clean. It shall be free from veins, adherent coating injurious amounts of disintegrated pieces, alkali, vegetable matter and other deleterious substances. It shall be roughly cubical in shape. Flaky and elongated pieces shall be avoided. Shall conform to IS: 383 unless otherwise specified.
- b) **GRAVEL:** It shall consist of naturally occurring (uncrushed, crushed or broken) river bed single or pit gravel. It shall be sound, hard and clean. It shall be free from flat particles of shales or similar laminated material, powdered clay, silt, loam, adherent coatings, alkali, vegetable matter and other deleterious substances. Pit gravel shall be washed if it contains soil materials adhering to it. These shall conform to IS:383 unless otherwise specified.
- c) **BRICK AGGREGATE:** Brick aggregate shall be obtained by breaking well burnt or over burnt dense brick/brick bats. They shall be homogeneous in texture, roughly cubical in shape and clean. They shall be free from unburnt clay particles, soluble salt, silt, adherent coating of soil, vegetable matter and other deleterious substances. Such aggregates should not contain more than one percent of sulphates and should not absorb more than 10% of their own mass of water, when used in cement concrete and 20% when used in lime concrete. It shall conform to IS:306-1983 unless otherwise specified.
- d) Light weight aggregates such as sintered fly ash aggregate may also be used provided the Engineer-in-charge is satisfied with the data on the properties of concrete made with them.

**4.1.2.2 DELETERIOUS MATERIAL:** Coarse aggregate shall not contain any deleterious material, such as pyrites coal, lignite, mica, shale or similar laminated material, clay, alkali, soft fragments, sea shells and organic impurities in such quantity as to affect the strength or durability of the concrete. Coarse aggregate to be used for reinforced cement concrete shall not contain any material liable to attack the steel reinforcement. Aggregates which are chemically reactive with alkalies of cement shall not be used. The maximum quantity of deleterious material shall not be more than five percent of the weight of coarse aggregate when determined in accordance with IS:2386(I).

**4.1.2.3 SIZE AND GRADING**

- i) **Stone aggregate and gravel:** It shall be either graded or single sized as specified. Nominal size and grading shall be as under:
  - i. Nominal sizes of graded stone aggregate or gravel shall be 40, 20, 16 or 12.5 mm as specified. For any one of the nominal sizes, the proportion of other sizes shall be in accordance with Table 1.

**TABLE 1**

**GRADED STONE AGGREGATE OR GRAVEL**

IS SIEVE	PERCENTAGE PASSING (BY WEIGHT) FOR NOMINAL SIZE OF			
	40MM	20MM	16MM	12.5MM
DESIGNATION				
75mm	100	-	-	-
37.5mm	95 to 100	100	-	-
19mm	30 to 70	95 to 100	100	-
16mm	-	-	95-100	100
11.2mm	-	-	-	90-100
9.5mm	10 to 35	25 to 55	30 to 70	40-85
4.75mm	0 to 5	0 to 10	0 to 10	0 to 10

- b) Nominal sizes of single sized stone aggregate or gravel shall be 63,40,20,16,12.5 or 10mm as specified. For any one of the normal size, the proportion of other sizes shall be in accordance with Table 2.

**TABLE 2**  
**SINGLE SIZED (UNGRADED) STONE AGGREGATE OR GRAVEL]**

IS SIEVE	PERCENTAGE PASSING (BY WEIGHT) FOR NOMINAL SIZE OF				
	40MM	20MM	16MM	12.5MM	10MM
DESIGNATION					
63mm	100	—	—	—	—
40mm	85-100	100	—	—	—
20mm	0-25	85-100	100	—	—
16mm	—	—	85-100	100	—
12.5mm	—	—	—	85-100	100
10mm	0-5	0-20	0-20	0-20	85-100
4.75mm	—	0.5	0-5	0-5	0-20
2.36mm	—	—	—	—	0-5

- c) When stone aggregate or gravel brought to site is single sized (ungraded), it shall be mixed with single sizes aggregate of different sizes in the proportion to be determined by field tests to obtain graded aggregate of specified nominal size. For the required nominal size, the proportion of other sizes in mixed aggregate shall be in accordance with Table 1. Recommended proportions by volume for mixing of different sizes of single size (ungraded) aggregate to obtain the required nominal size of graded aggregate are given in Table 3.

**TABLE 3**  
**SINGLE SIZED (UNGRADED) STONE AGGREGATE OR GRAVEL**

CEMENT CONCRETE	NOMINAL SIZE OF GRADED AGGREGATE REQUIRED	PARTS OF SINGLE SIZE AGGREGATE OF SIZE				
		50MM	40MM	20MM	12.5MM	10MM
1:6:12	63	9	—	3	—	—
1:6:12	40	—	9	3	—	—
1:5:10	63	7½	—	2½	—	—
1:5:10	40	—	7½	2½	—	—
1:4:8	63	6	—	2	—	—
1:4:8	40	—	6	2	—	—
1:3:6	63	4½	—	1½	—	—
1:3:6	40	—	4½	1½	—	—
1:3:6	20	—	—	4½	—	1½
1:2:4	40	—	2½	1	—	½
1:2:4	20	—	—	3	—	1
1:2:4	12.5	—	—	—	3	1
1:1½:3	20	0	0	2	—	1

- i) **Note** : The proportion indicated in table 3 above are by volume when considered necessary, these proportions may be varied marginally by Engineer-in-charge after making sieve analysis of aggregate brought to site for obtaining required graded aggregate. No adjustments in rate shall be made for any variation in the proportions so ordered by the Engineer-in-charge. If single size coarse aggregate are not premixed at site to obtain the graded coarse aggregate required for the mix the volume of single size aggregate required for the mix shall be suitably increased to account for reduction in total volume at the site of mixing.
- ii) **BRICK AGGREGATE**: Nominal size of brick aggregate shall be 40mm and its grading shall be as specified in Table 4.

**TABLE 4**  
**BRICK AGGREGATE**

IS Sieve Designation	Percentage passing (By Weight)
75 mm	100
37.5mm	95-100
20mm	45-100
4.75mm	0-5

- 4.1.2.4 STACKING**: Aggregate shall be stacked on a hard, dry and level patch of ground. When stack piling, the aggregate shall not form pyramids resulting in segregation of different sized materials. It shall be stacked separately according to nominal size of coarse aggregate. Stacking shall be done in regular stacks of height not exceeding 100 cm.
- 4.1.2.5 TESTING**: Coarse aggregate shall be tested for the followings (as per IS:2386):
- a) Determination of particle size and shape
  - b) Estimation of organic impurities (As per IS:2386 part II)
  - c) Surface moisture
  - d) Determination of 10% fine value
- 4.1.2.6 MEASUREMENTS**: The aggregates shall be measured in stacks and paid for after making a deduction of 7.5% of the gross measurements of stacks in respect of aggregates of nominal size 40mm and above. Unless otherwise specified no deduction from the gross measurements of stocks is to be made in respect of aggregates of nominal size below 40 mm.



#### 4.1.3 CHEMICAL ADMIXTURES

When required, admixtures of approved quality shall be mixed with concrete, as specified. The admixtures shall conform to IS:9103.

4.1.3.1 Admixtures may be any one of the following classes for use in concrete:

- a) Water-reducing Admixtures
- b) Retarding Admixtures
- c) Accelerating Admixtures
- d) Water reducing and retarding Admixtures
- e) Water reducing and accelerating Admixtures
- f) Permeability reducing (water proofing) Admixtures.

4.1.3.2 Liquid admixtures: Admixtures introduced into the concrete as liquids generally fall into the following categories:

- a) Air entraining
- b) Water reducing
- c) Water reducing retarders
- d) Retarders
- e) Water reducing accelerators
- f) Accelerators

4.1.3.3 Dosage of these admixtures may vary according to manufacturers specification.

4.1.3.4 Two or more admixtures may not be compatible in the same solution. It is therefore mandatory that when two admixture manufactured by the same manufacturer is being used simultaneously; the manufacturer shall certify their compatibility. In case the two or more admixtures are produced by different manufacturers, then, before their use in concrete, test shall be performed by the manufacturer to establish their compatibility, all such test reports shall be furnished to the Engineer-in-Charge for his approval before their use in concrete.

4.1.3.5 Some admixtures may be in the form of powder, particle or high concentration liquids which may require mixing with water prior to dosing. Under these conditions water in solution shall be considered as part of total water content in the batch in order to maintain the water- cement ratio.

4.1.3.6 Admixture manufacturer's recommendation shall be carefully followed so as to ensure complete solution of the product or to prepare a standard solution of uniform strength for easier use.

- 4.1.3.7 Certain admixtures may contain significant amounts of finely divided insoluble materials or active ingredients which may or may not be readily soluble. It is essential for such admixtures that precautions are taken to ensure that these constituents are kept in a state of uniform suspension before actual batching. Then relatively small amounts of powdered admixtures are to be used directly, these shall be pre-blended with cement .
- 4.1.3.8 Admixtures are sold under various trade names and may be in the form of liquids or powders. The proprietary name and the net quantity of content shall be clearly indicated in each package or container of admixtures. The admixtures shall be uniform within each batch and uniform between all batches.
- 4.1.3.9 No admixtures shall be accepted for use in concrete unless these are tested in accordance with I.S 9103 and the test results are approved by the Engineer-in-charge.
- 4.1.3.10 Following shall be kept in view while admixtures are used in concrete :
- The admixture shall comply with IS 9103. Previous experience, data and also manufacturers specification for the material should be considered in relation to the likely standards of supervision and workmanship to the work being specified.
  - Admixture should not impair durability of concrete nor combine with constituent to form harmful compounds nor increase the risk of corrosion of reinforcement.
  - The workability, compressive strength and the slump loss of concrete with and without use of admixture shall be established during the trial mixes before use of admixtures.
  - The relative density of liquid admixture shall be checked for each drum containing admixtures and compared with specified value before acceptance.
  - The chloride content of admixture shall be independently tested for each batch before acceptance.
  - If two or more admixtures are used simultaneously in the same concrete mix data should be obtained to assess their interaction and ensure their compatibility.

## **4.2 CEMENT CONCRETE**

- 4.2.1 The concrete shall be in grade designated as under :

**TABLE 5**  
**GRADES OF CONCRETE**

GROUP	GRADE DESIGNATION	SPECIFIED CHARACTERISTIC COMPRESSIVE STRENGTH OF 150MM CUBE AT 28 DAYS IN N/MM <sup>2</sup>
(1)	(2)	(3)
Ordinary Concrete	M10	10
	M15	15
Standard Concrete	M20	20
	M25	25
High Strength Concrete	M30	30
	M35	35
	M40	40
	M45	45
	M50	50
	M55	55
High Strength Concrete	M60	60
	M65	65
	M70	70
High Strength Concrete	M75	75
	M80	80

**Notes:**

- i) In the designation of concrete mix M refers to the mix and the number to the specified compressive strength of 150mm size cube at 28 days, expressed in N/mm<sup>2</sup>.
- ii) For concrete of compressive strength greater than M55, design parameters given in the standard may not be applicable and the values may be obtained from specialized literatures and experimental result.

4.2.1.1 The characteristic strength is defined as the strength of material below which not more than 5 percent of the test results are expected to fall.

TABLE 6

**MINIMUM CEMENT CONTENT, MAXIMUM WATER CEMENT RATIO AND  
MINIMUM GRADE OF CONCRETE FOR DIFFERENT EXPOSURES WITH  
NORMAL WEIGHT AGGREGATES OF 20MM NOMINAL MAXIMUM SIZE  
(CLAUSES 4.2.1.1)**

Sl.#	Exposure	Plain concrete			Reinforced concrete		
		Minimum cement content kg/m <sup>3</sup>	Maximum free water cement ratio	Minimum grade of concrete	Minimum cement content kg/m <sup>3</sup>	Maximum free water cement ratio	Minimum grade of concrete
1	2	3	4	5	6	7	8
1	Mild	220	0.60	—	300	0.55	M20
2	Moderate	240	0.60	M15	300	0.50	M25
3	Severe	250	0.50	M20	320	0.45	M30
4	Very Severe	260	0.45	M20	340	0.45	M35
5	Extreme	280	0.40	M25	360	0.40	M40

**Notes:**

1. Cement content prescribed in this table is irrespective of the grades of cement. The additions such as fly or ground granulated blast furnace slag may be taken into account in the concrete composition with respect to the cement content and water cement ratio if the stability is established and as long as the maximum amount taken into account do not exceed the limit of pozzolona and slag specified in IS:1489 (part 1) and IS:455 respectively.
2. Minimum grade for plain concrete under mild exposure condition is not specified.
3. The above minimum cement content and maximum water cement ratio apply only to 20 mm nominal maximum size aggregate. For other size aggregate, these should be changed as per table 6 of IS:456:2000.
4. The minimum grade of concrete for plain and reinforced concrete shall be as per Table 6.
5. Adjustments to minimum cement contents for aggregates other than 20mm nominal minimum size.

Sl.#	NOMINAL MAXIMUM AGGREGATE SIZE MM	ADJUSTMENTS TO MINIMUM CEMENT CONTENTS IN KG/CUM
1	10	+ 40
II	20	0
III	40	- 30

4.2.1.2 Concrete of grades lower than those given in Table 5 may be used for plain concrete constructions, lean concrete, simple foundations, foundation for masonry walls and other simple or temporary reinforced concrete construction.

#### 4.2.2 WORKABILITY OF CONCRETE

4.2.2.1 The concrete mix proportion chosen should be such that the concrete is of adequate workability for the placing conditions of the concrete and can properly be compacted with the means available. Ranges of workability of concrete measured in accordance with IS:1199 are given below:

PLACING CONDITIONS	DEGREE OF WORKABILITY	SLUMP (MM)
1	2	3
Blinding concrete; shallow sections; pavements using pavers	Very low	See 4.2.22
Mass concrete; lightly reinforced sections in slabs, beams, wall, columns: floor; hand placed pavements, canal lining, strip footings	Low	25-75
Heavily reinforced sections in slabs, beams, walls, columns	Medium	50-100
Slip form work; pumped concrete	Medium	75-100
Trench fill; in-situ piling	High	100-150
Tremie concrete	Very high	See 4.2.2.3

**Note:** For most of the placing conditions, internal vibrators (needle vibrators) are suitable. The diameter of the needle shall be determined based on the density and spacing of reinforcement bars and of section. For tremie concrete, vibrators are not required to be used (see also 4.2.7).

4.2.2.2 In the 'very low' category of workability where strict control is necessary, for example. Pavent quality, quality concrete, measurement of workability by determination of compacting factor will be more appropriate than slump (see IS:1199) and a value of compacting factor of 0.75 to 80 is suggested.

4.2.2.3 In the 'very high' category of workability, measurement of workability by determination of flow will be appropriate (see IS:9103).

**TABLE 7**  
**PROPORTIONS FOR NOMINAL MIX CONCRETE**  
**(CLAUSE 4.2.3.2)**

GRADE OF CONCRETE	TOTAL QUANTITY OF DRY AGGRGATES BY MASS PER 50 KG OF CEMENT, TO BE TAKEN AS THE SUM OF THE INDIVIDUAL MASSES OF FINE AND COARSE AGGREGATE KG. MAX	PROPORTION OF FINE AGGREGATE TO COARSE AGGREGATE (BY MASS)	QUANTITY OF WATER PER 50 KG OF CEMENT MAX 1.
1	2	3	4
M5	800	Generally 1:2 but subject to an upper limit of 1:1½ and a lower limit of 1:2 ½	60
M7.5	625		45
M10	480		34
M15	330		32
M20	250		30

**Note:** The proportion of the fine of coarse aggregates should be adjusted from upper limit progressively as the grading of fine aggregates becomes finer and the maximum size of coarse aggregate becomes larger. Graded coarse aggregate shall be used.

**Example:** For an average grading of fine aggregate (that is Zone II of table 4 of IS:383) the proportions shall be 1:1½ and 1:2½ for a maximum size of aggregates 10mm, 20mm, and 40mm respectively.

#### 4.2.3 CONCRETE MIX PROPORTIONING

4.2.3.1 The determination of the proportion of cement, aggregate and water to attain the required strengths shall be made as follows:

- a) By designing the concrete mix; such concrete shall be called 'Design Mix concrete' for details reference may be made to RCC chapter.
- b) By adopting nominal concrete mix; such concrete shall be called 'Nominal mix concrete'.

Design mix concrete is preferred to nominal mixes. If design mix concrete can not be used for any reason on works for grade M20 or lower nominal mixes may be used with the permission of Engineer-in-charge, which, however, is likely to involve a higher cement content.

**4.2.3.2 NOMINAL MIX CONCRETE:** Nominal Mix concrete may be used for concrete of M20 or lower. The proportions of materials for nominal mix concrete shall be in accordance with Table 7

The cement content of the mix specified in table 7 for any nominal mix shall be proportionately increased if the quantity of water in the mix has to be increased to overcome the difficulties of placement and compaction. So that the water cement ratio as specified is not exceeded.

#### **4.2.4 BATCHING**

To avoid confusion and error in batching, consideration should be given to using the smallest practical number of different concrete mixes on any site or in any one plant. In batching concrete, the quantity of both cement and aggregate shall be determined by mass. Admixture if solid, by mass, Liquid admixture may however be measured in volume or mass, Water shall be weighed or measured by volume in a calibrated tank (see also IS:4925)

Ready mixed concrete supplied by ready – mixed concrete plant shall be preferred. For large and medium project sites the concrete shall be sourced from ready mixed concrete plants or from on site or off site batching and mixing plants (see IS:4926)

4.2.4.1 Except where it can be shown to the satisfaction of the Engineer-in-charge that supply of properly graded aggregate of uniform quality can be maintained over a period of work, the grading aggregate should be controlled by obtaining the coarser aggregate in different sizes and blending them in the right proportions.

When required, the different sizes being stocked in separate stock piles. The material should be stock piled for several hours preferably a day before use. The grading of coarse and fine aggregate should be checked as frequently as possible, the frequency for a given job being determined by the Engineer-in-charge to ensure that the specified grading is maintained.

4.2.4.2 The accuracy of the measuring equipment shall be within  $\pm 2$  percent of the quantity of cement being measured and within  $\pm 3$  percent of the quantity of aggregate, admixtures and water being measured.

4.2.4.3 Proportion / Type and grading of aggregates shall be made by trial in such a way so as to obtain densest possible concrete. All ingredients of the concrete should be used by mass only.

4.2.4.4 Volume batching may be allowed only where weigh-batching is not practical provided accurately bulk densities of materials to be actually used in concrete

have earlier been established. Allowance for bulking shall be made in accordance with IS:2386 (part 3) The mass volume relationship should be checked as frequently as necessary, the frequency for the given job being determined by Engineer-in-charge to ensure that the specified grading is maintained.

- 4.2.4.5 It is important to maintain the water-cement ratio constant at its correct value. To this end, determination of moisture contents in both fine and coarse aggregates shall be made as frequently as possible, the frequency for a given job being determined by the Engineer-in-charge according to weather conditions. The amount of the added water shall be adjusted to compensate for any observed variation in the moisture contents. For the determination of moisture content in the aggregate IS:2386 (part 3) may be referred to. To allow for the variation in mass to aggregate due to variations in their moisture content suitable adjustments in the masses of aggregates shall also be made. In the absence of exact data only in the case of nominal mixes, the amount of surface water may be estimated from the values given in Table 8.

**TABLE 8**  
**SURFACE WATER CARRIED BY AGGREGATE**  
**(CLAUSE 4.2.4.5)**

SL.#	AGGREGARE	APPROXIMATE QUANTITY OF SURFACE WATER PERCENT BY MASS	litre/m <sup>3</sup>
1	2	3	4
i	Very wet sand	7.5	120
ii	Moderately wet sand	5.0	80
iii	Moist sand	2.5	40
iv	Moist gravel or crushed rock	1.25-2.5	20-40

Coarser the aggregate, lesser the water it will carry.

- 4.2.4.6 No substitutions in materials used on the work or alteration in the established proportion as permitted in 4.2.4.4. and 4.2.4.5 shall be made without additional tests to show that the strength of concrete are satisfactory.

#### 4.2.5 MIXING

Concrete shall be mixed in mechanical batch type concrete mixers conforming to IS:1791 having two blades and fitted with power loader (lifting hopper type). Half bag mixers and mixers without lifting hoppers shall not be used for mixing concrete. In exceptional circumstances, such as mechanical break down of mixer, work in



remote areas or power breakdown and when the quantity of concrete work is very small, hand mixing may be done with the specific prior permission of the Engineer-in-charge in writing subject to adding 10% extra cement. When hand mixing is permitted, it shall be carried out on a water tight platform and care shall be taken to ensure that mixing is continued until the concrete is uniform in colour and consistency. Before mixing the brick aggregate shall be well soaked with water for a minimum period of two hours and stone aggregate or gravel shall be washed with water to remove, dirt, dust and other foreign materials. For guidance, the mixing time may be 1½ to 2 minutes, for hydrophobic cement it may be taken 2½ to 3 minutes.

**4.2.5.1 POWER LOADER:** Mixer will be fitted with a power loader complying with the following requirements:

- i) The hopper shall be of adequate capacity to receive and discharge the maximum nominal batch to unmixing materials without spillage under normal operating conditions on a level site.

**NOTE:** In such a case the volume of the maximum nominal batch of mixed materials is 50% greater than the nominal mixed batch capacity.

- ii) The design of the loader shall be such that it allows the loading hopper to be elevated to such a height that the center line of the chute plate of the hopper when in discharge position is at an angle of not less than 50° to the horizontal. A mechanical device to aid discharge of the contents as quickly as possible from the hopper to the drum may also be provided. Even when a mechanical device is provided, it is recommended that the angles of center line of the chute plate of the hopper when in discharge position should be as large as practicable preferably not less than 40° to horizontal.
- iii) When the means of raising and lowering the loading hopper includes flexible wire ropes winding on to a drum or drums, the method of fastening the wire to rope to the drums shall be such as to avoid as far as possible any tendency to cut the strands of the ropes and the fastening should preferably be positioned clear of the barrel of the drum for example, outside the drums flange. When the loading hopper is lowered to its normal loading position, there should be at least one end a half drums of rope on the drum.
- iv) Clutch brake and hydraulic control lever shall be designed so as to prevent displacement by liberation or by accidental contact with any person.
- v) Clutch and brake control arrangements shall also be so designed that the operator can control the falling speed of the loader.
- vi) Safety device shall be provided to secure the hopper in raised position when not in use.

#### 4.2.5.2 PRECAUTIONS TO BE TAKEN WHILE USING A WEIGH BATCHER

- i) **Calibration of dial regularly at site:** EIC should ensure calibration of weigh batch periodically and keep record of the same. The machine should be installed to perfect level. The material should be loaded in the center of bucket. The machine should be kept clean.
- ii) **Installation of the machine in perfect level:** The weigh batcher or the platform scale should be fixed in perfect level.

**4.2.5.3 MIXING EFFICIENCY:** The mixer shall be tested under normal working condition in accordance with the method specified in IS:4643 with a view to check its ability to mix the ingredients to obtain concrete having uniformity with in the prescribed limits. The uniformity of mixed concrete shall be evaluated finding the percentage variation in quantity (mass in water) of cement, fine aggregate and coarse aggregate in a freshly mixed batch of concrete.

The percentage variation between the quantities of cement, fine aggregate and coarse aggregate (as found by weighing in water) in the two halves of a batch and average of the two halves of the batch shall not be more than the following limits:

Cement	8%
Fine aggregate	6%
Coarse aggregate	5%

**4.2.5.4 MACHINE MIXING:** The mixer drum shall be flushed clean with water. Measured quantity of coarse aggregate shall be placed first in the hopper. This shall be followed with measured quantity of fine aggregate and the cement. In case fine aggregate is damp, half the required quantity; of coarse aggregate shall be placed in the hopper, followed by fine aggregate and cement. Finally the balance quantity of coarse aggregate shall be fed in the hopper and then the dry materials are slipped into the drum by raising the hopper. The dry material shall be mixed for atleast four turns of the drum. While the drum is rotating, waters shall be added gradually to achieve the water cement ratio as specified or as required by the Engineer-in-charge. After adding water, the mixing shall be continued until concrete of uniform colour, uniformly distributed material and consistency is obtained. Mixing shall be done for atleast two minutes after adding water. If there is segregation after unloading from the mixer, the concrete should be remixed.

The drum shall be emptied before recharging. When the mixer is closed down for the day or at any time exceeding 20 minutes, the drum shall be flushed cleaned with water.

**4.2.5.5 HAND MIXING:** When hand mixing has been specifically permitted in exceptional circumstance by the Engineer-in-Charge in writing, subjected to adding 10% extra cement, it shall be carried out on a smooth clean and water tight platform of suitable size. Measured quantity of sand shall be spread evenly on the platform and the cement shall be dumped on the sand and distributed evenly. Sand and cement shall be mixed intimately with spade until mixture is of even colour throughout. Measured quantity of coarse aggregate shall be spread on top of cement sand mixture and mixing done by shovelling and turning till the coarse aggregate gets evenly distributed in the cement sand mixture. Three quarters of the total quantity of water required shall be added in a hollow made in the middle of the mixed pile and the material is turned towards the middle of pile with spade. The whole mixture is turned slowly over and again and the remaining quantity of water is added gradually. The mixing shall be continued until concrete of uniform colour and consistency is obtained. The mixing platform shall be washed and cleaned at the end of the day.

**4.2.5.6** Method for converting mix proportion by weight to volume for concrete of specified grade based on grades and proportions of nominal mix concrete shall be as prescribed in IS:456-2000.

**4.2.5.7 TRANSPORTATION AND HANDLING:** Concrete shall be transported from the mixer to the place of laying as rapidly as possible by methods which will prevent the segregation or loss of any of the ingredients duly maintaining the required workability.

During hot or cold weather, concrete shall be transported in deep containers. Other suitable methods to reduce the loss of water by evaporation in hot weather and heat loss in cold weather may also be adopted.

#### **4.2.6 PLACING**

The concrete shall be deposited as nearly as practicable in its final position to avoid rehandling. It shall be laid gently (not be thrown) and shall be thoroughly vibrated and compacted before setting commences and should not be subsequently disturbed. Method of placing shall be such as to preclude segregation. Care shall be taken to avoid displacement of reinforcement or movement of form work and damage due to rains. As a general guidance, the maximum free fall of concrete may be taken as 1.5 metre.

#### **4.2.7 COMPACTATION**

Concrete shall be thoroughly compacted and fully worked around embedded fixtures and into corners of the form work. Compaction shall be done by mechanical vibrator of appropriate type till a dense concrete is obtained. The mechanical vibrators shall conform to IS:2505, IS:2506, IS:2514 and IS:4656. To prevent segregation, over vibration shall be avoided.

Compaction shall be completed before the initial setting starts. For the items where mechanical vibrators are not to be used, the contractor shall take permission of the Engineer-in-charge in writing before the starts of the work. After compaction the top surface shall be finished even and smooth with wooden trowel before the concrete begins to set.

#### **4.2.8 CONSTRUCTION JOINTS**

- 4.2.8.1 Concreting shall be carried out continuously upto construction joints. The position and arrangement of construction joints shall be as shown in the structural drawings or as directed by the Engineer-in-Charge. Number of such joints shall be kept minimum. Joints shall be kept as straight as possible. Construction joints should comply with IS:11817.
- 4.2.8.2 When the work has to be resumed on a surface which has hardened, such surface shall be roughened. It shall then be swept clean and thoroughly wetted. For vertical joints, neat cement slurry, of workable consistency by using 2 Kgs of cement per sqm shall be applied on the surface before it is dry. For horizontal joints, the surface shall be covered with a layer of mortar about 10-15mm thick composed of cement and sand in the same ratio as the cement and sand in concrete mix. This layer of cement slurry of mortar shall be freshly mixed and applied immediately before placing of the concrete.
- 4.2.8.3 Where the concrete has not fully hardened, all laitance shall be removed by scrubbing the wet surface with wire or bristle brushes, care being taken to avoid dislodgement of particles of coarse aggregate. The surface shall be thoroughly wetted and all free water removed. The surface shall then be coated with neat cement slurry @ 2 kgs of cement per sqm. On this surface, a layer of concrete not exceeding 150mm in thickness shall first be placed and shall be well rammed against corners and close spots work, thereafter, shall proceed in the normal way.

#### **4.2.9 CONCRETING UNDER SPECIAL CONDITIONS**

- 4.2.9.1 **WORK IN EXTREME WEATHER CONDITIONS:** During hot and cold weather, the concreting shall be done as per the procedure set out in IS:7861 (part -1) and IS:7861 (Part II) respectively. Concreting shall not be done when the temperature falls below 4.5 deg C. In cold weather, the concrete placed shall be protected against frost. During hot weather, it shall be ensured that the temperature of wet concrete does not exceed 38 deg C.
- 4.2.9.2 **UNDER WATER CONCRETING:** concrete shall not be deposited under water if it is practicable to de-water the area and place concrete in the regular manner. When it is necessary to deposit concrete under water, the methods, equipment, materials and proportions of the mix to be used shall be submitted to and approved by the EIC before the work is started.

Under water concrete should have a slump recommended in 4.2.2. The water cement ratio shall not exceed 0.6 and may need to be smaller, depending on the grade of concrete or the type of chemical attack. For aggregates of 40mm maximum particle size, the cement content shall be atleast 350 kg/m<sup>3</sup> of concrete.

**4.2.9.3 CONCRETE IN SEA WATER:** Concrete in sea – water or exposed directly along the sea-coast shall be at least M20 grade in the case of plain concrete and M 30 in case of reinforced concrete. The use of slag or pozzolana cement is advantageous under such conditions.

- i) Special attention shall be given to the design of the mix to obtain the densest possible concrete slag, broken brick, soft lime stone, soft sand stone, or other porous or weak aggregates shall not be used.
- ii) As far as possible, preference shall be given to precast members, unreinforced, well cured and hardened, without sharp corners, and having trowel – smooth finished surfaces, free from crazing, cracks or other defect. Plastering should be avoided.
- iii) No construction joints shall be allowed within 600mm below low water level or within 600mm of the upper and lower planes of wave action. Where unusually severe conditions of abrasion are anticipated. Such parts of the work shall be protected by bituminous or silico – fluoride coating or stone facing bedded with bitumen.
- iv) In reinforced concrete structures, care shall be taken to protect the reinforcement from exposure to saline atmosphere during storage, fabrication and use. It may be achieved by treating the surface of reinforcement with cement wash or by suitable methods.

#### **4.2.10 CURING**

Curing is the process of preventing loss of moisture from the concrete. The following methods shall be employed for effecting curing.

**4.2.10.1 Moist curing :** Exposed surfaces of concrete shall be kept continuously in a damp or wet condition by ponding or by covering with a layers of sacking, canvas, Hessians or similar materials and kept constantly wet for atleast 7 days from the date of placing concrete in case of ordinary Portland cement and atleast 10 days where mineral admixtures or blended cements are used. The period of curing shall not be less than 10 days for concrete exposed to dry and hot weather conditions. In the case of concrete where mineral admixtures or blended cements are used. It is recommended that above minimum periods may be extended to 14 days.

4.2.10.2 Membrane Curing: Approved curing compounds may be used in lieu of moist curing with the permission of the Engineer-in-charge. Such compound shall be applied to all exposed surfaces of the concrete as soon as possible after the concrete has set. Impermeable membrane such as polythene sheet covering the concrete surface may also be used to provide effective barriers against the evaporation.

4.2.10.3 Freshly laid concrete shall be protected from rain by suitable covering.

4.2.10.4 Over the foundation concrete, the masonry work may be started after 48 hours of its compaction but the curing of exposed surfaces of cement concrete shall be continued along with the masonry work for atleast 7 days. And where cement concrete is used as base concrete for flooring, the flooring may be commenced before the curing period of base concrete is over but the curing of base concrete shall be continued along with top layer of flooring for a minimum period of 7 days.

#### **4.2.11 TESTING OF CONCRETE WILL BE DONE AS DESCRIBED IN CHAPTER OF RCC**

#### **4.2.12 FORM WORK**

Form work shall be as specified in RCC chapter and shall be paid for separately unless otherwise specified.

#### **4.2.13 FINISHES**

Plastering and special finishes other than those, obtained through form work shall be specified and paid for separately unless otherwise specified.

#### **4.2.14 DURABILITY OF CONCRETE**

A durable concrete is one that performs satisfactorily in the working environment during its anticipated exposure conditions during service. The materials and mix proportions shall be such as to maintain its integrity and, if applicable, to protect, reinforcement from corrosion.

The factor influencing durability include:

- a) the environment ;
- b) the cover to embedded steel
- c) the type and quality of constituent materials;
- d) the cement content and water/ cement ratio of the concrete;
- e) workmanship, to obtain full compaction and efficient curing; and
- f) the shape and size of the member.

#### 4.2.14.1 Requirements for Durability

4.2.14.1.1 General Environment: The general environment to which the concrete will be exposed during its working life is classified into five levels of severity, that is, mild, moderate, severe, very severe and extreme as described in Table 10.

**TABLE 10**  
**ENVIRONMENTAL EXPOSURE CONDITIONS**

SL.#	ENVIRONMENT	EXPOSURE CONDITIONS
1	2	3
i)	Mild	Concrete surfaces protected against weather or aggressive conditions, except those situated in coastal area.
ii)	Moderate	Concrete surfaces sheltered from severe rain or freezing whilst wet concrete exposed to condensation and rain Concrete continuously underwater Concrete in contact or buried under non-aggressive soil / ground water Concrete surfaces sheltered from saturated salt air in coastal area.
iii)	Severe	Concrete surfaces exposed to severe rain, alternate wetting and drying or occasional freezing whilst wet or severe condensation. Concrete completely immersed in sea water Concrete exposed to coastal environment.
iv)	Very severe	Concrete surfaces exposed to sea water spray, corrosive fumes or severe freezing conditions whilst wet. Concrete in contact with or buried under aggressive sub-soil / ground water.
v)	Extreme	Surfaces of members in tidal zone Members in direct contact with liquid / solid aggressive chemicals.

**NOTE:** For the purpose determining exposure conditions, all places within a distance of 10 Kms. of coastal line sea front would be treated as coastal area.

4.2.14.1.2 Freezing and thawing : Where freezing and thawing actions under wet conditions exist, enhanced durability can be obtained by the use of suitable air entraining admixtures when concrete lower than grade M50 is used under these conditions the mean total air content by volume of the fresh concrete at the time of delivery into the construction should be.

NOMINAL MAXIMUM SIZE AGGREGATE (mm)	ENTRAINED AIR PERCENTAGE
20	5 ±1
40	4 ±1

4.2.14.1.3 EXPOSURE TO SULPHATE ATTACK: For the very high sulphate concentration some form of lining such as polyethylene or polychloroprene sheet or surface coating based on asphalt chlorinated rubber, epoxy or polyurethane materials should also be used to prevent access by the sulphate solution.

4.2.14.1.4 CHLORIDES IN CONCRETE: The total amount of chlorides content in the concrete at the time of placing shall be as under:

Sl. No	TYPE OF USE OF CONCRETE	MAXIMUM TOTAL ACID SOLUBLE – CHLORIDE CONTENT EXPRESSED AS KG/M <sup>3</sup> OF CONCRETE
1	2	3
i)	Concrete containing metal and steam cured at elevated temperature and pre-stressed concrete.	0.4
ii)	Reinforced concrete or plain concrete containing embedded metal	0.6
iii)	Concrete not containing embedded metal or any material requiring protection from chloride	3.0

4.2.14.1.5 SULPHATES IN CONCRETE: The total water – soluble sulphate content of the concrete mix expressed as SO<sub>3</sub> should not exceed 4 percent by mass of the cement in the mix. The sulphate content should be calculated as the total from the various constituents of the mix.

The 4 percent limit does not apply to concrete made with supersulphated cement complying with IS:6909.



#### **4.3 DAMP PROOF COURSE**

##### **4.3.1 CEMENT CONCRETE LAYER**

This shall consist of cement concrete of specified proportions and thickness. The surface of brick or stone masonry work shall be leveled and prepared before laying the cement concrete. Edge of damp proof course shall be straight, even and vertical. Side shuttering shall consist of steel forms and shall be strong and properly fixed so that it does not get disturbed during compaction and the mortar does not leak through. The concrete mix shall be of workable consistency and shall be tamped thoroughly to make a dense mass. When the sides are removed, the surface should come out smooth without honey-combing. Continuity shall be maintained while laying the cement concrete layer and laying shall be terminated only at the predetermined location where damp proof course is to be discontinued. There shall be no construction joint in the Damp Proof course.

##### **4.3.2 CURING**

Damp proof course shall be cured for atleast seven days, after which it shall be allowed to dry.

##### **4.3.3 APPLICATION OF HOT BITUMEN**

Where so directed, hot bitumen in specified quantity shall be applied over the dried up surface of cement concrete, properly cleaned with brushes and finally with a piece of cloth soaked in kerosene oil. Bitumen of penetration A 90 or equivalent where used shall be heated to a temperature of  $160^{\circ} \pm 5^{\circ}\text{C}$ . The hot bitumen shall be applied uniformly all over, so that no blank spaces are left anywhere. It will be paid for separately unless otherwise specified.

##### **4.3.4 WATER PROOFING MATERIALS**

Where so specified, water proofing material of approved quality shall be added to the concrete mixture in accordance with the manufacture's specifications stating the quantity of water proofing material in litre or Kg per 50 Kg of cement and will be paid for separately unless otherwise specified.

#### **4.4 SELF COMPACTING CONCRETE (SCC)**

**4.4.1 SCC:** SCC is basically a concrete which should be capable of flowing into the form work, without segregation to fill uniformly and completely every corner of form work by its own weight without any application of vibration or other energy, during placing.

**4.4.2 PROPORTIONING:** There is no standard proportions for self compacting concrete. Therefore, each mix of self compacting concrete has to be got designed for a

particular structure / purpose by approved / competent laboratory / institution duly taking into account basic performance requirements / properties of self compacting concrete such as grade, plastic viscosity, deformability, flow ability and resistance to segregation etc.]

#### **4.4.3 TYPES OF SCC**

For catering the performance requirements, generally following three types of self compacting concretes are available:

- a) Powder type self compacting concrete
- b) Viscosity agent type self compacting concrete.
- c) Combination type self compacting concrete

#### **4.4.4 MIX DESIGN FOR SCC**

The mix design for SCC is primarily concerned with determining the quantities of ingredients of the self compacting concrete, namely Cement, fillers, fine aggregate, coarse aggregate, water; air entrainer, admixture, (super plasticizer) etc., for arriving at the desired strength, performance requirements and other properties of SCC like flowability, stability for placing the concrete readily into place without segregation and filling the formwork without consolidation etc. An appropriate balance between volume of paste and volume of aggregates shall be aimed at so that concrete shall be adequately plastic at the same time will have resistance for segregation some to the methods for mix design for SCC are as below:

There is no BIS for SCC. However design methods are governed under relevant codes of Japan.

- a) Japanese method
- b) Method proposed by Games, Ravindra Gettu
- c) Method of Nan-Su

As this is comparatively new material design and making have to be controlled through specialisation only.

#### **4.4.5 TESTS AND ACCEPTANCE CRITERION FOR SCC**

Test required to be conducted on SCC are as follows:

##### **a) SLUMP FLOW AND T50 cm SLUMP FLOW**

It is used to assess horizontal free flow to SCC. In this method the slump cone filled with concrete, is lifted off and concrete is allowed to flow. The horizontal diameter of the flowed material is measured. The average diameter of the concrete circle is a measure for filling ability of the concrete.

A slump flow ranging from 500 to 700 mm is considered to be self compacted. At more than 700mm, the concrete might segregate and at less than 500mm the flow of concrete may be insufficient to pass through highly congested reinforcement.

**b) V FUNNEL FLOW TEST**

This test is to assess the tendency for segregation and also to measure the viscosity of concrete in an empirical manner.

In this the funnel is filled with about 12 litres 24 of concrete and the time taken for it to flow through the narrow end of the apparatus is measured. A flow time of less than 6 secs. is recommended for concrete to qualify as SCC. Shorter flow time indicates greater flowability.

**c) L BOX TEST**

The passing ability of SCC is determined using L box test.

The apparatus consists of a "L" shaped box of cross section 200 x 150 mm with 700mm length on both arms of "L" section. With obstacle of 12mm dia 3 bars equally spaced at the junction of vertical and horizontal arm i.e., at the mouth of lower arm of "L" section.

The specified requisites for SCC are the time needed to flow up to 20 cm (T20) =  $1 \pm 0.5$  sec; the time needed to flow upto 40cm (T40) =  $2 \pm 0.5$  sec and the ratio between the heights of the concrete at each end (or) blocking ratio – 0.80

**d) U BOX TEST**

This test is used to measure the filling ability of SCC. The apparatus consists of a U shaped vessel that is divided by the middle wall into two compartments. The vessel will be of 45cm height of straight section (beyond "U" bend) and with total width of 28 cms (14 x 2cms). The specified requisites for SCC in this test is the difference in height of concrete between the two sections should not be more than 30mm

**e) J RING TEST**

This test gives assessment of filling ability of SCC. The equipment consists of steel ring of outer diameter 330mm and inner diameter 270mm made of metallic section 30mm x 25mm. In this section holes are drilled vertically to accept threaded portions of reinforcement bars of different diameters. The holes shall be spaced at different intervals in accordance with spacing of reinforcement under considerations. Reinforcement rods of length about 110mm shall be inserted in the holes in ring and the arrangement placed on level surface high.

A slump cone is placed inside of ring filled with concrete and then the cone is lifted to allow concrete to flow. In this test the difference in height between the concrete inside and that just outside the J ring is measured. This is an indication of the passing ability or the degree to which the passage of concrete through the reinforcement bars has been restricted. For qualifying for SCC the difference shall not be more than 10mm.

**f) FILL BOX TEST**

The apparatus consists of a transparent box container with flat and smooth surface with 35 obstacles of 20mm dia PVC pipes with 50mm C/C spacing.

The passing ability and segregation resistance are assessed in this test.

For qualifying for SCC 90% to 100% of concrete shall pass through the fill box.

**g) GTM SCREEN STABILITY TEST**

This test is to be assess segregation resistance (Stability).

In this test a sample of 10 ltrs of concrete is allowed to stand for a period to allow any intervals segregation to occur. Then pouring half of it into a 5mm sieve of 350mm diameter which stands on a sieve pan on a weigh scale. After two minutes the mortar which passes through the sieve is weighed and expressed as a percentage of the original sample taken on the sieve.

If the percentage of mortar which has passed through the sieve (the segregation ratio) is between 5% to 15% of the weight of the sample, the segregation resistance is considered satisfactory. Below 5% the resistance is excessive and likely to affect the surface finish. Above 15% and particularly above 30% there is a strong tendency of segregation.

**h) Slump-flow – test by Abrams Cone Test.**

**i) Time increase, V-funnel T5 minutes Test.**

**4.4.6 TESTS TO BE FULFILLED TO QUALIFY AS SCC**

Though there are several test methods no single method or combination method caters all the requirements of SCC. Accordingly to qualify any mix for adoption for SCC at least three workability tests shall be conducted out of 9 tests listed above. The sample should pass in all the three tests.

**4.4.7** The measurement shall be as specified for normal cement concrete.

**4.4.8** Rate shall include the cost of all materials and labour involved in all the operations described above unless otherwise stated.

## CHAPTER 5

### REINFORCED CEMENT CONCRETE WORK

#### 5.0 GENERAL

Reinforced cement concrete work may be cast-in-situ or Precast as may be directed by Engineer In-charge according to the nature of the work. Reinforced cement concrete work shall comprise of the following which may be paid separately or collectively as per the description of the item of work

- (a) Form work (Centring and Shuttering)
- (b) Reinforcement
- (c) Concreting 1 (Cast-in-situ 2) Precast

#### 5.1 MATERIALS

- 5.1.1 Water, cement, fine and coarse aggregate shall be as specified under respective clauses of Chapter 03-mortars and Chapter 04-concrete work as applicable. Portland pozzolona Cement (Fly ash based) and Portland Pozzolona cement (Calced clay based) shall not be used for RCC work.

#### 5.1.2 STEEL FOR REINFORCEMENT

- 5.1.2.1 The steel used for reinforcement shall be of any of the following types:

- (a) Mild steel and medium tensile bars conforming to IS:432 (Part I)
- (b) High strength deformed steel bars conforming to IS:1786
- (c) Hard drawn steel wire fabric conforming to IS:1566
- (d) Structural steel conforming to Grade A of IS:2062
- (e) Thermo-mechanically treated bars (TMT Bars).

- 5.1.2.2 **TYPES AND GRADES:** Reinforcement supplied in accordance with this standard shall be classified into the following types:

- (a) Mild steel bars: It shall be supplied in the following two grades
  - (i) Mild steel bars grade I designated as Fe 410-S
  - (ii) Mild steel bars grade II designated as FE 410-O
- (b) Medium tensile steel bars, grade II designated as Fe 540-W-HT

5.1.2.3 Mild steel and Medium tensile steel: Physical requirement are given in the following Table 1.

**TABLE 1**

Sl. No.	Type and nominal size of bar	Ultimate tensile Stress N/mm <sup>2</sup> minimum	Yield stress N/mm <sup>2</sup>	Elongation percent minimum
1.	Mild steel grade I For bars upto and including 20mm.	410	250	23
	For bars over 20 mm upto and including 50mm	410	250	23
2.	Mild steel grade II For bars upto and including 20mm	370	225	23
	For bars over 20mm, upto and including 50mm	370	215	23
3.	Medium tensile steel For bars upto & including 16mm	540	350	20
	For bars over 16mm, upto and including 32mm	540	340	20
	For bars over 32mm, upto and including 50mm	510	330	20

Elongation percent on gauge length 5.65 S<sub>0</sub> where 's<sub>0</sub>' is the cross sectional areas of the test piece.

- NOTE:**
- Grade (II) Mild steel bars are not recommended for the use in structures located in earthquake zone subjected to severe damage and for structures subjected to dynamic loading (other than wind loading) such as railway and highway bridges.
  - Welding of reinforcement bars covered in this specification shall be done in accordance with the requirement of IS:2751.

Nominal mass/weight: The tolerance on mass/weight for round and square bars shall be the percentage given in Table 2 of the mass/weight calculated on the basis that the masses of the bar/wire of nominal diameter and of density 0.785 kg/cm<sup>3</sup>.

**TABLE 2**  
**TOLERANCE ON NOMINAL MASS**

Nominal size in mm	Tolerance on the nominal mass Percent		
	Batch	Individual sample +	Individual sample for coil (-x-)
(a) upto and including 10	± 7	± 8	± 8
(b) over 10, upto and including 16	± 5	- 6	± 6
(c) over 16	± 3	- 4	± 4

"+" For individual sample plus tolerance is not specified

"x" For coil batch tolerance is not applicable

Tolerance shall be determined in accordance with method given in IS:1786.

Tests – Following type of lab test shall be carried out

- (1) Tensile Tests : This shall be done as per IS:1608
- (2) Bend Test : This shall be done as per IS:1599
- (3) Re-test : This shall be done as per IS:1786
- (4) Rebend Test : This shall be done as per IS:1786

Should any one of the test pieces first selected fail to pass any of the tests specified above, two further samples shall be selected for testing in respect of each failure. Should the test pieces from both these additional samples pass, the materials represented by the test samples shall be deemed to comply with the requirement of the particular test. Should the test piece from either of these additional samples fail the material represented by the test samples shall be considered as not having complied with standard.

5.1.2.4 High strength deformed bars & wires shall conform to IS: 1786. The physical properties for all piece of steel bars are mentioned below in Table 3.

**TABLE 3**

Property	Grade		
	Fe 415	Fe 500	Fe 550
0.2% proof Stress/yield stress, min. N/mm <sup>2</sup>	415	500	550
Elongation, percent min. on gauge length 5.65 OA, Where A is the X Sectional	14.5	12	8
Area of the tests piece Tensile strength	10% more than actual 0.2% proof stress but not less than 465 N/mm <sup>2</sup>	8% more than actual 0.2% proof stress but not less than 545 N/mm <sup>2</sup>	6% more than actual 0.2% proof stress but not less than 585 N/mm <sup>2</sup>

**Tests:** Selection and preparation of Test sample. All the tests pieces shall be selected by the Engineer In-charge or his authorised representative either:

- (a) Form cutting of bars or
- (b) If he so desired, from any bar after it has been cut to the required or specified size and the test piece taken from any part of it.

In neither case, the test pieces shall be detached from the bar or coil except in the presence of the Engineer-in-charge or his authorised representative.

The test pieces obtained in accordance with as above shall be full sections of the bars as rolled and subsequently Tensile cold worked and shall be subjected to physical tests without any further modifications. No deductions in size by machining or otherwise shall be permissible. No test piece shall be enacted or otherwise subject to heat treatment. Any straightening which a test piece may require shall be done cold.

- Tensile test : This shall be done as per IS:1599
- Re-test : This shall be done as per IS:1786
- Rebend test : This shall be done as per ISI:1786

### **5.1.3 STACKING AND STORAGE**

Steel for reinforcement shall be stored in such a way as to prevent distorting and corrosion. Care shall be taken to protect the reinforcement from exposure to saline atmosphere during storage, fabrication and use. It may be achieved by treating the surface of reinforcement with cement wash or by suitable method. Bars of different classifications, sizes and lengths shall be stored separately to facilitate issue in such sizes and lengths to cause minimum wastage in cutting from standard length.

### **5.2 FORM WORK (CENTRING & SHUTTERING)**

#### **5.2.1 FORM WORK**

Form work shall include all temporary or permanent forms or mould required for forming the concrete which is cast-in-situ, together with all temporary construction required for their support.

#### **5.2.2 DESIGN & TOLERANCE IN CONSTRUCTION**

Form work shall be designed and constructed to the shapes, lines and dimensions shown on the drawings with the tolerance given below:

- (a) Deviation from specified dimension of cross section of columns and beams +12mm  
6mm



- (b) Deviation from dimensions of footings
  - (i) Dimension in plan
    - +50mm
    - 12mm
  - (ii) Eccentricity in plan 0.02 times the width of the footings in the direction of deviation but not more than 50 mm
  - (iii) Thickness
    - $\pm 0.05$  times the specified thickness.

(Note : Tolerance apply to concrete dimensions only, and not in positioning of vertical steel dowels.)

### 5.2.3 GENERAL REQUIREMENT

It shall be strong enough to withstand the dead and live loads and forces caused by ramming and vibrations of concrete and other incidental loads, imposed upon it during and after casting of concrete. Shall be made sufficiently rigid by using adequate number of ties and braces, Screw jacks or hard board wedges where required shall be provided to make up any settlement in the form work either before or during the placing of concrete.

Forms shall be so constructed as to be removable in sections in the desired sequence, without damaging the surface of concrete or disturbing other sections. Care shall be taken to see that no piece is keyed into the concrete.

#### 5.2.3.1 MATERIALS FOR FORM WORK

- (a) Propping and Centring

All propping and centring should be either of steel tubes with extension pieces or built up sections of rolled steel.

#### 5.2.3.2 CENTRING/STAGING

- (a) Staging should be as designed with required extension pieces as approved by Engineer In-Charge to ensure proper slopes, as per design for slabs/beams etc. and as per levels as shown in drawings. All the staging to be either of Tubular steel structure with adequate bracings as approved or made of built up structural sections made from rolled structural steel sections.
- (b) In case of structures with two or more floors, the weight of concrete, centring and shuttering of any upper floor being cast shall be suitably supported on one floor below the top most floor already cast.

- (c) Form work and concreting of upper floor shall not be done until concrete of lower floor has set atleast for 14 days.

#### **5.2.3.3 SHUTTERING**

Shuttering used shall be of sufficient stiffness to avoid excessive deflection and joints shall be tightly butted to avoid leakage of slurry. If required, rubberised lining of material as approved by the Engineer-in-Charge shall be provided in the joints.

Steel shuttering used for concreting should be sufficiently stiffened. The steel shuttering should also properly repaired before use and properly cleaned to avoid strains, honey combing, seepage of slurry through joints etc.

- (a) Runner Joists: RSJ, MS Channel or any other suitable section of the required size shall be used as runners.
- (b) Assembly of beam head over props. Beam head is an adopter that fits snugly on the head plates of props to provide wider support under beam bottoms.

#### **5.2.3.4**

Form work shall be properly designed for self weight. Weight of reinforcement, weight of fresh concrete and in addition, the various live loads likely to be imposed during the construction process (such as workmen, materials and equipment). In case the height of centring exceeds 3.50 meters, the prop may be provided in multi-stages.

#### **5.2.3.5 CAMBER**

Suitable camber shall be provided in horizontal members of structure especially in cantilever spans to counteract the effect of deflection. The form work shall be so assembled as to provide for camber. The camber for beams and slabs shall be 4 mm per metre (1 to 250) or as directed by the Engineer-in-Charge so as to offset the subsequent deflection. For cantilevers the camber at free end shall be 1/50<sup>th</sup> of the projected length or as directed by the Engineer-in-Charge.

#### **5.2.3.6 WALLS**

The form faces have to be kept at fixed distance apart and an arrangement of wall ties with spacer tubes or bolts are considered best. The two shutters of the wall are to be kept in place by appropriate ties, braces and studs.

- 5.2.3.6.1 REMOVAL OF FORM WORK (STRIPPING TIME)** : In normal circumstances and where ordinary portland cement is used, forms may generally be removed after the expiry of the following periods subject to prior approval of Engineer-in-charge:

Type of Formwork	Minimum Period Before Stripping Formwork
(a) Vertical formwork to columns, walls, beams	16-24 h
(b) Soffit formwork to slabs (Props to be refixed immediately after removal of formwork)	3 days
(c) Soffit formwork to beams (Props to be refixed immediately after removal of formwork)	7 days
(d) Props to slabs:	
(1) Spanning upto 4.5m	7 days
(2) Spanning over 4.5m	14 days
(e) Props to beams and arches:	
(1) Spanning upto 6m	14 days
(2) Spanning over 6m	21 days

**Note 1:** For other types of cement, the stripping time recommended for ordinary portland cement may be suitably modified. If portland pozzolana or low heat cement has been used for concrete, the stripping time will be 10/7 of the period stated above.

**Note 2:** The number of props left under, their sizes and disposition shall be such as to be able to safely carry the full dead load of the slabs, beam or arch as the case may be together with any live load likely to occur during curing or further construction.

**Note 3:** For rapid hardening cement 3/7 of above periods will be sufficient in all cases except for vertical side of slabs, beams and columns which should be retained for atleast 24 hours.

**Note 4:** In case of cantilever slabs and beams, the centring shall remain till structures for counter acting or bearing down have been erected and have attained sufficient strength.

**Note 5:** Proper precautions should be taken to allow for the decrease in the rate of hardening that occurs with all types of cement in cold weather and accordingly stripping time shall be increased.

**Note 6:** Work damaged through premature or careless removal of forms shall be reconstructed.

## 5.2.4 SURFACE TREATMENT

### 5.2.4.1 OILING THE SURFACE

Shuttering gives much longer service life if the surfaces are coated with suitable mould oil which acts both as a parting agent and also gives surface protections.

A typical mould oil is heavy mineral oil or purified cylinder oil containing not less than 5% pentachlorophenol conforming to IS:716 well mixed to a viscosity of 70-80 centipoise.

After 3-4 uses and also in cases when shuttering has been stored for a long time, it should be recoated with mould oil before the next use.

- 5.2.4.2 The design of form work shall conform to sound Engineering practices and relevant IS codes.

## 5.2.5 INSPECTION OF FORM WORK

The completed form work shall be inspected and approved by the Engineer In-Charge before reinforcement bars are placed in position.

Proper form work should be adopted for concreting so as to avoid honey combing, blow holes, loss, stains or discolouration of concrete etc. Proper and accurate alignment and profile of finished concrete surface will be ensured by proper designing and erection of form work which will be approved by Engineer-in-charge.

Shuttering surface before centering should be free from any defect/deposits and fully cleaned so as to give perfectly straight smooth concrete surface. Shuttering surface should be therefore checked for any damage to its surface and excessive roughness before use.

### 5.2.5.1 ERECTION OF FORM WORK (CENTERING AND SHUTTERING)

Following points shall be borne in mind while checking during erection.

- (a) Any member which is to remain in position after the general dismantling is done, should be clearly marked.
- (b) Material used should be checked to ensure that, wrong items/rejects are not used.
- (c) If there are any excavations nearby which may influence the safety of form works, corrective and strengthening action must be taken.
- (d)
  - (i) The bearing area must be hard surface like PCC and the sole plates shall bear well on this hard surface.
  - (ii) Sole plates shall be properly seated on their bearing pads or sleepers.
  - (iii) The bearing plates of steel props shall not be distorted.
  - (iv) The steel parts on the bearing members shall have adequate bearing areas.

- (e) Safety measures to prevent impact of traffic, scour due to water etc., should be taken. Adequate precautionary measures shall be taken to prevent accidental impacts etc.
- (f) Bracing, struts and ties shall be installed along with the progress of form work to ensure strength and stability of form work at intermediate stage. Steel sections (especially deep sections) shall be adequately restrained against tilting, over turning and form swork should be restrained against horizontal loads. All the securing devices and bracing shall be tightened.
- (g) The stacked materials shall be placed as catered for, in the design.
- (h) When adjustable steel props are used, they should:
  - 1. be undamaged and not visibly bent.
  - 2. have the steel pins provided by the manufacturers for use.
  - 3. be restrained laterally near each end.
  - 4. have means for centralising beams placed in the forkheads.
- (i) Screw adjustments of adjustable props shall not be over extended.
- (j) Double wedges shall be provided for adjustment of the form to the required position wherever any settlement/elastic shortening of props occurs. Wedges should be used only at the bottom end of single prop. Wedges should not be too steep and one of the pair should be tightened/clamped down after adjustment to prevent their shifting.
- (k) No member shall be eccentric upon vertical member.
- (l) Props shall be directly under one another in multistage constructions as far as possible.
- (m) Guy ropes or stays shall be tensioned properly.
- (n) For form work of span exceeding 4.5m and/or height exceeding 3.5m shall be designed and approval of Engineer-in-Charge in writing shall be obtained.
- (o) Whenever proprietary form work are intended to be used, all the requisite technical information should be obtained from the manufacturers before hand.

## **5.2.6 MEASUREMENTS**

5.2.6.1 The form work shall include the following:

- (a) Splayed edges, notchings, allowances for overlaps and passing at angles, sheathing battens, strutting, bolting, nailing, wedges, easing, striking and removal.

- (b) All supports, struts, braces, wedges, piles or other suitable arrangements to support the form work.
- (c) Bolts, wireties, clamps, spreaders, nails or any other items to hold the sheeting together.
- (d) Working scaffolds, ladders, gangways and similar items
- (e) Filleting to form stop chamfered edges of splayed external angles not exceeding 20mm wide to beams, columns and the like
- (f) Where required temporary openings provided in the forms for pouring concrete, inserting vibrators and cleaning holes for removing rubbish from the interior of the sheathing before pouring concrete
- (g) Dressing with oil to prevent adhesion and
- (h) Raking or circular cutting.

#### **5.2.6.2 CLASSIFICATION OF MEASUREMENTS**

Where it is stipulated that the form work shall be paid for separately measurements shall be taken of the area of shuttering in contact with the concrete surface. Dimensions of the form work shall be measured correct to a cm.

- 5.2.6.3 Centring and shuttering where exceeding 3.5 metre height in one floor shall be measured and paid separately unless otherwise stated in work order.
- 5.2.6.4 Where it is not specifically stated in the description of the item that form work shall be paid for separately, the rate of the RCC item shall be deemed to include the cost of form work.
- 5.2.6.5 No deductions from the shuttering due to the openings obstructions shall be made if the area of such openings/obstructions does not exceed 0.1 square metre. Nothing extra shall be paid for forming such openings.
- 5.2.7 **RATE:** The rate of the form work includes the cost of labour and materials required for all the operations described above.

### **5.3 REINFORCEMENT**

#### **5.3.1 GENERAL REQUIREMENTS**

Steel Conforming to para 5.1.2 for reinforcement shall be clear and free from loose milscales, dust, loose rust, coats of paints, oil or other coatings which may destroy or reduce bond. It shall be stored in such a way as to avoid distortion and to prevent deterioration and corrosion. Prior to assembly of reinforcement on no account any oily substance shall be used for removing the rust.

### 5.3.1.1 ASSEMBLY OF REINFORCEMENT

Bars shall be bent correctly and accurately to the size and shape as shown in the detailed drawing and directed by Engineer-in-Charge. Preferably bars of full length shall be used. Necessary cutting and straightening is also included. Over lapping of bars, where necessary shall be done as directed by the Engineer-in-Charge. The overlapping bars shall not touch each other and these shall be kept apart with concrete between them by 25 mm or 1 1/4 times the maximum size of the coarse aggregate whichever is greater. But where this is not possible, the overlapping bars shall be bound together at intervals not exceeding twice the dia of such bars with two strands annealed steel wire of 0.90mm to 1.6mm twisted tight. The overlaps/splices shall be staggered as per directions of the Engineer-in-Charge. But in no case the over lapping shall be provided in more than 50% of cross sectional area at one section. The bars of 36 mm and above shall not be lapped but welded. In case lapping is unavoidable this may be allowed with additional spirals over the lapped portion as per approved drawing.

### 5.3.1.2 BONDS AND HOOKS FORMING END ANCHORAGES

Reinforcement shall be bent and fixed in accordance with procedure specified in IS 2502, code of practice for bending and fixing of bars for concrete reinforcement.

#### (a) U – Type Hook

In case of mild steel plain bars standard U type hook shall be provided by bending ends of into semicircular hooks having clear diameter equal to four times the diameter of the bar and straight ends of hook beyond semicircular bend shall be minimum 4 times the diameter.

**Note:** In case of work in seismic zone, the size of hooks at the end of the rod shall be eight times the diameter of bar or as given in the structural drawing.

#### (b) Bends

Bend forming anchorage to a M.S. plain bar shall be bent with an internal radius equal to two times the diameter of the bar with a minimum length beyond the bend equal to four times the diameter of the bar.

### 5.3.1.3 ANCHORING BARS IN TENSION

Deformed bars may be used without end anchorages provided development length requirement is satisfied. Hooks should normally be provided for plain bars in tension. Length of bars will be determined as per IS:456.

### **5.3.1.4 ANCHORING BARS IN COMPRESSION**

The anchorage length of straight bar in compression shall be equal to the Development length of bars in compression as specified in IS:456. The projected length of hooks, bends and straight lengths beyond bend, if provided for a bar in compression, shall be considered for development length.

### **5.3.1.5 BINDERS, STIRRUPS, LINKS ETC.**

In case of binders, stirrups, links etc the straight portion beyond the curve at the end shall be not less than eight times the nominal dia of bar.

### **5.3.1.6 WELDING BARS**

Wherever facilities for electric arc welding is available, welding of bars shall be done in lieu of over lap. The location and type of welding shall be got approved by Engineer-in-Charge. Welding shall be as per IS:2751 and IS: 9417.

5.3.1.7 The stipulations in IS:456-2000 shall be followed wherever applicable even though the same has not be specifically stated in this booklet.

### **5.3.2 PLACING IN POSITION**

5.3.2.1 Fabricated reinforcement bars shall be placed in position as shown in the drawings and/or as directed by the Engineer In-Charge. The bars crossing one another has to be tied together at every intersection with two strands of annealed steel wire 0.9 to 1.6mm thickness twisted tight to make the skeleton of steel work rigid so that the reinforcement does not get displaced during deposition of concrete. Tack welding in crossing bars shall also be permitted in lieu of binding with steel wire if approved by Engineer-in-Charge.

#### **5.3.2.2 The bars shall be kept in correct position by the following methods**

- (a) In case of beam and slab construction precast cover blocks in cement mortar 1:2 (1 cement : 2 coarse sand) about 4 x 4 cm section and of thickness equal to the specified cover shall be placed between the bars and shutterings, so as to secure and maintain the requisite cover of concrete over reinforcement.
- (b) In case of cantilevered and doubly reinforced beams or slabs, the vertical distance between the horizontal bars shall be maintained by introducing chairs, spacers or support bars of steel at 1 m or at shorter spacing to avoid sagging.
- (c) In case of columns and walls, the vertical bars shall be kept in position by means of timber templates with slots accurately cut in them: or with block of



cement mortar 1:2 (1 cement : 2 coarse sand) of required size suitably tied to the reinforcement to ensure that they are in correct position during concreting.

- (d) In case of other R.C.C. structure such as arches, domes, shells, storage tanks etc. a combination of cover blocks, spacers and templates shall be used as directed by Engineer-in-Charge.

**Note:** The cover block shall be approved by Engineer-in-Charge. In case of concrete cover blocks only are approved by Engineer-in-Charge the same shall be used and the cover block for normal concrete should be one grade more than grade of concrete. PVC cover blocks if approved by Engineer-in-Charge may be used.

### 5.3.2.3 TOLERANCE ON PLACING OF REINFORCEMENT

Unless otherwise specified by the Engineer-in-Charge reinforcement shall be placed within the following tolerances:

Tolerance in spacing

- (a) For effective depth, 200 mm or less + 10 mm  
(b) For effective depth, more than 200 mm + 15 mm

Minimum cover in structural members shall be maintained for relevant exposure as per drawing. The minimum nominal cover to meet durability requirements shall be as under:

Exposure	Nominal Concrete cover in mm not less than
Mild	20
Moderate	30
Severe	45
Very Severe	50
Extreme	75

- Notes:**
1. For main reinforcement upto 12mm diameter bar for mild exposure the nominal cover may be reduced by 5 mm.
  2. Unless specified otherwise, actual concrete cover should not deviate from the required nominal cover by +10mm.
  3. For exposure condition 'severe' and 'very severe', reduction of 5 mm may be made where concrete grade is M35 and above.

### 5.3.2.4 BENDING AT CONSTRUCTION JOINTS

Where reinforcement bars are bent aside at construction joints and afterwards bent back into their original position care should be taken to ensure that at no time the radius of the bend is less than 4 bar diameters for plain mild steel or 6 bar diameters for deformed bars. Care shall also be taken when bending back bars to ensure that the concrete around the bar is not damaged.

### 5.3.3 MEASUREMENT

Reinforcement including authorised spacer bars and lappages shall be measured in length of different diameters, as actually (not more than as specified in the drgs.) used in the work nearest to a centimetre and their weight calculated on the basis of standard weight given in Table below. Wastage and unauthorised overlaps shall not be paid for. Annealed steel wire required for binding or tack welding shall not be measured, its cost being included in the rate of reinforcement.

Wherever tack welding is used in lieu of binding, such welds shall not be measured. Chairs separators etc. shall be provided as directed by the Engineer in-charge and measured separately and paid for.

**Cross Sectional area and mass of steel bar  
(As per Clause 5.2 of IS:1786)**

Nominal size mm.	Cross Sectional area sq mm	Mass per meter Run kg
		Weight per kg per m
6	28.3	0.222
7	38.5	0.302
8	50.3	0.395
10	78.6	0.617
12	113.1	0.888
16	201.2	1.580
18	254.6	2.00
20	314.3	2.47
22	380.3	2.98
25	491.1	3.85
28	616.0	4.83
32	804.6	6.31
36	1018.3	7.99
40	1257.2	9.85
45	1591.1	12.50
50	1964.3	15.42

#### **5.3.4 RATE**

The rate for reinforcement shall include the cost of labour and materials required for all operations described above such as cleaning of reinforcement bars, straightening, cutting, hooking, bending, binding placing in position etc as required or directed including tack welding on crossing of bars in lieu of binding in wires etc.

#### **5.4 CONCRETING**

5.4.1 The concrete shall be as specified under Chapter 4 concrete work. The proportion by volume or by the weight of ingredients shall be as specified.

#### **5.4.2 CONSISTENCY**

The concrete which will flow sluggishly into the forms and around the reinforcement without any segregation of coarse aggregate from the mortar, shall be used. The consistency shall depend on whether the concrete is vibrated or hand tamped. It shall be determined by slump test as prescribed in chapter "Concrete under para workability".

#### **5.4.3 PLACING OF CONCRETE**

5.4.3.1 Concreting shall be commenced only after Engineer-in-Charge has inspected the centering, shuttering and reinforcement as placed and passed the same. Shuttering shall be clean and free from any shavings, saw dust, pieces of wood, or other foreign material and surfaces shall be treated as prescribed in 5.2.4.

5.4.3.2 In case of concreting of slabs and beams, wooden plank or cat walks of chequered MS plates or bamboo chalties or any other suitable material supported directly on the centring by means of wooden blocks or lugs shall be provided to convey the concrete to the place of deposition without disturbing the reinforcement in any way. Labour shall not be allowed to walk over the reinforcement.

5.4.3.3 In case of columns and walls, it is desirable to place concrete without construction joint and progress of concreting in the vertical direction, shall be restricted to one metre per hour.

5.4.3.4 The concrete shall be deposited in its final position in a manner to preclude segregation of ingredients. In deep trenches and footings concrete shall be placed through chutes or as directed by the Engineer-in-Charge. In case of columns and walls, the shuttering shall be so adjusted that vertical drop of concrete is not more than 1.5 metres at a time.

5.4.3.5 During cold weather concreting shall not be done when temperature falls below 4.5.C. The concrete placed shall be protected against frost by suitable covering. Concrete damaged by frost shall be removed and work redone.

- 5.4.3.6 During hot weather precaution shall be taken to see that the temperature of the wet concrete does not exceed 38°C. No concrete shall be laid within half an hour of closing time of the day unless permitted by the EIC.
- 5.4.3.7 It is necessary that the time between mixing and placing of concrete shall not exceed 30 minutes so that the initial setting process is not interfered with.

#### **5.4.4 COMPACTION**

It shall be as specified in para 4.2.7 of concrete work of this specification booklet.

- 5.4.4.1 Concrete shall be compacted into dense mass immediately after placing by means of mechanical vibrators designed for continuous operations. The EIC may however relax this conditions at his discretion for certain items depending on the thickness of the members and feasibility of vibrating the same and permit hand compact. Hand compacting shall be done with the help of tamping rods so that concrete is thoroughly compacted and completely worked around the reinforcement, embedded fixtures and into corners of form. The layers of the concrete shall be so placed that the bottom layer does not finally set before the top layer is placed. The vibrator shall maintain the whole of concrete under treatment in an adequate state of agitation, such that deaeration and effective compaction is attained at a rate commensurate with the supply of concrete from the mixers. The vibrating shall continue during the whole period occupied by placing of concrete; the vibrators being adjusted so that the centre of vibrators approximates the centre of the mass being compacted at the time of placing.
- 5.4.4.2 Concrete shall be judged to be properly compacted when the mortar fills the space between the coarse aggregate and begins to cream upto form an even surface. When this condition has been attained, the vibrator shall be stopped in case of vibrating tables and external vibrators. Needle vibrators shall be withdrawn slowly so as to prevent formation of those pockets in case of internal vibrators. In case of both internal and external vibrators are used the internal vibrators shall be first withdrawn slowly after which the external vibrator shall be stopped so that no loose pocket is left in the body of the concrete. The specific instructions of the makers of the particular type of vibrator use shall be strictly complied with. Shaking of reinforcement for the purpose of compaction should be avoided. Compaction shall be completed before the initial setting starts i.e., within 30 minutes of addition of water to the dry mixture.

#### **5.4.5 CONSTRUCTION JOINTS**

- 5.4.5.1 Concreting shall be carried out continuously upto the construction joints, the position and details of which shall be as shown in structural drawing or as directed by Engineer-in-Charge. Number of such joints shall be kept to minimum. The joints shall be kept at places where the shear force is the minimum. These shall

be straight and shall be at right angles to the direction of the main reinforcement. Construction joints should comply with IS: 11817.

5.4.5.2 In case of columns the joints shall be horizontal and 10 to 15 cm below the bottom of the beam running into the column head. The portion of the column between the stepping off level and the top of the slab shall be concreted with the beam.

5.4.5.3 When stopping, the concrete on a vertical plane in slabs and beams approved stop board shall be placed with necessary slots for reinforcement bars or any other obstructions pass the bars freely without bending. The construction joints shall be keyed by providing a triangular or trapezoidal fillet nailed on the stop-board. Inclined or feather joints shall not be permitted. Any concrete flowing through the joints of stop-board shall be removed soon after the initial set. When concrete is stopped on a horizontal plane, the surface shall be roughened and cleaned after the initial set.

5.4.5.4 When the work has to be resumed, the joint shall be thoroughly cleaned with wire brush and loose particles removed. A coat of neat cement slurry at the rate of 2.75 kg of cement per square meter shall then be applied on the roughened surface before fresh concrete is laid.

#### **5.4.6 EXPANSION JOINTS**

Expansion joints shall -i In-Charge. However it is recommended that structures exceeding 45 m in length shall be divided by one or more expansion joints. Unless otherwise specified the filling of these joints with bitumen filler, bitumen felt or any such material and provision of copper plate etc. shall be paid for separately in running metre. The measurement shall b taken upto two places of decimal stating the depth and width of joint.

#### **5.4.7 CURING**

After the concrete has begun to harden i.e., about 1 to 2 hours after laying, it shall be protected from quick drying by covering with moist gunny bags, sand, canvass hessian or any other material approved by the Engineer-in-Charge. After 24 hours of laying of concrete the surface shall be cured by ponding with water for a minimum period of 7 days from the date of placing of concrete in case of OPC and least 10 days where mineral admixtures or blended cements are used. The period of curing shall not be less than 10 days for concrete exposed to dry and hot weather condition.

#### **5.4.8 FINISHING**

5.4.8.1 In case of roof slabs the top surface shall be finished even and smooth with wooden trowel before the concrete begins set.

5.4.8.2 Immediately on removal of forms, the R.C.C works shall be examined by the Engineer-in-Charge before any defects are made good.

- a) The work that has sagged or contains honey combing to an extent detrimental to structural safety or architectural concept shall be rejected on visual inspection test.
- b) Surface defects of a minor nature may be accepted. On acceptance of such a work by the Engineer-in-Charge, the same shall be rectified as follows:
  1. Surface defects which require repair when forms are removed, usually consists of bulges due to movement of forms, ridges at form joints, honey combed areas, damage resulting from the stripping of forms and bolt holes, bulges and ridges are removed by careful chipping or tooling and the surface is then rubbed with a grinding stone. Honey-combed and other defective areas must be chipped out, the edges being cut as straight as possible and perpendicular to the surface, or preferably slightly undercut to provide a key at the edge of the patch.
  2. Shallow patches are first treated with a coat of thin grout composed of one part of cement and one part of fine sand and then filled with mortar similar to that used in the concrete. The mortar is placed in layers not more than 10mm thick and each layer is given a scratch finish to secure bond with the succeeding layer. The last layer is finished to match the surrounding concrete by floating, rubbing or tooling on formed surfaces by pressing the form material against the patch while the mortar is still plastic.
  3. Large and deep patches require filling up with concrete held in place by forms. Such patches are reinforced and carefully dowelled to the hardened concrete.
  4. Holes left by bolts are filled with mortar carefully packed into places in small amounts. The mortar is mixed as dry as possible, with just enough water so that it will be tightly compacted when forced into place.
  5. Tiered holes extending right through the concrete may be filled with mortar with a pressure gun similar to the gun used for greasing motor cars.
  6. Normally, patches appear darker than the surrounding concrete, possibly owing to the presence on their surface of less cement laitance. Where uniform surface colour is important this defect shall be remedied by adding 10 to 20 percent of white portland cement to patching mortar, the exact quantity being determined by trial.

7. The same amount of care to cure the material in the patches should be taken as with the whole structure. Curing must be started as soon as possible, after the patch is finished, to prevent early drying. Damp hessian may be used but in some locations it may be difficult to hold it in place. A membrane curing compound in these cases will be most convenient.
- a) The exposed surface of R.C.C. work shall be plastered with cement mortar 1:3 (1 cement: 3 fine sand) of thickness not exceeding 6 mm to give smooth and even surface true to line and form any R.C.C. surface which remains permanently exposed to view in the completed structure shall be considered exposed surface for the purpose of this specification.
  - b) Where such exposed surface exceeding 0.5 sqm in each location is not plastered with cement mortar 1:3 (1 cement: 3 fine sand) 6mm thick, necessary deduction shall be made for plaster not done.
  - c) The surface which is to receive plaster or where it is to be joined with brick masonry wall, shall be properly roughened immediately after the shuttering is removed, taking care to remove the laitance completely without disturbing the concrete. The roughening shall be done by hacking. Before the surface is plastered, it shall be cleaned and wetted so as to give bond between concrete and plaster.
  - d) RCC shall be done carefully so that the thickness of plaster required for finishing the surface is not more than 6 mm.
  - e) The surface of RCC slab on which the cement concrete or mosaic floor is to be laid shall be roughened with brushes while the concrete is green. This shall be done without disturbing concrete.

#### 5.4.9 STRENGTH OF CONCRETE

The compressive strength on work tests for different nominal mix on volume basis shall be as given in table below:

**TABLE**

Concrete Mix (Normal Mix on Volume Basis)	Compressive Strength in Kg/Sqcm	
	7 days	28 days
1:1:2	210	315
1:1 ½ :3	175	265
1:2:4	140	210

#### **5.4.10 TESTING OF CONCRETE**

5.4.10 Regular mandatory tests on the workability of fresh concrete shall be done to ensure to achieve the specified compressive strength of concrete. These will be of two types:

- (a) Mandatory Laboratory Test
- (b) Mandatory Field Test.

Result of mandatory field test will prevail over mandatory laboratory test.

##### **5.4.10.1 WORK TEST**

Mandatory lab test shall be carried out as prescribed in relevant IS.

##### **5.4.10.2 ADDITIONAL TEST**

Additional test if required shall also be carried out as directed by Engineer-in-Charge.

##### **5.4.10.3 SLUMP TEST**

Shall be carried out as prescribed under Chapter 4.

##### **5.4.10.4 VISUAL INSPECTION TEST**

The concrete shall be inspected after removal of form work as described under para 5.4.7.2. The question of carrying out mandatory test or other tests prescribed will arise only after satisfactory report of visual inspection.

The concrete is liable for rejection if

- (i) It is porous or honey combed
- (ii) Its placing has been interrupted without providing proper construction joint.
- (iii) The reinforcement has been displaced beyond tolerance specified or construction tolerances have not been met.

However the hardened concrete may be accepted after carrying out suitable remedial measures to the satisfaction of the Engineer-in-Charge at the risk and cost of contractor.

#### **5.4.11 STANDARD OF ACCEPTANCE – for nominal mix**

##### **5.4.11.1 MANDATORY LAB TEST**

For concrete sampled and tested following requirement shall apply.



5.4.11.2 Out of six samples cubes, three cubes shall be tested at 7 days and remaining three cubes at 28 days.

#### 5.4.11.3 7 DAYS TESTS

**Sampling:** The average of the strength of three specimen shall be accepted as the compressive strength of the concrete provided the variation in strength of individual specimen is not more than  $\pm 15\%$  of the average. Difference between the maximum and minimum strength should not exceed 30% of the average strength of three specimens. If the difference between maximum and minimum strength exceeds 30% of the average strength, then 28 days' test shall have to be carried out.

**Strength:** If the actual average strength of sample accepted in para 'sampling' above is equal to or higher than specified strength upto 15% then strength of the concrete shall be considered in order. In case the actual average strength of sample accepted in the above para is lower than the specified or higher by more than 15% then 28 days' test shall have to be carried out to determine the compressive strength of concrete cubes.

#### 5.4.11.4 28 DAYS' TEST

- (a) The average of the strength of three specimen be accepted as the compressive strength of the concrete provided the strength of any individual cube shall neither be less than 70% nor higher than 130% of the specified strength.
- (b) If the actual average strength of accepted sample exceeds specified strength by more than 30% the Engineer-in-Charge, if he so desires, may further investigate the matter. However the strength of any individual cube exceeds more than 30% of specified strength, it will be restricted 130% only for computation of strength.
- (c) If the actual average strength of accepted sample is equal to or higher than specified strength upto 30% then strength of the concrete shall be considered in order and the concrete shall be accepted at full rates.
- (d) If the actual average strength of accepted sample is less than 70% of the specified strength, the concrete may be accepted at reduced rate at discretion of Engineer-in-Charge (See para 5.4.13.2).
- (e) If the actual average strength of accepted sample is less than 70% of specified strength the Engineer-in-Charge shall reject the defective portion of work represented by sample and nothing shall be paid for the rejected work. Remedial measures necessary to retain the structure shall be taken

at the risk and cost of contractor. If, however, the Engineer-in-Charge so desires he may order additional tests to be carried out to ascertain if the structure can be retained. All the charges in connection with these additional tests shall be borne by the contractor.

5.11.4.1 Acceptance Criteria of Field Test (Additional Test – Not Mandatory). These shall be done if found necessary at the discretion of Engineer-in-Charge.

- (A) Preparation of Standard Test Cubes for Calibration of Rebound Hammer at Site.
- (a) In the beginning the standard test cubes of the specified mix shall be prepared by field units before undertaking any concrete work in each project.
  - (b) At least 18 standard cubes necessary for formation of one specimen of specified mix, shall be cast by site staff well in advance. From these 18 cubes any 3 cubes may be selected at random to be tested for crushing strength of 7 days. The crushing strength obtained should satisfy the specified strength for the mix as per specification or agreement. If the strength is satisfactory then the remaining cubes will form the standards samples for calibration of rebound hammer. In case of failure, the site staff should totally reject the samples and remove them also and then make another set of samples by fresh mixing or alternatively, out of the remaining 15 cubes, 3 cubes will be tested on 28 days. If the 28 days tests are found satisfactory then remaining 12 cubes will form the standard sample for calibration at 28 days' strength otherwise all samples shall be rejected and whole procedure repeated to form a fresh specimen. All the results shall be recorded in register.
  - (c) No concreting will be allowed unless the standard specimen cubes are obtained. The criteria for acceptance and calibration of hammer will be 28 days' strength. The 7 days' strength is only to facilitate the work to start.
  - (d) No work (for the concrete cast between 8<sup>th</sup> and 28<sup>th</sup> day) shall be allowed to be paid unless 28 days' cube strength is obtained. For the concrete cast between 8<sup>th</sup> and 28<sup>th</sup> day, the decision to make the payment may be taken by the Engineer-in-Charge on the basis of existing criteria and all such payments are only advance payment subject to achievement of 28 days' prescribed strength. Concrete work will be rejected if 28 days' strength falls short as per acceptance criteria and any advance payment made on the same shall be recovered. No further work will be allowed till the acceptable standard cubes are obtained.

- (e) **Frequency:** It will be once in each quarter or as per the direction and discretion of Engineer-in-Charge. Whenever the acceptance criteria is changed or concrete mix or type of cement is changed or Engineer-in-Charge feels it necessary for recorded reasons with the approval of the authority according technical sanction, fresh specimen shall be prepared.

#### **(B) CALIBRATION OF HAMMER**

- (a) Simultaneously, same three cubes to be tested on 28 days as referred in para A. (b) above shall be used to correlate the compressive strength of their concrete with rebound number as per procedure described in para 5.2 of the IS 13311 (para 2) 'Indian Standard for non-destructive testing of concrete method of test by rebound hammer which is given below in para B (b). The average of values of the rebound number (minimum readings) obtained in respect of same three cubes passing on 28 days' work test shall form the datum reference for remaining cubes for the strength of cubes.
- (b) The concrete cubes specimens are held in a compression testing machine under a fixed load, measurements of rebound hammer taken and then compressive strength determined as per IS 516. The fixed load required is of the order of 7N/mm<sup>2</sup> when the impact energy of the hammer is about 2.2NM.

If the specimen are wet cured, they should be removed from wet storage & kept in the laboratory atmosphere for about 24 hours before testing.

Only the vertical faces of the cubes as cast should be tested for rebound number. At least nine readings should be taken on each of the three vertical faces accessible in the compression testing machine when using rebound hammers. The points of impact on the specimen must not be nearer than 20mm from the edge & should not be less than 20 mm from each other. The same points must not be impacted more than once.

- (c) The rebound number of hammer will be determined on each of the remaining (18-3-3=12) cubes. Whenever the rebound number of hammer of any individual cube varies by more than +25% from the datum readings referred to in para B(a) above, that cube will be excluded and will not be considered for standard specimen cubes for calibration. It must be ensured that at least 8 cubes out of 12 that is 66.67% are within the permissible range of variation of rebound number i.e., +25% or otherwise whole procedure shall have to be repeated and fresh specimen prepared.

These 8 cubes will form one standard sample in the beginning before commencement of work and shall be kept carefully for the visiting officers who will calibrate their hammers on these cubes.

- (d) This calibration will be done by field staff with their hammer and then chart of calibration giving the details of the average readings, date & month of casting, mix of the concrete etc. shall be prepared and signed by Engineer-in-Charge and will be duly preserved for future reference as and when required.

**(C) PRESERVATION OF CUBES AT SITE**

Standard sample cubes cast shall be carefully preserved at site under the safe custody of site Engineer or his representative for making them available together with the charts, to the officers of inspecting or any other senior departmental officer, during their inspection of the work. They will calibrate their hammer on these cubes if required.

**(D) TESTING AT SITE**

**(D-1) Testing Equipments**

(D-2) Testing will be done generally by non-destructive methods like rebound hammer etc. It is desirable that each major work site will purchase rebound hammers and keep them in working order at work site. The testing will be done only by hammers which are duly calibrated.

(D-3) The relative strength of actual field work will be tested with reference to strength of these standard cubes and calibration charts of a hammer for determining the rebound number on the field work. The hammer will be used as per manufacturer's guideline at various locations chosen at random. The number of location/reading on each wall, beam column etc. shall not be less than 12. All the readings should be within the +25% range of values prescribed in calibration chart normally. However, reading indicating good strength will be when it is at par with calibrated value or between 100% & 125% and very good more than 125%. Any value between 100% & 75% of calibrated value shall be considered satisfactory. Values from 75% to 50% shall be considered for payment at rates reduced on prorata basis. The concrete indicating rebound number less than 50% of calibrated shall be rejected and not paid for.

**(E) ACCEPTANCE OF FIELD TESTS AND STRENGTH**

If the relative strength of actual field work is found satisfactory considering the calibration charts with reference to the standard cube test kept at site, the representative work will be considered satisfactory. If the work is

considered below satisfactory, the same will be dealt as stated in para D-3 above.

**(F) 7 DAYS' STRENGTH IN RARE CASES ONLY**

Normally cube crushing strength on 28 days' test shall form the basis of acceptance. However in rare cases of time bound projects/urgent repairs 7 days' cube test strength criteria may be adopted on similar lines using 7 days' standard test cubes and calibration graphs/curves charts for 7 days' in lieu of 28 days' and testing work done at 7 days'.

**(G) PRECAUTIONS**

(G-1) The testing shall be done generally as per the guidelines of manufacturer of the apparatus and strictly in accordance with the procedure laid down in clause 6 or IS 13311 (part 2) Indian Standard for Non-Destructive Testing of concrete-Method of Test by Rebound Hammer.

(G-2) The rebound hammers are influenced by number of factor like type of cement aggregate surface conditions, moisture content, age of concrete & extent of calibration of concrete. Hence care shall be taken to compare the cement, aggregate etc. and tested under the similar surface conditions having more or less same moisture content and age. However effect of age can be ignored for concrete between 3 days & 3 months old.

**5.4.12 MEASUREMENT**

5.4.12.1 Dimensions shall be measured nearest to a cm except for the thickness of slab which shall be measured correct to 0.5cm. The areas shall be worked out nearest to 0.01 sq.mt. The cubical contents shall be worked out to nearest 0.01 cubic metre.

5.4.12.2 Reinforced cement concrete whether cast-in-situ or precast shall be classified and measured accurately as follows unless otherwise specified

- (a) Raft, footing, bases of columns etc. and mass concrete.
- (b) Walls (any thickness) including attached pilasters, buttresses, plinth and string course, fillets etc.
- (c) Suspended floors, roofs, landings and balconies
- (d) Shelves
- (e) Chajjas
- (f) Linthel, beams and bressummers
- (g) Columns, pillars, piers, abutments, posts and struts
- (h) Stair-cases including waist or waistless slab but excluding landing except in (I) below.

- (i) Spiral stair-case (including landing).
- (j) Arches, arch ribs, domes and vaults
- (k) Chimneys and shafts.
- (l) Well steining
- (m) Vertical and horizontal fins individually or forming box, louvers and facias.
- (n) Kerbs, steps and the like.
- (o) String courses, bands, coping, bed plates, anchor blocks, plain window sills and the like.
- (p) Mouldings as in cornices window sills etc.
- (q) Shell, dome and folded plates.
- (r) Extra for shuttering in circular work in plan.

5.4.12.3 Work under the following category shall be measured separately unless otherwise specified.

- (a) Rafts, footings, basis of columns etc. and mass concrete
- (b) All other items upto floor two level
- (c) From floor two level to floor three level and so on
- (d) R.C.C. above roof level shall be measured along with R.C.C work in floor just below.

5.4.12.4 No deduction shall be made for the following:

- (a) Ends of dis-similar materials (e.g. Joists, beams, post grids, rafters, purlins trusses, corbels steps etc.) upto 500 sq cm in cross-section.
- (b) Opening upto 0.1 sqm.

**Note:** In calculating area of openings upto 0.1 sqm the size of opening shall include the thickness of any separate lintels or sills. No extra labour for forming such openings or voids shall be paid for.

- (c) The volume occupied by reinforcement.
- (d) The volume occupied by water pipes, conduits etc. not exceeding 25 sq cm each in cross sectional area. Nothing extra shall be paid for leaving and finishing such cavities and holes.

5.4.12.5 Measurement shall be taken before any rendering is done in concrete members. Measurement will not include rendering. The measurement of R.C.C. work between various units shall be regulated as below.

- (a) Slabs shall be taken as running continuously through except when slab is monolithic with the beam. In that case it will be from the face to face of the beam.

- (b) Beams shall be measured from face to face of columns and shall include haunches, if any, between columns and beam. The depth of the beam shall be from the bottom of slab to the bottom of beam if beam and slab are not monolithic. In case of monolithic construction where slabs are integrally connected with beam, the depth of beam shall be from the top of the slab to the bottom of beam.
- (c) The column measurement shall be taken through.
- (d) Chajjas alongwith its bearing on wall shall be measured in cubic metre nearest to two places of decimal. When chajjas is combined with lintel, slab or beam, the projecting portion shall be measured as chajjas, built in bearing shall be measured as per item of lintel, slab or beam in which chajjas bears.
- (e) Where the band and lintel are of the same height and the band serve as lintel, the portion of the band to be measured as lintel shall be for clear length of opening plus twice the over all depth of band.

#### 5.4.13 TOLERANCES

Subject to the condition that structural safety is not impaired and architectural concept does not hamper, the tolerances in dimensions of R.C.C. members shall be as specified in the drawings by the designer. Whenever these are not specified the permissible tolerance shall be decided by the Engineer-in-Charge after consultations with the Designer, if necessary.

When tolerances in dimensions are permitted, following procedure for measurements shall apply

- (a) If the actual dimensions of R.C.C. members do not exceed or decrease the design dimension of the members plus or minus tolerance limit specified above, the design dimensions shall be taken for the purpose of measurements.
- (b) If the actual dimensions exceed the design dimensions by more than the tolerance design dimensions only shall be measured for the purpose of payment.
- (c) If the actual dimensions decrease more than the tolerance limit specified the actual dimension of the RCC members shall be taken for the purpose of measurement and payment.
- (d) For acceptance of RCC members whose dimensions are not exactly as per design dimensions, the decision of Engineer-in-Charge shall be final. For the purpose of payment however, the clarification as given in para a, b & c above shall apply.

#### **5.4.14 RATE**

- 5.4.14.1 The rate includes the cost of materials and labour involved in all the operations, described above except for the cost of centring and shuttering and those specifically excluded in particular work order.
- 5.4.14.2 On the basis of mandatory lab tests, in case of actual average compressive strength being less than specified strength but upto 70% of specified strength, the rate payable shall be in the same proportion as actual average compressive strength bears to the specified compressive strength.

#### **Example :**

1. Average compressive strength in 80% of specified strength. Rate payable shall be 80% agreement rate.
  2. In case average compressive strength is less than 70% of the specified strength, the work represent by the sample shall be rejected.
  3. However, on the basis of mandatory field tests, where they prevail, the rates of the work represented by samples showing actual compressive strength less than specified strength shall be worked out as per para 5.4.10.5 (D-3) above. In addition, Engineer In-Charge may order for additional tests to be carried out at the cost of contractor to ascertain if the portion of structure where in concrete represented by the samples has been used, can be retained on the basis of these tests. Engineer In-Charge may take further remedial measures as necessary to retain the structure at the risk and cost of the contractor.
- 5.4.14.3 No extra payment for richer mix which projects into any member from another member during concreting of junctions of beams and columns etc. will be made except to the extent structurally considered necessary and when so indicated in the structural drawings. The payments for works done under items of different mixes shall be limited strictly to what is indicated in the structural drawings.

#### **5.5 ENCASING ROLLED STEEL SECTIONS**

- 5.5.1 Before concrete work is started, the Engineer In-Charge shall check that all rolled steel sections to be encased, have been erected truly in position. The sections shall be unpainted and shall be wire brushed to remove the loose rust/scales etc. When so specified, ungalvanised metal, having mesh or perforations large enough to permit the free passage of 12.5mm nominal size aggregate through them, shall be wrapped round the section to be encased in concrete and paid for separately unless otherwise specified.



## **5.5.2 WRAPPING**

- 5.5.2.1 In case of columns, the wrapping shall be arranged to pass through the centre of the concrete covering. The wrapping of the entire length of the columns to be carried out in stages and no stage shall cover more than 1.5 metre of height of columns. Successive wrappings shall be carried out only after the immediate adjacent wrapping has been encased in concrete. The surface and edges of the flanges of the steel columns shall have a concrete cover of not less than 50mm. The wrappings of successive stages shall be tied together.
- 5.5.2.2 In the case of beams and grillages, the wire mesh or expanded metal shall be wrapped round the lower flange of the beam and the wrapping shall be suspended by wire hangers 5mm diameter placed at about 1.2 metres centres. The surfaces and edges of the steel sections shall have a concrete cover of not less than 50mm. The wrapping shall pass through the centre of the concrete covering at the edges and soffits of the flanges.
- 5.5.3 Form work shall be as prescribed in 5.2.

## **5.5.4 CONCRETING**

Concrete shall consist of a mix of 1:2:4 (1 cement : 2 coarse and :4 graded stone aggregate of 12.5 mm nominal size) unless a richer mix is specified. The mix shall be poured solidly around the steel sections and around the wrapping by vibrating the concrete into position. Consistency of concrete, placing of concrete and its compaction, curing finishing and strength of concrete shall be as described in 5.4.

## **5.5.5 MEASUREMENTS**

The length shall be measured correct to one cm and other dimensions correct to 0.5 cm. The cement concrete shall be measured as per gross dimensions of the encasing exclusive of the thickness of plaster. No deduction shall be made for the volume of steel sections, expanded metal, mesh or any other reinforcement used therein. However, incase of boxed stanchions or girders, the boxed portion only shall be deducted.

Unless otherwise stated the fabric reinforcement such as expanded metal shall be measured separately in square metres stating the mm and size of strands.

The description shall include the bending of the fabric as necessary, Raking or circular cutting and waste shall be included in the description.

## **5.5.6 RATE**

Unless otherwise state in work order the rate shall include the cost of materials for all the operations described above except the cost of fabric reinforcement. The cost of providing and erecting steel section and wire hanger shall be paid for separately.

## **5.6 PRECAST REINFORCEMENT CONCRETE**

### **5.6.1 GENERAL REQUIREMENT**

Precast reinforced concrete units such as columns, fencing posts, door and window frames, lintels chajjas, copings, sills, shelves, slabs, louvers etc. shall be of grade of mix as specified and cast in forms or moulds. The forms/moulds shall be of fiber glass or of steel sections for better finish. Provision shall be made in the forms and moulds to accommodate fixing devices such as nibs, clips, hooks, bolts and forms of notches and holes. The contractor may precast the units on a cement or steel platform which shall be adequately oiled provided the surface finish is of the same standard as obtained in the forms. Each unit shall be cast in one operation.

5.6.2 Concrete used for precasting the units should be well proportioned, mixed, placed and thoroughly compacted by vibrations or tamping as approved by Engineer-in-charge to give a dense concrete free from voids and honey combing.

5.6.3 Precast articles shall have a dense surface finish showing no coarse aggregate and shall have no cracks or crevices likely to assist in disintegration of concrete or rusting of steel or other defects that would interfere with the proper placing of the units. All angles of the precast units with the exception of the angles resulting from the splayed or chamfered faces shall be true right angles. The arises shall be clean and sharp except those specified or shown to be rounded. The wearing surface shall be true to the lines. On being fractured, the interior of the units should present a clean homogeneous appearance.

5.6.4 The longitudinal reinforcement shall have a minimum cover of 12mm or twice the diameter of the main bar, whichever is more, unless otherwise directed in respect of all items except fencing posts or electric posts where the minimum cover shall be 25mm.

### **5.6.5 CURING**

After having been cast in the mould or form the concrete shall be adequately protected during setting in the first stages of hardening from shocks and from harmful effects of frost, sunshine, drying winds and cold. The concrete shall be cured at least for 7 days from the date of casting.

5.6.6 The precast articles shall be matured for 28 days before erection or being built in so that the concrete shall have sufficient strength to prevent damage to units when first handled.

### **5.6.7 MARKING**

Precast units shall be clearly marked to indicate the top of member and its location and orientation in the structure.

- 5.6.7.1 Precast units shall be stored, transported and placed in position in such a manner that they will not be overstressed or damaged.

## **5.7 PRECAST CEMENT CONCRETE JALI**

- 5.7.0 The jali shall be of cement concrete 1:2:4 (1 cement : 2 coarse sand : 4 stone aggregate 6 mm size) reinforced with 1.6 mm thick mild steel wire, unless otherwise specified.

### **5.7.1 FIXING**

The jali shall be set in position true to plumb and level before the joints sills and soffits of the openings are plastered. It shall then be properly grouted with cement mortar 1:3 (1 cement : 3 coarse sand) and rechecked for levels. Finally the jambs, sills and soffits shall be plastered embedding the jali uniformly on all sides.

## **5.8 DESIGN MIX / READY MIX CONCRETE**

### **5.8.0 DEFINITION**

Design mix concrete is that concrete in which the design of mix i.e., the determination of proportion of cement, aggregate & water is arrived as to have target mean strength for specified grade of concrete. The minimum mix of M25 shall be used in all structural elements in both load bearing & RCC framed construction.

### **5.8.1 MIX DESIGN AND PROPORTIONING**

- 5.8.1.1 Mix proportions shall be designed to ensure that the workability of fresh concrete is suitable for conditions of handling and placing, so that after compaction it surrounds all reinforcements and completely fills the formwork. When concrete is hardened, it shall have the stipulated strength, durability and impermeability.
- 5.8.1.2 Determination of the proportions by weight of cement, aggregates and water shall be based on design of mix.
- 5.8.1.3 As a trial the manufacturer of concrete may prepare a preliminary mix according to provision of SP:23.1982. Reference may also be made to ACI 211.1.77 for guidance.
- 5.8.1.4 Mix design shall be tried and the mix proportions checked on the basis of tests conducted at a recognized laboratory approved by the Engineer-in-Charge.
- 5.8.1.5 All concrete proportions for various grades of concrete shall be designed separately and the mix proportions established keeping in view the workability for various structural elements, methods of placing and compacting.

## **5.8.2 STANDARD DEVIATION**

- 5.8.2.1 Standard deviation calculations of test results based on tests conducted on the same mix design for a particular grade designation shall be done in accordance with clause 9.2.4 of IS 456.

## **5.8.3 ACCEPTANCE CRITERIA**

- 5.8.3.1 **COMPRESSIVE STRENGTH:** The concrete shall be deemed to comply with the strength requirements when both the following conditions are met:

- (a) The mean strength determined from any group of four consecutive test results complies with the appropriate limits in col 2 of Table below (characteristic compressive strength compliance requirement).
- (b) Any individual test result complies with the appropriate limits in col 3 of the Table.

- 5.8.3.2 **FLEXURAL STRENGTH:** When both the following conditions are met, the concrete complies with the specified flexural strength:

- (a) The mean strength determined from any group of four consecutive test results exceeds the specified characteristic strength by at least 0.3 N/mm<sup>2</sup>.
- (b) The strength determined from any test result is not less than the specified characteristic strength less 0.3 N/mm<sup>2</sup>.

## **5.8.3.3 QUANTITY OF CONCRETE REPRESENTED BY STRENGTH TEST RESULTS**

The quantity of concrete represented by a group of four consecutive test results shall include the batches from which the first and last samples were taken together with all intervening batches.

For the individual test result requirements given in col 3 of Table below or in item (b) of 5.8.3.2, only the particular batch from which the sample was taken shall be at risk.

Where the mean rate of sampling is not specified the maximum quantity of concrete that four consecutive test results represent shall be limited to 60m<sup>3</sup>.

- 5.8.3.4 If the concrete is deemed not to comply pursuant to 5.8.3.3 the structural adequacy of the parts selected shall be investigated and any consequential action as needed shall be taken.
- 5.8.3.5 Concrete of each grade shall be assessed separately.
- 5.8.3.6 Concrete is liable to be rejected if it is porous or honey-combed, its placing has been interrupted without providing a proper construction joint, the reinforcement

has been displaced beyond the tolerances specified, or construction tolerances have not been met. However, the hardened concrete may be accepted after carrying out suitable remedial measures to the satisfaction of the Engineer-in-Charge.

#### 5.8.4 CEMENT CONTENT OF CONCRETE

5.8.4.1 For all grades of concrete manufactured/produced, minimum cement content in the concrete shall be 310 kg per cubic metre of concrete. Also, irrespective of the grade of concrete, the maximum cement content shall not be more than 500 kg per cubic meter of concrete. These limitations shall apply for all types of cements of all strengths.

5.8.4.2 Actual cement content in each grade of concrete for various conditions of variables shall be established by design mixes within the limits specified in para 5.8.4.1 above.

#### 5.8.5 WATER CEMENT RATIO AND SLUMP

5.8.5.1 In proportioning a particular mix the manufacturer/ producer/ contractor shall give due consideration to the moisture content in the aggregates, and the mix shall be so designed as to restrict the maximum free water cement ratio to be less than 0.5.

5.8.5.2 Due consideration shall be given to the workability of the concrete thus produced. Slump shall be controlled on the basis of placement in different situations. For normal methods of placing concrete maximum slump shall be restricted to 100mm when measured in accordance with IS:1199.

**TABLE**

**CHARACTERISTIC COMPRESSIVE STRENGTH COMPLIANCE REQUIREMENT**

Specified Grade	Mean of the Group of 4 Non-Overlapping Consecutive Test Results in $N/mm^2$	Individual Test Results in $N/mm^2$
(1)	(2)	(3)
M15	$\geq f_{ck} + 0.825 \times$ established standard deviation (rounded off to nearest 0.5 $N/mm^2$ ) or $f_{ck} + 3 N/mm^2$ whichever is greater	$\geq f_{ck} - 3 N/mm^2$
M20 Or Above	$\geq f_{ck} + 0.825 \times$ established standard deviation (rounded off to nearest 0.5 $N/mm^2$ ) or $f_{ck} + 4 N/mm^2$ , whichever is greater	$\geq f_{ck} - 4 N/mm^2$

**Note:** In the absence of established value of standard deviation, the values given in Table may be assumed, and attempt should be made to obtain results of 30 samples as early as possible to establish the value of standard deviation.

#### **5.8.6 APPROVAL OF DESIGN MIX**

5.8.6.1 The producer/manufacturer/contractor of concrete shall submit details of each trial mix of each grade of concrete designed for various workability conditions to the Engineer-in-Charge for his comments and approval. Concrete of any particular design mix and grade shall be produced/manufactured for works only on obtaining written approval of the Engineer-in-Charge.

5.8.6.2 For any change in quality/quantity in the ingredients of a particular concrete, for which mix has been designed earlier and approved by the Engineer-in-Charge, the mix has to be redesigned and approval obtained again.

#### **5.8.7 READY MIX CONCRETE**

5.8.7.0 The concrete manufactured for delivery to a purchaser in a plastic and unhardened state is Ready Mixed Concrete (RMC).

The RMC shall be ordered only on approved suppliers. The RMC plant should have equipments with automatic batching system having microprocessor/computer control. The design mix of the RMC shall be approved by Engineer-in-Charge prior to supply and conformity to the same shall be periodically checked as per the mandatory requirements for periodical testing of quality of concrete.

All the specifications for concrete and RCC indicated in this booklet shall hold good for RMC to the extent they are relevant and not specifically indicated otherwise in this detailed specification for RMC or indicated otherwise in the description of the work in the work order. Further interalia following shall be strictly ensured for RMC.

#### **5.8.7.1 MIXING**

Thorough mixing is essential for production of uniform concrete. Equipment and methods used shall be capable of effectively mixing concrete materials to produce uniform mixes of the lowest slump practical of the work.

#### **5.8.7.2 CHARGING OF MIXER**

5.8.7.2.1 Mixers both stationary and truck mounted shall be so charged that there is a pre blending of the ingredients as the stream flows into the mixer.

5.8.7.2.2 Water shall enter the mixer first, but must continue to flow while other ingredients are entering the mixer. Water charging pipes shall be of proper design and of

adequate size so that water enters at a point well inside the mixer. Water charging shall be complete within the first 25% of the mixing time.

- 5.8.7.2.3 Cement shall be charged along with other materials, but it shall be ensured that cement enters the stream after approximately 10% of the aggregate is in the mixer. When it is necessary to charge cement into truck mixers separately, additional mixing time shall be allowed to obtain desired uniformity of mix.
- 5.8.7.2.4 Admixtures shall be charged to the mixer at the same time in the mixing sequence for every batch. Liquid admixtures shall be charged with the water. Powdered admixtures shall be sprinkled into the mixer with other dry ingredients. When more than one admixture is used, they shall be batched separately and they shall not be premixed before entering the mixer.

### **5.8.7.3 MIXER PERFORMANCE**

- 5.8.7.3.1 Mixer performance checks shall be made at regular intervals to ensure uniformity of the concrete. Visual examination of the concrete shall be one of the aids for maintaining and checking mixer performance.
- 5.8.7.3.2 Results of tests on air content, slump, unit weight of air free mortar shall be guide lines on mixer performance.
- 5.8.7.4 Mixing Time
  - 5.8.7.4.1 Mixing time shall be measured from the time all ingredients are in the mixer.
  - 5.8.7.4.2 Mixing time shall be established from mixer performance tests conducted at frequent intervals throughout the period of the works. However, as an initial guide, mixer manufacturer's recommendation may be followed. Other guide line being 1.33 mins, for 1 cum capacity of mixer and 0.33 min for every additional 1 cum of mixer capacity.
  - 5.8.7.4.3 Mixer shall be designed to have audible indicators and combination inter locks which prevent mixer discharge prior to completion of a preset mixing time. Mixer shall also be designed to start and stop operation with full load.

### **5.8.7.4 RE-TEMPERING**

- 5.8.7.5.1 Provided that design water-cement ratio is not exceeded, small increments of re-tempering water may be added to mixed batches to obtain the desired slump.
- 5.8.7.5.2 Addition of water in excess of designed water-cement ratio to compensate for slump loss resulting from delays in delivery or placing of concrete shall not be permitted.

#### **5.8.7.6 MIX TEMPERATURE**

5.8.7.6.1 Batch to batch uniformity of concrete with regard to slump, water requirement and air content is dependent on temperature of concrete. It shall, therefore, be ensured that the maximum and minimum temperatures of concrete throughout all seasons of the year do not vary beyond the limits given below:

Maximum : 30° C

Minimum : 20° C

5.8.7.6.2 Necessary measures shall be taken to lower or raise the temperature of water to maintain the mixed concrete between the specified temperature limits.

#### **5.8.7.7 DISCHARGING OF MIXER**

5.8.7.7.1 Mixer shall be capable of and handled properly so that concrete of lowest desired slump can be effectively discharged without causing segregation.

#### **5.8.7.8.1 READY – MIX CONCRETE MAY BE**

- + Mixed in a central plant and transported to the job in agitating or non-agitating truck bodies.
- + Mixed entirely in transit.
- + Mixed entirely after reaching the job site.
- + Mixed partially in a central plant and completed in transit or after reaching the job site (shrink mixing).

5.8.7.8.2 In ready mix concrete, special attention shall be given to the addition of mixing water quantity, which if incorrect, shall result in reduction of concrete quality.

#### **5.8.7.8.3 CONCRETE CONSISTENCY (SLUMP) IS ALSO AFFECTED BY**

- + Amount and rate of mixing.
- + Length of haul.
- + Time period for unloading.
- + Temperature conditions.

5.8.7.8.4 In cool weather or short haul and with prompt delivery concrete quality may not be significantly affected. But with reverse conditions, quality of concrete may be significantly affected.

Addition of water to compensate for slump loss shall not exceed that quantity necessary to compensate for a maximum 25mm slump loss. However,



by this additional quantity of water, the design water cement ratio shall not be exceeded.

5.8.7.8.5 Loss in workability in warm weather shall be minimised by expediting delivery and placement and by controlling the concrete temperature.

5.8.7.8.6 If it becomes necessary to use retarders to prolong the time the concrete will respond to vibrations after placement, prior approval shall be obtained from Engineer-in-Charge for the use.

5.8.7.8.7 In hot weather conditions or delays in delivery placement, use may be made of the procedure of withholding some of the mixing water till the mixer arrives at the job site. In such cases, after addition of the balance (withheld) quantity of water, an additional 30 revolutions of mixer at mixing speed shall be given to adequately incorporate the additions water into the mix.

5.8.7.8.8 When loss of slump or workability cannot be controlled by measures stated above, complete mixing shall be done at the job site using centrally dry batched ingredients.

#### **5.8.7.9 SUPPLY AND PLACING OF READY-MIX CONCRETE**

5.8.7.9.1 Responsibility of in-place quality of ready-mix concrete shall be shared by the manufacturer supplier of ready mix concrete and the placing contractor.

5.8.7.9.2 They shall work in close co ordination. The placing crew shall be in direct radio/telecommunication contact with the batch plant to ensure:

- + Avoidance of delay in dispatching concrete from batch plant.
- + Inform batching plant delays in formwork, reinforcement work, handling or placing.

5.8.7.9.3 The placement contractor shall give in writing his requirement of a particular batch of concrete to the supplier.

5.8.7.9.4 The ready-mix concrete manufacturer/supplier shall, along with each batch of concrete delivered to the placement contractor, give him a concrete delivery ticket. The supplier shall give copies of all such delivery tickets to the Engineer-in-Charge for his record and also shall get duplicate copies of all such delivery tickets duly received and signed from the placement contractor.

5.8.7.9.5 Ready mixed concrete as supplied by the manufacturer and as placed by the contractor shall in no way be different from the specifications of concrete as approved by the Engineer-in-Charge.

- 5.8.8 TRANSPORTATION:** The transportation of RMC to job site should be as quick as possible to avoid stiffening of concrete slump loss, loss of consistency and resultant difficulties for full consolidation and proper finishing. This shall be achieved by keeping the concrete in slow state of agitation during transit. The transit time shall be kept within 1½ hours.

Equipment for transporting and placing RMC:

Keeping in view the type and range of concrete following equipments may be adopted for transporting and placing RMC. Selection of methods and equipments for transit and placing of RMC shall be from the point of view to avoid segregation of concrete.

Sl. No.	Type and Range of Work	Equipment
1	Transportation of RMC for all uses	Truck agitator
2	Conveying RMC from central discharge to formwork at all levels in high rise building	Concrete pump with/without mobile boom
3	Work in high rise building and using concrete pump	Crane with/ without bucket
4	Short flat/ horizontal haul with restricted accessibility	Burrows and buggies
5	Spreading concrete over flat area as in pavements	Screw spreaders
6	Laying large volume of concrete without joints	Mobile continuous mixer
7	Restoration work, protective coating, thin lining etc. in difficult localities in large areas	Pneumatic guns
8	Concrete in vertical forms	Drop chutes
9	Concrete under water	Tremies
10	Conveying huge concrete from main discharge point to secondary discharge point or like conveying	Belt conveyors (with cover for long reaches in adverse weather situations like hot, windy condition etc.)

- 5.8.8.1 Fresh concrete can be transported to the placement area by a variety of methods. Common among them are:

- + Mixer tucks
- + Stationary truck bodies with or without agitators

- + Buckets hauled by trucks
- + Conveyor belts
- + Hose or pipe line by pumping

Each type of transportation has specific advantages and limitations depending on the conditions of mix, accessibility and location of placing.

#### **5.8.8.2 TRANSPORTATION BY MIXER TRUCKS**

5.8.8.2.1 These are essentially revolving drums mounted on truck chassis. Truck mixers used in the job shall be labeled permanently to indicate the manufactures' specifications for mixing like:

- + Capacity of drum
- + Total number of drum revolutions required for complete mixing
- + Mixing speed
- + Maximum time limit before completion of discharge and after cement has entered the drum
- + Reduction in time period of discharge
- + Due to warm weather or other variables

All above information shall only form guidelines for the manufacture/producer of concrete.

5.8.8.2.2 Fulfillment of the stipulated number of revolutions or elapsed time shall not be acceptable criterion. As long as the mixing water limit is not exceeded and the concrete has satisfactory plastic physical properties and is of satisfactory consistency and homogeneity for satisfactory placement and consolidation and is without initial set, the concrete shall be acceptable.

5.8.8.2.3 When the concrete is totally mixed in transporting trucks or in case of shrink-mix concrete, volume of concrete being transported shall not exceed 63% of the rated capacity of the drum. In case the concrete is totally mixed in the central batching plant, the transporting truck may be loaded upto 80% of the rated capacity of the drum. In this case the drum shall be rotated at charging speed during loading and reduced agitating speed after loading is complete.

5.8.8.2.4 When transporting concrete by truck mixers, delivery time shall be restricted to 1.50 hours from the time cement has entered the mixer to completion of discharge.

#### **5.8.8.3 TRANSPORTING BY AGITATING / NON-AGITATING TRUCKS**

- 5.8.8.3.1 Transporting ready mix concrete by this method shall consist of truck chassis mounted with open top bodies. The metal body shall be smooth and streamlined for easy discharge. Discharge may be from the rear when the body is mechanically tilted. Body of the truck shall have a provision of discharge gate. Mechanical vibrators shall be installed at the discharge gate for control of discharge flow.
- 5.8.8.3.2 Agitators, if mounted, also aid in the discharging of concrete from the truck in addition to keeping the concrete alive.
- 5.8.8.3.3 Water shall not be added to concrete in transport through this system.
- 5.8.8.3.4 Bodies of trucks shall be provided with protective covers during period of inclement weather.
- 5.8.8.3.5 Delivery period, when adopting this system of transporting, concrete shall be restricted to 30 minutes from the moment all ingredients including cement and water enters in mixer to completion of discharge.

#### **5.8.8.4 TRANSPORTING BY BUCKETS**

- 5.8.8.4.1 This method of transportation is very common for transportation of centrally mixed concrete. Buckets of suitable capacities may be fitted with concrete which is totally mixed in central plant and hauled to the job site. Buckets then may be conveyed to the actual point of placement either with the help of crane/hoist or they may be carted.
- 5.8.8.4.2 As in the case of open truck transportation, water shall not be added to concrete transported in buckets. Concrete shall be protected from inclement weather by necessary covering arrangements. Also maximum delivery period for this system of transportation from the time cement is introduced into the mixer to completion of discharge shall not exceed 30 minutes.

#### **5.8.8.5 CLEANING**

- 5.8.8.5.1 Before loading concrete in either truck mixer, open bodied trucks or buckets, the containers shall be thoroughly cleaned, washed and dried, so that there is no water or moisture in the container which may be the designed water content of the concrete.

#### **5.8.8.6 OTHER METHOD OF TRANSPORTATION**

- 5.8.8.6.1 Transportation of concrete either by belt conveyors or by pumping is envisaged in this work.

5.8.8.6.2 If, however, producer/manufacturer/purchaser of ready mix concrete desires to use such method of transportation, they may do so provided their scheme and complete specifications are submitted to the Engineer-in-Charge for his record and approval.

## **5.8.9 OBJECTIVE**

### **5.8.9.1 Method of transportation used shall ensure:**

Efficient deliver of concrete: No significant alteration of properties with regard to water cement ratio, slump air content and homogeneity.

5.8.9.2 All variables in transportation, considering type and accessibility of placement locations, distance, interval time etc. shall be carefully studied before arriving at the method used.

## **5.8.10 PLACING CONCRETE BY PUMPING METHODS**

### **5.8.10.1 GENERAL**

5.8.10.1.1 Concrete conveyed by pressure through either rigid pipes or flexible hoses and discharged directly in to the desired area is termed as pumped concrete. The method of conveying the concrete through pipe lines is dealt with in these specification.

5.8.10.1.2 Method of applying pressure to concrete is by pumps. Pumps to be used shall be either of the two types as mentioned below:

- (a) Piston type pumps
- (b) Squeeze pressure type pumps.

Compressed air pressure pumps shall not be used in the works.

### **5.8.10.2 PUMPING EQUIPMENTS**

#### **5.8.10.2.1 Piston pumps**

5.8.10.2.1.1 Piston pump to be used in the works shall consist of a receiving hopper for mixed concrete, an inlet valve, an outlet valve and the pump shall be a twin – piston pump.

The two pistons shall be so arranged that one piston retracts when the other is moving forward and pushing concrete into the pipe line to maintain a reasonably steady flow of concrete. Single piston pumps shall not be acceptable.

Inlet and outlet valves shall be any one of the following types:

- + Rotating plug type
- + Sliding plate type
- + Guided plunger type
- + Swing type
- + Flapper type
- + Or any combination of the above.

The pistons shall be mechanically driven using a crank or chain hydraulically driven using oil or water.

The receiving hopper shall have a minimum capacity of 1.0 cum and the hopper shall be fitted with remixing rotating blades capable of maintaining consistency and uniformity of concrete.

The primary power for pumps may be supplied by gasoline, diesel, or electric motors.

The primary power unit and the pump unit may be truck, trailer or skid mounted.

#### **5.8.10.2.2 SQUEEZE PRESSURE PUMPS**

5.8.10.2.2.1 Squeeze pressure pumps shall consist of a receiving hopper fitted with remixing blades. Re-mixing blades shall be such that these can push the concrete into the flexible hose connected at the bottom of the hopper.

The flexible hose shall pass through a metal drum around the inside periphery of the drum and come out through the top part of the drum.

The drum shall be maintained under a very high degree of a vacuum during operation. The drum shall be so fitted with hydraulically operated metal rollers which when rotating, create a squeeze pressure on the flexible hose carrying concrete and force the concrete out into the pipe line.

#### **5.8.10.2.3 EFFECTIVE RANGE AND DISCHARGE OF PUMPS**

5.8.10.2.3.1 Effective range of pumps to be used in the work shall be decided by the contractors after studying the site conditions. However, the minimum horizontal range shall not be less than 150 meters and minimum vertical range shall not be less than 50 metres.

5.8.10.2.3.2 Selection of pumps based on discharge capacity shall be decided by the contractor after studying the requirements for the project. Discharge capacity

shall be worked out by the contractors and approval obtained from the Engineer-in-Charge. As guide line figure the contractors may assume a discharge capacity of 15 cubic metre/hour/pump.

### **5.8.10.3 PIPE LINES**

5.8.10.3.1 All concrete carrying pipe lines shall generally be rigid pipe lines. Flexible pipe lines may only be used at bend curves in lines or at discharge ends if required. Placements of flexible units shall be done judiciously and connected to the pipe lines only when it meets the approval of the Engineer In-Charge

5.8.10.3.2 Rigid line/ Hard Line/ Slick Line: Such Lines shall be made either of steel or plastic. Aluminum alloy pipes shall not be used.

Minimum pipelines diameter shall be 100 millimeters and shall have normal maximum length of 3 metre in each section connected through couplers.

5.8.10.3.3 Flexible Pile Line: Flexible lines shall be made out of rubber or spiral wound flexible metal or plastic. The pipe shall again be such that they are in Sections of 3 metre length each and connected through couplers. These pipes shall be such that they are interchangeable with rigid lines. While installing flexible units, care shall be taken that there are no kinks in the pipeline, which is a normal tendency with these pipes having diameters 10mm and above.

### **5.8.10.4 COUPLERS**

5.8.10.4.1 Couplers to be used for connection pipeline sections (either hard or flexible) shall have adequate strength to withstand stresses due to handling, misalignments, poor support to pipe lines etc.

For horizontal runs of pipes and for vertical runs upto 30 metre height the couplers shall be rated for minimum pressure of 35 kg/cm square. Couplers used for rising runs between 30m metre and 50m metre height shall have a minimum pressure rating of 50 kg/cm square. Couplers shall be designed to allow for replacement of any pipe section without displacing other sections. These shall provide for the full internal cross section with no constructions or service, which may disrupt the smooth flow of concrete. For pipelines of size 150mm and above, double toggled type coupler with a thick rubber gasket and secondary wedge-take-up is recommended. Types of couplers that may be used shall be any of the following:

- + Grooved end coupler
- + One piece extended lever swing type couplers
- + And full oil line type couplers.

### **5.8.10.5 OTHER ACCESSORIES**

5.8.10.5.1 Other accessories which shall be catered for, are as under;

- ✦ Rigid and flexible pipes of varying lengths
- ✦ Curved sections of rigid pipes
- ✦ Swivel joints and rotary distributors
- ✦ Pin and gate valves to prevent back flow in pipelines
- ✦ Switch valves to direct the flow into another pipelines
- ✦ Connection devices to fill forms from the bottom up
- ✦ Splints, rollers, and other devices for protection of conduit over rock concrete Reinforcing steel and form and to provide lifting and lashing points in the pipe line
- ✦ Transitions for connecting different sizes of pipe line
- ✦ Air vents for downward pumping
- ✦ Clean out equipment.

5.8.10.5.2 For concrete of columns, walls and scattered small placements, recommendation is made for special cranes or power controlled booms carrying pipelines with a pendant type concrete delivery hose.

### **5.8.10.6 LUBRICATING OF PIPE LINE**

5.8.10.6.1 Before pumping concrete into the pipeline, the line shall be lubricated with a properly designed mortar/grout lubricant. This shall be ensured by starting the pumping operation with a properly designed mortar or with a batch of regular concrete with the coarse aggregate omitted. The quantity of mortar required as lubricant is dependent on the smoothness and cleanliness of the pipelines. As a guide line, for 100mm diameter pipe line of 100 metre length, 0.08 cum to 0.10cum of mortar should normally be adequate but this shall not be taken as specified, and the contractor shall establish his requirement.

The quantity of mortar that comes out of the delivery end of the pipeline shall not be used in place of the concrete work. However, with the approval of Engineer-in-Charge, this mortar may be used as bedding mortar against construction joints. The rest of the mortar shall be wasted.

Lubrication shall be maintained as long as the pumping of concrete continues.

### **5.8.10.7 GUIDE LINES FOR FIELD PRACTICE**

5.8.10.7.1 Proper planning of concrete supply, pump locations, line layout, placing sequence and the entire pumping operation will result in savings of time and expense.



- 5.8.10.7.2 The pump shall be placed as near the placement area as practicable. The surrounding areas of the pump shall be free of obstructions to allow for movement of concrete delivery trucks. The surface must be strong enough to withstand the loaded trucks operating on it. If the surface is a suspended slab, the truck route shall be adequately supported in consultation with the Engineer-in-Charge.
- 5.8.10.7.3 Pipe lines from the pump to the placing area shall be laid with minimum number of bends. For large placement areas, alternate lines shall be installed for rapid connection when required. A flexible pipe at the discharge end will permit placing over a large area directly without rehandling of pipelines. Pipeline shall firmly supported.
- If more than one size of pipe has to be used, the smaller diameter pipe shall be placed at the pump end and the larger diameter at the discharge end.
- 5.8.10.7.4 When pumping downwards, an air releases valve shall be provided at the middle of the top end to prevent vacuum or air build up. Similarly, while pumping upwards, a no-return valve shall be provided near the pump to prevent the reverse flow of concrete during the fitting of clean up equipments or when working on the pump.
- 5.8.10.7.5 It is essential that direct radio/telecommunication be maintained between the pump operator and the concrete placing crew. Good communication between the pump operator and the batching plant is also essential. The placing rate shall be estimated by the pump operator so that concrete can be ordered at an appropriate delivery rate.
- 5.8.10.7.6 The pump shall be started for a check run and operated without concrete to ensure that all moving parts are in operation properly. Before placing concrete, the pump shall be run with some grout /mortar for lubricating the line.
- 5.8.10.7.7 When concrete is received in the hopper, the pump shall be run slowly until the lines are completely full and the concrete is steadily moving. A continuous pumping must be ensured, because if the pump is stopped, concrete in the line may be difficult to move again.
- 5.8.10.7.8 When a delay occurs because of concrete delivery or some form repair works or for any other reason, the pump shall be slowed down to maintain some movement of concrete in the pipeline. For longer delays, concrete in the receiving hopper shall be made to last as long as possible, by moving the concrete in the lines occasionally with intermittent strokes of the pump. It is sometimes essential to run a return line back to the pump so that concrete can be re-circulated during long delays.

- 5.8.10.7.9 If after a long delay, concrete cannot be moved in the line, it may be necessary to clean out the entire line. However, quite often only a small section of pipeline may be plugged and require cleaning. The pump operator who knows such details as the length of line, age of concrete in the line etc., should be consulted for deciding the appropriate section to be cleaned.
- 5.8.10.7.10 When the form is nearly full, and there is enough concrete in the line to complete the placement, the pump shall be stopped and a "go-devil" inserted at the appropriate time so that concrete ahead of the go-devil shall be forced completion of the work. The go-devil shall be forced through pipeline to clean it out. Use of water pressure is a safer method. The go-devil shall be stopped at discharged end to ensure that water does no spill on the placement area. If air pressure is used extreme care shall be taken and the pressure must be carefully regulated. A trap shall be installed at the end of the line to prevent the go-devil being ejected as a dangerous projectile. An air release valve shall also be installed in the line to prevent air pressure build up.
- 5.8.10.7.11 It is essential to clean the line after concrete placing operation is complete. Cleaning shall be done in the reverse direction from the work end to the pump-end where the concrete in the line can be dumped in a bucket. After removal of all concrete, all pipe lines and other equipments shall be cleaned thoroughly and made ready for the next use.

#### **5.8.10.8 INFORMATION TO BE FURNISHED BY CONTRACTORS**

- 5.8.10.8.1 Along with their bid the contractors if called for shall be required to submit the following information regarding the equipments proposed to be used by them:
- ✦ Type, number, capacity, range, mounting, nature of primary power used and the operating weights of pump and mounting.
  - ✦ Manufacturer's specifications for pipe lines giving pressure ratings, sizes and material for straight and curved sections.
  - ✦ Manufacture's certificates.

#### **5.8.11 SAMPLING AND TESTING (MATERIALS)**

##### **5.8.11.1 AGGREGATES**

- 5.8.11.1.1 If called for the supplier of aggregates shall furnish the following informations before the materials is delivered to site:
- Precise location of source from where the material is to be supplied.
  - Trade group of principal rock type.

- Presence or reactive minerals.
- Trade group names of aggregates to be used for concrete viz., Granite, Gabbro Dolerite, Rhyolite, Basalt, Quartzite, Gneiss.

5.8.11.1.2 If called for the supplier shall also furnish reports on test results giving the following informations for approval to Engineer-in-Charge before delivery of material at site:

- ✦ Specific gravity
- ✦ Bulk density
- ✦ Moisture content
- ✦ Absorption value
- ✦ Aggregate crushing strength
- ✦ Aggregate impact value
- ✦ Abrasion value
- ✦ Flakiness index
- ✦ Elongation index
- ✦ Limits of deleterious substances in the aggregate
- ✦ Soundness of aggregate
- ✦ Potential reactivity of aggregate.

All test shall be conducted in accordance with IS 2386 (Part – I to VIII).

5.8.11.1.3 Change in quality of aggregates under the trade group name shall not be acceptable in the work. Change in source of aggregates shall also not be acceptable under normal circumstances, even if the aggregates belong to the same trade group. Engineer-in-Charge, may with his discretion allow a change in the source. But, in that case, all test mentioned in para 5.8.11.2 above shall have to be repeated for the aggregates from the changed source and the test results submitted to Engineer-in-Charge for his approval before the delivery of material at site.

5.8.11.1.4 If called for, in addition to provision in paras 5.8.11.1.1, 5.8.11.1.2 and 5.8.11.1.3 above the following tests have to be performed on representative samples from every lot of aggregates after delivery at site. These tests results are to be submitted to the Engineer-in-Charge for his approval. Acceptance criteria for aggregates shall be based-i In-Charge, the results are not within permissible limits, the lot of aggregates from which the samples have been obtained for testing shall stand rejected and the material shall be removed from the site.

## MANDATORY TESTS ON AGGREGATES AT SITE

Sl No.	Tests	No. of test on each 10 cum of Material or part of thereof
1	Specific gravity	3
2	Bulk density	3
3	Aggregate crushing strength	3
4	Limits of deleterious substances	3
5	Aggregate impact value	3

Mean value of the results from above test shall be taken as the representative value and the acceptance criteria shall be based on these. All test procedures and computations for test results shall be as per IS: 2386

5.8.11.1.5 All other test in para 5.8.11.1.4 being in compliance with requirements set in specifications, if only the limits of deleterious substances do not meet the requirements, an attempt may be made to wash the aggregate to bring the limits within permissible values. Under such circumstances, moisture content check shall be made and allowance made before batching.

5.8.11.1.6 Apart from mandatory tests specified in para 5.8.11.1.4 above, the Engineer-in-Charge may at his discretion, call for any additional tests that he may consider necessary. Sampling, procedure and computations for such test shall be done in accordance with IS:2430 and IS:2386 as applicable.

### 5.8.11.2 CEMENT

5.8.11.2.1 Supplier of cement shall furnish the following documents before the cement is delivered to site.

5.8.11.2.1.1 Certificate confirming that chemical composition and physical characteristics are within the stipulated values for types of cement supplied as per relevant codes.

5.8.11.2.1.2 Certificate confirming that the chloride content in the cement is not in excess of 0.05 percent of mass of cement.

5.8.11.2.2 If during subsequent testing of cement supplied in lots any of the properties are found to be outside the acceptable limits, the lot of cement shall be rejected.

5.8.11.2.3 Each 1000 bags or part thereof of cement, or each wagon load of cement shall constitute one lot of cement for the purpose of conducting tests at site before cement is accepted.

- 5.8.11.2.4 Samples for testing at site shall be taken at random from 2% of the total quantity supplied in one lot. For example supplied in bags, samples shall be drawn for minimum of 5 bags and the 2% value shall be rounded off to the next higher integer.

For bulk cement, sampling shall be done with the help of slotted sampler to be as per IS:3535

- 5.8.11.2.5 Results of test conducted on samples drawn as mentioned in para 5.8.11.2.4 shall be submitted to the Engineer-in-charge for his approval. If in the opinion of the Engineer-in-Charge, the test results are not within permissible limits, the lot of cement from which samples have been obtained for testing shall stand rejected and the material shall be removed from site.

- 5.8.11.2.6 Following tests shall be conducted at site on each lot of cement delivered:

Sl. No.	Mandatory Tests	Number of test/lot
1	Consistency of standard Cement paste	5
2	Initial and final setting time	5 each
3	Compressive strength test	10

Mean values of the results from the above results shall be taken as the representative value and the acceptance criteria shall be based on these test. All test procedures and computation of test results shall be as per IS:4031.

- 5.8.11.2.7 Apart from mandatory tests specified in para 5.8.11.2.6 above, the Engineer In-charge may at his discretion, call for any additional tests that he may consider necessary. All such tests shall be done on representative samples taken from each lot described para 5.8.11.2.4 and testing and computation of test results shall be done as per IS:4031.

### **5.8.11.3 WATER**

- 5.8.11.3.1 Water to be used in manufacturing and curing of concrete shall be tested before use. All such test results shall be submitted to the Engineer-in-Charge for his approval before water is used.

- 5.8.11.3.2 Manufacturer/Contractor responsible for concrete work shall identify and inform the Engineer-in-Charge, precisely the location of source of water intended to be used. Each such source of water shall be separately tested. In the event of a change in the source of water all tests specified herein shall have to be repeated.

- 5.8.11.3.3 In the event water is drawn from tube wells or open-wells, water samples shall be tested for seasonal fluctuations in water table or at intervals to be directed by the Engineer-in-Charge.

5.8.11.3.3 Water samples from each source shall be tested as under:

Test	Number of tests each source
Acidity	3
Alkalinity	3
Presence of solids	3

Mean values of the above test shall be taken as the representative value and the acceptance criteria shall be based on these test results. All testing procedures and computation of test results shall conform to IS:3025

#### 5.8.11.4 ADMIXTURES

5.8.11.4.1 If called for suppliers of Admixtures for concrete, contractor shall supply the following before any admixtures is approved by Engineer-in-Charge for their use:

- (a) Certificate confirming that the use of a particular brand of admixture shall not be harmful to concrete in any way.
- (b) Certificate confirming the exact dosage of admixture of a particular brand.
- (c) Certificate stating the specific purpose for which the admixture is to be used
- (d) Special precautionary measures to be taken in the manufacture of concrete when using the particular brand of admixture.
- (e) Certificate confirming that the admixture conforms to specifications of IS:9103 or to ASTM-C260, ASTM-C 10, ASTM-C 595 or to ASTM-C 618.

5.8.11.4.2 Engineer-in-Charge at his discretion may require tests to be performed to reconfirm the characteristic properties of any admixture. All such tests shall be done in accordance with IS:9103.

5.8.11.5 All tests described in paras 5.8.11.1 to 5.8.11.4 above shall be done at the site laboratory or at laboratory to be identified by the Engineer-in-Charge depending on the test to be conducted.

5.8.11.6 All test shall be done in the presence of a representative nominated by the Engineer-in-Charge and a representative of the concrete Manufacturer/ Contractor when test are performed at the site laboratory. All observation and reports of test shall be jointly signed by the two representatives before the test results are submitted to the Engineer-in-Charge for his approval.

5.8.11.7 Unless otherwise stated in the contract expenses for all materials used for testing, sampling procedures and testing including preparing report shall be borne by the Concrete Manufacturer/Contractor.

## **5.8.12 SAMPLING AND TESTING FOR QUALITY CONTROL OF CONCRETE**

### **5.8.12.1 FRESH CONCRETE**

5.8.12.1.1 Fresh concrete shall be tested for slump

Compacting Factor/Workability

Consistency

Weight per cubic metre, cement factor and air content.

### **5.8.12.1.2 SLUMP**

5.8.12.1.2.1 For concrete totally mixed in a central plant, slump shall be checked at:

- (a) Immediately during loading of trucks
- (b) Point of discharge from the delivery truck
- (c) Final placement location

At placement location the slump measured shall conform to the design slump. Manufacturer of concrete shall adjust for loss of slump in transit and establish the requirements of design mix. All slump measurements shall be done within a period of 20 minutes from the time cement is added to the mixer. Placement contractor shall transport concrete from truck discharge point to actual placement location within 10 minutes of delivery, before the final slump reading is taken at placement location.

5.8.12.1.2.2 For concrete entirely mixed in transit or for shrink mix concrete, slump readings shall be taken at:

- (a) Point of discharge from delivery trucks
- (b) Final placement location.

In this case also, the slump measured at the final placement location shall conform to the designed slump. The placement contractor shall be responsible for transporting concrete from delivery truck discharge point to final placement location within 10 minutes. However, in this case, the truck shall discharge the concrete within 1 hour and 30 minutes from the time cement is added in the mixer and slump measured at the point of discharge immediately on delivery. Manufacturer of concrete shall ensure that the final slump measurement corresponds to the ordered slump.

- 5.8.12.1.2.3 For measuring concrete slump at point of discharge from delivery trucks, samples shall be taken from concrete omitting the first and the last 15% of the load. For concrete delivery or placed by pumping, sampling shall be similar to those specified for delivery trucks.
- 5.8.12.1.2.4 Slump measurement of ready mix concrete transported by buckets shall be at a location specified in para 5.8.12.1.2.1 with same limits on time.
- Sampling from buckets shall be such that the bucket containing discharge from mixer for the first and last 15% are omitted.
- 5.8.12.1.2.5 At placement locations, samples for checking slump shall be collected from every 20 cum of concrete or part thereof placed at location for each type of concrete.
- 5.8.12.1.2.6 For all slump checks in the field atleast two recordings shall be made and the average value taken as the recorded slump.
- 5.8.12.1.2.7 Slump checks for concrete in the laboratory shall be carried out as and when required by the manufacturer of concrete during the mix design stage and during the progress of work for control on field results.
- 5.8.12.1.2.8 Slump readings shall only be a guideline for concrete consistency and shall not be taken as the acceptability criteria for concrete placed at location. All slump tests shall be carried out in accordance with IS:1199.

### **5.8.12.1.3 COMPACTING FACTOR**

- 5.8.12.1.3.1 For concrete whose ordered slump is 50mm or less, compacting factor test shall be conducted at both field and central batch plant in addition to slump tests mentioned in para 5.8.12.1.2.
- 5.8.12.1.3.2 Compacting factor check shall be done in field only at placement location, and shall also be conducted at central batch plant if concrete is totally mixed in plant.
- 5.8.12.1.3.3 For this test sampling shall be done as for slump measurements in field and within the same time frame as for slump test.
- 5.8.12.1.3.4 Only one compaction factor test shall be conducted for every 20 cum of concrete or part thereof placed at location for each type of concrete. Since the tests is sensitive, every care shall be taken to conduct this test totally in compliance with procedure mentioned in IS:1199.
- 5.8.12.1.3.5 Laboratory tests for determining compacting factor of concrete shall be done as per manufacturer's requirement for establishing and controlling the design mix of concrete.



- 5.8.12.1.3.6 Compacting factor test shall not be taken as an acceptance criteria and shall be treated only as a guide line to workability of concrete.

#### **5.8.12.1.4 CONSISTENCY OF CONCRETE**

- 5.8.12.1.4.1 This test shall be performed only at the batching plant laboratory using a Vee-Bee consistometer for determining and predicting the slump of concrete. Number and frequency of these tests shall be based on requirements of the manufacturer of concrete. Care shall be taken in producing mix design of required characteristic strengths of concrete within limits of Vee-Bee – Degree Between 1.6 and 4.5 for concrete transported and placed by normal methods and between 0.8 and 3.5 for concrete transported and placed by pumping methods.

#### **5.8.12.1.5 WEIGHT, CEMENT FACTOR AND AIR CONTENT TEST**

- 5.8.12.1.5.1 If directed by Engineer-in-Charge freshly mixed concrete for every type shall be tested in the batch plant laboratory for each batch of concrete produced to determine weight per cubic metre of freshly mixed concrete, cement factor in concrete and the air content of the concrete. Frequency and number of test shall be finalized by the manufacturer of concrete in consultation with the Engineer In-Charge for his requirement on the mode of measurement of concrete produced.
- 5.8.12.1.6 The Engineer-in-Charge may at his discretion require further tests over and above those specified above in para 5.8.12.1.1 to be conducted on fresh concrete. The manufacturer and the placement contractor shall have to comply with all such requirement.

#### **5.8.12.2 HARDENED CONCRETE**

- 5.8.12.2.1 For quality control a strict check on the strength of concrete shall be maintained along with other field requirements such as workability, consistency, slump etc., mentioned in para 5.8.12.1.1 above.
- 5.8.12.2.2 Acceptability criterion of concrete as specified in para 5.8.1.5, shall only be applicable.
- 5.8.12.2.3 Test on cube crushing strength of concrete in accordance and compliance with IS:456 and IS:516 shall be done as under:
- (1) Samples of fresh concrete shall be taken from concrete at central batch plant mixer while loading delivery trucks or other transport and also from concrete transported to placement location.
  - (2) Test on specimens made from samples collected at placement location shall be considered strength. Test in specimens made from samples at the batch plant shall only be taken as guide lines test. Only in the case

of doubtful result, the Engineer-in-Charge may refer to such guide lines results for deciding on the quality of concrete.

- (3) For truck mix concrete and shrink mix concrete guide line test specimens shall be made from samples collected at discharge location from mixing trucks. For this purpose first and last 15% of the load shall be omitted while collecting samples.
- (4) Frequency of sampling shall be as given below in Table below for each grade of concrete of different workability and for each type of specimens (field test specimens and guideline test specimens) for conducting 28 days crushing strength tests.

**TABLE**

Quantity of concrete Delivered (cum)	Number of Samples
Less than 5	1
6 to 15	2
16 to 30	3
31 to 50	4
51 and above	4 plus one additional samples for each additional 15 cum or part thereof

Each sample shall be of adequate quantity so that a minimum of 3 specimen cubes can be made for the test of the sample in accordance with IS:516.

- (5) All test specimens shall be made compacted cured and tested in compliance with IS:516 and test results interpreted in accordance with IS:456. For acceptance of concrete strength, field specimens test results shall not be less than values given in table above (Characteristic compressive strength compliance requirement).
- (6) In addition to 28 days crushing strength test on specimens made at frequencies specified in para 4 above, early strength tests at 7 days shall also be conducted on field specimens as well as guide line test specimens. Frequency of sampling for this set of test shall also be same as those specified earlier Table above. 7-day strengths also shall conform to values given in Table for the same above. But these test results even if conforming to specified values shall only be taken as guide line values for projecting concrete strength and shall not be construed as conforming to specifications.

- (7) For each grade of concrete and for all workability conditions with different water – cement ratios and compositions of admixtures, preliminary test shall be conducted for crushing strengths on finalization to design mix for each type of concrete. Such tests shall be conducted both at 7 days and 28 days under laboratory conditions. Six test specimens shall be made for 7 days test and six test specimens shall be made for 28 days test.

Average of the six test results of different periods shall not be less than those specified above.

- (8) Crushing strengths on cubes shall also be conducted during the process of finalisation of concrete design mix. Frequency and number of such tests shall be as per requirement of concrete manufacturer.
- (9) All test specimens for conducting crushing strength shall be properly labeled for identification indicating:
- + Date of making specimen
  - + Grade of concrete
  - + Placement location exact
  - + Purchasers order number
- (10) In addition to crushing strength test on concrete, the Engineer-in-Charge may call for other tests on hardened concrete. The placement contractor and the manufacturer of concrete shall comply with all such instructions.

#### **5.8.12.2.4 NON-DESTRUCTIVE TEST**

5.8.12.2.4.1 When the 28 days crushing values on field specimens and /or specimens made for guideline test fall short of specified values, or in case of doubtful placement of concrete, the Engineer-in-Charge shall call for non-destruction tests on the structure. Such tests may be any one or a combination of the following:

- + Rebound hammer test
- + Windsor penetration probe test
- + Pulse velocity (Sonic or Ultrasonic) test
- + Core test
- + Load test

- 5.8.12.2.4.2 Interpretation of rebound hammer, Windsor Probe and Pulse velocity test results shall rest with the Engineer-in-Charge.
- 5.8.12.2.4.3 Core test, if ordered by the Engineer In-charge, shall be done in accordance with IS:516 samples for such test shall be taken from locations to be identified by the Engineer-in-Charge and such samples shall be collected in compliance with IS:1199.
- 5.8.12.2.4.4 If felt necessary, the Engineer-in-Charge may instruct load testing for any part of the structure based on doubtful concrete strengths. Such test shall be carried out as per details to be provided by the Engineer-in-Charge in consultation with the structural consultants.
- 5.8.12.3 Unless otherwise specified in contract, the concrete manufacturer/ concrete placement contractor shall arrange for all test to be conducted in accordance with these specifications, including all necessary tools, plants, equipments and material, and shall be responsible for conducting all tests at his cost.
- 5.8.12.4 All test conducted at the field laboratory shall be carried out by qualified technicians employed by the concrete manufacturer/concrete placement contractor, in presence of authorized representative of the Engineer-in-Charge. All test reports and observation reports shall be jointly signed by the Engineer -in-charge or his authorized representative and the technician conducting such test.
- 5.8.12.5 Engineer-in-Charge shall alone decide where such tests are to be conducted. He may instruct tests to be conducted at laboratories other than the field laboratory and such instructions shall be followed without claiming extra charges on this account.
- 5.8.12.6 When directed by Engineer In-Charge, the concrete Manufacturer/Placement contractor shall set up a laboratory at this own expense which shall have facilities, for conducting all necessary field test on materials and field and laboratory test on concrete. The laboratory shall be staffed by the concrete Manufacturer/Placement Contractor with qualified and experienced scientists and technicians.
- 5.8.12.7 Special Care with respect to centering / formwork in case of RMCApart from attending to all the requirements of formwork detailed under RCC chapter, while RMC is being used special additional care shall be taken to ensure that form work is adequately strong for receiving RMC by pumping. While concreting it should be ensured that dumping of large quantities of concrete

at the mouth of delivery pipe for subsequent spreading should be avoided as the centering / formwork might not have been designed for this additional load of dumping concrete at one point. As far as possible uniform spreading of concrete over the entire area shall be ensured to avoid unintended additional loads at random locations.

## **5.9 THERMO MECHANICALLY TREATED BARS (TMT-BARS)**

### **5.9.1 Introduction**

Thermo Mechanically Treated (TMT) Bars is a recent technological advancement for production of strength deformed steel bars for concrete reinforcement. In this process higher strength is obtained in thermo mechanical treatment, wherein the steel bars get intensive cooling immediately after rolling. Sudden reduction in temperature creates a hardened surface layer with the internal core still being hot. While further cooling in atmosphere, tempering takes place by the heat from the core. This process is expected to improve the properties of strength and ductility of the bars.

### **5.9.2 ADVANTAGE**

Generally, the higher strength in steel can be obtained by increasing Carbon content, Micro alloying, Thermo Mechanical Treatment or Cold Twisting. So far in India, cold twisting of bars was used extensively for production of high strength bars. These bars can easily be identified by the two main ribs being helical, where as in hot rolled bars these ribs are straight. In the case of TMT Bars the higher strength is obtained by thermo mechanical treatment and the Carbon content also has been brought down leading to improved Ductility.

### **5.9.3 PERMISSION TO USE**

However, it may be noted that deliberations are going on at the Bureau of Indian Standard (BIS), for making appropriate provisions in relevant BIS codes and it is expected that this will be done shortly. Meanwhile, the properties of these bars have been examined and it has now been decided that these bars may be allowed to be used in CED works.

### **5.9.4 PROPERTIES**

This steel is currently being produced in various grades by M/S Steel Authority of India Ltd. (SAIL), M/S Tata Steel and M/S Rashtriya Ispat Nigam Ltd. The trade names for these bars are SAIL-TMT, TISCON-TMT and REBARS respectively. The grades, chemical properties and mechanical properties are indicated in Table I, II & III.

TABLE - I

M/s Sail	M/s Tata Steel	M/s Rashtriya Ispat Nigam Ltd.	Yield Stress (0.2% proof Stress) Considering Equivalent As per IS:1786
SAIL TMT 415	TISCON TMT 42	REBARS 415	415 N/MMF
SAIL TMT 500	TISCON TMT 50	REBARS 500	500N/MMF
SAIL TMT 520			530 N/MMF

TABLE - II

## CHEMICAL COMPOSITION IN %

IS 1786 FE 415	Sail TMT All Grades	Tiscon TMT-42	TMT - 50	Vizag Steel (RINL) Rebarsall Grades
Carbon	0.30	0.25	0.17	0.20
Sulphur	0.06	0.05	0.045	0.04
Phosphorus	0.06	0.05	0.045	0.05
Sulphur+Phosphorus	0.11	0.10	0.90	0.09

TABLE-III

## MECHANICAL PROPERTIES

	IS - 1786	SAIL - TMT			TISCON		Vizag Steel (RINL) Rebar	
Grade	Fe 415	415	500	550	TMT-42	TMT-50	Fe 415	Fe 500
Yield Strength	415	415	500	550	450	530	460	540
Tensile Strength	485	500	580	630	510	580	520	585
Elongation in %	14.5	22	20	18	20	18	20	16

## 5.9.5 LIMITATIONS

- 5.9.5.1 Standard Table of SP 16 (Design Aid to IS:456) can be used for utilising these design process. However, there are limitations when it comes to using the strengths 415 Mpa in Earthquake prone areas IS:13920 forbids using strengths higher than 415 Mpa under following situations:

The Structure is located in Seismic zone IV & V.

- (i) The Structure is located in Seismic Zone - III and has the importance factor (I) greater than 1.

- (ii) The structure is located in Seismic Zone – III and is an Industrial Structure
- (iii) The Structure is located in Seismic Zone – III and is more than 5 storey high.

5.9.5.2 While every care shall be taken to avoid mixing different types and grades of bars in structure members as main reinforcement to satisfy Clause 25.1 of IS:456, if approved by competent authority / indicated in approved structural drawing, under exigencies where two grades/types of bars are to be used in the same building the same may be used.

#### **5.9.6 IDENTIFICATION**

Care shall also be taken to property identify these bars at site. The staff shall be specially looking for identification marks on these bars. While TISCON Bars are available with embosses on their bars SAIL – TMT are yet to do so. Currently SAIL is providing Bundled bars colour coded yellow for TMT 500 and Green for TMT 550 (No colour code for TMT 415) at the ends along with a tally indicating the grade with each bundle Rashtriya Ispaat Nigams's rebar can be identified with In-Signia which is embossed on every rebar during the rolling process itself. However, the grade of rebar can be identified by means of colour coding. Grade Fe 415 is coded Blue colour and Fe 500 is coded with Blue-Green colour. Hence, it will be advisable to see that the type/grade of bars are brought to site and used in the project after conducting tests for each lot.

#### **5.10 VACUUM DEWATERED CONCRETE**

- 5.10.1 The concrete from which the excess water, not required for hydration is extracted, by vacuum process, when the concrete is freshly laid, and consolidated is known as vacuum dewatered concrete (VDC).
- 5.10.2 In addition to the specification with respect to concrete works, concrete pavement works, stipulated in this booklet, following specific requirements shall be ensured when attending to VDC works.
- 5.10.3 The water cement ratio adopted in concrete based on workability consideration will always be more than the minimum water content required for full hydration of cement. This excess water is not required once the concrete is mixed, laid and consolidated. This water is extracted from concrete by application of vacuum process at the surface of the concrete. Approximately 20% to 25% of water from the concrete may be removed by this process and this results in settlement of the concrete to the extent of about 3% of the depth over which the suction acts. Power troweling will be done to the surface of VDC. This reduction in water cement ratio and power troweling will increase the strength of concrete, improve wear resistance, imparts high abrasion value, ensure rapid stiffening of concrete, enabling early usage of the area.

VDC are generally used where high strength floors, concrete roads and pavements are required with high abrasion value and wear resistance. Due to its high impermeability it may be used where impermeable concrete is required.

There shall be a base leveling concrete for VDC for floor, road and pavements etc.

Based on design consideration and effective depth of suction the thickness of VDC slabs shall be decided.

The VDC are to be laid in alternate panels. The size of the panel is guided by length of the screed vibrator which is generally 4 m long. The base concrete where VDC to be laid shall be cleaned and M.S channel forms are to be fixed in panels of suitable sizes keeping the top level of the channel in level with top of VDC. The reinforcement shall be placed in position with covers at top, bottom and allround as specified. All embedments, requirement of construction joint, expansion joints etc. to be attended. There on the design mix concrete of approved grade shall be uniformly poured into the form/panel and leveled. The concrete shall be vibrated by poker vibrator for proper consolidation. There on surface vibration of the concrete shall be done using double beam screed broad motor guided vibrator moving along the M.S. channels. Over this vibrated concrete surface a bottom sieve mat has to be placed to act as a fine filter bed to prevent removal of cement together with water during extraction of excess water by vacuum dewatering process. A porous mat connected to a vacuum pump is placed over the sieve mat and dewatering of concrete is done with vacuum pump of appropriate capacity. A Vacuum of 0.8 Mpa is applied for a period of about 15 to 20 minutes. The extracted water may be collected to broadly cross check that adequate water is still retained in the concrete for full hydration.

The process of dewatering leaves a few voids behind on the concrete surface. Hence poker vibrator shall be gently applied again as may be required. Thereon a power trowel fitted with circular disc shall be applied judiciously to get a level hard top surface. Finally the power trowel with adjustable plates shall be operated over the concrete surface for obtaining perfect finish to the VDC surface.

With respect to curing, provision of construction joints, expansion joints, removal of form work and all other related works the relevant specification under concrete; RCC; concrete pavement concrete flooring etc in this booklet shall hold good for VDC also.



## CHAPTER – 6

### BRICK WORK

#### 6.0 TERMINOLOGY

**Bond :** The arrangement of the bricks in successive courses to tie the brick work together both longitudinally and transversely. The arrangement is usually designed to ensure that no vertical joint of one course is exactly over the one in the next course above or below it, and there is greatest possible amount of lap.

**BED JOINT:** Horizontal joint in brick work or masonry.

**Closer:** Any portion of a brick used in constructing a wall, to close up the bond next to the end brick of a course.

**Coping or Weathering:** The cover applied over or the geometrical form given to a part of the structure to enable it to shed rain water.

**Corbel:** A cantiever projecting from the face of wall to form a bearing.

**Cornice:** Horizontal or ornamental feature projecting from the face of a wall.

**Course:** A layer of brick including bed mortar.

**Cross Joint:** A joint other than a bed joint normal to the wall face.

**Efflorescence:** A powdery incrustment of salts left by evaporation. This may be visible on the surface or may be below surface. In the latter case this is termed as crypto efflorescence.

**Header:** A brick laid with its length across the wall.

**Indenting:** The leaving recesses into which future work can be bonded.

**Jamb:** The part of the wall at the side of an opening .

**Joint:** A junction of bricks.

**Jointing:** The operation of finishing joints as the masonry work proceeds.

**Pier:** A thickened section forming integral part of the wall placed at intervals along the wall primarily to increase the stiffness of the wall or to carry a vertical

concentrated load. The thickness of a pier is the over all thickness including the thickness of the wall, or when bonded into one leaf of a cavity wall the thickness obtained by treating this leaf as an independent wall.

**Pillar:** Pillar means a detached masonry support. This can be rectangular, circular, elliptical etc in case of rectangular pillar, the breadth shall not exceed three times the thickness and thickness itself shall not exceed more than thrice the length of brick.

**Quoin:** An external corner in brick work, the term may also denote the brick used to form the quoin.

**Scaffolding :** A temporary erecting of timber or steel work used in the construction, alteration demolition or repairs of a building to support or to attend of the hoisting or lowering of workmen their tools and materials.

**Sill:** A brick work forming the lower boundary of door or window opening.

**Spandrel:** The space between the haunches and the road decking of an arch.

**Stretcher:** A brick laid with its length in the direction of the wall.

**String Course:** A horizontal course projecting from a wall usually introduced at every floor level or windows or below parapet for imparting architectural appearance to the structure and also keeping off the rain water.

**Templet:** A pattern of sheet metal used as a guide for setting out specific section and shape.

**Toothing:** Bricks left projecting in alternate courses to bond with future work.

**Wall joint:** A joint parallel to the wall face.

**Arises:** The edges of the brick formed by intersection of the plain surface of brick.

**QUEEN CLOSER:** Queen closer is made by cutting brick longitudinally in two equal parts or by cutting bricks breadth wise in quarter lengths.

**KING CLOSER:** King closer is made by cutting the brick half portion of header face and half portion of stretcher face in a triangular portion.

**BEVELLED CLOSER:** Bevelled closer is made by cutting a triangular portion of the brick from half the width of brick to end of length side.

**MITRED CLOSER:** Mitred closer is made by cutting a triangular portion of the brick through its width at an angle of 45° to 60° with the adjacent length of the brick.

**FROG:** The depression of brick on its flat face for the purpose of forming key for holding the mortar with the brick is known as frog.

Bricks may be sand or shop moulded or machine pressed and wire cut and may be kiln or clamp burnt shall have a minimum compressive strengths of 35 kg/sqm unless otherwise specified. All bricks shall conform with the following requirements:

- a) They shall be sound, hard and well burnt with sharp edges of uniform size an regular shape, free from cracks,stones, or nodules of lime and other defects.
- b) They shall give a clear metallic ring when struck together
- c) They shall be uniform in colour and of the size indicated.
- d) They shall not be broken, cracked, stratified, under burnt, overburnt or soft.
- e) Bricks broken to examine the texture shall show that they are of clean homogenous nature, free from stones and lumps of lime.

#### **6.1.0 BRICKS TILES / BRICK BATS**

Bricks used in the masonry may be of the following type:

- a) **Common Burnt clay bricks:** Shall be hand moulded. They shall be free from nodules of free lime, visible cracks, flaws warpage and organic matter, have a frog 100 mm in length 40mm in width and 10mm to 20mm deep on one of its flat sides. Bricks made by extrusion process and brick tiles may not be provided with frogs. Each brick shall be marked (in the frog where provided) with the manufacturers identification mark or initials.
- b) **FLY ASH LIME BRICKS (FALG BRICKS):** The fly Ash lime bricks (FALG bricks shall conform to IS:12894. Visually the bricks shall be sound, compact and uniform in shape free from visible cracks, warpage flaws and organic mater. The bricks shall be solid and with or without frog on one of its flat side.

**FLY ASH:** Fly ash shall conform to grade 1 or grade 2 of IS: 3812.

**NOTE:** [This item will be operated only for load bearing structure upto 2 storeys and for non-load bearing walls 23 cms thick for multi storeyed buildings].

Bottom ash used as replacement of sand shall not have more than 12% loss on ignition when tested .

Sand: Deleterious materials, such as clay and silt in the sand shall preferably be less than 5%.

Lime: Lime shall conform to class 'C' hydrated lime of IS:712.

**Additives:** Any suitable additive considered not detrimental to the durability of bricks may be used.

- c) **Clay Fly Ash Bricks:** The clay fly ash bricks shall conform to IS:13757. The bricks shall be sound, compact and uniform in shape and colour. Bricks shall have smooth rectangular faces with sharp and square corners. The bricks shall be free from visible cracks, flaws, warpage, nodules of free lime and organic matter, the brick shall be hand or machine moulded. The bricks shall have frog of 100 mm in length 40mm width and 10 to 20 mm deep on one of its flat sides. If made by extrusion process may not be provided with frogs.

Fly Ash conform to grade 1 or grade 2 of IS:3812.

Fly ash conform to grade 1 or grade II of IS:3812.

(Calcium Silicate Bricks: The bricks shall conform to IS:4139. The Calcium Silicate bricks shall be sound, compact and uniform in shape. Bricks shall be free from visible cracks, warpage organic matter, large pebbles and modules of free lime. Bricks shall be solid and with or without frog. The bricks shall be made of finely grounded sand siliceous rock and lime. In addition limited quantity of fly ash conforming to IS:3812 may be used in the mix. These bricks are also known as Fly Ash Sand Lime bricks in the construction industry).

**Tile Brick:** The bricks of 4 cm height shall be moulded without frogs. Where modular tiles are not freely available in the market, the tile bricks of F.P.S thickness 44mm (1-3/4") may be used unless otherwise specified.

**Brick Bats:** Bricks bats shall be obtained from well burnt bricks.

#### 6.1.1 DIMENSIONS

The bricks may be modular or non-modular. Sizes for both types of bricks / tiles shall be as per table -1. While use of modular bricks /tiles is recommended, non-modular (FPS) bricks / tiles can also be used where so specified. Non-modular bricks/tiles of sizes other than the sizes mentioned in table 1 may also be used where specified.

TABLE 1

TYPES OF BRICKS / TILES	NOMINAL SIZE/MM	ACTUALS SIZE/MM
Modular bricks	200 x 100 x 100 mm	190 x 90 x 90mm
Modular tile bricks	200 x 100 x 40mm	190 x 90 x 40 mm
Non-modular tile bricks	229 x 114 x 44 mm	225 x 111 x 44mm
Non-modular bricks	229 x 114 x 70mm	225 x 111 x 70mm

### 6.1.2 Classification

Bricks / Brick tiles shall be classified on the basis of their minimum compressive strength as given below:

TABLE 2

CLASS / DESIGNATION	AVERAGE COMPRESSIVE STRENGTH			
	NOT LESS THAN		LESS THAN	
	N/MM <sup>2</sup>	Kgf/cm <sup>2</sup>	N/mm <sup>2</sup>	Kgf/cm <sup>2</sup>
10 (100)	10	(100)	12.5	125
7.5 (75)	7.5	(75)	10	100
5 (50)	5	(50)	7.5	75
3.5 (35)	3.5	(35)	5.0	50

The bricks shall have smooth rectangular faces with sharp corner and shall be uniform in colour and emit clear ringing sound when struck.

**Note:** Upper limits specified in Table 2 are for calculating the average compressive strength.

### 6.1.3 SAMPLING AND TESTS

- \* Samples of bricks shall be subjected to the following tests:
- \* Dimensional tolerance
- \* Water absorption
- \* Efflorescence
- \* Compressive Strength

**6.1.3.1 SAMPLING:** For carrying out compressive strength, water absorption, efflorescence and dimensional tests, the samples of bricks shall be taken at random, according to the size of lot as given in Table 3 below. The sample

thus taken shall be stored in a dry place until tests are made. For the purpose of sampling, the following definition shall apply:

- a) **Lot:** A collection of bricks of same class and size, manufactured under relatively similar conditions of production. For the purpose of sampling a lot shall contain a maximum of 50000 bricks in case a consignment has bricks more than 50,000 of the same classification and size and manufactured under relatively similar conditions of production, it shall be divided into lots of 50,000 bricks or part thereof.
- b) **Sample:** A collection of bricks selected for inspection and / or testing from a lot to reach decision regarding the acceptance or rejection of the lot.
- c) **Defective:** a brick failing to meet one or more of the specified requirements.

6.1.3.2 The samples shall be taken as below:

**Sampling from a Stack:** When it is necessary to take a sample from a stack, the stack shall be divided into a number of real or imaginary sections and the required number of bricks drawn from each section. For this purpose bricks in the upper layers of the stock shall be removed to enable units to be sampled from places within the stack.

**Note:** For other methods of sampling i.e sampling in motion and sampling from lorries or trucks S:5454 may be referred.

Scale of sampling and criteria for conformity for visual and dimensional characteristics:

**Visual Characteristics:** The bricks shall be selected and inspected for ascertaining their conformity to the requirements of the relevant specifications.

The number of bricks to be selected from a lot shall depend on the size of lot and shall be in accordance of Col. 1 and 2 of Table 3 for visual characteristics in all cases and dimensional characteristics if specified for individual bricks.

All the bricks selected above in accordance with Col. 1 and 2 of Table 3 shall be examined for visual characteristics. If the number of defective bricks found in the sample is less than or equal to the corresponding numbers as specified in Col 3 of Table 3 the lot shall be considered as satisfying the requirements of visual characteristics, otherwise the lot shall be deemed as not having met the visual requirements.

**Dimensional Characteristics:** The number of bricks to be selected for inspecting the dimensions and tolerance shall be in accordance with Col. 1 and 4 of Table 3. These bricks will be divided into groups of 20 bricks at random and each of the group of 20 bricks thus formed will be tested for all the dimensions

and tolerances. A lot shall be considered having found meeting the requirements of dimensions and tolerance if none of the groups of bricks inspected fails to meet the specified requirements.

**TABLE 3**

**SCALE OF SAMPLING AND PERMISSIBLE NUMBER OF DEFECTIVES FOR VISUAL AND DIMENSIONAL CHARACTERISTICS**

NO. OF BRICKS IN THE LOT	FOR CHARACTERISTICS SPECIFIED FOR INDIVIDUAL BRICKS		FOR DIMENSIONAL CHARACTERISTICS FOR GROUP OF 20 BRICKS
	NO. OF BRICKS TO BE DEFECTIVE IN THE SAMPLE	PERMISSIBLE NO. OF	NO. OF BRICKS TO BE SELECTED
1	2	3	4
2001-10000	20	1	40
10001-35000	32	2	60
35001-50000	50	3	80

**Note:** In case the lot contains 2000 or less bricks the sampling shall be as per decision of the Engineer-in-charge.

**SCALE OF SAMPLING AND CRITERIA FOR PHYSICAL CHARACTERISTICS**

The lot which has been found satisfactory in respect of visual and dimensional requirements shall be next tested for physical characteristics like compressive strength, water absorption, efflorescence as specified in relevant material specification. The bricks for this purpose shall be taken at random from those already selected above. The number of bricks to be selected for each of these characteristics shall be in accordance with relevant columns of Table 4.

**TABLE 4**

**SCALE OF SAMPLING FOR PHYSICAL CHARACTERISTICS**

LOT SIZE	SAMPLE SIZE FOR COMPRESSIVE STRENGTH, WATER ABSORPTION AND EFFLORESCENCE	PERMISSIBLE NO. OF DEFECTIVES FOR EFFLORESCENCE
(1)	(2)	(3)
2001-10000	5	0
10001-35000	10	0
35001-50000	15	1

**Note:** In case the lot contains 2000 or less bricks, the sampling shall be as per decision of Engineer-in-charge.

- v) A lot shall be considered having satisfied the requirements of physical characteristics if the condition stipulated here in are all satisfied.
- a) From the test results of compressive strength, the average shall be calculated and shall satisfy the requirements specified in relevant material specification.

**Note:** In case any of the test results for compressive strength exceeds the upper limit for the class of bricks, the same shall be limited to the upper limit of the class for the purpose of averaging.

- b) Wherever specified in the material specification, the compressive strength of any individual bricks tested in the sample shall not fall below the minimum average compressive strength specified for the corresponding class of brick by more than 20 percent.
- c) From the test results for water absorption, the average for the bricks in the sample shall be calculated and shall satisfy the relevant requirements specification in material specification.
- d) The number of bricks failing to satisfy the requirements of the efflorescence specified in the relevant specification should not be more than the permissible no. of defectives given etc. Col. 3 of Table 4.

### 6.1.3.3 DIMENSIONAL TOLERANCES

The dimensions of modular bricks when tested as described above as per procedure described shall be within the following limits per 20 bricks.

Length 372 to 388 cm ( $380 \pm 8$  cm).

Width 176 to 184 cm ( $180 \pm 4$  cm).

Height 176 to 184 cm ( $180 \pm 4$  cm) for 90 mm high bricks.

#### Brick tiles

76 to 84 cm ( $80 \pm 4$ ) for 40 mm high brick tiles.

In case of non-modular bricks, % age of tolerance will be  $\pm 2\%$  for group of 20 numbers of class 10 bricks, and  $\pm 4\%$  for other class of bricks.

- 6.1.3.4 Compressive Strength:** The bricks, when tested in accordance with the procedure laid down shall have a minimum average compressive strength for various classes as given in Table 2. The compressive Strength of any individual



brick tested shall not fall below the minimum average compressive strength specified for corresponding class of brick by more than 20%. Compressive strength of any individual brick tested exceeds the upper limit specified in Table 2 for the corresponding class of bricks; the same shall be limited to upper limit of class as specified in Table 2 for the purpose of calculating the average compressive strength.

6.1.3.5 **Water absorption:** The average water absorption of bricks when tested in accordance with the procedure laid down shall be not more than 20% by weight.

6.1.3.6 **Efflorescence:** The rating of efflorescence of bricks when tested shall be not more than moderate.

#### 6.1.4 **STORAGE AND HANDLING OF BRICKS**

Bricks shall not be dumped at site. They shall be stocked in regular tiers as they are unloaded to minimise breakages and defacements. Brick selected for particular purpose / situation shall be stocked separately.

6.1.5 Higher strength bricks when indicated must satisfy the strength requirements and also conform to other standards specified.

#### 6.1.6 **Fire Bricks**

Fire bricks may be white or slightly yellowish in colour and shall not absorb water more than 10% by weight when immersed in cold water for 14 hours.

### 6.2 **BRICK WORK**

#### 6.2.1 **CLASSIFICATION**

The brick work shall be classified to the class designation of bricks used.

#### 6.2.2 **MORTAR**

The mortar for the brick work shall be as specified, and conform to accepted standards. Lime shall not be used where reinforcement is provided in brick work.

#### 6.2.3 **SOAKING OF BRICKS**

Bricks shall be soaked in water before use for a period for the water to just penetrate the whole depth of brick. Alternatively bricks may be adequately soaked instacks by spraying with clean water for a period not less than six hours. The bricks required for masonry work using mud mortar shall not be

soaked. When the bricks are soaked they shall be removed from the tank sufficiently early so that at the time of laying they are skin – dry. Such soaked bricks shall be stacked on a clean place where they are not again spoiled by dirt earth etc.

**Note 1:** The period of soaking may be easily found at site by a field test in which the bricks are soaked in water for different periods and then broken to find the extent of water penetration. The least period corresponds to complete soaking will be the one to be allowed for in construction work.

**Note 2:** If the bricks are soaked for the required time in water that is frequently changed the soluble salt in the bricks will be leached out, and subsequently efflorescence will be reduced.

## **6.2.4 LAYING**

**6.2.4.1** Bricks shall be laid in English Bond unless otherwise specified. For brick work in half brick wall, brick shall be laid in stretcher bond. Half or cut bricks shall not be used except as closer where necessary to complete the bond. Closers in such cases, shall be cut to the required size and used near the ends of the wall. Header bond shall be used preferably in all courses in curved plan for ensuring better alignment.

**Note:** Header bond shall also be used in foundation footings unless thickness of walls (width of footing) makes the use of headers impracticable. Where thickness of footing is uniform for a number of courses, the top course of footing shall be headers.

**6.2.4.2** All loose materials, dirt and set lumps of mortar which may be lying over the surface on which the brick work is to be freshly started, shall be removed with a wire brush and surface wetted. Bricks shall be laid on a full bed of mortar, when laying, each brick shall be properly bedded and set in position by gently pressing with the handle of a trowel. Its inside face shall be buttered with mortar before the next brick is laid and pressed against it. Joints shall be fully filled and packed with mortar such that no hollow space are left inside the joints.

**6.2.4.3** The walls shall be taken up truly in plumb or true to the required batter where specified. All courses shall be laid truly horizontal and all vertical joints shall be truly vertical. Vertical joints in the alternate course shall come directly one over the other. Quoin, jambs and other angles shall be properly plumbed as the work proceeds. Care shall be taken to keep the preponds properly aligned within following maximum permissible tolerances.

- a) Deviation from vertical within a storey shall not exceed 6 mm per 3 m height.

- b) Deviation in vertically in total height of any wall of building more than one storey in height shall not exceed 12.5mm.
- c) Deviation from position shown on plan of any brick work shall not exceed 12.5mm.
- d) Relative displacement between load bearing wall in adjacent storeys intended to be vertical alignments shall not exceed 6mm.
- e) A set of tools comprising of wooden straight edge, Mason's spirit levels, square, 1 meter rule line and plumb shall be kept on the site of work for every 3 masons for proper check during the progress of work.

6.2.4.4 All quoins shall be accurately constructed and the height of brick courses shall be kept uniform. This will be checked using graduated wooden straight edge or storey rod indicating height of each course including thickness of joints. The position of damp proof course, windows, sills, bottom of lintels top of the wall, etc along the height of the wall shall be marked on the graduate straight edge or storey rods. Acute and obtuse quoins shall be bonded, where practicable in the same way as square quoins. Obtuse quoins shall be formed with squint showing three quarters brick on one face and quarter brick on the other.

6.2.4.5 The brick work shall be built in uniform layers.

No part of the wall during its construction shall rise more than one metre above the general construction level. Parts of wall left at different levels shall be raked back at an angle of 45 degree or less with the horizontal. Toothing shall not be permitted as an alternative to raking back. For half brick partition to be keyed into main walls, indents shall be left in the main walls.

6.2.4.6 All pipe fittings and specials, spouts, hold fasts and other fixtures which are required to be built into the walls shall be embedded, as specified, in their correct position as the work proceeds unless otherwise directed by the Engineer-in-charge.

6.2.4.7 Top courses of all plinths, parapets, steps and top of walls below floor and roof slabs shall be laid with brick on edge, unless specified other wise. Brick on edge laid in the top courses at corner of the wall shall be properly radiated and keyed into position to form cut (maru) corners where bricks cannot be cut to the required shape to form cut (maru) corners, cement concrete 1:2:4 (1 cement, 2 coarse and sand:4 graded stone aggregate 20mm nominal size) equal to thickness of course shall be provided in lieu of cut bricks.

6.2.4.8 Frog if provided shall be of suitable size and shape formed centrally on one of the larger sides of the brick and shall not occupy more than 6% volume of brick. No frog shall be provided for wire cut bricks. Bricks shall be laid with frog up.

However, when top course is exposed bricks shall be laid with frog down. For the bricks to be laid with frog down, the frog shall be filled with mortar before placing the bricks in position.

- 6.2.4.9 In case of walls one brick thick and under, one face shall be kept even and in proper plan, while the other face may be slightly rough. In case of wall more than one brick thick, both the faces shall be kept even and in proper plane.
- 6.2.4.10 To facilitate taking service lines later without excessive cutting of completed work sleeve shall be provided, where specified, while raising the brick work. Such sleeves in external walls shall be sloped down outward so as to avoid passage of water inside.
- 6.2.4.11 Top of the brick work in coping and sills in external walls shall be slightly tiled. Where brick coping and sills are projecting beyond the face of the wall, drip course / throating shall be provided where indicated.
- 6.2.4.12 Care shall be taken during construction that edges of jambs, sills and projections are not damaged in case of rain. New built work shall be covered with gunny bags or tarpaulin so as to prevent the mortar from being washed away. Damage, if any, shall be made good to the satisfaction of the Engineer-in-charge.
- 6.2.4.13 Vertical reinforcement in the form of bars (MS or high strength deformed bars), considered necessary at the corners and junction of walls and jamb opening doors, windows etc. shall be encased with cement mortar not leaner than 1:4 (1 cement : 4 coarse sand) or cement concrete mix as specified. The reinforcement shall be suitably tied, properly embedded in the foundation and at roof level. The dia of bars shall not be less than 8 mm and concrete grade shall be minimum 1:3:6 (1 cement :3 coarse sand :6 graded stone aggregate 20mm nominal size)
- 6.2.4.14 In retaining walls and the like, where water is likely to accumulate, weep holes, 50 to 75mm square shall be provided at 2 m vertically and horizontally unless otherwise specified. The lowest weep holes shall be at about 30cm above the ground level. All weep holes shall be surrounded by loose stones and shall have sufficient fall to drain out the water quickly.
- 6.2.4.15 Green work shall be protected from rain by suitable covering. Masonry work in cement, mortar shall be kept constantly, moist on all the faces for a minimum period of seven days. The top of masonry work shall be left flooded at the close of the day.

6.2.4.16 Work of cutting chases, wherever required to be made in the walls for housing GI pipes, CI pipe or any other fixtures shall be carried out in various locations as per guidelines given below:

- a) cutting of chases in one brick thick and above load bearing walls.
  - i) As far as possible services should be planned with the help of vertical chases. Horizontal chases should be avoided.
  - ii) The depth of vertical chases and horizontal chases shall not exceed one-third and one-sixth of the thickness of the masonry respectively.
  - iii) When narrow stretches of masonry (or short length of walls) such as between doors and windows, cannot be avoided they should not be pierced with openings for soil pipes or waste pipes or timber joints, etc. where there is a possibility of load concentration such narrow lengths of walls shall be checked for stresses and high strength bricks in mortar or concrete walls provided, if required.
  - iv) Horizontal chases when unavoidable should be located in the upper or lower one-third of height of storey and not more than three chases should be permitted in any stretch of a wall. No continuous horizontal chases shall exceed one metre in length. Where unavoidable, stresses in the affected area should be checked and kept within the permissible limits.
  - v) Vertical chases should not be closer than 2m in any stretch of a wall. These shall be kept away from bearings of beams and lintels. If unavoidable, stresses in the affected area should be checked and kept within permissible limits.
  - vi) Masonry directly above a recess, if wider than 30 cm horizontal dimension should be supported on lintel. Holes in masonry may be provided upto 30 cm width and 30 cm height without any lintel. In case of circular holes in the masonry, no lintel need be provided for holes upto 40 cm in diameter.
- b) Cutting of chases in half brick load bearing walls:
  - i) No chases shall be permitted in half brick load bearing walls and as such no recessed conduits and concealed pipes shall be provided with half load bearing walls.
- c) Cutting of chases in half brick non-load bearing wall:
  - i) Services should be planned with the help of vertical chases. Horizontal chases should be provided only when unavoidable.

## **6.2.5 JOINTS**

The thickness of all types of joints in brick work shall be such that four courses and three joints taken consecutively shall measure as follows:

- i) In case of modular brick conforming to IS:1077 specification for common burnt clay building bricks equal to 39 cm.
- ii) In case of non modular brick it shall be equal to 31 cms.

**Note:** Specified thickness of joints shall be of 1 cm. Deviation from the specified thickness of all joints shall not exceed one fifth of specified thickness.

**6.2.5.1 Finishing of Joints:** The face of brick work may be finished flush or by pointing. In flush finishing either the face joints of the mortar shall be worked out while still green to give a finished surface flush with the face of the brick work or the joints shall be squarely racked out to a depth of 1 cm while the mortar is still green for subsequent plastering. The faces of brick work shall be cleaned with wire brush so as to remove any splashes of mortar during the course of raising the brick work. In pointing, the joints shall be squarely racked out to a depth of 1.5cm while the mortar is still green and racked joint shall be brushed to remove dust and loose particles and well wetted and shall be later refilled with mortar to give ruled finish. Some such finishes are "flush", "weathered", ruled etc.

## **6.2.6 CURING**

The brick work shall be constantly kept moist on all faces for a minimum period of seven days. Brick work done during the day shall be suitably marked indicating the date on which the work is done so as to keep a watch on curing period.

## **6.2.7 SCAFFOLDING**

Scaffolding shall be strong to withstand all dead, live and impact loads which are likely to come on them. Scaffolding shall be provided to allow easy approach to every part of the work.

## **6.2.8 MEASUREMENTS**

**6.2.8.1** Brick work shall be measured in cubic metres unless otherwise specified.

Any extra work over the specified dimensions shall be ignored. Dimensions shall be measured correct to the nearest 0.01m i.e 1 cm. Area shall be calculated to the nearest 0.01 sq mtrs and the cubic contents shall be worked out to the nearest 0.01 cubic metres.

6.2.8.2 Brick work shall be measured separately in the following stages unless otherwise specified:

- a) From foundation to floor one level (plinth level)
- b) Plinth (floor one) level to floor two level
- c) Between two specified floor levels above floor two level.

**Note:** Brick work in parapet walls, mummy, lift machine room and water tanks constructed on the roof to 1.2m height above roof shall be measured together with the corresponding work of the floor next below.

6.2.8.3 No deductions or additions shall be done and no extra payment made for the following:

**Note:** Where minimum area is defined for deduction of an opening, void or both, such area shall refer only to opening or void within the space measured.

- a) Ends of dissimilar materials (that is, joists, beams, lintels, posts, girders, rafters, purlins, trusses, corbels, steps, etc) up to 0.1m<sup>2</sup> in section;
- b) Opening up to 0.1m<sup>2</sup> in area (see Note);
- c) Wall plates, bed plates, and bearing of slabs, chhajjas and the like, where thickness does not exceed 10 cm and bearing does not extend over the full thickness of wall;
- d) Cement concrete blocks as for hold fasts and holding down bolts;
- e) Iron fixtures, such as wall ties, pipes upto 300 mm diameter and hold fasts for doors and windows;
- f) Chases of section not exceeding 50 cm in girth; and
- g) Bearing portion of drip course, bearing of moulding and cornice.

**Note:** In calculating area of an opening, any separate lintel or sills shall be included with the size of the opening but end portions of lintel shall be excluded. Extra width of rebated reveals, if any shall also be excluded.

6.2.8.4 Walls half brick thick and less shall each be measured separately in square metres stating thickness.

6.2.8.5 Walls beyond half brick thickness shall be measured in multiples of half brick which shall be deemed to be inclusive of mortar joints. For the sizes of bricks specified in 6.1.1, half brick thickness shall mean 100 mm for modular and 115 mm for non-modular bricks.

Where fractions of half brick occur due to architectural or other reasons, measurement shall be as follows:

- a) Upto  $\frac{1}{4}$ <sup>th</sup> brick – actual measurements and
  - b) Exceeding  $\frac{1}{4}$ <sup>th</sup> brick – full half bricks
- 6.2.8.6 String courses, projecting pilasters, aprons, sills and other projections shall be fully described and measured separately in running metres stating dimensions of each projection.
- 6.2.8.7 Square or rectangular pillars shall be measured like the brick work in straight walls and shall include all cutting and wastage of bricks, tapered vertical joints and use of extra mortar, if any. Brick work curved on plan to a mean radius not exceeding six metres shall be measured separately and extra shall be payable over the rates for brick work in straight walls. Unless otherwise stated nothing extra shall be payable if the mean radius of the brick work curved in plan exceeds six metres.
- 6.2.8.8 Tapered walls shall be measured net as walls and extra payment shall be allowed for making tapered surface for brick work in walls.
- 6.2.8.9 Brick work with brick tiles shall be measured and paid for separately.

#### **6.2.9 RATE**

The rate shall include the cost of materials and labour required for all the operations described above except the vertical reinforcement and its encasement in cement mortar or cement concrete. The rates shall also include the following:

- a) Raking out joints or finishing joints flush as the work proceeds;
- b) Preparing tops of existing walls and the like for raising further new brick work.
- c) Rough cutting and waste for forming gables, splays at eaves and the like; leaving holes for pipes upto 150mm dia, and encasing hold fasts, etc.
- d) Rough cutting and waste for brick work curved in plan and for backing to stone or other types of facing.
- e) Embedding in ends of beams, joists, slabs, lintels, sills, trusses, etc.
- f) Bedding wall plates, lintels, sills, roof tiles, corrugated sheets, etc in or on walls if not covered on plan to a mean radius exceeding six meters.



### **6.3 BRICK WORK IN ARCHE**

The detailed specifications for brick work mentioned in 6.2 shall apply, in so far as they are applicable. Arch work shall include masonry for both gauged as well as plain arches. In gauged arches cut or moulded bricks shall be used. In plain arches, uncut bricks shall be used.

#### **6.3.1 CIRCULAR ARCH**

These shall be either (a) plain arches, and shall be built in half brick concentric rings with break joints or (b) gauged arches built with bricks cut or moulded to proper shape. The arch work shall be carried up from both ends simultaneously and keyed in the center. The brick shall be flush with mortar and well pressed into their positions so as to squeeze out a part of their mortar and leave the joints thin and compact. All joints shall be full of mortar and thickness of joints shall not be less than 5 mm nor more than 15mm.

After the arch is completed, the haunches shall be loaded by filling up the spandrels upto the crown level of the arch. Care shall be taken to load the haunches on two sides of the spandrels.

When the arch face is to be pointed (and not plastered) the face brick shall be cut to proper shape or moulded so as to have the joints not more than 5 mm thick. These shall be laid with radial joints to the full depth of the arch. The voussoirs shall break joints to the full depth of the arch.

#### **6.3.2 FLAT ARCHES**

These shall be gauged arches of brick cut or moulded to proper shape. The extrados shall be kept horizontal and the intrados shall be given slight camber of 1 in 100 of the span. The center of the arch from which joints shall radiate, shall be determined by the point of the inter-section of the two lines drawing from ends of the arch at the springing level and at 60° to horizontal.

In flat arches, bricks shall be laid with radial joints to the full depth of arch and voussoirs breaking joints with each other. The arch work shall be carried up from both ends simultaneously and keyed in the center. The thickness of the joints shall not exceed 5 mm. Flat arches may be used for the sake of appearance but for the purpose of carrying loads of the wall above, these shall be used in conjunction with relieving arches, lintel placed below.

#### **6.3.3 CENTRING AND SHUTTERING**

The centering and shuttering for the arch shall be got approved by the Engineer-in-charge before the arch work is started. It shall be strong enough to bear the dead load of the arch and the live loads that are likely to come upon it during construction, without any appreciable deflections.

The shuttering shall be tightened with hard wood wedged or sand boxes, so that the same could be used without jerks being transmitted to the arch. The sequence of easing the shuttering shall be got approved from the Engineer-in-charge. The shuttering shall be struck within 48 hours of the completion of the arch but not before 24 hours. This shall be done after the spandrel has been filled in and the arch loaded.

#### **6.3.4 MEASUREMENTS**

The length of the arch shall be measured as the mean of the extrados and intrados of the arch correct to a cm. The thickness of the arch shall be measured in multiples of the half brick.

The breadth in the direction of the thickness of wall shall be measured as specified.

The cubical contents shall be calculated in cubic metre, correct to two places of decimal.

For arches exceeding 6m in spans extra payment shall be made on the actual area of the soffit for additional cost of centring including all strutting, bolting, wedging, easing, striking and its removal.

#### **6.3.5 RATE**

The rate inclusive of the cost of the materials and labour required for all the operations described.

#### **6.4 HALF BRICK WORK**

Brick work in half brick walls shall be done in the same manner as described above in 6.2.4 except that brick shall be laid in stretcher bond. When the half brick work is to be reinforced providing stiffeners at every 0.9m height with RCC 1:2:4; 115mm (wall thickness) 75mm conforming to relevant specification under concrete /RCC or providing 2 Nos. M S bars of 8 mm dia shall be embedded in every third course as given in the item (the dia of bars shall not exceed 8 mm). These shall be securely anchored at their end where the partitions end. The free ends of the reinforcement shall be keyed into the mortar of the main brick work to which the half brick work is joined. The mortar used for reinforcement brick work shall be rich dense cement mortar of [mix 1:4 (1 Cement: 4 Coarse Sand) lime mortar shall not be used. Over laps in reinforcement, if any shall not be less than 30 cm. The mortar interposed between the reinforcement bars and the brick shall not be less than 5 mm. The mortar covering in the direction of joints shall not be less than 15mm.

**16.4.1 Rate**

The rate includes the cost of all materials and labour involved in all the operations described above except the reinforcement which is to be paid for separately unless specified otherwise.

**16.4.2 Brick Tile work**

The work shall be done in the same manner as described in 6.2.4 except that brick tile shall be used instead of bricks. The measurement and rate shall be same as specified under 6.2.

**16.4.3 HONEY COMB BRICK WORK**

The brick honey comb work shall be done with specified class of brick, laid in specified mortar. All joints and edges shall be struck flush to given an even surface.

The thickness of the brick honey comb work shall be half-brick only, unless otherwise specified. Opening shall be equal and alternate with half brick laid with a bearing of 2 cm on either side.

**16.4.4 MEASUREMENTS**

The length and the height shall be measured correct to a cm. Area shall be calculated in square metres correct to two place of decimal. Honey comb openings shall not be deducted.

**16.4.5 Rate**

The rate includes the cost of materials and labour involved in all the operations described above.

**6.5 JOINING OLD BRICK WORK WITH NEW BRICK WORK**

6.5.1 In case the height of the bricks of old as well as new work is same, the old work shall be toothed to the full width of the new wall and to the depth of a quarter of bricks in alternate courses. In case the height of the bricks is unequal, then the height of each course of new work shall be made equal to the height of the old work by adjusting thickness of horizontal mortar joints in the new wall. Where necessary adjustment shall be made equal to thickness of old wall by adjusting the thickness of vertical joints.

6.5.2 For joining new cross wall to old main walls, a number of rectangular recesses of width equal to the thickness of cross wall, three courses in height and half a brick in depth shall be cut in the main walls. A space of the three courses shall be left between two consecutive recesses. The new cross wall shall be bonded into the recesses to avoid any settlement.

- 6.5.3 Joining of old brick work with the new brick work shall be done in such a way that there shall not be any hump or projection at the joint.

**6.5.4 MEASUREMENT**

The height and thickness of vertical face in contact with new work shall be measured to the nearest 0.01 m and shall be calculated to the nearest 0.01 sqm.

**6.5.5 RATE**

The rate includes the cost of labour and materials involved in all the operations described above.

**6.6 MOULDING AND CORNICES**

- 6.6.0 The specifications described under 6.2 shall apply in so far these are applicable. Moulding and cornices shall be made with bricks as specified for brick work. The bricks shall be cut and dressed to the required shape as shown in the architectural drawings.

- 6.6.1 Cornices shall not ordinarily project by more than 15 cm to 20 cm and this projection shall be obtained by projecting each brick length. For cornices projecting more than 20 cm and requiring more than quarter bricks projection, metal clamps shall be used and paid for separately.

- 6.6.2 Corbelling shall be brought roughly to shape by plastering with the specified mortar. When the mortar is still green, the mouldings shall be finished straight and true with the help of metal templates.

**6.6.3 CURING AND PROJECTION**

The mouldings and cornices shall be cured for at least seven days. These shall be projected from the effects of sun and rain by suitable covering and also from damage during the execution of the work.

**6.6.4 MEASUREMENTS**

For the purpose of measurements, the sectional periphery of mouldings and cornices (excluding the portion in contact with wall) shall be measured in centimeters and length in metres (The girth and length shall be measured correct to a cm. No deduction shall be made from the masonry of wall for the bearing of the moulding and cornices.

**6.6.5 RATE**

The rate includes the cost of materials and labour involved in all the operations described above.

## 6.7 BRICK WORK UNDER WATER OR FOUL POSITIONS

Brick work under following conditions:

- i) Work in or under water / or liquid mud;
- ii) Work in or under foul positions shall be measured separately for payment of extra rate over and above the quantity measured and paid under para 6.2.8.

## 6.8 EXPOSED BRICK WORK

### 6.8.1 Facing Bricks

The facing bricks made from suitable soils shall be free from cracks, flaws, nodules of free lime warpages and organic matter. These shall be thoroughly burnt and shall have plane rectangular faces with parallel sides and sharp straight right angled edges. Facing bricks shall have uniform colour and even texture. Unless otherwise specified, facing bricks shall be machine moulded. Selected hand moulded bricks may also be used as facing bricks where specified. As far as possible, total requirement of facing bricks for a work shall be arranged from the same kiln. Bricks with chipped edges and broken corners shall not be used.

### 6.8.2 DIMENSIONS AND TOLERANCES

The standard sizes of machine moulded facing bricks shall be as specified in 6.1.1.

6.8.2.1 The permissible tolerances shall be as under:

	DIMENSION	TOLERANCE (for Machine moulded bricks) in mm
Length	190 or 225	±3
Width	90 or 111	±1.5
Thickness	40 to 44	±1.5

**Note:** Tolerance and Dimensions for selected hand moulded bricks ±4 mm in length and ±3mm in width and thickness.

### 6.8.3 SAMPLING

As per para 6.1.3 and 6.1.3.2.

### 6.8.4 PHYSICAL REQUIREMENTS

Facing bricks shall be of class designation 75 unless otherwise specified. Average compressive strength shall not be less than 7.5 N/mm<sup>2</sup>, water absorption

shall not exceed 20 percent by weight and efflorescence rating shall be nil when tested in accordance with the procedure laid down and tolerance in dimensions shall be checked as per the procedure laid down

Mortar, soaking of bricks and laying shall be as specified in paras 6.2.2, 6.2.3 and 6.2.4.

6.8.5 Joints in the exposed brick work shall be truly horizontal and vertical and kept uniform with the help of wooden or steel strips. The thickness of joints shall be as per 6.2.5.0.]

6.8.6 Curing and scaffolding shall be as specified in 6.2.6 and 6.2.7 respectively.

#### 6.8.7 MEASUREMENTS

Exposed brick work in face using machine moulded bricks and selected hand moulded bricks shall be measured separately and the measurement shall be as specified in 6.2.8.

#### 6.8.8 RATE

The rates shall be as specified in 6.2.9 and shall also include the following:

- a) Labour for selecting bricks and wastage of bricks where use of selected hand moulded brick is specified.
- b) Leaving uniform horizontal and vertical grooves of specified depth and providing joints of required thickness using wooden or steel strips as the work proceeds.

#### 6.9.1 CAVITY WALL

It is a wall comprising of two leaves, each leaf being built of masonry units and separated by a cavity so as to provide an air space within the wall and tied together with metal ties or bonding units to ensure that two leaves as one structural unit. The width of the cavity shall not be less than 50 mm and not more than 115mm. Each leaf of the cavity wall shall not be less than 75mm. The space between the leaves being either left as cavity or filled with non-load bearing insulating and water proofing material.

#### 6.9.2 METAL TIES

These may be of galvanized iron, wrought iron, gun metal, brass, copper, stainless steel or any such corrosion resistant metal, made of flats 20 x 5 mm cranked or twisted at their mid point with ends split and fish tailed. The ties shall be built into horizontal bed joints during erection, placed sloping towards



## CHAPTER-7

### STONE WORK

#### 7.1 RANDOM RUBBLE MASONRY

##### 7.1.1 STONE

The stone shall be of the type specified such as granite, trap, limestone, sand stone, quartzite, etc. and shall be obtained from the quarries, approved by the Engineer-in-Charge. Stone shall be hard, sound and durable and free from weathering decay and defects like cavities, cracks, flaws, sand holes, injurious veins, patches of loose or soft materials and other similar defects that may adversely affect its strength and appearance. As far as possible stones shall be uniform colour, quality and texture. Generally stone shall not contain crypt crystalline silica or chart, mica and other deleterious materials like iron-oxide organic impurities etc.

Stones with round surface shall not be used.

The compressive strength of common types of stones shall be as per Table 1 and the percentage of water absorption shall generally not exceed 5% for stones other than specified in Table 1. For laterite this percentage is 12%.

TABLE 1

Type of Stone	Maximum Water Absorption percentage by weight	Minimum compressive strength kg/sq cm
Granite	0.5	1000
Basalt	0.5	400
Lime Stone (Slab & Tiles)	0.15	200
Sand Stone (Slab & Tiles)	2.5	300
Marble	0.40	500
Quartzite	0.40	800
Laterite (Block)	12	35

**Note 1 :** Test for compressive strength shall be carried out as laid down in IS:1121 (Part I).

**Note 2 :** Test for water absorption shall be carried out as laid down in IS:1124.



### **7.1.2 SIZE OF STONES**

Normally stones used should be small enough to be lifted and placed by hand. Unless otherwise indicated, the length of stones for stone masonry shall not exceed three times the height and breadth or base shall not be greater than three-fourth the thickness of wall, or not less than 15 cm. The height of stone may be upto 30cm.

7.1.3 Random Rubble Masonry shall be uncoursed or brought to courses as specified. Uncoursed random rubble masonry shall be constructed with stones of sizes as referred to in para 7.1.2 and shapes picked up random from the stones brought from the approved quarry. Stones having sharp corners or round surfaces shall, however, not be used.

7.1.4 Random rubble masonry brought to the course is similar to uncoursed random rubble masonry except that the courses are roughly levelled at intervals varying from 30cm to 90cm in height according to size of stones used.

### **7.1.5 DRESSING**

Each stone shall be hammer dressed on the face, the sides and the bed. Hammer dressing shall enable the stones to be laid close to neighboring stones such that the bushing in the face shall not project more than 40mm on the exposed face and 10mm on the face to be plastered.

### **7.1.6 MORTAR**

The mortar used for joining shall be as specified.

### **7.1.7 LAYING**

All stones shall be wetted before use. Each stone shall be placed close to the stones already laid so that the thickness of the mortar joints at the face is not more than 20mm. Face stones shall be arranged suitably to stagger the vertical joints and long vertical joints shall be avoided. Stones for hearting interior filling shall be hammered down with wooden mallet into the position firmly bedded in mortar. Chips or spraws of stones may be used for filling of interstices between the adjacent stones in hearting and these shall not exceed 20% of the quantity of stone masonry. To form a bond between successive courses plumb stones projecting vertically by about 15 to 20 cm shall be firmly embedded in the hearting at the interval of about one metre in every course. No hollow space shall be left anywhere in the masonry.

The masonry work in wall shall be carried up true to plumb or to specified batter.

Random rubble masonry shall be brought to the level courses at plinth, window sills lintel and roof levels. Levelling shall be done with concrete comprising of

one part of the mortar as used for masonry and two parts of graded stone aggregate of 20mm nominal size.

The masonry in structure shall be carried uniformly. Where the masonry of one part is to be delayed the work shall be raked back at an angle not steeper than 45°.

#### **7.1.8 BOND STONES**

Bond or through stones running through the thickness of walls, shall be provided in walls upto 60cm thickness and in case of walls above 60 cm thickness, a set of two or more bond stones overlapping each other by atleast 15cm shall be provided in a line from face of the wall to the back.

In case of highly absorbent types of stones (porous lime stone and sand stone etc.) single piece bond stone may give rise to dampness. For all thicknesses of such walls, a set of two or more bond stones stepping each other by at least 15cm shall be provided. Length of each such bond stone shall not be less than two-third of the thickness of the wall.

Where bond stones of suitable lengths are not available precast cement concrete block of 1:3:6 mix (1 cement :3 coarse sand : 6 graded stone aggregate 20mm nominal size) of cross section not less than 225 sq cm and length equal to the thickness of wall shall be used in lieu of bond stones. (This shall be applicable only in masonry below ground level and where masonry above ground level is finally required to be plastered).

Atleast one bond stone or a set of bond stones shall be provided for every 0.5 sqm of the area of wall surface. All bond stones shall be marked suitably with paint as directed by the Engineer In-Charge.

#### **7.1.9 QUOIN AND JAMB STONES**

The quoin and jamb stones shall be selected stones neatly dressed with hammer or chisel to form the required angle. Quoin stones shall not be less than 0.01 cum in volume. Height of quoins and jamb shall not be less than 15 cm. Quoins shall be laid in header and stretcher alternatively.

#### **7.1.10 JOINTS**

Stones shall be so laid that all joints are fully packed with mortar and chips. Face joints shall not be more than 20mm thick.

The joints shall be struck flush and finished at the time of laying when plastering or pointing is not be done. For the surface to be plastered or pointed, the joints shall be raked to a minimum depth of 20mm when the mortar is still green.

#### **7.1.11 SCAFFOLDING**

Single scaffolding shall not be adopted. Double scaffolding only shall be permitted for all stone wall work where scaffolding is required.

#### **7.1.12 CURING**

Masonry work in cement or composite mortar shall be kept constantly moist on all faces for a minimum period of seven days. In case of masonry with fat lime mortar curing shall commence two days after laying masonry and shall continue for at least seven days thereafter.

#### **7.1.13 PROTECTION**

Green work shall be protected from rain by suitable covering. The work shall also be suitably protected from damage, mortar dropping and rain during construction.

#### **7.1.14 MEASUREMENTS**

7.1.14.1 Unless otherwise stated measurements shall be as below. The length, height and thickness shall be measured correct to a cm. The thickness of wall shall be measured at joints excluding the bushing. Only specified dimension shall be allowed; anything extra shall be ignored. The quantity shall be calculated in cubic metre nearest to two places of decimal.

7.1.14.2 The work under the following categories shall be measured separately.

- (i) From foundation to plinth level (level one):
  - (a) Work in or under water and or liquid mud,
  - (b) Work in or under foul positions.
- (ii) From plinth level (Level one) to floor two level.
- (iii) From floor two level to floor three level and so on.
- (iv) Stone masonry in parapet shall be measured together with the corresponding item in the wall of the storey next below.

7.1.14.3 No deduction shall be made nor extra payment made for the following:

- (i) Ends of dissimilar materials (that is joints, beams, lintels, posts, girders, rafters purlins, trusses, corbels, steps etc.) upto 0.1 sqm in section.
- (ii) Openings each upto 0.1 sqm in area. In calculating the area of openings, any separate intel or sills shall be included alongwith the size of opening

but the end portions of the intels shall be excluded and the extra width of rebated reveals, if any, shall also be excluded.

- (iii) Wall plates and bed plates, and bearing of chhajjas and the like, where the thickness does not exceed 10cm and the bearing does not extend over the full thickness of the wall.

**Note: The bearing of floor and roof shall be deducted from wall masonry.**

- (iv) Drain holes and recesses for cement concrete blocks to embed hold fasts for doors, windows etc.
- (v) Building in masonry, iron fixture, pipes upto 300mm dia, hold fasts of doors and windows etc.
- (vi) Forming chases in masonry each upto section of 350 sq cm.

- 7.1.14.4 Masonry (excluding fixing brick work) in chimney breasts with smoke or air flues not exceeding 20 sq dm (0.20 sq m) in sectional area shall be measured as solid and no extra payment shall be made pargetting and coring such flues. Where flues exceed 20 sq dm (0.20 sq m) sectional area, deduction shall be made for the same and pargetting and coring flues shall be measured in running metres stating size of flues and paid for separately. Aperture for fire place shall be deducted and no extra payment made for splaying of jambs and throating.
- 7.1.14.5 Apertures for fire places shall not be deducted and extra labour shall not be measured for splaying of jambs, throating and making arch to support the opening.
- 7.1.14.6 **SQUARE OR RECTANGULAR PILLARS :** These shall be measured as walls, but payment shall be allowed for stone work in square or rectangular pillars over the rate for stone work in walls. Rectangular pillar shall mean a detached masonry support rectangular in section, such that its breadth does not exceed two and a half times the thickness.
- 7.1.14.7 **CIRCULAR PILLARS (COLUMNS):** These shall be measured as per actual dimensions but extra payment shall be allowed for stone work in circular pillars over the rate for stone work in walls. The diameter as well as length shall be measured correct to a cm.
- 7.1.14.8 Tapered walls shall be measured not, as per actual dimensions and paid for as other walls.
- 7.1.14.9 **CURVED MASONRY:** Stone masonry curved on plan to a mean radius exceeding 6 m shall be measured and included with general stone work. Stone

work circular on plan to a mean radius not exceeding 6 m shall be measured separately and shall include all cuttings and waste and templates. It shall be measured as the mean length of the wall.

#### **7.1.15 RATE**

The rate shall include the cost of materials and labour required for all the operations described above and shall include the following:

- (a) Raking out joints for plastering or pointing done as a separate item, or finishing flush as the work proceeds
- (b) Preparing tops and sides of existing walls for raising and extending.
- (c) Rough cutting and waste for forming gables cores, skew backs or spandrels of arches, splays at eaves and all rough cutting in the body of walling unless otherwise specified.
- (d) Bond stones or cement concrete bond blocks.
- (e) Leading and making holes for pipes etc.
- (f) Bedding and pointing wall plates, lintels, sills etc. in or on walls, bedding roof tiles and corrugated sheets in or on walls.
- (g) Building in ends of joists, beams, lintels etc.

### **7.2 COURSED RUBBLE MASONRY-FIRST SORT**

#### **7.2.1 Stone**

Shall be as specified in 7.1.1.

#### **7.2.2 Size of Stone**

Shall be as specified in 7.1.2.

#### **7.2.3 DRESSING**

Face stone shall be hammer dressed on all beds, and joints so as to give them approximately rectangular block shape. These shall be squared on all joints and beds. The bed joint shall be rough chiselled dressed for at least 8 cm back from the face, and side joints for at least 4 cm such that no portion of the dressed surface is more than 6 mm from straight edge placed on it. The bushing on the face shall not project more than 4 cm as an exposed face and one cm on a face to be plastered. The hammer dressed stone shall also have a rough tooling for minimum width of 2.5 cm along the four edges of the face of the stone, when stone work is exposed.

#### **7.2.4 MORTAR**

The mortar for jointing shall be specified.

#### **7.2.5 LAYING**

All stones shall be wetted before use. The walls shall be carried up truly plumb or to specified batter. All courses shall be laid truly horizontal and all vertical joints shall be truly vertical. The height of each course shall not be less than 15cm nor more than 30cm.

Face stones shall be laid alternate headers and stretchers. No pinning shall be allowed on the face. No face stone shall be less in breadth than its height and at least one-third of the stones shall tail into the work for length not less than twice their height.

The hearting or the interior filling of the wall shall consist of stones carefully laid on their proper beds. In mortar chips and spalls of stone being used where necessary to avoid thick beds of joints of mortar and at the same time ensuring that no hollow spaces are left anywhere in the masonry. The chips shall not be used below the hearting stone to bring these up to the level of face stones. The use of chips shall be restricted to the filling of interstices between the adjacent stones in hearting and these shall not exceed 10% of the quantity of stone masonry.

The masonry in a structure shall be carried up uniformly but where breaks are unavoidable, the joints shall be replaced back at angle not steeper than 45°.

Toothing shall not be allowed.

#### **7.2.6 BOND STONES**

Shall be as specified in 7.1.8 except that a bond stone or a set of bond stones shall be inserted 1.5 to 1.8m apart, in every course.

#### **7.2.7 QUOINS**

Quoins shall be of the same height as the course in which these occur. These shall be at least 45cm long and shall be laid stretchers and headers alternatively. These shall be laid square on the beds, which shall be rough-chisel dressed to a depth of at least 10cm. In case of exposed work, these stones shall have a minimum of 2.5cm wide chisel drafts at four edges, all the edges being in the same plane.

## **7.2.8 JOINTS**

Joints shall be horizontal and all side joints vertical. All joints shall be fully packed with mortar, face joints shall not be more than one cm thick.

When plastering or pointing is not required to be done the joints shall be struck flush and finished at the time of laying. Otherwise, joints shall be raked to a minimum depth of 20mm by raking tool during the progress of work, when the mortar is still green.

7.2.9 Curing, Scaffolding, measurements and rates shall be as specified under 7.1.

## **7.3 COURSED RUBBLE MASONRY-SECOND SORT**

7.3.1 **Stone:** Shall be as specified in 7.1.1.

7.3.2 **Size of Stone:** Shall be as specified in 7.1.12.

7.3.3 **Dressing:** Shall be as specified in 7.2.3 except that no portion of dressed surface shall exceed 10mm from a straight edge placed on it.

7.3.4 **Mortar:** The mortar for jointing shall be as specified.

7.3.4.1 **Laying:** Shall be as specified in 7.2.5 except that the use of chips shall not exceed 15% of the quantity of stone masonry and stone, in each course need not be of the same height but not more than two stones shall be used in the height of a course.

## **7.3.5 BOND, STONE, QUOINS**

Shall be as specified in 7.2.6 and 7.2.7 respectively.

## **7.3.6 JOINTS**

All bed joints shall be horizontal and all side vertical. All joints shall be fully packed with mortar, face joints shall not be more than 2 cm thick.

When plastering or pointing is not required to be done, the joints shall be struck flush and finished at the time of laying. Otherwise the joints shall be raked to a minimum depth of 20mm by raking tool during the progress of work, when the mortar is still green.

7.3.8 Curing Scaffolding, measurement and rates: Shall be as specified under 7.1.

## **7.4 PLAIN ASHLAR MASONRY**

7.4.1 Stone shall be of the type specified. It shall be hard, sound, durable and tough, free from cracks, delayed with weathering and defects like cavities, cracks, flaws, sand holes, veins, patches of soft or loose materials etc.

Before starting the work, the contractor shall get the stones approved by Engineer-in-Charge.

#### **7.4.2 SIZE OF STONE**

Normally stones used should be small enough to be lifted and placed by hand. The length of the stone shall not exceed three times the height and the breadth on base shall not be greater than three-fourth of the thickness of wall nor less than 15cm. The height of stone may be upto 30cm.

#### **7.4.3 DRESSING**

Every stone shall be cut to the required size and shape, so as to be free from waviness and to give truly vertical and horizontal joints. In exposed masonry, the faces that are to remain exposed in the final position and the adjoining faces to a depth of 6 mm shall be fine chisel dressed so that when checked with 60cm straight edge, no point varies from it by more than 1mm. The top and bottom faces that are to form the bed joints shall be chisel dressed so that variation from 60cm straight edge at no point exceed 3mm. Faces which are to form the vertical joints should be chisel dressed so that variation at any point with 60cm straight edge does not exceed 6mm. Any vertical face that is to come against backing of masonry shall be dressed such that variation from straight edge does not exceed 10mm. All angles and edges that are to remain exposed in the final position shall be true square and free from chippings.

A sample of dressed stone shall be prepared for approval of Engineer-in-Charge. It shall be kept at the work site as a sample after being approved.

7.4.4 The mortar for joining shall be as specified.

#### **7.4.5 LAYING**

All stone shall be wetted before placing. These shall be floated on mortar and bedded properly in positing with wooden mallets without the use of chips or under pinning of any sort.

The walls pillars shall be carried up truly plumb or battered as shown in drawings. All courses shall be laid truly horizontal and all vertical joints shall be truly vertical.

In case of ashlar work without backing of brick work or coursed rubble masonry, face stone shall be laid headers and stretchers alternately unless otherwise directed. The headers shall be arranged to come as nearly as possible in the middle of stretchers above and below. Stone shall be laid in regular courses of



not less than 15cm in height and all the courses shall be of same height, unless otherwise specified. For ashlar facing with backing of brick work or coursed rubble masonry face stone shall be laid in alternate courses of headers and stretchers unless otherwise directed. Face stone and bond stone course shall be maintained throughout. All connected masonry in a structure shall be carried up nearly at one uniform level throughout, but where breaks are unavoidable, the joints shall be made in good long steps so as to prevent cracks developing between new and old work. Bond stone provided in masonry shall be payable in the item of Ashlar masonry. Neither any deduction will be made from the brick masonry for embedding the bond stone in the backing nor any extra payment shall be made for any extra labour involved in making holes in brick masonry backing.

When necessary jib crane or other mechanical appliances shall be used to hoist the heavy pieces of stones and place these into correct positions, care being taken that the corners of the stone are not damaged. Stone shall be covered with gunny bags, before tying chain or rope is passed over it, and it shall be handled carefully. No piece which has been damaged shall be used in work.

**7.4.6 BOND STONES :** Shall be as specified in 7.1.8.

**7.4.7 JOINTS**

All joints shall be full of mortar. These shall be not more than 6mm thick. Face joints shall be uniform throughout and a uniform recess of 20mm depth from face shall be left with the help of the steel plate during the progress or work.

**7.4.8 POINTING**

All exposed joints shall be pointed with mortar as specified. The pointing when finished shall be sunk from stone face by 5mm or as specified. The depth of mortar in pointing work shall not be less than 15mm.

**7.4.9 CURING**

Masonry work in cement or composite mortar shall be kept constantly moist on all faces for a minimum period of seven days. In case of masonry with fat lime mortar, curing shall commence two days after laying of masonry and shall continue for atleast seven days thereafter.

**7.4.10 PROTECTIONS**

Green work shall be protected from rain by suitable covering. The work shall also be suitably protected from damage, mortar dropping and rain during construction.

#### 7.4.11 SCAFFOLDING

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.

#### 7.4.12 MEASUREMENTS

Unless otherwise stated measurements shall be as below:

The finished work shall be measured correct to a centimeter in respect of length, breadth and height. The cubical contents shall be calculated in cubic metre nearest to two places of decimal.

7.4.12.1 No deduction nor any extra payment shall be made for the following:

- (i) Ends of dissimilar materials (that is joists, beams, lintels, posts, girders, rafters, purlins, trusses, corbels, steps etc.) upto 0.1 sqm in section.
- (ii) Openings upto 0.1 sqm in area. In calculating the area of opening, any separate lintels or sills shall be included along with the size of the opening but the end portion of the lintels shall be excluded and extra width of rebated reveals, if any, shall also be excluded.
- (iii) Wall plates and bed plates and bearing of chhajja and the like, where the thickness does not exceed 10cm and the bearing does extend over the full thickness of the wall.

**Note:** The bearing of floor and roof slabs shall be deducted from wall masonry.

- (iv) Drainage holes and recesses left for cement concrete blocks to embed hold-fasts for door and windows, building in the masonry iron fixture and pipes upto 300mm diameter.
  - (v) Stone walling in chimney breasts, chimney stacks, smoke or air flues not exceeding 0.2 sqm in sectional area shall be measured as solid and no extra measurement shall be made for pargetting and coring such flues. Where flues exceed 0.20 sqm. In sectional area, deduction shall be made for the same and pargetting and coring flues paid for separately.
- 7.4.12.2 **SQUARE, RECTANGULAR OR CIRCULAR PILLARS:** Shall be measured and paid for as walls, but extra payment shall be allowed for such pillars and columns over the rate for stone work in walls.

Rectangular pillars shall mean a detached masonry support, rectangular in section, such that its breadth shall not exceed two and half time the thickness.

**7.4.12.3 CURVED STONE WORK:** Stone work curved on a plan to a mean radius exceeding six meters shall be measured net and included with general stone work. Stone work circular on a plan to a mean radius not exceeding six metres shall be measured separately and extra payment shall be allowed and shall include all cutting and waste and templates. It shall be measured as the mean length of wall.

#### **7.4.13 RATE**

The rate shall include the cost of materials and labour required for all the operations described above. Unless otherwise specified stone facing or wall lining upto and not exceeding 8cm thickness shall be paid for under "Stone work for wall lining etc. (Veneer work)". The stone work of thickness exceeding 8 cm shall be paid under relevant items of work.

### **7.5 STONE VENEERING WORK**

Stone lining upto 8cm shall generally be treated as veneering work and lining of greater thickness as plain Ashlar masonry.

#### **7.5.1 STONE**

Shall be as specified in 7.4.1. The stone shall be cut into slabs of required thickness along the planes parallel to the natural bed of stone.

#### **7.5.2 DRESSING**

Shall be as specified in 7.4.3 except that dressing at the back shall not be done, so as to ensure better grip with hearting or backing. The dressed slabs shall be of the thickness as specified, with permissible tolerance of  $\pm 2$  mm.

**7.5.3 MORTAR:** Mortar for fixing shall be as specified.

#### **7.5.4 LAYING**

The stone shall be wetted before laying. They shall then be fixed with mortar in position to line and level without the use of chips or under pinning of any sort.

**7.5.4.1** Where so desired, the adjoining stones shall be secured to each other by means of copper pins 75mm long, 6mm diameter or as specified.

**7.5.4.2** Further the stones shall be secured to the backing by means of clamps. The material for clamps shall have high resistance to corrosion under conditions of dampness and against the chemical action of mortar or concrete in which clamps are usually embedded.

Clamps shall be 25mm x 6mm and 30cms long in case of backing of stone masonry walls and bricks masonry walls thicker than 230mm. In case of backing with brick masonry walls 230mm or less thick or RCC members clamps shall be of 25 x 6mm and length as per requirement, made out of gun metal or any other metal specified in para 7.5.4.6. Generally the outer length of clamps in half brick work backing shall be 115mm and in one brick work backing shall be 150mm. The typical shape and details of clamps for such backing shall be as per drawing for the work. Clamps shall be spaced not more than 60cm apart horizontally.

Alternatively the stone may be secured to the backing by means of stone dowels 10 x 5 x 2.5 cm as per shape indicated in drawing and the adjoining stone secured to each other by means of gun metal clamps or copper pins of the specified size. Minimum one clamp/stone dowel shall be used to secure one slab to the backing.

- 7.5.4.3 Clamps may be attached to its sides or top and bottom or sides, top and bottom. The minimum number of clamps required for fixing unit to the wall are as in drawing. The actual number of clamps and their sections, however, shall be as per requirements of design to carry the loads.
- 7.5.4.4 Where clamps are used to hold the unit in position only, the facings shall be provided with a continuous support on which the stones rest at the ground level and other storey levels, the support being in the form of projection from or recess into the concrete floor slab, or a beam between the columns or a metal angle attached to the floor slab or beams. These supports shall preferably be at vertical intervals not more than 3.5 m apart and also over the heads of all openings. Such supports shall also be provided where there is transition from thin facings below to thick facings above.
- 7.5.4.5 Alternatively clamps may be used to hold the units in position and in addition to support the units thus transferring the weight of the units to the backing. Such clamp should be properly designed as IS:4101 (Part 1)
- 7.5.4.6 The clamps may be of gun metal or copper alloyed with zinc, tin, nickel, lead and/or stainless steel.
- 7.5.4.7 The pins, clamps and dowels shall be laid in cement mortar 1:2 (1 cement :2 fine sand) and their samples got approved by the Engineer In-Charge and kept at site.
- 7.5.4.8 The walls shall be carried up truly plumb. All courses shall be laid truly horizontal and all vertical joints truly vertical. The stone shall break joints on the face for at least half the height of the course, unless otherwise shown in the drawings. The stone shall be laid in regular courses not less than

20cm height and all the stones shall be of the same height unless otherwise specified. No stone shall be less in length than one and half times its height unless otherwise specified.

- 7.5.4.9 As far as possible the backing shall be carried up simultaneously with the face work. In case of reinforce cement concrete backing, the lining shall be secured to the backing after it has set and got cured. The clamps shall be fixed in concrete at the required positions, while laying.

#### **7.5.5 JOINTS**

The joints shall be done with composite cement lime mortar 1:1:6 (1 cement : 1 lime putty : 6 fine sand) or as specified. All joints shall be full of mortar. Special care shall be taken to see that the groundings for veneer work are full of mortar. If any hollow groundings are detected by taping the face stones, these shall be taken out and relaid. The thickness of joints shall be as small as possible, not exceeding 5mm. For a close but joined facing the thickness shall not exceed 1.5 mm. The face joints shall be uniform throughout.

- 7.5.5.1 Where joint filler or compound is to be used, the joints shall be raked out to a depth of atleast 25 mm after the mortar in the joints has set sufficiently and the filler or compound applied. The joints may be subsequently finished with a mortar suited to the appearance of the work. It is preferable to use joint sealing compound where the facing are exposed to heavy rainfall and winds and their selections would depend upon local experience and availability of joint sealing compounds. In their absence only masonry mortar 1:1:6 (1 cement : 1 lime putty : 6 sand) which are proved to be successful from local exposure conditions shall be used.

#### **7.5.6 OTHER DETAILS**

Specifications for pointing, curing, protections and scaffolding shall be as specified under 7.4.

#### **7.6 SHELVES, COPING, PLAIN, CORNICES, STRING COURSES ETC.**

- 7.6.1 **STONE:** Stone shall be of uniform colour and texture and of the kind as stipulated.

##### **7.6.2.1 DRESSING**

The exposed faces and sides of shelves shall be chisel dressed such that the dressed surface shall not have more than 3mm from a straight edge placed on it. All visible angles and edges shall be free from chippings. The surfaces to be buried in the masonry shall be rough dressed.

### **7.6.2.2 LAYING**

These shall be laid in mortar of specified mix and fixed as shown in drawing or as directed by the Engineer-in-Charge.

### **7.6.2.3 Other Details**

Specifications for pointing, curing, protections and scaffolding shall be as specified under 7.4.

## **7.6.3 LATERITE STONE MASONRY**

### **7.6.3.1 DRESSING**

Laterite stones shall be hammer dressed into rectangular blocks so that all faces are free from waviness and unevenness, and the edges are true and square. The least thickness/breadth shall be not less than height. The length shall generally be equal to twice the breadth, unless otherwise specified.

### **7.6.3.2 LAYING**

The dressed stones shall be laid in regular courses of not less than 15cm height. All courses in the masonry shall be of the same height unless otherwise directed. The stones shall be laid in alternate header stretcher fashion, alternative courses of header and stretchers or in any other suitable fashion as directed. The vertical joints shall break by atleast 65mm. No specific corner stones are necessary. Quion may be provided, where so indicated.

### **7.6.3.3 JOINTS**

All bed joints shall be truly level and side joints truly vertical, the thickness of joints shall not exceed 15mm. Each stone shall be carefully laid in place with joints completely filled with mortar. On faces, where no plastering or pointing is required to be done, the joints shall be struck flush as the work proceeds. In other cases, joints shall be racked square to a minimum depth of 15mm by a racking tool during the progress of work while the mortar is still green.

### **7.6.3.4 SCAFFOLDING, CURING AND PROTECTION**

Same as in para 7.4.

## **7.7 PRECAST CONCRETE STONE BLOCKS MASONRY**

### **7.7.0 TERMINOLOGY**

For the purpose of this standard, the following definition shall apply:

**Block Density** – The density calculated by dividing the mass of a block by the over all volume including holes or cavities.

**Stone Spalls** – Broken stone pieces of varying sizes obtained by breaking the natural river boulders or quarry stones.

**Concrete Stone Masonry Block** – A precast cement solid block having stone splaes in it (25 to 30 percent of block volume) and cement concrete with dense stone aggregate and sand. It is 100% solid.

**Stone Face Exposed Block** – A concrete stone masonry block where the stone spalls are exposed at one of its face. The face, when forms the exposed wall face, the wall gets the texture of stone surface exposed.

#### **7.7.1 DIMENSIONS AND TOLERANCES**

Concrete stone masonry block is a solid block and shall be referred to by its nominal dimensions the term 'normal' means that the dimensions includes the thickness of the mortar joint. Actual dimensions shall be 10mm short of the nominal dimensions.

The nominal dimensions of concrete stone masonry block shall be as follows:

Length	300 mm
Height	150 mm and
Width	100, 150 and 200 mm

In addition, block shall be manufactured in one-third, half, two-third and three quarters of its full length. The nominal dimensions of the units are so designed that taking account of the thickness of mortar joints, they will produce wall lengths and heights which will conform to the principles of modular coordination.

Blocks or other nominal dimensions may also be made if so directed by the Engineer In-Charge

- 7.7.2 For accommodation vertical, reinforcement required in earthquake resistant construction, special block of half width and with semi-circular recess in it shall be used. These dimensions are suitable for 200 mm thick wall. Similar blocks shall be made for walls of thickness greater than 200 mm.
- 7.7.3 The maximum variation in the length of the units shall not be more than  $\pm 5$ mm and maximum variation in height and width of units more than  $\pm 3$  mm.
- 7.7.4 Subject to the tolerance specified in 7.7.3 the faces of blocks shall be flat and rectangular, opposite faces shall be parallel, and all arises shall be square. The bedding surfaces shall be at right angles to the faces of the blocks.

7.7.5 Blocks with special faces

Blocks with special faces shall be manufactured and supplied as specified in the item of agreement.

7.7.6 **CLASSIFICATION**

Concrete stone masonry blocks shall be classified according to their average compressive strength as given in Table 2.

7.7.7 **MATERIALS**

7.7.7.1 Cement: Cement complying with any of the following Indian Standards may be used at the discretion of the Engineer-in-Charge IS:269, 455, 1489, 6909, 8041, 8043.

7.7.7.2 When cement conforming to IS:269 is used, replacement of cement by flyash conforming to IS: 3812 may be permitted up to a limit of 20%. However, it shall be ensured that blending of flyash with cement is as intimate as possible, at achieve maximum uniformity.

7.7.7.3 **STONE SPALLS:** The stone spalls shall be of size ranging from 50 to 250mm in dimension. The stone spalls shall be hard, sound, round in shape, durable, free from decay and weathering. These shall not be flaky. The Spalls shall have rough surface for better bond with cement concrete. Good quality stone such as granite, sand stone and basalt shall be used., Slate shale or any other soft and flaky stone shall not be used. The spalls shall be obtained from approved quarry or by breaking river boulder. Larger size shall be broken into the required sizes and shall be stacked into two categories:

(a) 100mm and above and

(b) Below 100 mm.

7.7.7.4 **AGGREGATES:** The aggregates used in the manufacture of block shall be clean and free from all deleterious matter, and shall conform to the requirements of IS:383.

Maximum size of the coarse aggregate shall be 10 mm. Sand used in the manufacture of blocks shall be well graded, clean and free from deleterious mater, and shall conform to the requirements of IS:383. Besides it shall have fine particles 15 to 20% passing 300 micron I.S. Sieve and 5 to 15% passing 150 micron I.S Sieve.

It is recommended that the fineness modules of the combined aggregate shall be between 3.6 to 4.

7.7.7.5 Flyash conforming to IS:3812 may be used for part replacement of fine aggregate upto a limit of 20%.



## **7.7.8 MANUFACTURE**

Blocks may be manufactured either at construction site or in factory on a central casting plate form using steel moulds with or without surface vibration of compaction of cement concrete.

- 7.7.8.1 **Mould:** Moulds shall be fabricated using mild steel plates and mild steel angles for stiffening the plates.

The mould shall be either fixed type (bolt with four side walls fixed at corners, and top and bottom open) or split type.

Split type may be either individual or gang mould. Where the compaction of the concrete is done manually, the mould may be either fixed type or split type. When the compaction of the blocks is done with surface vibrator, the mould shall be only split type (individual or gang mould).

## **7.7.9 MIX**

- 7.7.9.1 The cement concrete mix for concrete stone masonry blocks shall not be richer than one part by volume of cement to 9 parts by volume of combined fine and coarse aggregates, and shall not be leaner than one part by volume of cement to 13 parts by volume of combined fine and coarse aggregates.

- 7.7.9.2 In case of blocks where compaction is done manually, concrete mix of medium consistency (10 – 12 mm slump) shall be used in order to enable proper compaction and demoulding. The consistency of the mix should be such that it may cohere when compressed in the hand without free water being visible.

- 7.7.9.3 In case of blocks where compaction is done by external vibrator, concrete mix of very low consistency (zero slump) shall be used in order to vibrate and compact the concrete under pressure.

- 7.7.9.4 **MIXING:** Concrete shall normally be mixed in a mechanical mixer unless otherwise permitted by Engineer-in-Charge. In case of hand mixing 10% extra cement shall be used without any extra payment.

Mixing shall be continued until there is a uniform distribution of the materials, and the mass is uniform in colour and consistency.

## **7.7.10 PLACING AND COMPACTION**

Depending upon the size of the stone spalls, these shall be used either in one layer or in two layers. When used in two layers, large size spalls of 100 mm and above shall be placed in the bottom and concrete poured all around and

at top, and shall be tamped manually. Second layer of stone spalls of size 50mm and above shall be placed over the first layer, and again concrete is poured all around upto 20 to 30mm above the top level of mould.

- 7.7.10.1 Depending upon the size of block the average volume of stone spalls used should generally between 25 to 30%. However, in no block, it shall be less than 20% of the volume of block.
- 7.7.10.2 Each stone spall shall have a minimum space of about 15 to 20mm around it. For blocks with exposed stone texture, the stone spalls shall touch the surface of the mould.
- 7.7.10.3 Blocks may be compacted manually as well as mechanically. In case of manual compaction the concrete laid after the first layer of stone spalls shall be tamped with mason's toll and again it shall be tamped with suitable tampers and compacted from top and finally struck off level with trowel.

In case of mechanical compaction, the mould shall be filled up to overflow, vibrated and mechanically tamped using external vibrator and struck off level.

- 7.7.10.4 Demoulding shall be done 5 to 10 minutes after compaction. In case of fixed type mould it shall be pulled up with side handles while pressing down the block with the plate at top with thumb. In case split type mould, the sides shall be removed first and the partition plates (gang mould) shall be pulled up subsequently.
- 7.7.10.5 After demoulding, the blocks shall be protected until they are sufficiently hardened to permit handling without damage.

#### **7.7.11 CURING**

The blocks hardened shall than be cured in a curing water tank or in a curing yard and shall be kept continuously moist for atleast 14 days.

- 7.7.11.1 **DRYING:** After curing, the blocks shall be dried for a period of two to four weeks depending upon weather before being used on the work. The blocks shall be allowed to complete their initial shrinkage before they; are laid in a wall.

#### **7.7.12 PHYSICAL REQUIREMENT**

- 7.7.12.1 **General:** All blocks shall be sound and free from cracks or other defects which may interfere with proper placing of the unit or impair the strength or performance of the construction.
- 7.7.12.2 Where blocks are to be used in exposed wall construction, the face or faces that are to be exposed shall be free of chips, cracks or other imperfections,

expect that not more than 5% of a consignment contains slight cracks or small chipping.

**7.7.12.3 DIMENSIONS:** The overall dimensions of the blocks when measured as given in Appendix A of IS:12440 shall be in accordance with 7.7.1 subject to the tolerance mentioned therein.

**7.7.12.4 COMPRESSIVE STRENGTH:** The minimum compressive strength at 28 days, being the average of eight blocks and the minimum compressive strength at 28 days of individual blocks, when tested in the manner described in Appendix B, of IS:12440, shall be as prescribed in Table 2.

**TABLE 2**

**COMPRESSIVE STRENGTH OF CONCRETE STONE MASONRY BLOCKS**

Designation	Minimum average compressive strength on blocks N/mm <sup>2</sup>	Minimum strength of individual blocks N/mm <sup>2</sup>
5	5.0	3.5
6	6.0	4.2
7	7.0	5.0
9	9.0	6.3
10	10.0	7.5

For 100mm wide blocks (for 100mm thick walls), the minimum strength may be 3.5 N/mm<sup>2</sup>.

**7.7.12.5 WATER ABSORPTION:** The water absorption being the average of three blocks, when determined in the manner prescribed in Appendix C, of IS:12440 shall be not more than 6% by mass.

#### **7.7.13 TESTS**

**7.7.13.1** Tests as described in Appendix IS:12440 shall be conducted on samples of blocks selected according to the sampling procedure given in 7.7.13.2 to ensure conformity with the physical requirements laid down in 7.7.12.

**7.7.13.2** A sample of 15 blocks shall be taken from a lot of 5000 or part thereof manufactured under similar conditions of the same size and batch.

#### **7.7.14 CRITERIA FOR CONFORMITY**

**7.7.14.1** The lot shall be considered as conforming to the requirements of the specification if the conditions mentioned in 7.7.14.1, 7.7.14.3 are satisfied.

- 7.7.14.2 Number of blocks with dimension outside the tolerance limit and/or with visual defects, among those inspected shall not be more than two.
- 7.7.14.3 For compressive strength, the mean value determined shall be greater than or equal to the minimum limit specified in 7.7. 12.4.
- 7.7.14.4 For water absorption the mean value determined shall be equal to or less than maximum limit specified in 7.7.12.5.
- 7.7.15 Laying: The laying of precast concrete stone block masonry shall be as per para 7.8.8.

## **7.8 HOLLOW AND SOLID CONCRETE BLOCK MASONRY**

### **7.8.1 HOLLOW AND SOLID CONCRETE BLOCKS**

Shall conform to the requirements of IS:2185. Specification for hollow and solid concrete blocks except with regard to the mix cement concrete and sizes of aggregates which shall be as indicated. Hollow blocks shall be sound, free from cracks, broken edges, honey combing and other defects that would interfere with the proper placing of block or impair the strength of performance of construction.

### **7.8.2 DIMENSIONS AND TOLERANCES**

- 7.8.2.1 Concrete masonry building units shall be made in sizes and shapes to fit different construction needs. They include stretcher, corner, double corner or pier, jamb, header, bull nose, and partition block and concrete floor units.
- 7.8.2.2 Concrete Block-hollow (open or closed cavity) or solid shall be referred by its nominal dimensions. The nominal dimensions of concrete block shall be, as follows:

Length : 400, 500 or 600 mm  
Height : 200 or 100 mm  
Width : 50, 75, 100, 150, 200, 250 or 300 mm.

In addition, block shall be manufactured in half lengths of 200, 250 or 300 mm to corresponding to full lengths.

The maximum variation in the length of the units shall be not more than  $\pm 5$  mm and maximum variation in height and width of unit, not more than  $\pm 3$  mm.

### **7.8.3 CLASSIFICATION**

#### **7.8.3.1 HOLLOW (OPEN AND CLOSED CAVITY) CONCRETE BLOCKS**

The hollow (Open and closed cavity) concrete blocks shall conform to the following three grades:

- (a) Grade 'A' – These are used as load bearing units and shall have a minimum block density of 1500 kg/m<sup>3</sup>. These shall be manufactured for minimum

average compressive strength of 3.5, 4.5, 5.5 and 7.0 N/mm<sup>2</sup> respectively at 28 days (See Table 3).

- (b) Grade - 'B' These are also used as load bearing units and shall have a block density less than 1500 kg/m<sup>3</sup> but not less than 1000 kg/m<sup>3</sup>. These shall be manufactured for minimum average compressive strength of 2.0, 3.0, and 5.0 N/mm<sup>2</sup> respectively at 28 days (See Table 3).
- (c) Grade 'C' - These are used as non-load bearing units and shall have a block density less than 1500 kg/m<sup>3</sup> but not less than 1000 kg/m<sup>3</sup>. These shall be manufactured for minimum average compressive strength of 1.5 N/mm<sup>2</sup> at 28 days (See Table 3).
- (d) Grade 'D' - The solid concrete blocks are used as load bearing units and shall have a block density not less than 1800 kg/m<sup>3</sup>. These shall be manufactured for minimum average compressive strength of 4.0 and 5.0 N/mm<sup>2</sup> respectively (See Table 3).

#### 7.8.4 PHYSICAL REQUIREMENTS

7.8.4.1 **Compressive Strength:** The average crushing strength of eight blocks, when determined in accordance with IS:2185 shall be not less than as specified in table given below:

**TABLE 3**  
**PHYSICAL REQUIREMENTS**

Type	Grade	Density of Block kg/mm <sup>3</sup>	Minimum Average Compressive Strength of Units N/mm <sup>2</sup>	Minimum strength of Individual units N/mm <sup>2</sup>
(1)	(2)	(3)	(4)	(5)
Hollow (open & closed cavity) load bearing unit	A(3.5)	Not less than 1500	3.5	2.8
	A(4.5)		4.5	3.6
	A(5.5)		5.5	4.4
	A(7.0)		7.0	5.6
	B(2.0)	Less than 1500 but not less than 1000	2.0	1.6
	B(3.0)		3.0	2.4
	B(5.0)	5.0	4.0	
Hollow (open and closed cavity) non-load bearing units	C(1.5)	Less than 1500 but not less than 1000	1.5	1.2
Solid load Bearing units	D(5.0)	Not less than 1800	5.0	4.0
	D(4.0)		4.0	3.2

- 7.8.4.2 DRYING SHRINKAGE:** The drying shrinkage of the blocks (average of three blocks), when unrestrained shall be determined in accordance with IS:2185 (Shall not exceed) 0.1 per cent.
- 7.8.4.3 MOISTURE MOVEMENT:** The moisture movement (average of three blocks), when determined in the manner described in IS:2185 shall not exceed 0.09 per cent.
- 7.8.4.4 WATER ABSORPTION:** The water absorption (average of three blocks), when determined in the manner described in IS:2185 shall be not more than 10 per cent by mass.
- 7.8.4.5** Face shells and webs shall increase in thickness from the bottom to the top of the unit depending upon the core moulds used, the face shells and webs shall be flared and tapered or straight tapered, the former providing a wider surface for mortar. The thickness of the face shell and web shall be not less than the values given in Table below:

**TABLE 4**  
**MINIMUM FACE SHELL AND WEB THICKNESS**

Nominal Block width	Face shell Thickness, Min.	Thickness of Web, Min.	Total Web thickness per Course in any 200 mm length of Walling Min.
(1)	(2)	(3)	(4)
100 or less	25	25	25
Over 100 to 150	25	25	30
Over 150 to 200	30	25	30
Over 200	35	30	38

- 7.8.4.6** The dimensions said above are subject to the tolerance specified in 7.8.2.2.
- 7.8.4.7.** The face of Masonry units shall be flat and rectangular, opposite face shall be parallel, and all arises shall be square. The bedding surfaces shall be at right angles to the faces of the blocks.
- 7.8.4.8** Blocks with special faces shall be manufactured and supplied as directed by the Engineer-in-Charge.
- 7.8.5 CURING AND DRYING**

The blocks shall be cured in an immersion tank or in a curing yard and shall be kept continuously moist for at least 14 days. When the blocks are cured in

an immersion tank, the water of tank shall be changed at least once in every four days.

After curing, the blocks shall be dried in shade before being used on the work. They shall be stacked with voids horizontal to facilitate through passage of air. The blocks shall be allowed to complete their initial shrinkage before they are laid in wall.

#### **7.8.6 CONSTRUCTION OF MASONRY**

For single storeyed building, the hollows of blocks in foundation and basement masonry shall be filled up with sand and only the top foundation course shall be of solid blocks. But for two or more storeyed buildings, solid concrete blocks shall be used in foundation courses, plinth, and basement walls, unless otherwise indicated. If hollow blocks are used, their hollows shall be filled up with cement concrete 1:3:6 using 12.5mm nominal size aggregates.

#### **7.8.7 WETTING OF BLOCKS**

Blocks need not be wetted before or during laying in the walls. In case the climate condition so required the top and the sides of the blocks may only be slightly moistened so as to prevent absorption of water from the mortar and ensure the development of the required bond with the mortar.

#### **7.8.8 LAYING**

Blocks shall be laid in mortar, as indicated and thoroughly bedded in mortar, spread over the entire top surface of the previous course of blocks to a uniform layer of not less than 10mm and not more than 12 mm in thickness.

All courses shall be laid truly horizontal and all vertical joints made truly vertical. Blocks shall break joints with those above and below for not less than quarter of their length. Precast half-length closers (and not cut from full size blocks) shall be used. For battered faces, bedding shall be at right angles to the face unless otherwise directed. Care shall be taken during construction to see that edges of blocks are not damaged.

#### **7.8.9 PROVISIONS FOR DOOR AND WINDOW FRAMES**

A course of solid concrete block masonry shall be provided under door and window openings (or a 10 cm thick precast concrete sill block under windows). The solid course shall extend for at least 20 cm beyond the opening on either side. For jambs of very large doors and windows either solid units used, or the hollows shall be filled in with concrete of mix 1:3:6 using 12.5 mm nominal size aggregate.

#### **7.8.10 PROVISIONS FOR ROOF**

The course immediately below the roof slab shall be built with solid blocks. The top of the roof course shall be finished smooth with a layer of cement and coarse sand mortar 1:3, 10mm thick and covered with a thick coat of white wash or crude oil, to ensure free movement of slab.

#### **7.8.11 INTERSECTING WALLS**

When two walls meet or intersect and the courses are to be laid up at the same time, a true masonry bond between at least 50% of the units of the intersection is necessary. When such intersecting walls are laid up separately, pockets with 20mm maximum vertical spacing shall be left in the first wall laid. The corresponding course of the second wall shall be built into these pockets.

#### **7.8.12 PIERS**

The top course of block in the pier shall be built in solid blocks. Hollow concrete block shall not be used for isolated piers, unless their hollows are specified to be filled with cement concrete.

7.8.13 Where possible fixtures, fittings etc. shall be built into the masonry in cement and coarse sand mortar 1:3 while laying the blocks. Hold fasts shall be built into the joints of the masonry during the laying.

Holes, chases, sleeves, opening, etc. of the required size and shape shall be formed in the masonry with special blocks while laying, for fixing pipes, service lines, passage of water etc. After service lines pipes etc. are fixed, voids left, if any, shall be filled up with cement concrete 1:3:6 (1 cement : 3 coarse sand : 6 stone aggregate 20 mm nominal size) and neatly finished.

#### **7.8.14 FINISHES**

Rendering shall not be done to the walls when walls are wet. Joints for plastering or pointing as specified shall be raked to a depth of 12 mm.

Joints on internal faces, unless otherwise indicated, shall be raked for plastering. If internal face of masonry are not to be plastered the joints shall be finished flush as the work proceeds or pointed flush where so indicated.



## CHAPTER – 8

### MARBLE WORK

Marble shall be hard, sound, dense and with homogenous crystalline structure. It shall be of uniform colour and free from defects.

#### 8.1 CLASSIFICATION

Broadly classified as

- (a) White marble
- (b) Colour Marble (Black, Green, Pink Brown, Grey etc.)

#### 8.2 SIZES AND TOLERANCES

- 8.2.1 The sizes shall be as per drawing, work order/ as directed by the Engineer In-Charge.
- 8.2.2 Marble Blocks will be of linear dimensions 30 cm to 250 cm and of thickness 30 cms to 90 cms. Slabs will be of linear dimension 70 cm to 250 cm and of thickness 2 cms to 15 cms. Tiles will have linear dimension 10 cms to 60 cms and of thickness 0.8 cms to 2.4 cms.
- 8.2.3 The linear dimensions of marble blocks, slabs and tiles shall be in multiples of 30 cms, 10 cms, 10 cms, respectively.
- 8.2.4 The slabs and tiles shall be machine cut and factory made.
- 8.2.5 Tiles of 8mm thick shall require special precaution for fixing like special adhesive as per manufacturers specification. Such tiles shall not be used for areas exposed to rains/sun if used in large areas in continuous stretches. For tiles of thickness 20mm and more clamps are to be provided as per drawing.
- 8.2.6 The dimensional tolerances are as below:
- |        |  |
|--------|--|
| Blocks | (+) 2 percent for all dimensions                               |
| Slabs  | (+) 3 percent in thickness & (+) 2 percent other dimensions.   |
| Tiles  | (+) 3 percent linear dimension and (+) 1 percent in thickness. |

- 8.3 The physical **properties** of marble viz moisture absorption and specific gravity shall conform to IS:1124 and IS:1122 respectively. The hardness shall be minimum 3 in Mohs scale.
- 8.4 The contractor, prior to commencement of work shall furnish **sample** to Engineer-in-Charge and get it approved. The approved sample shall be kept in the custody of Engineer-in-Charge and actual material should conform to sample.
- 8.4.1 The sampling for testing the material shall be as detailed in standard specification for the same in the trade viz. in IS/CPWD etc.

## 8.5 DRESSING AND RUBBING

The dressing and rubbing shall be in a workman like manner as in standard specification for the same in trade as in IS/CPWD etc.

## 8.6 GENERAL MARBLE WORKS

### 8.6.1 LAYING

The stones shall be wetted before placing in position. These shall be floated on approved specified mortar bed. All courses shall be laid to true horizontal and vertical requirements as per drawing. Courses shall be of uniform height not less than 15 cms unless otherwise specified. Care shall be taken not to damage the corners of stone. The matching of grains shall be carried out as directed by the Engineer-in-Charge.

### 8.6.2 BOND STONES

Bond stone shall run through total thickness of wall upto 60cm thick. For more thickness bond stones should over lap each other by at least 15 cms. At least one bond stone for 0.5 sqm of wall surface shall be provided. All bond stones shall be suitably marked as directed by the Engineer In-Charge.

### 8.6.3 JOINTS, CURING, FINISHING, PROTECTION, SCAFFOLDING ETC.

Joints shall be as fine as possible but shall not be more than 1.5mm. The depth of joint upto 6mm from the surface shall be uniform beyond that it may be in 'V' shape for better mortar bond. The work shall be kept moist for at least 7 days. After curing period, the marble shall be rubbed with standard grades of carborandum stone in succession for obtaining highly smooth surface and washed with oxalic acid and finished clean. The green work shall be covered with suitable covering. Double scaffolding only shall be used wherever scaffolding is required.

#### **8.6.4 MEASUREMENT**

Correct to one cm in length and breadth and 0.5 cm in thickness. Cubical content shall be in cubic decimeter upto 2 places of decimal.

#### **8.6.5 RATE**

Rate to include cost of all material and labour required for work described in the description of work.

#### **8.7 WALL LINING / VENEER WORK**

The back of the tiles/slabs shall not be dressed in order to ensure good grip with hearing of backings. For the finished work the tolerance in wall lining shall be such that when straight edge of 3m length is placed the surface variation should not be more than 2 mm. The grains of the stone shall generally match for which slabs shall be judiciously selected preferably from same block from the quarry. For securing the stones to each other copper pins of 75 mm long and 6mm diameter shall have to be used apart from clamps of gun metal or material having high resistance to corrosion, of size 25 x 6 mm and 30 cm long for works with back walls of 230 mm or more thick all as per approved working drawings. For lesser wall thickness or RCC wall backing, the size of clamp to be suitably adjusted as in approved working drawing. Clamps spacing shall be 60 cm or less on both direction. The clamps, material viz. copper alloyed with zinc, tin, nickle, lead or stainless steel etc. fixing arrangements, spacing etc. shall be as per specification and approved drawing and as directed by Engineer-in-Charge.

- 8.7.1 The measurement of work, shall be generally as detailed above for general marble work. In case of radially dressed or circular slabs, the dimension of circumscribing rectangle dressed shall be measured. The area shall be in Sq mt nearest to two places of decimal. Veneer work/line work upto 4 cm thick shall be paid on area basis and that of greater thickness shall be by volume unless otherwise specified in agreement.

When factory finished materials are used no further finishing may be required if approved by Engineer in-Charge.

#### **8.8 MARBLE JALI**

- 8.8.1 The work shall be carried out as per specification and working drawing. A tolerance of (-)2mm shall be allowed in thickness.
- 8.8.2 The measurement and rates shall be generally as indicated above for marble lining work and also as specified in the agreement.

## CHAPTER 9

### WOOD WORK

#### WOOD WORK IN JOINERY

##### 9.1 TIMBER

- 9.1.1 The timber shall be free from decay, fungal growth, boxed heart, pitch pockets of streaks on the exposed edges, splits and cracks. All timber shall be of natural growth and uniform in colour texture and shall be well and properly seasoned. It shall be free from large loose dead or cluster knots, waves, discolouration, soft or sponge spots. Hollow pockets, pitch or center heart and all other defects and blemishes. The timber shall be graded as first grade (class I ) and second grad (second class) on the basis of permissible defects in the timber as given in Appendix "A" at the end of this chapter.

Timber shall either be obtained incut sizes or shall be cut to required sizes well in advance of the commencement of fabrication and stacked at site of work in a suitable manner for further seasoning.

##### 9.1.2 SEASONING OF TIMBER AND MOISTURE CONTENT

The seasoning of timber shall be as laid down in L.S No. 1141. The process of drying timber under controlled conditions is called seasoning of timber. The timber shall be either air seasoned or kiln seasoned. The seasoning of timber shall be judged from the moisture content as laid down in IS No. 287 control on moisture content of timber is necessary to ensure its proper utility in various climatic conditions. The maximum permissible moisture content in timber shall not exceed 12%. No individual hard and sound knot shall be more than 25mm diameter and aggregate area of all the knots shall not exceed 1% of the area of piece. There shall not be less than 2 growth rings per cm of width.

##### 9.1.3 DEFECTS IN TIMBER

- a. Timber with loose grains, splits, heart or sitar shakes, springs and cups, waness, compression wood in coniferous timber, heart wood, rot, sap rot, warps and holes made by powder pest beetles and pitch pockets shall be eliminated.
- b. Sap wood shall not be more than 15% of area of the section in case of first class timber, in other classes of timbers sap wood shall not be permitted

unless the timber is thoroughly impregnated with approved wood preservatives.

- c. Knots shall not exceed one per meter length of any member and the maximum diameter of individual knots shall not exceed the figures given below for various widths of face.

WIDTH OF FACES	MAXIMUM DIAMETER OF KNOT
Next 75mm	15mm
Exc 75mm N Exc 150mm	25mm
Exc 150mm N Exc 250mm	40mm
Exc 250mm	50mm

(N Exc means not exceeding).

**Note:** The diameter of a knot shall be the maximum distance between two points farthest apart on the periphery of a round knot on the face of which it becomes visible. In the case of a spike or a splay knot it shall be the maximum width of the knot visible.

In structural members knots shakes and checks shall not be permitted in regions of maximum stress intensities not shall they be permitted at locations where joints are to be provided.

#### 9.1.4 FIRST AND SECOND CLASS TIMBER

In first class wood the individual hard and sound knot shall not be more than 25mm in diameter and the aggregate area of all the knots shall not exceed one percent of the area of the piece.

#### 9.1.5 SECOND CLASS WOOD

In second class wood the individual hard and sound knots shall not be more than 40mm in diameter and aggregate of all the knots shall not exceed one and half percent of the area of the piece. Wood shall be generally free from sap wood, but traces of sap wood shall be allowed.

#### 9.1.6 PRESERVATION OF TIMBER

Preventive treatment does not improve basic properties of timber but gives varying degree of protection against deterioration due to attacks by fungi, termites, borers and marine organisms. Preservative treatment where specified shall be done using oil type, organic solvent type or water soluble type preservative. Oil type preservative shall be used if the timber is not required

to be polished or painted. Before preservative treatment, the timber shall be swan and seasoned. All surfaces exposed after treatment except due to planing shall be thoroughly brushed with the preservation before jointing. Preservative treatment of timber shall be done as per IS 401 in a plant approved by Engineer-in-charge.

## 9.2 PLY WOOD BOARDS

Ply wood boards are formed by gluing and pressing three or more layers of veneers with the grains of adjacent veneers running at right angles to each other. The veneers shall be sufficiently smooth to permit an even spread of glue. The thickness of veneers shall be uniform. With a tolerance of  $\pm 5\%$ . Corresponding veneers on either side of center one shall be of some thickness and species. The requirements of Veneers and core veneer shall be as follows:

- a) In 3 ply boards up to 5 mm thick the combined thickness of the face veneers shall not exceed twice the thickness of center ply.
- b) In multiply boards, the thickness of any veneer shall not be more than thrice the thickness of any other veneer.
- c) The sum of the thickness of the veneers in one direction shall approximate to the sum of the thickness of the veneers at right angle to them and shall not be greater than 1.5 times this sum except for 3 ply as specified in (a).

The boards are available in thickness 3 to 25 mm. Tolerance in thickness shall be  $\pm 10\%$ . For boards upto and including 5 mm;  $\pm 7\%$  for boards from 6 to 9 mm and  $\pm 5\%$  for boards above 9mm thickness. The boards shall be of uniform thickness and surface of boards shall be sanded to a smooth finish. Number of plys in ply woods board shall be as below:

Thickness in mm	Number of Plys
3,4,5,6	3
5,6,8,9	5
9,12,15,16	7
12,15,16,19	9
19,22,25	11

The moisture content of ply boards shall not be less than 5 percent and not more than 15 percent.

One sample for every 100 Sqm or part thereof shall be taken for testing. Testing may not be required if the total requirement is less than 308 Sqm. Unless otherwise stated only BWP grade plywood boards shall be used.

### 9.3 BLOCK BOARDS

- 9.3.1 Block board shall have solid core made up of uniform strip of wood each not exceeding 25mm in width, laid separately or spot glued or otherwise joined to form a slab which is glued between two or more outer veneers. With the direction of the grain of the core block running at right angles to that of the adjacent veneers. In any one block board, the core strips shall be of one species of timber only. Block board shall be Grade I (Exterior grade) as per IS 1659. The adhesive used shall be BWP type synthetic resin conforming to IS 848. The block boards are available in thickness ranging from 12 to 50 mm tolerance in the thickness shall be  $\pm 5\%$  for boards upto and including 25mm thick and  $\pm 2.5\%$  for boards above 25 mm thickness each boards shall be of uniform thickness. One sample for every 100 Sqmt or part there of shall be taken for testing. Testing may not be required if the total requirement is less than 30 Sqmt. Unless otherwise stated grade I (exterior grade) block board bonded with BWP grade shall be used.

### 9.4 SHEET GLASS

- 9.4.1 Sheet glass shall be flat, transparent and clear as judged by the unaided eye. It may however possess a slight tint when viewed edgewise. Sheet glass shall be of selected quality (SQ) or ordinary Quality (OQ) conforming to IS 2835 as stipulated. The glass shall be free from cracks. Unless otherwise specified ordinary quality sheet glass shall be used. The nominal thickness, range of thickness and weight of glass shall be as below:

NOMINAL thickness in mm	Range of Thickness in mm	Weight in Kg/ Sqm
3	2.8 – 3.2	7.5
4	3.8 – 4.2	10
4.8	4.6 – 5.1	11.9
5.5	5.2 – 5.8	13.5
6.3	6 – 6.6	15.5

Tolerance for cut size glass (length and width ) shall be  $\pm 2$ mm.

Upto panel area of 0.5 Sqm glass of 4mm nominal thickness may be used for bigger panels the thickness shall be as specified.

### 9.5 GYPSUM BOARD

- 9.5.1 Gypsum board is formed by enclosing and bonding together a core gypsum plaster (a calcium sulphate mineral) with or without fibre between two

sheets of highly durable paper. The board shall be non resonant, dimensionally stable and with flame retardant qualities. Board shall conform to IS 2095 and gypsum plaster shall conform to IS 2547. The surfaces of board shall be true and free from imperfections. The dimensions of the boards shall be as specified. The length of two longitudinal of the boards shall not differ more than  $\pm 3\text{mm}$  per meter length of the diagonal. The tolerances on dimension shall be as below:

TYPE	INWIDTH [MM]	IN LENGTH [MM]	IN THICKNESS [MM]
A Wall board	0 to (-) 5	0 to (-) 6	$\pm 0.6$
B Non perforated based board	0 to (-) 8	0 to (-) 6	$\pm 0.6$
C Perforated base	0 to (-) 8	0 to (-) 10	$\pm 0.6$

One sample for every 100 Sqm or part thereof shall be tested for transverse strength. The minimum breaking load shall be as below:

TYPE OF BOARD	THICKNESS IN MM	LOAD IN TRANSVERSE DIRECTION (N)	LOAD IN LONGITUDINAL DIRECTION (N)
Plaster Board	9.5	140	360
	12.5	180	500
	15	220	650
BASE BOARD	9.5	123	180
	12.5	165	235

## 9.6 WORKMANSHIP

### 9.6.1 SHUTTERS FOR DOORS

Joinery works shall be started immediately after commencement of the building work. All pieces shall be accurately cut and planed smooth to the full dimensions without any patching or plugging of any kind, and rebates, roundings and mouldings as shown in drawings made before assembling. The thickness of styles and rails shall be as specified for the shutters. Solid wood panels shall be made out of one or more pieces of timber of not less than 125 mm width. In order to avoid warping, splitting and cracking normally pieces not exceeding 200 mm l width should be used. When made from more than one piece, the pieces, shall be joined with a continuous tongued and grooved joint glued together and reinforced with metal dowels. The grains of the solid panel shall run along the longer dimension of the panel.



The corners and edges of panels shall be finished as shown in drawings, and these shall be feather tongued into styles and rails. Sash bars shall have mitered joints with styles. In measuring the width and thickness of Styles and rails for dimension not exceeding 35mm a tolerance can be allowed upto  $\pm 1$ mm and for dimension exceeding 35mm, a tolerance of  $\pm 3$ mm can be allowed.

Styles and rails shall be properly and accurately motorized and tenoned. Rails which are more than 180mm in width shall have two tenons.

Styles and end rails of shutters shall be made out of one piece only. Lock and intermediate rails exceeding 200 mm in width may be made out of one or more piece of timber but the width of each piece shall not be less than 75mm. Where more than one piece of timber is used, they shall be jointed with a continuous tongued and grooved joint, glued together and reinforced with metal dowels at regular intervals not exceeding 20cm or pinned with not less than 40mm rust proof pins of the lost head type. Jointed pieces of timber shall belong to the same specie.

The tenons shall pass clear through styles. When assembling a leaf, styles shall be left projecting as a horn. The styles and rails shall have 12mm groove in paneled portion for the panel to fit in.

The depth of rebate in frames for housing the shutters shall in all cases be 1.25cm and the rebate in shutters for closing in double shutter doors or windows shall be not less than 2cm . The joinery work shall be assembled and passed by Engineer-in-Charge and then the joints shall be pressed, and secured by bamboo pins of about 6mm diameter.

The shutters of flush doors shall be factory made exterior grade from approved manufacturer and conforming to IS No. 2202 thickness specified in the schedule of quantities and shall have solid core with finishes as described under relevant items and with internal teakwood lipping on all edges 25mm minimum depth as per IS 1659 glued under pressure. In the case of double shutter door, the depth of the lipping at the meeting of the styles shall not be less than 30mm and meeting of the styles shall be rebated 20 mm. The rebating shall be of either splayed or square type. The shutters shall be obtained from the approved manufacture. Samples for shutters shall be submitted free of cost for conducting tests as per IS specification No. 2202 and 2191 and the approval of Engineer-in-charge before bulk delivery is effected. The shutters shall be of single leaf or double leaves as described in the schedule of quantities. The adhesive for the manufacture of Flush doors shall be phenolformaldehyde resin.

The shutter of braced and battened door shall be wooden battens with bracing of thickness as specified in the schedule of quantities and as shown in drawing. All necessary rebates, recesses, holes etc if any for fixtures or otherwise shall also be provided and the visible surface finished with the finish specified in the relevant items of schedule of quantities. The paneled shutter for door shall be

of type and sizes as specified in the relevant items of schedule. All panels upto a width of 360mm shall be made out of one piece. The corners and the edges of panels shall be finished as shown in drawings, and these shall be feather tongued into styles and rails. Such panels shall have meter joints with styles. Styles and rails shall be properly and accurately mortised and tenoned. Rails which are more than 180mm in width, shall have two tenons. The tenons shall pass clear through style. When assembling styles and rails shall have 12mm groove in paneled portion for the panel to fit in. The joinery work shall be assembled and then passed by the Engineer-in-charge.

#### **9.6.2 SHUTTERS FOR WINDOWS AND VENTILATORS**

The shutters shall be of thickness specified in the schedule of quantities and as per drawings. Same specification as that of door shutter shall apply.

#### **9.6.3 FRAME AND SHUTTERS**

Frames shall be of first class wood of species and sizes as shown in detailed drawings. No tolerance in sizes is permitted. Each door frame shall be secured in walls with holdfasts as described in the schedule, of 40mm x 3mm sizes 400 mm long forked and split at one end, bent and fixed to frame at the other end with screws. The hold fasts shall be embedded in plain C C 1:2:4, 300 mm long x 150mm thick x width of wall. The rate for door and shutters is inclusive of cost of providing and fixing and painting the surface coming in contact with masonry or concrete work with a coat of solignum, fixing of all builders hardware, glass supplied free of cost by the Department (unless otherwise specified) and painting a coat of approved primer as indicated in the relevant schedule of items.

Shutters shall be generally as per general specification as detailed in drawings and items of schedule.

The rate shall include fixing such as tower bolts, handles, mortise locks, latches, but hinges etc. Which are supplied by Department free of cost (unless otherwise specified) The materials such as screws, The materials such as screws, nails etc shall be arranged by contractor.

The glass shall be fixed with wooden beading with necessary nails, screws etc as directed by Engineer-in-charge. The be adding shall be of same type or wood used in frames and shutters and shall be provided by the contractor where the shutters are also provided by them.

#### **9.6.4 VISION PANEL**

Where specified or shown in the drawings, opening for glazing shall be provided. The opening shall be as specified in drawing opening of vision panel shall be lipped internally with solid teakwood as per details in drawing.

#### **9.6.5 FINISH**

The frames, shutters, mullions, beading, etc shall be smooth finished with sand papering.

All wood work shall be treated with a coat of approved wood primer. The wood work coming in contact with the masonry shall be painted with one protective coat of painting as directed by Engineer-in-Charge. No extra will be paid for this painting.

#### **9.6.6 BUILDERS HARDWARE**

Builders hardware like fittings, locks and fixtures to be fixed on doors, windows, ventilators, wardrobes etc. may be supplied by the Department free of cost unless otherwise specified for fixing only. The contractor shall provide at incidentals required for fixing these without extra cost.

#### **9.6.7 FIXING OF DOORS AND WINDOWS AND VENTILATORS ETC.**

All doors frames, wooden frames for windows and ventilators and wooden frames for window shutter, wooden frames and wooden louver blades for louvered windows, sheet glass in available size, wooden beading for fixing glass, fitting and fixtures if supplied by the Department free of cost at Departmental Stores for fixing only as stipulated in schedule, the contractor shall take delivery of the materials at the stores and transport them to the site of work at his own cost. All necessary MS hold fasts, wooden plugs, putty, MS pins and hooks and eyes for fixing the frames, shutters, louver blades etc in position shall be provided by the contractor at his own costs. The frames shall be erected and fixed in positions as indicated in drawing and or as directed by the Engineer-in-Charge.

9.6.8 All necessary rebates, recesses, holes etc in the door and windows shutters required for fixing the fixtures and fittings or otherwise shall be provided by the contractor at no extra cost and the visible surface finished to match the finish of the shutters and frames.

9.6.9 Builders Hardware to be fixed on door may be supplied by the Department free of cost (unless otherwise specified) for fixing only. The contractor shall provide incidentals and labour required for fixing the fittings and locks. Any loss, theft, damage etc. during handling, transportation or fixing shall be borne by the contractor at his own cost. Builders hardware shall be fixed in a workman like manner as directed by the Engineer-in-Charge.

#### **9.6.10 GLASIER'S WORK**

Glass sheets should be of best quality of thickness and type specified in the schedule. In measuring thickness of glass panes a tolerance of  $\pm 0.2\text{mm}$  can be allowed as indicated at 9.4.1. These shall be free from flaws, specks or

bubbles. All glasses shall be cut to fit the rebate of the sashes or other members as required. All glasses shall be properly bedded, putted and fixed with wooden beading to the frames and finished in a workman like manner generally as indicated in drawings and or as directed by the Engineer-in-charge. The corner of wooden beadings shall be beveled at 45° to have photo frame finish. Glass panes shall be fixed by wooden beads and double putty i.e putty first applied in the rebate and then over the glass panels. Putty shall be prepared by mixing one part of white lead with three parts of finely powdered chalk and then adding boiled linsed oil to the mixture to form into a stiff paste. All stains and marks have to be removed from the surface of glass.

#### **9.6.11 LOUVERS FIXED TO FRAMES**

The louvers may be of wood, glass, and louvered shutter, AC sheet or as specified. These shall be fixed in grooves made in frames. The louvered blades shall slope down towards outside at an angle of 45° or as shown in the drawings. Louvers shall over lap each other by about half of their width or as shown in the drawing. The tolerance are  $\pm 1$  mm in thickness and  $\pm 2$ mm in width. The depth of groove for fixing louvers in the frame shall be minimum 1.25 cm depth.

- 9.6.12 All mandatory tests for the timber, factory made shutters shall be attended to as directed by the Engineer-in-Charge and material conforming to the requirements only shall be used in the work.

#### **9.7 MEASUREMENTS**

Wood work wrought, framed and fixed shall be measured for finished dimension with allowance for the wastage or for dimensions beyond specified dimension. However the members having mouldings, roundings or rebates and members of circular or varying sections, dimensions shall be taken as the sides of the smallest square or rectangle from which such can be cut. Length of each member shall be measured over all to the nearest cm so as to include for tenons. Width and thickness shall be measured to the nearest mm and the quantity should be worked out in unit of 10 cubic decimeter in whole number.

#### **9.8 RATE**

The rate shall include the cost of material and labour involved in all the operational described except the hold fasts or metallic fasteners which will be paid for separately.

## GRADES OF TIMBER

SL. NO.	DEFECTS	FIRST GRADE	SECOND GRADE
I.	Cross Grain	Not steeper than 1 in 15	Not steeper than 1 in 10
II.	Sound knots and live knots	<p><u>A. STYLES AND RAILS</u></p> <p>Not more than 15mm size and not more than 1 knot / meter</p> <p>(b) <u>LONG EXPOSED FACE</u></p> <p>Not more than 15mm size and not more than 1 knot/m. No knot shall occur with in 20mm of edges</p> <p><u>B. PANELS</u></p> <p>Not more than 20 mm size and not more than to 2 knots per sq. mt. No knot shall occur on edge of any component of a panel.</p>	<p><u>A. STYLES AND RAILS</u></p> <p>Not more than 15 mm size and not more than 3 knots per style and one knot per rail</p> <p>(b) <u>LONG EXPOSED FACE</u></p> <p>Not more than 20 mm size and not more than 3 knots/slite and one knot per nail</p> <p><u>B. PANELS</u></p> <p>Not more than 20 mm size and not more than to 4 knots per sq. mt. No knot should occur on edge of any component of panel</p>
III.	DEAD AND LOOSE KNOTS (PLUGGED)	<p><u>A. STYLES AND RAILS</u></p> <p>Not more than 10mm size centrally located and not more than 1 knot per M</p> <p><u>B. PANELS</u></p> <p>Not more than 15mm size and not more than 2 knots per sq. mt No knot shall occur on edges of any component of a panel</p>	<p><u>A. STYLES AND RAILS</u></p> <p>Not more than 10 mm size centrally located and not more than 3 knots per stiles and 1 knot per rail</p> <p><u>B. PANELS</u></p> <p>Not more than 15 mm size and not more than 4 knots per M<sup>2</sup>. No knot shall occur on edges of any component of a panel</p>

SL. NO.	DEFECTS	FIRST GRADE	SECOND GRADE
IV.	PITCH POCKETS OR STREAKS	None	Permissible except on exposed edges provided that they are clean and filled up with suitable putty or filler. When pitch pockets or streaks are located on the exposed edges of the core, they shall be at out and filled with piece of wood or similar species with grain running in the same direction. The piece shall be well glued.
V.	SAPWOOD	Total not exceeding 5 mm wide and 150 mm long per meter (This restriction applies only to super group species)	Total not exceeding 10 mm wide and 300 mm long per meter (This restriction applies only to super group species)
VI.	PIN HOLES	Permitted provided they are not in cluster	Permitted
VII.	WARM HOLES	None	Permitted provided they are not more than 10 mm in diameter and not more than one per meter and provided such worm holes and plugged with similar timber in such a manner that the plugging merges with the surrounding area both as to colour and grain

- Note :**
1. Dead and loose knots are permitted only if they are suitably plugged.
  2. Knots shall not occur where hinges or locks are to be fixed.

□□□□□□□□□□

## CHAPTER – 10

### STEEL WORK

#### 10.1 MATERIALS

##### 10.1.1 STEEL

Finished steel shall be well and cleanly rolled to the dimensions and weight subject to permissible tolerances as per IS:1852. Finished material shall be free from cracks, surface flaws, laminations, imperfect and rough edges and any other defects. They shall be free from rust, scaling and pitting and shall be well protected. For structural purpose following varieties of steel only should be used unless otherwise specified.

- (a) ST 42-S conforming to IS:226: For all types of structures (riveted or bolted) including those subjected to dynamic loading and where fatigue, wide fluctuation of stresses, reversal of stresses are involved like in crane gantry girders, road and rail bridges etc. It is suitable for welding only if the thickness of the materials does not exceed 20 mm.
- (b) S.T. 42-W conforming to IS 2062: This is fusion welding quality steel used for structures like crane gantry girders, road and rail bridges etc.
- (c) S.T. 42-O conforming to IS 1977: This is ordinary quality steel which shall be used only for structures not subjected to dynamic loading, where welding is not employed, structures not situated in earth quake zones and structures the design of which has not been based on plastic theory.
- (d) S.T.. 32-O conforming to IS 1977: This is ordinary quality steel which shall be used only for doors, window frames, window bars, grills, steel gates, hand railing, builders hardware, fencing posts, tie bars etc.
- (e) All structural steel work shall conform to code of practice for use of structural steel in general building construction IS:800.
- (f) All structural steel and electrodes shall comply in all respects with Indian Standard Specification for structural steel.

#### 10.2 PAINTING

Surfaces to be painted, oiled or otherwise treated shall be dry and thoroughly cleaned to remove all loose scales and loose rust.

Inaccessible surfaces after shop assembly shall receive full specified protective treatment before assembly except sealed hollow sections. The part of steel member to be encased in concrete shall not be painted or oiled. Prior to placing any steel member in position or taken out of workshop a priming coat of approved steel primer i.e., Red oxide zinc chromate primer conforming to IS:2074 should be applied.

### 10.3 WORKMANSHIP

All workmanship shall be of acceptable standard in every respect, and accuracy should be ensured so that all parts will fit together properly on erection.

All ends shall be cut true to planes. They must fit the abutting surfaces closely.

All stiffeners shall bear tightly at both ends.

All butt ends of compression members shall be in close contact throughout the area of the joint.

All holes in plates and sections between 12.7 mm and 19 mm thick shall be punched to such a diameter that 3.18 mm of metal is left all around the hole to be cleaned out to correct size by reamer.

The base connection shall be provided as shown in drawings and accurate workmanship shall be ensured to provide the connections.

Figured dimensions on the drawings shall be taken.

### 10.4 ERECTION

- (a) All the plants and equipments used for erection should be of adequate capacity and contractor has to furnish details of same to Engineer In-Charge well before the programmed date for erection and get his clearance/approval.
- (b) During erection, the work shall be securely braced and fastened temporarily to provide safety against all erection stresses etc. No permanent welding shall be done until proper alignment has been obtained.
- (c) Any parts which do not fit accurately or which are not in accordance with the drawings and specifications shall be liable to rejection and if rejected shall at once be made good.
- (d) Engineer-in-Charge shall have full liberty at all reasonable times to enter the contractor's premises for the purpose of inspecting the work and no work shall be taken down, painted or dispatched until it has been



inspected and passed. The contractor shall supply free of charge all labour and tools required for testing of work.

**NOTE :** On any straight weld the first run shall not ordinarily be deposited with a larger diameter electrode than 4 mm. For subsequent run the electrodes shall not be increased by more than two electrodes between consecutive runs.

## **10.5 WELDING OPERATIONS**

The contractor shall ensure that each welding operator employed on fabrication or erection is an efficient and dependable welder, who has passed qualifying tests on the types of welds which he will be called upon to make. Sample tests shall have to be given by the contractor to the entire satisfaction of the Engineer-in-Charge.

## **10.6 WELDING PROCESS**

- A) The work shall be positioned for downward welding wherever possible.
- B) Arc length, voltage and amperage shall be suited to the thickness of material, type of groove and other circumstances of the work. The welding current and electrode sizes for different types of joints shall be as per IS:9595.
- C) The sequence of welding shall be such as to avoid undue distortion and minimize residual shrinkage stresses. Recommendation of IS:9595 shall be followed.
- D) The electrode manipulation during welding shall be such as to ensure that:
  - 1) The parent metal is in a fused stage when the filler metal makes contact with it.
  - 2) The weld metal does not overflow upon any unfused parent metal forming overlappings.
  - 3) The parent metal is not under-cut along the weld toes.
  - 4) The flowing metal floats, the slag, 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 re-started ahead of the previous deposit and then moved back to fill the center or such alternative technique shall be used as will ensure complete filling of the crater, or complete fusion between the new and old deposit 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 deposit and the adjoining base metal shall be wire brushed and cleaned at all points. The requirements shall apply not only to successive layers, but also to successive beads, and to the over lapping area wherever a junction is made on starting a new electrode.

- 5) The welds shall be free from cracks, discontinuity in welding and other defects such as (i) under-size, (ii) over-size, (iii) under-cutting and (iv) over-cutting in the case of fillet welds and defects (ii), (iii) & (iv) in the case of butt welds.

All defective welds which shall be considered harmful to the structural strength shall be subjected to radiographic examination as described in IS:1182.

In case of welded butt joints in steel of thickness upto 50 mm the weld joint shall be subjected to radiographic examination as described in IS:1182.

All welds shall be cleaned of slag and other deposits after completion. Till the work is inspected and approved painting shall not be done. The surface to be painted shall be cleaned of spatter, rust, loose scale, oil and dirt.

Inspection and testing of welding shall be as per IS:822.

- 10.7 Welding shall generally be done by electric process or as per IS:816, 7069 and 823-1964. Gas Welding shall only be resorted to using oxyacetylene flame with specific approval of the Engineer-in-Charge. Gas welding shall not be permitted to structural steel work.

## **10.8 WORKMANSHIP**

### **10.8.1 PREPARATION OF FUSION FACES**

- (a) Fusion faces shall be cut by shearing machine or gas cutting and later dressed by filing or grinding, so that they shall be free from irregularities such as would interfere with the deposition of the specified size of weld to be the cause of defects. Fusion faces and the surrounding surfaces shall be free from heavy slag and free from oil, paints or any other substance which might affect the quality of the weld or impede the progress of welding.

- (b) The parts to be welded shall be brought into as close contact as possible and the gap due to faulty workmanship or incorrect fit up shall not exceed 1.6 mm. If separation of 1.6 mm or more occurs locally the size of the fillet welds shall be increased at such positions by an amount equal to the width of the gap.

## 10.9 WELDING

### SIZE OF ELECTRODES AND RUNS

The maximum dia of the electrodes for welding any work shall be as per IS:814 and appendix 'B' of IS:823 and in the following table whichever is least.

Average thickness of plate or section	Maximum cut diameter of electrodes to be used
Less than 5 mm	3.8 mm
5 mm upto but not including 8 mm	4 mm
8 mm upto but not including 10mm	5 mm
10 mm upto but not including 18 mm	6 mm
16 mm upto but not including 25 mm	9 mm
25 mm and over	9 mm

The parts to be welded shall be maintained to their correct position during welding. They shall be securely held in position by means of tackwelds, service bolts, clamps or rings before commencing welding so as to prevent any relative movement due to distortion, wind or any other cause. Step back mentioned should be used to avoid distortion.

The minimum leg length of a filler weld as deposited should be not less than the specified size and the throat thickness as deposited should be not less than that tabulated below:

### THROAT THICKNESS OF FILLET

Angle between fusion faces	60° – 90°	91° -100°	101° -106°	107° -113°
Throat thickness in cm	0.70	0.65	0.60	0.55

In no case should a concave weld be deposited without the specific approval of the Engineer-in-Charge unless the leg length is increased above the specified, so that the resultant throat thickness is as great as would have been obtained by the deposition of fillet.

All welds shall be deposited in a pre-arranged order and sequence taking due account of the effects of distortion and shrinkage stresses.

After making each run of welding, all slag shall be removed and final run shall be protected by clean boiled linseed oil till approved.

The weld metal, as deposited shall be free from crack, slag, excessive porosity, cavities and other faults.

The weld metal shall be properly fused with the parent metal without overlapping or series under-cutting at the tees of the weld.

The surfaces of the weld shall have a uniform and consistent contour and regular appearance.

In welds containing cracks, porosity or cavities in which the old metal tends to overlap in the parent metal without proper fusion the defective portions of the welds shall be cut out and re-welded. Where serious undercutting occurs additional weld metal shall be deposited to make good the reduction.

Peeling of welds shall be carried out only with the approval of the Engineer-in-Charge.

Immediately after de-slagging, inspection and approval, all site welds and the surrounding surfaces shall be painted to protect the metal with clean boiled linseed oil.

#### **10.10 BUTT WELDS**

The ends of butt joints shall be welded so as to provide the full throat thickness. The weld face shall be at all places proud of the surface of the parent metal but shall not exceed 3.18 mm.

#### **10.11 SHOP DRAWINGS**

The shop drawings indicating all the requisite details of structural steel based on contract drawings shall be submitted to the Engineer-in-Charge along with the necessary information for fabrication, erection, painting of structures etc, immediately after acceptance of the tender.

#### **10.12 FABRICATION OF BUILT UP SECTION BY WELDING**

The fabrication shall generally be done as specified in IS:800. Adequate care shall be taken while fabricating to ensure accuracy so that these can be assembled without being unduly packed, strained or unduly forced into position. The built up section shall be true and free from twist, kinks, buckles, or open

joints. Suitable templates of wood or metal shall be made to facilitate accurate fabrication. Unless approved in fabrication drawing no two pieces shall be welded or joined to make up for the required length of the member.

#### **10.13 ERECTION AND FIXING IN POSITION PREFABRICATED TRUSSES AND COLUMNS**

The prefabricated steel laced columns are to be strictly according to the details furnished in the drawing. All scaffolding, temporary supports, tools, trusses required for erecting, hoisting and fixing in position the columns and trusses shall be provided by the contractor at his own cost. The trusses and columns shall be erected and fixed in the position true to plumb and levels and lines in a workman-like manner as directed by the Engineer-in-Charge. The various components being erected shall be supported and held in position suitably till completion of erection. Any damage to the materials caused by the contractor shall be made good and rectified at his own cost to the entire satisfaction of the Engineer In-Charge.

#### **10.14 STEEL DOORS, WINDOWS AND VENTILATORS**

The doors, windows and ventilators shall be manufactured from uniform IS standard sections and or M.S. angles to suit sizes as given in the schedule of quantities. The weight of different rolled steel section used for the manufacture of doors, windows and ventilators, shall not be less than those specified in IS:103 or 1038 unless otherwise specified. The steel shall be of fusion welding quality St. 42 designation. The steel section shall conform in all respects to IS:4062. In case where the standard door and windows are of insufficient strength for the particular door, window, ventilator etc. suitable other M.S rolled or built up sections of sufficient strength shall be used. Necessary Mild Steel stiffeners are to be provided in doors wherever required for structural stability. The contractor shall produce detailed shop drawings for the doors, windows and ventilators showing the sizes and arrangement of the sections and units and system of operation for the approval of the Engineer-in-Charge and fabrication shall be commenced only after approval to these shop drawings.

Corners of doors, and ventilators shall be accurately mitred, jointed and fitted to produce flush joints and folded along the concealed line of contact. The corners of fixed and opening frame shall be electrically flash butt-welded to form a solid and true right angle and all frames shall be square and flat.

The weld shall thoroughly penetrate the metal resulting in complete fusion between frames. Mechanically jointed corners or those developed by the rods and/or superficial surface welding shall not be permitted.

All cut outs, recesses, mortising or milling operations required for hardware shall be accurately made and reinforced with backing plates as required to

ensure adequate strength of the connections. No field fabrication of frames shall be permitted.

Intermediate glazing bars shall be tenoned and riveted into the frames and inter-sections, the horizontal glazing bars shall pass through the vertical bars and the joints closed by hydraulic pressure.

The steel doors and windows shall be according to the specifications and design. The sizes of doors and windows shall be calculated so as to allow 1.24 cm clearance on all the four sides of opening to allow for easy fitting of doors, windows and ventilators. The actual sizes of doors, windows and ventilators shall not vary by more than 1.5 mm from those given in the design.

The thickness and type of glazing shall be as specified in the schedule. The glass panes shall be free from flaws, specks or bubbles and shall have square corners and straight loose in the frames.

The beading shall be of standard aluminium channel as shown on drawing and approved. The manufacturers shall be intimated in advance to drill holes for head screws. Beads shall be fixed with screws spaced not more than 10 cm from each corner.

The screws, nuts, washers, bolts, rivets, weather bars and any other miscellaneous fastening services shall be of steel. Samples of doors/windows/ventilators with all fittings, locking arrangement peg stays, handles etc. shall be submitted for approval to the Engineer-in-Charge and got approved before taking up the manufacture of full quantity. No extra payment will be made towards the supply of same for approval.

The component parts of doors, windows, ventilators shall all be as per approved working drawings.

Composite units consist of a combination of two or more units of doors, windows and ventilators etc. as the case may be. The different units shall be coupled by using coupling sections. The coupling sections shall be made from M.S sheet 3.15 mm in thickness and 56 mm wide as per IS:1038 para 5.2 and these shall be fixed with bolts and nuts.

Wherever the doors, windows and ventilators shall be coupled with a coupling section mastic cement shall be applied between the junction to make the joint water tight.

All steel surfaces shall be thoroughly cleaned of rust, scale and dirt by pickling and marking. A shop priming coat of superior quality redoxide or equivalent shall then be given before despatch.

Unless otherwise specified the contractor's rate for doors, windows, ventilators shall be inclusive of supply of necessary fixtures, fittings, fastenings like lugs, beading, peg slays, handles, locking arrangement, screws, spring catch, applying a priming coat, glazing etc. complete.

#### **10.15 REQUIREMENT OF WELDED JOINTS OF STEEL DOORS, WINDOWS, VENTILATORS AND COMPOSITE UNITS**

##### **(I) VISUAL INSPECTION TEST**

When two opposite corners of the frame are cut, paint removed and inspected the joint shall conform to:

- (a) Welds should have been made all along the place of meeting of the members and there is no tack welding.
- (b) Welds are properly grounded.
- (c) The joint is completely solid and no visible cavities.

##### **(II) MICRO AND MACRO EXAMINATION**

From the two opposite corners obtained for visual test, the flanges of the sections shall be cut with the help of a saw. The cut surface of the remaining portions shall be polished, etched and examined. The polished and etched faces of the weld and base metal shall be free from cracks and reasonably free from under cutting, over laps, gross porosity and entrapped slag.

##### **(III) FILLET WELD TEST**

The fillet weld in the remaining portion of the joint shall be fractured by hammering. The fractured surface shall be free from slag, inclusion porosity, crack penetration defects and fusion defects.

#### **10.16 FIXING OF STEEL DOORS, WINDOWS & VENTILATORS**

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.

Doors, windows and ventilators shall be fixed to masonry (inclusive of brick, RCC stone and marble) timber and steel work openings as shown in drawings in the following manner.

Openings may be flush or rebated as shown in the drawing. These openings may have rendered finish or a 'flair faced' finish (i.e., without rendering as in case of marble or stone facing). Where openings are flush and with a rendered finish a clearance of 1.25 cm shall be provided between the steel frame

and opening. In case of external masonry finish "fair faced" and with rebated jambs, a minimum 1.25 cm clearance between frame and opening shall be provided.

Steel work opening shall be so designed that the outer flange of the door, windows or ventilator frame section overlaps the steel surface by 10 mm.

Outer frame shall be provided with fixing holes centrally in the web of the sections in the position given in IS:1038. The materials for fixing frames to opening in different class of opening shall generally conform to IS:1038-1957.

## **10.17 FIXING PROCEDURE**

### **MASONRY OPENINGS**

#### **(a) Fixing with lugs:**

- (i) Doors, windows and ventilators unit, shall not be 'built' in as the work proceeds but opening shall be left around. The size of the opening shall first be checked and cleared of obstruction, if any.

The position of the unit of fixing holes shall be marked on the jamb. Necessary holes shall be made in the masonry and lugs not less than 10cm long 15 x 3 mm size fixed in cement concrete blocks 15 x 10 x 10 cm size of 1:3:6 mix (1 cement :3 coarse sand :6 graded stone aggregate 20 mm nominal size).

The frames of units shall be set in the openings by using wooden wedges at the jamb, head and sill, (wedges shall preferably be placed near the points where a glazing bar meets the frames) and be plumbed in position.

- (ii) Then it lugs shall be fixed with the frame with 20 mm long and 7.3 mm dia G.I. Counter sunk machine screws and nuts. In case of flush opening which are rendered smooth wedges shall be removed and gap between unit and the jambs shall be filled with approved filling material.
- (iii) In case of flush jamb with external 'fair faced' finish the gap between the opening and frame shall be filled with mastic from inside till it oozes out on external face. The oozing mastic shall be cleaned and flush pointed. The internal gap shall be filled with mastic to about 1/3<sup>rd</sup> depth and the rest with cement mortar.
- (iv) In case of rebated jambs and jambs finished 'fair faced' externally the mastic shall be freely applied to the inside channel of frame, jamb and sill, so as to ensure a water tight joint. After the unit is firmly fixed in position surplus mastic shall be cleaned and flush pointed.



**(b) Fixing with screws and plugs**

In RCC work where lugs cannot be embedded due to reinforcement bars etc. wooden plugs shall be fixed in RCC at proper position while laying concrete. Alternatively rawl plugs may be fixed in proper position and frames fixed to them with 60 mm galvanized wood screws. Alternatively approved anchore fastener may be used.

Wood Work Openings:

Wooden openings are normally rebated and mastic shall be applied to jambs, sill of a channel before fixing in position. The frame shall be set in opening using wooden wedges and fixed to the opening with 60 mm galvanized wood screws.

Extra timber fillets of hard wood to match the adjoining work shall also be provided around the frame to close the extra gap between opening and frame.

**STEEL WORK OPENINGS**

Before placing the unit frame in position mastic shall be applied and a Mild Steel or hard wood fillet shall be provided around the frame to close the extra gap between opening and frame. The unit shall then be fixed to the opening with fixing clips or with nuts and bolts as shown in the drawings or as directed by the Engineer In-Charge.

**10.18 FIXING OF COMPOSITE UNITS**

The fixing procedure for composite units shall generally be as described above except that:

- (a) Where large units shall be formed 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 assembly and after coupling. All oozing out mastic shall be cut out neatly.
- (b) Mullions normally project 2.5 cm at head and sill and are fixed in pockets made into the masonry, timber or steel work opening. But where it is at cross joint with a transom the shorter coupling unit shall run through unbroken and other coupling unit shall be cut square to form a butt with other members.

**10.19 COLLAPSIBLE GATES**

These shall be from the approved manufacturers and shall be fabricated from the mild steel sections. The details of vertical channels, flat iron diagonals, top and bottom rails, balls bearings etc. shall be as per approved manufacturers specification. The bolts, nuts, locking arrangements, stoppers, handles, special

fittings like springs, catch and locks shall all be as specified in the description of item. The gate shall open and close smoothly and easily.

The height of the gate shall be measured as length of the vertical double channels and breadth from outside to outside of the end fixed double channels in open position of the gate. The area shall be measured in sq meters correct to two decimals.

#### **10.20 M.S SHEET SLIDING SHUTTERS**

These shall be manufactured as per approved shop drawings.

The shutters, MS angle iron frame work, diagonal braces, gusset plates, MS sheet coverings, top and bottom guide rails, pulleys, ball bearings, stoppers, hold fasts, other fittings and all shall be indicated in detail in shop drawings and got approved by Engineer-in-Charge prior to fabrication. The guide rails shall be sufficiently long and continued along the wall on both ends so that sliding shutter can rest in the wall portion giving full opening if required.

The details of guide rail fixing to floor by anchor bolts embedded in cement concrete, supporting of steel sections at top, damping arrangement to avoid shutters rolling back with the opening shall all be indicated in the shop drawing and got approved.

Two channel sections shall be suitably fixed vertically below the extreme clamps in the wall and floor to avoid the shutter from going out of the support at top and bottom.

Damages if any to the adjoining work while erecting/fixing the sliding door shall be made good to match the adjoining finishes at the cost of sliding door fixing agency.

The measurement for steel sliding door shall be correct to cm and area calculated in sq meters correct to two decimal places. The height of the shelter shall be measured from outside to outside the guide rail and width outside to outside of shutter including vertical position channels in sides when closed.

#### **10.21 ROLLING SHUTTERS**

Rolling shutters are to conform to IS:6248. They shall be suitable for fixing in specified position as in the drawing and shall include handles, locking arrangements etc. They shall be of specified type viz. push and pull type; operated with mechanical devices supplied by the manufacturers, reduction gear operated by mechanical device with chain or handle etc.

The shutters shall conform to approved specification. The spring shall be coiled type, manufactured from high tensile spring steel wire or strip of strength conforming to IS:4454 part 1-1981. The roller material shall conform to IS:1161,

The material, dimension, specification etc. of suspension shaft, supporting brackets, clamps, pulleys, pipe shaft, springs, ball bearings. Casings, guide channels cover, lock plates, sliding bolts, anchoring rods etc. shall conform to relevant IS and shall be conforming to specification in the nomenclature of the work.

The arrangement for fixing of rolling shutter in different situations in the opening shall be as per IS:6248-1979. The fixing shall be done accurately in a workman like manner that the operation of the shutter is easy and smooth.

The measurement for the rolling shutter shall be clear width and clear height of opening correct to a mm. The clear distance between the two jambs of the opening shall be clear width and clear distance between the sill and the soffit (bottom of lintel) of the opening shall be the clear height.

## **10.22 ROLLING GRILLS**

Rolling grills are similar in design, construction, and operation of rolling shutter and all provisions of rolling shutter above shall be applicable to rolling grills except in respect of the shutter portion which shall conform to IS:6248.

A rolling shutter may have a rolling grill portion at top or bottom or at both places. The total height of all segments of grill portions shall not exceed 1 m and individual segment height shall not be more than 0.5m. The measurement of rolling grills shall be similar to rolling shutter.

## **10.23 MEASURE FOR STEEL WORK**

(a) Steel work in single sections/built up section

Steel as fixed in position shall be measured in running metre correct to millimeter and weight calculated on the basis of standard tables correct to nearest kilogram. Unless otherwise specified weight of cleats, brackets, packing pieces, bolts, nuts washers, distance pieces, separators, diaphragm gussets (taking over all square dimensions) fish plates etc. shall be added to the weight of respective items. No deductions shall be made for rivet or bolt holes if its area is not exceeding 0.02 sqm. The standard weight of steel sections as given in relevant Indian Standard shall be used.

## **10.24 RATE**

The rate shall include cost of all materials and labour involved in the job.

## CHAPTER 11

### FLOORING

#### 11.1 INDIAN PATENT STONE FLOORING

##### i) PREPARATION OF BASE

The base concrete surface shall be thoroughly cleaned to remove laitance, loose particles and dust and washed clean and watered until no more water is absorbed.

Where the IPS flooring is laid directly on the RCC slab, the surface of RCC slab shall be roughened with brushes without disturbing the concrete. Before laying the floor, the laitance shall be removed, the surface of slab hacked and a coat of cement slurry at 2.75 Kg of cement per sq.mtr shall be applied, so as to get good bond between RCC slab and IPS floor. The cost of applying a coat of cement slurry shall be included in the flooring items.

Dividing strips as specified shall be arranged to lay the concrete flooring in alternate panels. The size of panels shall be decided by the Engineer-in-charge, shall be uniform in size, not exceeding 3 sq.m in area and 2.5m in any direction. Alternate panels shall be laid on different days.

##### ii) MIXING

The concrete shall be of mix of one part cement, two parts of sand and four parts of well-graded stone chips of 10mm maximum size. The ingredients shall be thoroughly mixed with just sufficient water to obtain the required plasticity and shall generally conform to the specification of general concrete works.

##### iii) LAYING

A coat of cement slurry of the consistency of thick cream shall be brushed on the surface. On this fresh grouted base, the prepared concrete shall be laid immediately after mixing. The concrete shall be spread evenly and leveled carefully. When the layer is made even, the surface shall be compacted by ramming or beating and then screened to a uniform line and level.

- iv) 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. Excessive trowelling shall be avoided.

Use of dry cement and sand mixture sprinkled on the surface to stiffen the concrete or absorb excessive moisture, shall not be permitted.

Fresh quantity of cement at 27.50 Kg per 10 sqm of flooring, shall be mixed with water to form a thick slurry and spread over the surface, while the concrete is still green. The cement slurry shall be properly pressed twice by means of iron floats, once, when the slurry is applied, and the second time when cement starts setting. The junctions of floors with wall plaster, dado or skirting shall be rounded off where so required upto 25mm radius. Alternate panels only shall be concreted in one day and the remaining panel shall be concreted on next day or later. The joints between panels should come out as fine straight lines.

Flooring shall be laid in the pattern as given in the drawing or as directed by Engineer-in-Charge. The boarder shall have a mitered joint as the corners of the room and intermediate joints shall be straight line with the panel joints.

Flooring shall be laid in the pattern as given in the drawing or as directed by Engineer-in-Charge.

**v) FORM WORK**

The panel shall be bounded by wood battens or flat iron having the same depth as the concrete floor, these shall be fixed in position, with their top at proper level, giving slope where required. The surface of the battens of flats to come in contact with concrete, shall be smeared with soap solution or non-straining oil (form oil or raw linseed oil) before concreting. The flooring shall but against the masonry of wall, which shall not be plastered.

**vi) CURING**

As soon as the surface is hard enough it shall be covered and kept continuously wet for atleast a period of one week.

**vii) PRECAUTIONS**

Flooring in toilets and bathroom shall be laid only after fixing of water closet and floor traps. Traps shall be plugged while laying the floors and opened after floors are cured and cleaned. To facilitate rounding of junction of skirting, dado and floor, the skirting / dado shall be laid along with the boarder or adjacent panels of floor.

**11.2 GRANOLITHIC FLOORING AND SKIRTING**

- a) The preparation of base, mixing concrete for base; curing etc shall all be as per IPS flooring said above.

**b) LAYING GRANOLITHIC**

The free water on the surface of the base shall be removed and a coat of cement slurry of the consistency of thick cream shall be brushed on the surface.

The prepared concrete shall be laid immediately after mixing the fresh grouted case. The concrete shall be spread, evenly and leveled carefully. Low places shall be filled, humps removed and the whole surface again leveled. The layer shall be (25 mm or 38 mm) thick as specified and 13 mm below the finished level. The layer shall be compacted by ramming or beating the trowelled smooth and allowed to set.

**c) PREPARATION OF BASE OF WEARING COAT**

While the cement concrete bed is still wet specified dividing strips of size 25mm x 3mm shall be fixed over it at intervals both ways for laying topping.

**d) MIXING OF WEARING COAT (GRANOLITHIC)**

One part of cement in dry state shall be mixed with two parts of volume of well-graded crushed granite chips of 6 mm maximum size. The ingredient shall be then mixed with sufficient water as for ordinary concrete.

**e) LAYING TOPPING**

The wearing coat of topping of 13mm thickness shall be laid over the cement concrete base and then compacted and leveled with a steel trowel. Just sufficient trowelling shall be made to give a level surface. The surface shall not be over trowelled as excessive trowelling will bring the cement to the surface, which shall be strictly avoided.

When the initial set takes place further compaction by steel trowelling shall be done and final brushing shall be made before the topping becomes too hard. The surfaces shall be machine polished to give a smooth and even surface with granite chips exposed.

**11.3 IRONITE FLOORING**

**a) GENERAL**

The flooring shall consist of 38 mm thick cement concrete 1:2:4 and 13mm wearing coat of ionic topping.

**b) PREPARATION OF BASE**

The base concrete surface shall be thoroughly cleaned to remove laitance, loose particles and dust and washed clean and watered until no more water is absorbed.

Dividing strips shall be arranged to lay the cement concrete base in alternative panels. The sizes of panels shall be as decided by the Engineer-in-Charge. The base cement concrete 38 mm thick 1:2:4 with 20mm maximum size aggregate shall then be laid in square in alternative bays.

The layer shall be 38 mm thick or as specified in work order and shall be paid below the finished floor level. The layer shall be compacted by ramming, beating and trowelled smooth and allowed to set.

**c) PREPARATION OF BASE FOR IRONITE**

While the cement concrete bed is still wet 25 mm x 3 mm shall be fixed over it at not more than 1.20 m interval both ways for laying ironite topping.

**d) MIXING OF WEARING COAT WITH IRONITE TOPPING**

A mix of one part of ironite and four parts of cement by weight shall be well mixed together in dry state. The one part of this mix shall be mixed with two parts by volume of well-graded crushed granite chips of 6mm maximum size. The intergradient shall then be mixed with sufficient water as for ordinary concrete.

**e) LAYING CURING ETC. SIMILAR TO IPS FLOORING**

**11.4 CEMENT CONCRETE FLOORING WITH METALLIC HARDENER TOPPING**

11.4.1 Whenever 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 metallic hardener is justified on the basis of cost where metallic hardener topping is used, it shall be 12mm thick or as specified.

**11.4.2 METALLIC HARDENING COMPOUND**

The compound shall be of approved quality consisting of informally graded iron particles, free from non-ferrous metal particles, oil, grease, sand, soluble alkaline compounds.

11.4.3 **BASE CONCRETE:** It shall be as specified under para 11.1 above.

**11.4.4 TOPPING**

The topping shall consist of 12mm thick layer of mix 1:2 (1 cement: 2 stone aggregate of 6mm nominal size) by volume or as specified in the work order, with which metallic hardening compound is mixed in the ration of 1:4 (1 metallic

concrete hardener: 4 cement) by weight. Metallic hardener shall be dry mixed thoroughly with cement on a clean dry platform and mixed with stone aggregate of 6mm nominal size or as specified in the ratio of 1:2 (1 cement:2 stone aggregate) by volume just enough water shall then be added to this dry mix. The mixture so obtained shall be laid in 12mm thickness on cement concrete floor with in 2 to 4 hours of its laying. The topping 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.

- 11.4.5 The junction of floor with wall plaster, dado or skirting and finishing operations shall be dealt with as under 11.1 above.
- 11.4.6 Men engaged on finishing operations shall be provided with raised wooden platform to sit on, so as to prevent damage to new work.
- 11.4.7 The specification for curing, precautions to be taken, etc shall all be as specified in para 11.1. above.

#### **11.5 TERRAZZO TILE FLOORING AND SKIRTING**

- a) Unless otherwise specified terrazzo tiles shall be generally 25cm x 25cm , nominal size and shall be of approved manufacture conforming to IS:1237 and hydraulically pressed. Tiles shall be uniform in size, true and square, free from twist, cracks and / or other defects.

Tints of tiles shall be as specified in schedule of quantities. Samples for various varieties of tiles (colour) required for use on works shall first submitted to the Engineer-in-Charge, and got approved by him. All tiles which are to be incorporated in the works shall strictly conform to the samples failing which the materials are liable to be summarily rejected.

Tiles to be incorporated in the work shall be immersed in water for minimum period of 6 hours before laying.

- b) The tolerances on length and breadth shall be plus or minus one millimeter, and tolerance on thickness shall be plus 5 mm. The range of dimensions in any one delivery of tiles shall not exceed 1 mm on length and breadth and 3 mm on thickness. The terrazzo tile topping shall be laid while the under layer is still plastic, but has hardened sufficiently to prevent cement from rising to the surface.

The top surface of tiles shall be laid to a true plane and level or to falls as directed by; the Engineer-in-Charge. The joints shall be fine and nearly indistinguishable and shall be pointed in white cement mixed with



suitable mineral pigment of permanent colour to match the tiles. Laying the finishing shall be all according to IS-143. Floor tiles laid adjoining the wall shall project 12 mm under the plaster, skirting or dado as may be required by the Engineer-in-Charge. Half tiles and pieces shall be avoided as far as possible. After laying the mortar shall be allowed to be cured undisturbed for 10 days. Thereafter it may be allowed to be used for light traffic. Design traffic shall not be allowed on the floor for atleast 14 days after laying the tiles.

After the joints have developed sufficient strength, the floors shall be machine polished to the desire finish as approved by the Engineer-in-Charge. Sufficient quantity of water shall always be used during polishing to prevent scratching.

About a week after laying the tiles, each and every tile shall be lightly tapped with a small wooden mallet to find out if it gives a hollow sound. If it does, such tiles along with any other cracked or broken tiles, shall be removed and replaced to proper line and level. The same procedure shall be followed again after the tiles are finally polished.

- c) The bed mortar of the flooring shall be evenly spread over the base for two rows of tiles and about 3 to 5 m in length with thread. Levels fixed at both ends to act as a guide. The top of the mortar should be kept rough so that cement slurry can be absorbed. Based on this level bed mortar may be spread for an area that will be laid with tiles next day. Laying of tiles should commence in the next morning by which time the bedding becomes sufficiently hard to offer rigid cushion for the tile and enables masons to place wooden planks and squat on them. Neat cement slurry of honey like consistency can be spread over the mortar bed, over such an area at a time as could accommodate about 20 tiles. The tiles shall be fixed in this grout one after the other each tile being gently tapped with a wooden mallet till it is properly bedded and in level with the adjoining tiles.
- d) **CURING, POLISHING AND FINISHING**

The day after the tiles are laid all joints shall be cleaned of the grey cement grout with a wire brush or trowel to a depth of 5 mm and all dust and loose mortar removed and cleaned. Joints shall then be grouted with grey or white cement mixed with or without pigment to match the shade of the topping of the wearing layer of the tiles. The same cement slurry shall be applied to the entire surface of the tiles in thin coat with a view to protect the surface from abrasive damage and fill the pin holes that may exist on the surface.

The floor shall then be kept wet for a minimum period of 7 days. The surface shall thereafter be grouted evenly with machine fitted with coarse

grade blocks (No. 60 ) water shall be used profusely during grinding. After grinding the surface shall be thoroughly washed to remove all grinding mud, cleaned and mopped. The surface shall be allowed to cure for 5 to 7 days. It shall then be covered with a thin coat of grey or white cement, mixed with or wearing surface in order to fill any pin hole that appear.

The surface shall be again cured. The second grinding shall then be carried out with machine fitted with fine grade grit blocks (No. 120) The final grinding with machine fitted with finest grade grit blocks (No. 320) shall be carried out the day after the second grinding described in the preceding para or before handing over the floor, as ordered by the Engineer-in-Charge.

For small areas or where circumstances so require, hand polishing may be permitted in lieu of machine, polishing after laying, for hand polishing the following carborundum stones shall be used:

First grinding : Coarse grade stone (No. 60)

Second grinding : Medium grade (No. 80)

Final grinding : Fine grade (No. 120)

In all other respects, the process shall be similar as for machine polishing.

After the final polish, oxalic acid shall be dusted over the surface at the rate of 33 gms per sqm with water and rubbed hard with a 'namdah' block (pad of woolen rags). The following day the floor shall be wiped with a moist rag and dried with a soft cloth and finished clean and wax polishing shall be done last before handing over.

If any tile is disturbed or damaged, it shall be refitted or replaced, properly jointed and polished.

The finished floor shall not sound hollow when tapped with a wooden mallet.

For the purpose of ensuring that such replaced tiles match with these earlier laid, it is necessary that the contractor orders enough extra tiles from the factory to meet this contingency. The tiles shall finally be cleaned and polished by using light oxalic acid or any other method recommended by the manufacturers and approved by the Engineer-in-Charge.

**e) SKERTING**

This shall be as per flooring but the bedding shall be of 1:3 cement mortar and of the height as specified in the schedule of quantities. Skirting can be hand polishing to the entire satisfaction of Engineer-in-Charge.

**f) TERRAZO TILED DADO**

Terrazo tiled dado shall be provided with tiles used in flooring. The dado work shall be done in the best workman like manner on the backing of 1:3 cement mortar and neat cement slurry and jointed with neat cement mixed with pigment to match colour of tiles. The work shall be done truly in plumb line and level and the joints should be almost invisible. Polishing shall be done with manual labour after the tiles and joints are sufficiently set. The pricing is per square metre and measurements shall be taken for the work exactly carried out.

**11.6 CAST-IN-SITU TERRAZO FLOORING AND DADO**

- a) Over the approved base, 28 mm thick cement mortar as 1:3 bedding or backing shall be laid to levels or slopes as shown on drawing or as directed by the Engineer-in-Charge. Bedding shall be laid in regular bays not exceeding  $1.44^2$  i.e. 1.20m x 1.20 m or as directed by the Engineer-in-Charge. Dividing strips as specified shall be placed in such a way to form these regular bays of the desired size and shape. The top of these strips shall stand or project above the top of the bedding by 12mm i.e. equal to the thickness of the terrazzo layer.
- b) Marble chips for the terrazzo floor shall be approved crushed Indian marble of colours and size as specified in schedule of quantities. The marble chips can be of a single colour or a mixture of colours as directed by the Engineer-in-Charge.
- c) When coloured finish is ordered pigment shall be non-organic of approved manufacture and suitable for mixing with cement. Approved white Portland cement shall be used to obtain the specified shade. The quality of pigment required to produce the desired shades shall be determined before hand by experiment. The contractor may however, at no extra cost use coloured cement of approved manufacture in lieu of mixing cement with pigment.
- d) The laying of terrazzo mixture shall be as follows:
  - i) Surface of bedding shall be well scratched while it is not sufficiently hard to form key for terrazzo mixture.
  - ii) When the bedding has sufficiently hardened but not later than 24 hours it shall be thoroughly cleaned down, washed with water, and brushed over with neat cement slurry about the consistency of thin cream.
  - iii) Chipping shall be mixed dry well turned over, mixed wet into a partly stiff workable plastic condition and laid in position. The terrazzo mixture shall be laid in position slightly proud of the finished

surface so that after polishing the required level is obtained. Just before the initials set takes place, the top surface shall be rolled and trowelled to bring the maximum amount of marble chippings to the surface. Care being taken that no part of the surface is left without chips.

- iv) Polishing shall be done by machine. About 36 hrs after the floor is set the surface shall be watered and ground evenly with machine till the marble chips are evenly exposed and the floor is smooth. After the first grinding the surface shall be thoroughly washed to remove all grinding mud and covered with a grout of cement or colouring matter in the same mix and proportion as the topping in the order to fill any pin holes that appear. The surface shall be allowed to cure for 5 to 7 days and then second polishing done. The surface is cleaned and repaired as before and allowed to cure for 3 to 5 days, final polishing is then done to get even and smooth surface without pinholes.
- v) The surface of floor shall be finished to required levels and falls all as directed by the Engineer-in-Charge.
- vi) **JUNCTION AND CORNERS:**

The junction of floors, and walls dado or skirting shall be rounded off to uniform radius as directed without any extra payment.

#### **11.7 CEMENT MORTAR FLOORING DADO AND SKIRTING FINISHED SMOOTH WITH NEAT CEMENT**

The work shall be carried out as specified for cement plastering but without neeru finish but with a floating coat of neat cement.

The finished surface of flooring shall be provided threading mark, if directed.

#### **11.8 CUDDAPAH STONE SLABS FOR SHELVES, PLATFORMS**

Cuddapah stones shall be of best quality and shall be of approved quality. The stone slab shall be hard, even, sound, durable, rectangular in shape and shall be uniform in size. The slabs shall be without any soft veins, cracks or flaws and shall have a uniform colour. The top surface of slabs shall be double machine polished and edges shall be true and square and shall be machine cut.

Cuddapah stone slabs shall be of specified thickness. They shall be fixed to the platform or shelves, etc over a bedding backing of cement mortar 1:3, and shall be laid to level, slope or plumb as required. The stone slabs shall be of

size and shape as specified in the drawing. The joints shall be clean and indistinguishable and shall be filled with cement mortar 1:3 and pointed with matching cement slurry. The colour of the cuddapah stones shall be uniform and approved by the Engineer-in-Charge. The surface shall be cured for period of 7 days.

#### **11.9 ACID RESISTANT BRICK FLOORING / DADO**

Approved acid resistant bricks conforming to IS 4860-1982 shall be used. The base concrete or the RCC slab on which acid resistant flooring to be done shall be cleared. A bed acid resistant cement mortar of specified proportion and thickness shall be laid to level and allowed to dry. On this a coat of bitumastic compound of 85/25 penetration shall be laid at the rate of 1.5 kg/sqm over a approved bitumen primer, applied at the rate of 0.25 kg/sqm. On this acid resistant brick shall be laid to approved pattern leaving grooves of 4mm to 6mm between the bricks. The joints between the brick shall be thoroughly filled with acid resistant cement mortar of specified proportion and pointed with cashewnut shell liquid resin (CNSL). In case the floor has to resist nitric acid the pointing shall be done using first quality corophen cement of M/s. Coromandal Engg. Co. or equivalent unless otherwise specified the acid resistant cement mortar shall be prepared using acid proof cement SWK (potassium silicate or equivalent) conforming to latest IS 4832- part I, mixed in proportion of 2.7 parts of acid proof cement power/SWK powder and 1 part of acid proof cement solution /SWK solution by weight i.e 14.6 Kg/sqm of acid proof cement powder /SWK powder to 5.4 Kg/sqm of acid proof cement solution /SWK solution.

All materials and workman ship shall scrupulously conform to manufacturers specification.

#### **11.10 BRICKS ON EDGE FLOORING**

##### **a) BRICKS**

Bricks of the specified strength shall be used. These shall conform to the specifications. Broken bricks shall not be used in flooring except for closing the line. The brick shall be laid on edge.

##### **MORTAR**

The mortar used shall be as specified. In case of dry brick flooring fine sand shall be filled in the joints.

##### **SUB-GRADE**

Flooring shall be laid on concrete sub-grade, where so provided. The sub-grade shall be provided with slopes required for the flooring. Before laying the flooring the sub-grade shall be wetted and smeared with a coat of

cement slurry at 2 Kg of cement spread over an area of one Sq.m so to get a good bond between sub-grade and flooring.

Where sub grade is not provided, the earth below shall be properly sloped, watered, rammed and consolidated. Before laying the flooring, it shall be moisted.

**b) SOAKING OF BRICKS**

Bricks required for flooring shall be adequately soaked in stacks before use, by profusely spraying with clean water at regular intervals for a period of not less than six hours so as to keep them wet to the satisfaction of the Engineer-in-Charge. In case the joints are to be filled with sand, the bricks need not be soaked.

**c) LAYING**

The bricks shall be laid on edge in plain, diagonal herring bone bond, or other patterns as specified or directed by the Engineer-in-charge.

Bricks shall be laid on edge on 12mm thick mortar bed and each brick shall be properly bedded and set home by gentle tapping with handle trowel or wooden mallet. Its inside shall be buttered with mortar, before the next brick is laid and pressed against it.

On completion of a portion of flooring, the vertical joints shall be fully filled from the top with mortar. The surface of the flooring during laying, shall be frequently checked with a straight edge at least 2 m long, so as to obtain, a true plain surface with the required slope.

**d) JOINTS**

Bricks shall be so laid that all joints are full of mortar. The thickness of joints shall not exceed 1.0 cm for brick work with bricks of any class designation. All face joints shall be raked to a minimum depth of 15mm by raking tool during the progress of work when the mortar is still green so as to provide proper key for plaster or pointing to be done. Where plastering or pointing is not required to be done, the joints shall be struck flush and finished at the time of laying. The face of brick shall be cleaned of the same day on which brick work is laid and all mortar droppings removed promptly.

For dry brick flooring joints shall be as fine as possible, and not exceeding 5mm. These shall be filled with fine sand.

**e) CURING**

Brick work shall be protected from rain by suitably covering the mortar, lime mortar (lime of category specified) 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. In case of masonry with fat lime mortar curing shall commence two days after laying of masonry and shall continue for atleast seven days thereafter.

In case of dry brick flooring no curing shall be done.

#### **11.11 WHITE GLAZED TILE WORK**

White glazed tile flooring;

The tiles shall be of approved Indian manufacture unless foreign make is specified in the description of item. They shall be flat, and true to shape. They shall be free from cracks, crazing spots, chipped edges and corners. The glazing shall be of uniform shade.

The tiles shall be of nominal sizes such as 15 x 15 cm and 10 x 10 cm or other standard sizes with equal sides as specified in the schedule. The maximum variation from the stated sizes, other than the thickness of tiles shall be  $\pm 1.5$ mm.

The thickness of the tiles shall be as specifically mentioned in the item.

Tiles shall conform to IS 13753-1993 in all other respects.

#### **b) PREPARATION OF SURFACE AND LAYING**

Sub grade 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 thickness of the bedding shall be 20mm. Unless otherwise specified.

Mortar shall be spread, tamped and corrected to proper levels and allowed to harden sufficiently to offer a fairly rigid cushion for the tiles to set and enable the mason to place wooden plank across and squat on it.

Over this mortar bedding, neat grey cement slurry of honey consistency shall be spread at the rate of 3.3 kgs of cement per sq.m over such an area as could accommodate about 20 tiles. Tiles shall be washed clean and shall be fixed in the grout one after another. Each tile being gently tapped with a wooden mallet till, it is properly bedded and in level with the adjoining tiles. The joints shall be kept as thin as possible unless spaces are specified and in straight lines or to suit the required pattern.

The surface of the flooring during laying shall be frequently checked with a straight edge about 2 m long, so as to obtain a true surface with the required slope.

Where full size tiles cannot be fixed these shall be cut (SAWN) to the required size, and their edge rubbed smooth to ensure straight and true joints.

Tiles which are fixed in the floor adjoining the wall shall enter not less than 10 mm under the plaster skirting or dado.

After tiles have laid, surplus cement grout shall be cleaned off.

**c) POINTING AND FINISHING**

The joints shall be cleaned off the grey cement grout with wire brush or trowal to a depth of 5 mm and all dust and loose mortar removed. Joints shall be kept wet for 7 days.

After curing, the surface, shall be washed and finished clean. The finished floor shall not sound hollow when tapped with a wooden mallet.

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

**11.12 CERAMIC TILE FLOORING /DADOING**

The ceramic tiles shall conform to IS 13756-1993 of approved size and scratch hardness ( moh's scale) minimum 5 and other parameter to conform to IS 13630-1993 of regular series. The preparation of base, laying, pointing, finishing, curing etc. shall be similar to that detailed under para 11.11 for glazed tile flooring / dadoing.

**11.13 CEMENT TILE FLOORING**

The cement tiles shall be of approved quality, machine pressed conforming to IS 1237-1980 of specified size and thickness. The preparation of base, laying, curing etc shall be similar to that under para 11.5 for terrazzo tile flooring except polishing and finishing which is not involved in cement tile flooring.

**11.14 RECTIFIED TILE FLOORING / DADOING**

The tiles shall confirm to IS:13756-1993 and IS 13630-1993. The preparation of base, laying pointing, finishing, curing etc shall be similar to that specified for glazed tiles under para 11.11 above. Alternatively the fixing agency may be adopted duly following manufacturers.

**11.15 PVC TILE FLOORING**

- a) PVC floor tiles shall be of homogeneous flexible type, conforming to IS:3462-1986, specification for flexible PVC flooring. The PVC tiles shall neither



develop any toxic effect while put to use nor shall give off any disagreeable odour. Thickness of tiles shall be 2mm. A tolerance of  $\pm 0.15\text{mm}$  shall be allowed on the nominal thickness of the tiles. The tolerances with respect to width are

- i) 300mm square tiles  $\pm 0.2\text{mm}$
- ii) 600 mm square tile  $\pm 0.4\text{mm}$
- iii) 900 mm square tiles  $\pm 0.6$ ,
- iv) sheets and rolls  $\pm 0.1$  percent

PVC sheet / tiles shall be laid on a base that is finished even and smooth such as concrete, metal or timber boarding.

For deciding the thickness of PVC sheet / rolls the specimen shall be measured at twenty scattered points. When supplied in rolls the length of the rolls shall not be less than 10 metre.

Rubber based adhesives are suitable for fixing PVC flooring over concrete, wooden and metal sub floors. PVA based adhesive shall be used for concrete and wooden sub floors and it should not be used for metallic surfaces and also for locations where there is constant spillage of water.

Under normal conditions, in case of new work a period of 4 to 8 weeks shall be allowed for drying the sun floor. Prior to laying the PVC flooring.

Prior to laying the floor tiles / rolls / sheets shall be brought to the temperature of area in which it to be laid by stacking in a suitable manner within or near the laying area for a period of about 24 hours.

Where air conditioning is installed, the floor shall not be laid on the sub floor until the conditioning units have been in operation for atleast for 7 days during this period the temperature shall neither fall below  $20^{\circ}\text{C}$  nor exceed  $30^{\circ}\text{C}$ . These conditions shall be maintained during laying and 48 hours thereafter care should be taken while laying the flooring under high humidity conditions so that condensation does not take place of the adhesive. It is preferable to avoid laying under high humidity conditions.

#### **b) LAYING**

The concrete floor on which the PVC floor tiles are to be laid, as well as the back of every PVC tile shall be wiped dry with cloth or cotton waste. The layout or pattern to which the tiles (length and width wise) is to be laid, shall be marked on the floor to be covered.

Before each tile is laid, the portion of the floor to be covered shall be wiped with a wet cloth. The adhesive recommended by the manufacturers of PVC tiles, shall be applied evenly on this portion as directed by the Engineer-in-Charge, and allowed to dry slightly before the tiles are laid and pressed all over. The subsequent tiles shall be laid likewise, taking care to see that there is not gap between the tiles laid. After a row of tiles are laid, the alignment shall be checked and if need be, the edges of tiles trimmed. Any excess adhesive which may squeeze out on the surface of the tiles shall be wiped off immediately with a wet cloth before the adhesive hardens. If the adhesive stain on the surface dries and hardens up, it shall be removed with a solution of one part of commercial Butyl Acetate and three parts of turpentine oil.

Finally, the entire surface shall be cleaned with soap solution (2 table spoons of soft soap powder to 5 litres of water) using a cloth or mop, and the surface allowed to dry and then wiped with a soft dry cloth.

#### **11.16 VITRIFIED TILE FLOORING / DADO**

The tiles shall be of specified size and thickness. The tiles shall not be subjected to polish weathering, discolouring, colour and shade variation. The technical specifications of the tiles viz, dimensional stability, surface flatness, water absorption, moh's hardness, flexural strength, abrasion resistance, skid resistance, breaking strength, density, frost, chemical, colour, thermal shock, stain resistance, thermal expansion, moisture expansion etc shall all conform to manufacturers specification.

The bed / backing for floor laying shall be finished and kept ready including curing at least two weeks prior to laying. For fixing tile fixing adhesive or cement mortar may be adopted as specified. When using cement mortar the proportion ratio may be 1:4 (1 cement to 4 coarse sand) The mortar shall be of consistent paste. Once mixing is over water should not be added to the mortar. The mortar may be spread for an area of one square meter at a time of specified thickness. Apply a fine slurry to the back of the tile to ensure proper and full bedding press gently for even adherence. Iron hammer or heavy material should not be used for pressing the tiles. For dado work recommended adhesive may be used as per manufacturers specification.

The floor tiles shall be layed from center to side duly marking to ensure that cut pieces if any shall be on the outer edge towards the wall. The laid surface shall be allowed one or two days for bed curing unless otherwise specified joints shall be grouted with the joint sealant as per manufacturers specification to keep the grout free of dust. 15 minutes after finishing the grouting process, wipe off. Excess grout with damp sponge and polish surface with soft and dry cloth for a clean surface. For cleaning the surface Hydrofluoric acid and its derivatives should not be used.

All materials and workmanship shall be strictly as per manufacturers specification.

## 11.17 MARBLE FLOORING

Marble shall be hard and dense and homogenous in texture. It shall, be uniform in colour and free from stains, cracks, decay and weathering.

### a) DRESSING OF SLABS

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. The sides and top surface of slabs 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 chippages and the surface shall be true and plane.

The thickness of the slabs shall be 20, 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, a tolerance of  $\pm 5$ mm shall be allowed.

### b) LAYING

Sub-grade 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 the lime mortar (1 lime putty:1Surkhi:1 coarse sand) as given in the description of the item.

Unless otherwise specified the average thickness of the bedding mortar under the slab shall be 20mm and the thickness at any place under the slab not be less than 12 mm

Mortar of the specified mix shall be spread under the area of each slab, roughly to the average thickness specification/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 hollow. 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. The slab to be paved shall then be lowered gently back in position and trapped / tapped with wooden mallet till is properly bedded in level with and close to the adjoining slab with as fine a joint as possible. Subsequently 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 Engineer-in-charge.

The slabs shall be matched as shown in drawings or as instructed by the Engineer-in-charge.

Slabs which are fixed in the floor adjoining the wall shall enter not less than 12mm under the plaster skirting or dado. The junction between wall plaster and floor shall be finished neatly and without waviness.

**c) FINISHING**

Slight unevenness at the meeting edges of slab shall then be removed by fine chiseling.

**d) CURING**

The work shall be kept constantly moist on all the faces for a period of atleast 7 days.

**e) PROTECTION**

Green work shall be protected from rain by suitable covering. The work shall also be protected from damage during construction.

**f) POLISHING**

After the marble work is cured it shall be rubbed with carborundum stone of different grades No. 60,80,120 in succession so as to give a plane true and highly smooth surface. It shall then be cleaned with a solution of oxalic acid, washed and finished clean.

Cement slurry with or without pigments shall not be applied on the surface before each polishing. 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 metres and paid for extra. The width of tread in all cases shall be measured from the outer line of nosing to the finished face of riser.

**11.17.1 MARBLE STONE IN RISER OF STEPS AND SKIRTING / DADO**

**PREPARATION OF SURFACE**

Where necessary, the wall surface shall be cut uniformly to the requisite depth so that the skirting face shall have the projection on the finished face of wall as shown in drawings or as required by the Engineer-in-Charge.

## **LAYING**

The risers of steps and skirting shall be set 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 12mm and at no place the width shall be less than 10mm, if necessary the slabs shall be held in position by temporary MS hook.

### **11.18 MIRROR POLISHED GRANITE STONE FLOORING**

The specification shall be as per para 11.13 above except polishing instead of inspite polishing in marble slab flooring factory polished granite slabs shall be adopted. All the other specification shall be as per marble flooring.

For marble / granite flooring the sample of material of specified colour as in the work order shall be submitted to the Engineer-in-Charge and should be got approved prior to proving the material. The newly laid floor shall be protected with a layer of gypsum / pop laid over a polythene sheet covering entire surface and shall be maintained till completion of all finishing work of the building. This shall be thoroughly removed and flooring properly cleaned and polished just prior to handing over the building.

### **11.19 KOTA /SHAHABAD STONE FLOORING**

The slabs shall be of selected quality, hard, sound, dense and homogeneous in texture, free from cracks, decay, weathering and flaws. They shall be hand or machine cut to the requisite thickness, they shall be of the colour indicated in the drawings or as instructed by Engineer-in-Charge.

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 contractors shall get the samples of slabs approved by the Engineer-in-Charge.

The thickness of the slabs shall be 20, 30 or 40mm as specified in the description of the item. In respect of length and breadth of slabs, a tolerance of  $\pm 5$  shall be allowed.

## **DRESSING**

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 laying. All angles and edges of the tiles shall be true, square and free from chippings and the surface be true and plane.

## **PREPARATION OF SURFACE AND LAYING**

The specifications shall be as described under marble flooring above 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.

The specifications for laying shall be as described under marble flooring. Cement slurry with or without pigment shall not be applied on the surface before polishing.

### **11.19.1 CUDDAPAH / KOTA / SHAHABAD STONE IN RISERS OF STEPS, SKIRTING AND DADO**

Cuddapah kota / Shahabad stone slabs and dressing shall be as specified above under cuddapah kota/shahabad stone flooring except that the thickness of the slabs shall be 30mm or as specified in the description of the item. The slabs may be of uniform size if required.

Preparation of surface shall be as specified. Under marble stone risers steps/skirting / dado.

#### **LAYING**

Shall be as specified except that the joints of the slabs shall be set in grey cement mixed with pigment to match the shade of the slabs.

#### **CURING, POLISHING AND FINISHING**

Shall be as specified under marble stone work for Risers / Steps/ Skirting / Dado

### **11.20 INTER LOCKING PAVER BLOCK FLOORING**

Unless otherwise specified the interlocking paver blocks shall be of 65mm thick, load bearing strength not less than M20 grade. They shall strictly conform to manufacturers specification. The area where the paver blocks are to be laid shall be prepared as specified in the working drawings and as directed by the Engineer-in-Charge of work. Over this sub grade a bed of 75mm thick coarse sand shall be laid and consolidated. At all edges of the area to be provided with power block edge restraint blocks shall be provided. Over this the paver blocks has to be laid to proper line and level sand bed.

These blocks shall be bedded down by running plate vibrator over it and if necessary by topping level with mallet and large flat piece of timber. Prior to running the plate vibrator dry sand shall be spread over the laid blocks to ensure thorough filling of all the joints including joints at edge restraint blocks. The laying of blocks, colour pattern, design if any etc shall all be as per the drawing for the work. All materials and workmanship of providing interlocking power block shall be strictly as per the manufacturers specification.

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## CHAPTER 12

### ROOFING

#### 12.1 ASBESTOES CEMENT CORRUGATED SHEET ROOFING

The sheet shall be of approved quality and shall conform to IS459. The roof shall not be pitched at flatter slope than 1 Vertical to 5 Horizontal. Normally it should be 1 Vertical to 3 Horizontal. The maximum spacing of purlins under the sheets shall be 1.4 metres in case of 6 mm thick sheets unless otherwise specified. For cyclonic areas this has to be about 1m. The ridge purlins shall be fixed at 75mm to 115mm from the apex of the roof. The top bearing surface of all purlins shall be in one plane so that when the sheets are fixed they need not be forced down to rest on purlins. The finished roof shall have uniform slope with straight & true line of corrugations. The smooth side of sheet shall be upside. There shall be minimum half corrugation for side lap and 15 cm for end lap. For very exposed situation the minimum end lap shall be 20 cms. Side lap shall be laid on the side facing away from prevailing monsoon winds. Free overhanging shall not exceed 300mm. Sheets shall be laid left to right starting at the eaves. The first sheet shall be laid uncut. For snug fit where four sheets meet at a lap, the remaining sheets in bottom row shall have the top left hand corner cut or mitred. The sheet in intermediate rows, except the first and last sheet, shall have both the top left hand corner and bottom right hand corner cut.

The sheets shall be secured to the purlins and other roof members by means of 8mm diameter galvanized iron J or L hook bolts and nuts. "J" hooks are used for fixing to angle iron purlins. "L" hooks are used for fixing to R.S. joists, timber or precast concrete purlins. The grip of these hooks shall be minimum 25mm. Each hook bolts shall have a bitumen washer and a galvanized iron washer placed over the sheet before the nut is screwed down from the above.

G.I. flat washer shall be 25 mm in diameter, 1.6 mm thick. Bitumen washer shall be 35 mm in diameter and 1.5 mm thick. The length and number of bolts shall be as specified.

Holes for hook bolts shall be (drilled not punched), at the crown of corrugation. The diameter of hole shall be 2mm more than diameter of fixing bolt. There shall be no bolt near than 40mm from any edge or accessory. Wind ties of 40 x 6mm flat iron section shall be laid as specified

The length and breadth of A.C sheet roofing shall be measured correct to cm and the superficial area of roof covering shall be measured flat in the square

metres correct to two places of decimal. Portions of roof covering, over lapping the ridge or hips etc shall be included in the measurements of the roof. No deductions in measurements shall be made for openings upto 0.4 SqM<sup>2</sup> and nothing extra shall be allowed for forming such opening. When opening exceed 0.4 Sq M deductions shall be made and extra payment shall be made forming those openings.

#### **12.2 ASBESTOS CEMENT SEMI-CORRUGATED SHEET ROOFING**

Sheets shall be of specified thickness and shall conform IS459. The laying specification shall be same as that for Asbestos Cement Corrugated sheet roofing except that the sheets shall be laid with the end stamped "Top" on the smooth side pointing towards the ridge. The sheets shall invariably be laid from the right to left, starting at the eaves with the procedure for mitring etc. The side laps will be with one corrugation, the left hand small corrugation of each sheet being covered by the right hand large corrugation on the next sheet.

Asbestos cement expansion joints using specially manufactured expansion joint pieces shall be inserted at every 45 metres or so. The end lap of expansion joint shall not be less than 150 mm. The purlins at expansion joints should be stitched with seam bolts. The fixing specification shall be same as that for AC corrugated sheet but with hook bolts in every vertical side lap corrugation and at the two verges with additional hook-bolt through one of the two intermediate corrugations on each sheet. Wind ties shall be provided as in A.C. corrugated sheet roofing. The measurement shall be same as that for A.C. corrugated sheet roofing.

#### **12.3 RIDGES AND HIPPS OF ASBESTOS CEMENT**

Unless otherwise stated the ridges and hips shall be of the same manufactures of roofing sheet. The ridges shall be laid and fixed as per manufacturers instructions.

#### **12.4 EAVES AND VALLEY GUTTERS**

The eaves gutter shall be of specified type, of standard size procured from approved manufacturers. The valley gutters shall be of the "Plain" ended Valley types and of size as stipulated in the item procured from approved manufacturers.

The gutter shall be laid with a minimum slope of 1 in 120 which should be increased where possible. The size of outlet of drop ends and nozzles shall be of the same size as the size of the rain water pipes into which they shall be discharging the water. The supporting arrangement for fixing of gutters shall be



as per the working drawing. The brackets of the gutters shall be placed at not more than 90 cm centers. The connection bolts of the gutters shall be above the water line.

## **12.5 WATER PROOFING WITH BITUMEN FELT**

The treatment with self finished felt shall be four courses or six courses as specified in item. For normal duty treatment four courses and for heavy duty treatment of important building six courses shall be adopted .

### **12.5 .1 MATERIAL**

The self finished felt shall be one of the following types:

- a) Type 2 grade 1 is a glass fibre base bitumen felt conforming to IS 7193.
- b) Type 2 grade 1 is a fibre (Vigitable or animal) base felt conforming in all respects to IS 1322.
- c) Type 2 grade 2 is a fibre (Vigitable or animal) base felt conforming in all respects to IS 1322.
- d) Type 3 grade 1 is hessian base felt conforming in all respects to IS 1322.

Bonding material shall be of blown type petroleum bitumen conforming to IS 702 or residual petroleum bitumen conforming to IS 73 or mixing thereof. The penetration of bitumen shall not exceed 40.

Blown type petroleum bitumen S-90 shall be used for base and intermediate layers and for flashing. Residual type petroleum bitumen shall be used for finishing layer.

Where proprietary brands of bonding materials are proposed by contractor they shall conform in all respects the respective I.S. specification for bonding material.

### **12.5.2 PREPARATION OF SURFACE**

The surface shall have minimum slope of 1 in 120. The junctions roof and vertical faces shall be provided with running triangular fillets 7.5x7.5 cm size in concrete as specified.

For tucking the water proofing felts into masonry parapet walls, chimney stacks etc a horizontal groove of 6.5 cm deep 7.5 cm wide section with its lower edge at not less than 15 cm above the graded roof surface shall be left on the inner face of the same, during construction if possible. If grooves are not left they shall be cut. These grooves shall be finished smooth with C.M 1:4. The rate quoted for tar felt treatment shall include the cost of above work unless otherwise specified when height of parapet wall is 45 cm or less grooves are not cut but

water proofing treatment has to be carried out over the top of the parapet wall to its full thickness.

The area to be treated shall be thoroughly cleaned with wire brushes and all loose scales etc are removed, the surface shall be dusted off, cracks if any on roof shall be cut to "V" section cleaned and filled with cement mortar slurry 1:4 (1 Cement:4 Coarse sand) or blown type petroleum bitumen of IS grade 85/25 of approved quality.

#### **12.5.3 PRIMING COAT**

If specified priming coat consisting of a bitumen primer conforming to IS 3384 shall be applied with brush @ 0.24 lits per Sq m.

#### **12.5.4 TREATMENT**

The treatment consists of following layers for 4 course treatment:

- i. Initial layer of bonding material applied hot at specified quantity per unit area.
- ii. Second layer of self finished bitumen layer felt of specified brand and manufacture conforming to the type and grade given in the description of the item.
- iii. Third layer of bonding material
- iv. Final layer of stone grit of pea sized gravel spread at specified volume of material per unit area.

In six course treatment, above third layer of bonding material fourth layer of self finished felt and fifth layer of bonding material shall be laid. The sixth or final layer shall be of stone grit of pea sized gravel spread at specified volume per unit area.

#### **LAYING**

The bonding material to be heated to the working temperature. The working temperature for blown type petroleum bitumen of IS grade 85/25 is 180 degree C. and that for residual type petroleum bitumen of penetration 30/40 of IS grade S-35, is 180 degree to 190 degree C.

The water proofing treatment shall be carried into the drain pipe or out lets by at least 10 cm. At all over lapping areas of treatment there shall be at least 10 cm over lap.

- 12.5.5 While laying felts they shall be cleaned and laid horizontally eliminating curls and subsequent stretching. Normally felts to be laid at right angles to the

direction of the slope starting from lowest point. The felts laid in position shall be rolled for a distance of half of its lengths. The hot bonding material shall be poured on the roof across the full width of the rolled felt as the felt is steadily rolled out and pressed down. The bonding material shall be poured uniformly.

Excess, squeezed bonding material shall be levelled up as laying proceeds. When first half of strip of felt has been bonded to the roof the other half shall be rolled up and unrolled on the hot bonding material in the same way. Laying shall proceed accordingly. Each strip shall over lap 10 cm on longitudinal edges and 7.5 cm at ends. All over laps shall be firmly bonded with hot bitumen, Streaks and trailing of bitumen near edges of laps shall be leveled by heating the overlap with a blow lamps and leveling down unevenness. Other layers shall be laid similarly.

At vertical and horizontal junctions flats shall be laid as flashing with 10 cm longitudinal lap and lower layer shall over lap the roof water proofing by not less then 20 cms and upper layer not less than 10 cms. In flashing the final course of stone grit or pea sized gravel shall be replaced by an application of bituminous solution of approved quality in two coats on exposed surfaces of flashing.

The measurement shall be taken to the entire exposed area of roof and flashing treatments, correct to a cm and area calculated in sq meter correct to two decimal points.

Vertical and sloping surfaces of water proofing treatment shall also be measured under same item, irrespective of the fact that the final course of grit or pea sized gravel is replaced by bitumen layer. No deductions shall be made for openings for areas upto 40 sq decimeter nor any thing shall be paid for forming such openings.

## **12.6 OVER DECK THERMAL INSULATION USING 50 MM THICK EXPANDED POLYSTYRENE SLAB**

The roof over which the treatment has to be provided shall be dry and thoroughly cleaned by removing all loose particles, dust etc. Over this one coat of hot bitumen of penetration 85/25 shall be evenly spread at the rate of 2 kg per sq mt and expanded polystyrene slab of not less than 16 kg/cum for normal density or expanded polystyrene slab of not less than 20 kg/cum for high density, shall be laid and pressed. Bitumen stitches shall be provided wherever required. Bitumen emulsion shall be spread on all edges, joints and over the expanded polystyrene. All joints are sealed carefully. The top of polystyrene slab shall be finished with a layer of 15mm thick cement mortar of proportion 1:4 (one cement of 4 coarse sand) with an inter layer of chicken mesh of 12 mm x 26 g.

The superficial area of the treatment will be measured with linear measurement in cm and area in square meter upto second decimal.

## **12.7 THREE COURSE WATER PROOFING TREATMENT**

The acrylic water proofing compound to be used shall be chemseal manufactured by M/s Overseas Water Proofing Corporation, Mumbai or complast x 421c manufactured by M/s Fosroc Chemicals (India) Ltd., Bangalore or Roff Hyproof manufactured by M/s Roffee Construction Chemicals (Pvt.) Ltd. or equivalent to above. The dosage and mixing etc shall be as per manufacturer specification unless otherwise specified.

### **12.7.1 PREPARATION OF SURFACE**

The surface of the roof slab shall be thoroughly cleaned of all loose material, laitence, dust etc using wire brush and gunny cloth. The construction joint if any shall be racked and cleaned and surface shall be made suitable for treatment without any foreign and loose particles.

### **12.7.2 FIRST COURSE**

A coat of cement slurry at the rate of 4.4 kg/sqm, mixed with approved acrylic water proofing compound as per manufactures specification shall be grouted uniformly over the RCC roof area. Care to be taken to ensure that the slurry penetrates into the RCC slab below and fills all micro cracks and all other porous areas. Over this a layer of 15 mm thick cement mortar 1:5 mixed with approved acrylic water proofing compound (as per manufacturers specification) shall be laid to place the second course.

### **12.7.3 SECOND COURSE**

A single layer of brick on edge (that is brick laid vertically on its 115 mm x 75 end or 75 mm x 230 mm side as may be required to provide the slope) shall be laid when the mortar of first course is still green, with about 15 mm gap around the individual bricks. The bricks shall be laid with their top in slope not less than 1 in 60 as per the roof drainage scheme. The gap around the bricks shall be thoroughly filled with cement mortar 1:5 (1 cement and 5 coarse sand) mixed with approved acrylic water proofing compound as per manufacturer's specification. The bricks used shall be well burnt with water absorption not more than 20 percent. The minimum thickness of this layer shall be 65 mm at outer edge including the top and bottom plastering of 15mm thick and 20 mm thick I and III coarse respectively. Full brick or cut brick may be used for this course as per the requirement of the gradient/slope of treatment. However brick over brick shall not be laid and it should be a single layer of brick of required size.

#### **12.7.4 THIRD COURSE**

Over the second course said above, third course of 20 mm thick cement mortar 1:4 mixed with approved acrylic water proofing compound with a intermediate layer of chicken mesh of 12 mm x 26 g shall be laid immediately on completing second layer, without allowing to form a cold joint between 2<sup>nd</sup> layer and 3<sup>rd</sup> layer so that the entire treatment shall form an integral three courses. For laying of intermediate layer of chicken mesh the third course may be laid in two stages viz. 10 mm thick base mortar layer first and after laying chicken mesh over it laying 10 mm thick top mortar layer. It shall be ensured that the chicken mesh is properly laid evenly with adequate cover and without surface unevenness tending it to sprout out of mortar. For this the mesh has to be fixed appropriately to stay in position without curling, sprouting out etc by nailing to second course. The top of the mortar layer shall be levelled to required slope and finished rough with float. 300mm x 300mm false square mark shall be made over the finished surface of the third/final course. The third courses shall appropriately continued over concrete fillets at roof and parapet junction for at least 10cm above fillet top.

The entire work shall be cured for a minimum of 7 days. The superficial plan area of the work done shall be measured correct to cm in longitudinal dimensions and area in sq mt upto two decimal.

#### **12.8 UNDER DECK THERMAL INSULATION**

##### **12.8.1 MATERIAL**

50 mm thick resin bonded fibre glass of density 24kg/cum (UPTWIGA or equivalent make) or resin bonded mineral wool of density 48kg/cum conforming to IS:8183 in slab form of M/S Lloyd insulation (India) Ltd., or equivalent may be used as specified.

The wool shall be placed in polythene bags made of 250 micron LDPE sheet of 0.92 g/cc in grids of required size as per drawing and shall be laid over structural frame work for fixing thermal insulation material.

The frame work for fixing the insulation material may be of second class teakwood, first class country wood, GI sheet U shaped channel made of 50mm x 50mm x 20g with 30mm flat sides on either sides of channel for fixing to the ceiling or of M.S structural steel work consisting of ISA 25 x 25 x 5mm grid @ 1220mm c/c both ways in grid pattern and residual grids as per drawing, with ISNT 40 wall angle etc. all as per the item description in work order.

##### **12.8.2 FRAME WORK**

In case of wooden frame work 65 mm wide, 50mm deep reapers shall be used unless otherwise specified.

In case of U shaped G.I. sheet channel the frame work shall be generally in staggered grid pattern as per working drawings. 50mm x 50mm x 75mm long wooden block shall be provided on main line at every 1200mm length at suitable intervals. The main channel shall be fixed to roof slab using 8mm dia anchor fasteners and cross channel fixed by 40 x 8 mm CP brass screws at every 300mm c/c with PVC rawl plugs.

In case of structural steel frame work, ISA 25 x 25 x 5mm wall angles shall be provided. The frame work shall be made up of ISNT- 40 @ 1220 c/c. The frame work shall be suspended from 8mm dia anchor fasteners with bolts and nuts and cleat angles etc for fixing structural grid to it all as per working drawing.

All frame work shall have protective painting or galvanizing as the case may be.

### **12.8.3 COVERING**

The frame work will be covered with 6mm thick plan A.C. sheet 4 mm thick E board or any other building board covering as specified.

### **12.8.4 INSULATION**

The thermal insulation material shall be covered by polythene bag made from 250 micron LDPE sheet of 0.92 grms/cc density and shall be properly stitched and placed over the A.C. sheet / E board covering of under deck insulation.

All works shall be executed as per working drawing for the work in a workman like manner for providing a level/plain/even under deck thermal insulation covering to the roof slab.

### **12.9 CEILING WITH BUILDING BOARDS VIZ. INSULATION BUILDING BOARDS; HARD BOARD; PARTICLE BOARD, A.C. SHEET CEILING, PLASTER OF PARIS TILES**

#### **12.9.1 MATERIALS**

The boards shall be of approved quality conforming to relevant I.S As below:

- |                                |          |
|--------------------------------|----------|
| (i) Insulation building boards | IS 3348  |
| (ii) Particle Board            | IS 3087  |
| (iii) Fibre Board              | IS 12406 |
| (iv) Asbestos cement Board     | IS 2096  |
| (v) Gypsum Board               | IS 2095  |

The medium hard board shall have density exceeding  $480 \text{ kg/m}^3$  but not exceeding  $800 \text{ kg/m}^3$ . Normal hard board shall have density exceeding  $800 \text{ kg/m}^3$  but not exceeding  $1200 \text{ kg/m}^3$ . The tempered hard board shall have further treatment over normal hard board, during the course of manufacture to further increase the density, strength and water resistance.

#### **12.9.2 FRAME**

The frame as in the description of the relevant item in the work order has to be provided. The frame shall be provided with preservative painting as per specification. In case of fixing sheets to wooden frames G.I. headless nails 2.2 to 4mm dia shall be used unless otherwise specified.

When the joints to be covered with beading the sheets are to be fixed to frames scantling with G.I. felt headed (clout) nails 2.5mm dia., The length of nails shall generally be thickness of sheet plus 25mm for adequate grip on the framing members.

#### **12.9.3 FIXING**

The fixing of the boards shall be as per manufacturers' specification. In case of wooden frame for exposed joints the sheets shall be butt laid with their edges abutting in moderate contact without having to force them into the place. The boards may have to be supported with timber pieces to the ground while nailing the boards to intermediate framing members, proceeding from the center of the board outwards, the edges being nailed last. After nailing, the supporting timber pieces may be removed. When joints are to be left exposed the outer rows of nails are placed at 10cm centers and at about 12mm from edge of the sheet. In the rows on the middle of the sheets the nails are placed 20 cm apart. The nails to be counter sunk in the underside of board with suitable punch. Care shall be taken in driving the nails so that sheets are not marked by hammer blows. Where the joints are to be covered with beading, felt headed (clout) nails shall be used instead of lost head nails. The spacing of nails in the interior rows in the boards shall be the same as in previous para. In the outer rows at edges to be covered by beading the nails to be spaced at 20cm center in each row but with the nails staggered. The beading will then be fixed over the sheets with screws 20cm center in each row with screws in two rows staggered and passing through beading, sheet and framing so that ultimately the spacing of the fixing (nails and screws taken together) in each row will be at 10cm center so far as the sheets and frames are concerned.

#### **12.9.4 FINISHING**

The exposed sides of the boards shall be truly level and plane without any local bulges or sags. The joints shall be truly parallel and/or perpendicular to

the walls. The width of the joints shall be uniform. Care shall be taken to see that the shape, uniform colour, finishing etc. of the sheet is not spoiled during fixing operation. If specified the ceiling shall be treated with distemper, painter etc.

In case of Hardboard/particle Board/A.C sheet ceiling the maximum spacing of longitudinal scantling shall be 40cm centers. In case hard board, the sheets shall be damped with water on the textured face before they are fixed. This shall be carried out by brushing the textured face evenly and liberally with sponge or swab soaked in water. After this the sheets are stacked with damped sides against each other, in pairs and left to remain for a period of 24 or 48 hours as recommended by respective manufacturers, duly protecting from sun and strong heat.

In case of plaster of paris tiles the maximum size of tiles shall be limited to 75cms in each direction. A good plaster of paris tile shall give a ringing sound when struck. The tiles shall be fixed to wooden ceiling frame using slightly counter sunk 40 mm cp brass screws fixed at not more than 20 cm center to center 15mm away from the edge of the tiles. The head of screws shall be covered up with plaster of paris and smooth finished

#### **12.10 THERMOCOLE FALSE CEILING WITH ALUMINIUM FRAME WORK**

Aluminium framing shall consist of patent aluminium framing of approved make in 600 x 600mm panel.

High density thermocole slabs for ceiling shall be 50mm thick and shall be of approved make conforming to relevant IS specification. The slabs shall be uniform textured and shall be free from holes, stains or any other defects. Materials not conforming to standard specifications or otherwise found to be defective shall be rejected. The thermocole slabs shall be cut to required size in a workman like manner. The edges shall be perfectly straight and neatly finished. The frame work for the ceiling shall be erected as shown on relevant drawings and as directed by Engineer-in-Charge.

Thermocole slabs shall be fixed to the frame work by means of necessary pins, clips screws etc. Necessary openings with extra frame work for lighting panels, etc, are to be provided as indicated in drawings or as directed by Engineer-in-Charge. No extra payment will be made for additional framework in ceiling required for lighting panels etc.

The tenderers are requested to particularly note that the false ceilings in certain areas are intended for rooms which are to be air-conditioned.

The false ceiling shall be perfectly airtight and no leakage of air-conditioned air through the ceiling shall be permitted. The contractor should guarantee ceiling



work against any leakage of air from inside the room. The finished surface shall be perfectly plain, neat, tidy and present a uniform appearance.

#### **12.11 FLEXO BOARD FALSE CEILING**

The wooden runners and cross members of the false ceiling be of second class teak wood or first class country wood or any other specified frame and shall conform to the specifications of joinery works.

FLEXO BOARD for ceiling shall be 6mm thick and shall be of approved make conforming to relevant IS specifications. The sheets shall be strong, uniform textured and shall be free from cracks, holes or any other defects. Materials not conforming to standard specification or otherwise found to be defective shall be rejected. The flexo boards shall be cut to required sizes in a workman like manner. The edges shall be perfectly straight and neatly finished. All holes for screws etc., shall be drilled and not punched.

The frame work for the ceiling shall be fabricated and erected as shown on relevant drawings and as directed by the Engineer-in-Charge. All wooden or metallic frame work shall be provided with protective coat as specified in the schedule of quantities.

FLEXO BOARD shall be fixed to the frame work by means of suitable counter sunk screws or otherwise as directed and all holes after fixing the screws shall be filled with approved filler. Flexo boards shall be fixed to the frame work with requisite gaps at the joints. Necessary openings with extra frame work for lighting panels, etc., are to be provided as indicated in drawings or as directed by the Engineer-in-Charge. No extra payment will be made for additional framework in the ceiling required for lighting panels etc.

The tenderers are required to particularly note that the false ceiling in certain areas are intended for rooms which have to be air-conditioned. The false ceiling shall be perfectly airtight and no leakage of air-condition air thorough the ceiling shall be permitted. The contractor should guarantee the ceiling work against any leakage of air from inside the room. The finished surface shall be perfectly plain. The finished work shall be neat, tidy and present a uniform appearance.

#### **12.12 METALLIC FALSE CEILING/STEEL TILE FALSE CEILING ON ALUMINIUM FRAME MATERIAL**

##### **12.12.1 TILE / PLANKS**

The tiles shall be manufactured from galvanized steel (Base Steel Galvanized as per IS:277, 120gm/sq m zic coating – total mass of both sides). The tiles

shall be fixed firm to false ceiling frame yet allow for demounting of individual tiles. The tiles shall be of specified size, square or rectangular, with leveled edges or square edges as required.

#### **12.12.2 ALUMINIUM TILE**

The tiles shall be manufactured from aluminium alloy and shall be fixed firm to the false ceiling frame yet allow for demounting of individual tiles. The tiles shall be of specified edges or square edges as required.

#### **12.12.3 PLANK STEEL/ PLANK ALUMINIUM**

The maximum plank area for steel planks shall be 0.75 sqm. The plank width dimensions may be 200 to 600mm and length between 1000mm or 3000 mm. The steel plank shall be manufactured using base steel galvanized as per IS:277, 120gm/sqm zinc coating total mass of both sides.

The aluminium planks shall be manufactured out of aluminium alloy. The planks width dimension of aluminium plank may be 254mm or 305mm and length not more than 1264mm.

The planks sides shall be of such shape to allow firm fixing of the same to false ceiling frames/each other planks yet allow for demounting of individual planks. The planks would have square edges.

If specified perforated tiles/planks shall be used with standard perforation. The perforation will allow not less than 16% open area with 2.5mm dia holes at 5.5mm center or with any other approved patterns.

#### **12.12.4 SUSPENSION**

The tiles/planks would be suspended by means of suspension system comprising of 0.5mm galvanized steel clip in profiles installed at correct spacing to support the tiles or planks. Any other approved system is also acceptable. Suspension profile would be suspended from the roof structure by any approved system like G.I. ceiling bracket, G.I. suspension angle and aluminium hold on clamp at maximum 1200mm center to center along clip in profile.

#### **12.12.5 WALL ANGLES**

Tiles/planks to be trimmed along the wall perimeter by means of minimum 25 x 25 x 0.6 mm extruded aluminium powder coated perimeter angle.

#### **12.12.6 FINISHING**

The tiles or planks shall be finished with protective coating as specified, of approved shade. Unless otherwise specified steel tiles/planks would be finished with polyester coil coating in finish surface (nominal 20 microns) and backing coat or rear surface (nominal 5 microns). Similarly aluminium tiles/planks would be finished with 50 microns epoxy polyester powder paint in approved shade on exposed surface. Aluminium wall trim would also be finished with 50 microns epoxy polyester powder paint in broken white shade.

#### **WORKMANSHIP**

All work should be executed in an acceptable workmanship manner. The ceiling shall be erected in a continuous sequence. Spans would not exceed those recommended by manufacturer.

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## CHAPTER 13

### FINISHING

#### 13.1 SCAFFOLDING

For all masonry work, finishing works etc, wherever necessary only, double scaffolding independent of work has to be adopted. In case of any special work / special type of scaffolding requirement etc the scaffolding scheme shall be got approved from the Engineer-in-charge well in advance of actual erection of scaffolding.

#### 13.2 PLASTERING

The term plastering shall cover all types of rough or fair finished plastering rendering, floating and setting coats screed etc in lime, cement lime or cement mortar.

Dubbing out shall mean filling in hollows in the surface of wall and roughly leveling up irregular or out of plumb surfaces prior to rendering.

Rendering shall mean the plastic coat which is applied following the dubbing out where required or final coat in case of one coat work.

Floating coat shall mean the second coat used in a three coat work to bring the rendering coat to a true and even surface before the setting coat is applied.

Setting coat shall mean final coat in a two or three coat work.

Thickness of plaster shall mean minimum thickness at any point on a surface. This does not include thickness of dubbing out.

The term even and fair as referred to finishing of the final plastered surface shall mean a surface finished with a wooden float.

The terms even and smooth as referred to finishing of the final plastered surface shall mean a surface leveled with wooden float and subsequently finished with a steel trowel.

The type and mix of mortar for plastering, the number of coats, the surface finish, and the background which the plaster is to be applied shall be as indicated.

The mortar for dubbing out and rendering coat shall be of the same type and mix of proposed plastering.

Ceiling plastering shall be completed before commencement of wall plastering in any area.

### **13.2.1 MIX OF MORTAR**

The mix of mortar shall be as indicated.

#### **a) PREPARATION OF SURFACES**

The surfaces to be plastered shall be prepared in the following manner.

##### **i) BRICK WORK AND MASONRY**

The joints in row work shall be raked out to a depth of not less than 10mm as the work proceeds.

##### **ii) CONCRETE SURFACES**

For new work, surface shall be left sufficiently rough to provide adhesion. For old work surface shall be roughened by hacking or bush hammering. All dust, loose particles, laitance efflorescence, grease and oil and all such matters shall be removed where so directed. In all cases mentioned above the surface before plastering shall be thoroughly brushed down to remove dust, loose particles and efflorescence if any and kept well wetted. Plastering shall not be commenced unless preparatory work has been passed in writing by EIC.

#### **b) APPLICATION OF PLASTER**

Mortar shall be firmly applied in a little more than the required thickness and well pressed into joints. Correct thickness of plaster shall be obtained by using wood screed or laying plaster screeds at intervals of 1.5m. The dubbing out rendering and floating coats shall be left rough or scored to provide key for the subsequent coats of plaster and kept damp. In the case of one coat work or after the completion of setting coat the final surface shall be kept wet atleast seven days. In hot weather surfaces exposed to sun shall be screened with wet matting or by other approved means. Unless otherwise indicated the final surfaces of external plaster work shall be finished rough and fair internal plaster shall be finished with even smooth.

Plastering shall be done from top to bottom and care shall be taken to avoid joints in continuous surface. Partly set and dried mortar shall not be used.

### **13.2.2 CEMENT PLASTERING WITH NEERU FINISH FOR INTERNAL WALLS AND CEILING**

Cement, sand and water required for the work shall conform to specifications laid down herein before under section 'Cement Concrete' (plain and reinforced) except that sand for finishing coat shall be fine sand. The surface to be plastered shall first be thoroughly cleaned down. All joints shall be raked out in case of brick work, stone masonry as the work proceeds. The surface to be plastered shall be well wetted for a minimum period of 24 hours before commencing the work. The mortar for all plaster shall be cement and sand of mix as specified in the schedule of quantities. Care should be taken to avoid damage to the floor due to scaffolding by adopting suitable measures. Damages if any shall be rectified by contractor at his own cost.

The surface to be plastered shall first be dubbed out with cement mortar to cover any irregularities and faces upto the proudest part. The dubbing coat shall then be done to provide key for the rendering coat. The rendering coat of cement and sand mortar shall then be applied over the dubbed surfaces.

The surfaces thus rendered shall then be finished smooth with good quality lime neeru. Neeru shall be prepared at site out of best quality fat lime, slaked at site with fresh water and slaked in accordance with the relevant IS code for slaking lime. The slaked and silted limes shall be reduced to a fine paste by grinding in a mortar mill (150 turns). Sufficient quantity which can be used within 10 days only shall be prepared at a time.

All exposed angles and junctions of walls and doors etc shall be carefully finished so as to furnish a neat and even surface. An entire unobstructed area shall be plastered in one operation. Before the base coat sets the neeru finish should be applied and finished smooth. The entire plastered surface shall be truly plain. Plaster work shall be cured for atleast 7 days by approved methods taking precaution against damage to plaster during this operation.

The contractor shall take every precaution right from the commencement of the plaster work to prevent any craziness that may appear on the surface of plaster.

The contractor shall be responsible for making good any portion of plaster which in the opinion of the Engineer-in-Charge required removal and redoing.

The plastering shall be finished at skirting level.

### **13.2.3 SAND FACED CEMENT PLASTER**

Sand faced plastering shall be executed as described below:

- a) The surfaces shall be cleaned and dubbed out as specified under cement plaster.
- b) A rendering coat of cement and sand mortar (1:4) shall be applied over the dubbing coat, the thickness excluding key not to be less than 38mm.
- c) While the rendering is still green, the surfaces shall be roughened lightly with wire brush. All loose particles shall be dusted and 6 mm thick cement mortar (1:4) shall be applied. The finished surface shall be slightly pressed with closed pricked wooden board or a wet sponge to bring the sand particles into prominence.
- d) General workman ship, curing etc shall be all as specified under cement plaster work.

### **13.2.4 CEMENT PLASTERING FINISHED ROUGH FOR EXTERNAL WALLS**

Plastering shall be carried out generally as specified above for cement plastering with neeru finish. Neeru finish is not required for the surface plastering is to be finished rough. The sand to be used for the rough plastering shall be coarse sand.

### **13.2.5 ROUGH CAST PLASTER**

- 13.2.5.1 Rough cast finish comprises of a mixture of sand and gravel in specified proportion dashed over freshly plastered surface. The scaffolding, preparation of surface, mortar etc shall all be as specified and generally as per that for cement mortar plastering.

### **13.2.5.2 APPLICATION**

The plaster base over which rough cast finish is to be applied shall consist of two coats comprising under layer 12mm thick and top layer 10mm thick. The under layer shall be applied in the same manner as for cement mortar plaster except that the surface shall be rough finished. The top layer shall be laid a day or two after the under layer has attained initial set. The under layer shall not be allowed to dry out before the top layer is laid on. The mortar used for applying top layer shall be sufficiently plastic and of rich mix 1:3 (1 cement : 3 fine sand) or otherwise specified, so that the mix of sand and gravel get well pitched with plaster surface. In order to make the base plastic about 10% of finely ground hydrated lime by volume of cement shall be added when preparing mortar for top layer unless specified otherwise.

### **13.2.5.3 FINISHING**

The base surface which has to receive rough cast mixture shall be in plastic state when dashed over it. The rough cast mixture shall consist of sand or gravel or crushed stone as specified. The crushed stone shall be of uniform colour and size of 2.36mm to 12.55 mm as specified. The mixture shall be wetted and shall be dashed on the plaster base in plastic state by hand scoop so that the mix get well pitched into the plaster base and surface represent a homogeneous surface. A sample rough cast plaster shall be got approved by the Engineer-in-charge well in advance of actual work.

### **13.2.6 PEBBLE DASH FINISH (INSITU WORK)**

The specification shall be similar to rough cast plaster except washed pebble or crushed stone of size 6.3mm to 12.5mm as specified shall be used in lieu of gravel or crushed stone in rough cast plaster work.

### **13.2.7 PLASTERING WITH TERRAZZO FINISH**

13.2.7.1 The scaffolding, preparation of surface, etc shall all be as specified under cement mortar plastering. The mortar shall be prepared as that under terrazzo dado work specified earlier. A 12mm thick under coat and 6 mm top coat shall be provided for 18mm thick plastering with terrazzo finish. The under coat shall consist of cm1:3 (1 cement : 3 coarse sand) unless otherwise specified. The specification for 6mm top coarse shall be as per cast in site. Tarrozzo dado work said above.

### **13.2.7.2 APPLICATION**

The 12mm under coat shall be laid as in cement mortar plastering except that the surface shall be rough and furrowed 2mm deep with scratching tool diagonally both ways to from key for the top coat. The scratching lines shall be at not more than 15cm apart. The surface shall be kept wet till finishing coat is applied. After under coat has sufficiently set but not dried at any case. Within 48 hours the top layer has to be laid in the same manner under 40mm marble chips flooring as far as applicable. The finished surface shall be smooth, highly polished and absolutely even so that when light from side ways is reflected on it, it does not show any kind of waviness curing shall be done as soon as the plaster has hardened and not to be damaged when watered and continued for 7 days. Any cracks which appear in the surface and all portions which sound hollow when tapped or are found to be soft or otherwise defective shall be cut out in rectangular shape and redone as directed by the EIC. The finish of rectification work shall be indistinguishable from the rest of the portion and does not show as a patch.



### **13.3 POINTING ON STONE WORK / BRICK WORK / TILE WORK**

The following general specifications shall apply to all types of pointing:

#### **13.3.1 SCAFFOLDING**

Independent double scaffolding shall be done wherever required.

#### **13.3.2 PREPARATION OF SURFACE**

This shall be done as specified for plastering item except that the joints shall be raked to such a depth that the minimum depth of the new mortar measured from either the sunk surface of the finished pointing or from edge of the stone shall not be less than 12mm.

13.3.3 The mortar shall be pressed into the raked out joints, with a pointing trowel, either flush, sunk or raised. According to the type of pointing required. The mortar shall not be spread over the corner, edges or surfaces of the masonry. The pointing shall then be finished with the proper tool. The excess mortar shall then be cut off from the edges of the lines and surface of masonry shall also be cleaned off all mortar. The pointing has to be to the exact size and shape stipulated. The pointing shall be cured for 7 days and it should be protected from damages during this period.

13.3.4 The pointing shall be truly horizontal and vertical except where the joints are slanting as in random rubble masonry. Lines of joints from different directions should meet neatly at the junctions instead of crossing beyond.

#### **13.4 CEMENT WATER PROOFING COMPOUND**

Wherever admixture of water proofing compound is specified for cement plastering work or concrete work integral water proofing compound conforming to IS 2645 and of approved brand and manufacturer only shall be used. The contractor shall bring the material to the site in their original packing. The containers shall be opened in the presence of EIC or his representative. The material shall be mixed with dry cement in the proportion by weight recommended by the manufacturers or as described in the item as directed by the EIC. The water proofing mixer shall get well and integrally mixed with the cement and does not run out separately when water is added. It shall be measured by weight unless otherwise stated. The rate shall include all labour and materials involved in mixing.

#### **13.5 PAINTING / POLISHING**

##### **GENERAL**

The material required for painting, varnishing etc for the work shall be brought from approved manufacturers. Prior to bulk procurement the sample to be got

approved from EIC. Adequate quantity required for the work should be brought at a time and kept in joint custody of contractor and EIC. The empty tins should not be removed from site till the relevant item of work has been completed, cleaned off dust prior to next coat. No left over paint shall be put back into stock tin. When not in use the container shall be kept properly closed. Top of the surfaces and surfaces in similar hidden locations shall not be left out.

Plastic emulsion, Acrylic emulsion, flat oil paint, synthetic enamel paint etc., shall be of special quality from approved manufacturers. Inferior quality (Bazaar quality paints even though manufactured by the approved manufacturers) shall not be used on the work.

Sample tins of paints for all coats to be submitted to the EIC for his approval prior to bulk procurement. The priming under coating and finishing coats shall be from different tins. The finishing coat shall be semi-gloss or matt finish as directed by the Engineer-in-Charge.

All the materials shall be kept properly protected when not in use. Lids of containers shall be kept closed and the surface of paint in open or partially open containers shall be covered with a thin layer of turpentine to prevent the formation of skin. Materials which in the opinion of the Engineer-in-Charge have become stale shall not be used on the works and shall be removed from the site of the work.

The paints shall generally conform to the chemical composition and other characteristics in the relevant IS Specification.

The paint shall be put on with approved brushes, kept well bound and well worked during its application. For iron work, fairly stiff brushes shall be used. The painting to be carried out in such order as directed by Engineer-in-Charge. The brushes shall be thoroughly cleaned before being used for a different types of class of materials.

### **13.5.1 POLISHING**

#### **WAX POLISH**

A mixture of Bee's wax and turpentine in proportion 2:1 weight shall be used. The wax is melted and added to the turpentine, mixed well and allowed to cool.

The surface of the wood work shall be prepared as for oil painting before waxing. The wood work shall be smeared and rubbed with the mixture and allowed to remain overnight so that the mixture may soak into the pores of the wood. After drying, the surface shall be lightly rubbed with a fine sand paper prior to second and third coats. After the final coat, the surface shall be rubbed up with a soft flannel to a fine polish.

The wood work shall show an even polished surface and to be approved by Engineer-in-charge.

### **13.6 PAINTING**

- 13.6.1 a) All paints to be of best manufacture and to be delivered on the site in the maker's original packages and tins and the maker's guarantee to be produced if called for by the Engineer-in-Charge. The paints shall be of the qualities suitable for use in the local climatic conditions. Thinners must be those recommended by the manufacturers and used as directed by them.
- b) The paints to be used for the various categories of painting work shall be of those manufactured by one of the standard manufacturers e.g M/s Nerolac, Shalimar or any other manufacturers, as may be approved by the Engineer-in-Charge. Only the best quality paint of various categories shall be used. Paints for the application by brush shall be strained through paint strainer. The paint shall be kept stirred and used within the specified time. Hardened or damaged paint shall not be use.

#### **c) APPLICATION**

The paint shall be applied by means of brushes and in the manner specified by the manufacturer. The number of coats shall be as mentioned in the Item. When more than one coat is ordered subsequent, coats shall be applied after the preceding coat is properly finished / cured and thoroughly hardened, inspected and approved, and as per manufacturers specifications.

Absorbant surfaces shall be evenly damped so as to give an even suction. In dry weather, freshly cement painted surfaces shall be kept damp for atleast 2 days and protected from direct sun.

### **13.6.2 WATER PROOF CEMENT PAINT**

- a) The water proof cement paint shall be of approved manufacturer and it shall be of approved colour and shade. The contractor shall bring them to the site in original air tight containers with seals intact.
- b) The brushes to be used shall be as specified by the manufacturers and they shall be got approved by Engineer-in-Charge. The surface to be painted shall be prepared as specified by the manufacturers of the paint. Surfaces shall be thoroughly cleaned free from dirt, dust etc. by brushing and washing down with clean water. Any grease, oil paint or any other foreign materials shall be removed by approved methods.

Rough cast surface shall be thoroughly brushed and washed to remove dirt and dust.

**c) MIXING THE PAINT**

The dry cement paint shall be thoroughly mixed with clean fresh water so as to produce paint of required consistency which for normal work shall be that of ordinary paints. In mixing and application, the contractor shall follow the manufacturer's instructions.

**13.6.3 STEEL WORK**

All iron and steel work delivered to the site already primed, to be examined so as to ascertain the quality and condition of the existing primer to satisfy that it is hard, firmly adhering, and not chalking, blistered or cracked. If the quality or condition of the existing primer is not satisfactory, it shall be completely removed and the surface thoroughly cleaned and wire brushed and primed immediately with the appropriate primer. All iron and steel works delivered to the site un-primed shall be scrapped and wire brushed to remove any rust and loose scale and cleaned to remove all dirt and grease and then primed immediately with the appropriate primer.

The primer coat shall be of red lead paint conforming to IS-102. Primer coat shall be applied only after completely drying the surface to be painted but immediately after cleaning. The contractor shall adhere to the time schedule given by the paint manufacturer regarding application of primer coat.

Under coating puttying shall be done if necessary and directed by the Engineer-in-Charge.

**13.6.4 PAINTING WOOD WORK**

**a) EMBEDDED TIMBER**

Timber embedded in masonry shall be given two coats of hot coal tar or solignum before erection.

**PRIMING COAT**

This shall consist of equal parts of white and red lead mixed to boiled linseed oil to the required consistency applied uniformly over the surface. When this coat is dry, all cracks, holes and other such defects shall be filled with a mixture of one part white lead and three parts ordinary putty. The surface shall then be rubbed down with sand paper and dusted clean.

## **FINISHING COATS**

The first coat shall be thin so that plaster may be thoroughly saturated. The second coat oil plus 1½ oz of litharge or patent driers and shall be applied before the wood work is fixed in position.

### **b) ON OUT SIDE WOOD WORK**

Priming shall consist of 10 lbs of white lead plus 2.28 ltr of raw linseed oil plus 1 ox of red lead plus 2 ox of litharge or patent driers and shall be applied before the wood work is fixed in position.

### **c) STOPPING**

After priming, all small holes, cracks, open joints and similar minor defects of every kind shall be stopped with putty made from pure whiting mixed to the proper consistency with raw linseed oil, a little white lead being worked in after mixing to help the hardening of the putty. On no account putty is to be used before the priming coat is put on.

### **d) ADDITIONAL COATS**

After applying primer coats, the work shall be lightly rubbed down smooth with sand paper and the subsequent coats of paint of the specified shade approved by the Engineer-in-charge shall be applied. The paint shall be applied with brushes. It shall be spread as smoothly as possible with the brush by means of crossing (right angles to the grain) and then laying off crossing with the brush marks are not visible. Each coat of paint shall be allowed to dry thoroughly and shall be lightly rubbed down before the next is laid. Every coat of paint shall be passed by the Engineer-in-Charge before the next is laid on it. The finished surface shall not show any rain marks, ridges, or dry patches of paints and no puddles shall be left in the corners of panels and angle of moulding.

### **e) USE OF SAND PAPER**

The surface shall be rubbed smooth with sand paper, first with coarse grade and then finished with a medium grade paper. Sand papering must be finished with the grain. When finished no scratches from the coarse paper should show.

### **f) Before priming coat is applied, the knotting shall be done by one of the following methods as directed by the Engineer-in-Charge.**

a) Ordinary or size knotting – This shall be applied in two coats. The first to be made by grinding red lead in water and mixing it with strong glue size, used hot. The second coat shall be of red lead ground in linseed oil and thinned with boiled linseed oil and turpentine.

- b) Lime knotting – Cover the knot with hot lime and leave for 24 hours then scrap off and coat the surface with size knotting as above.
- c) Patent knotting – This consists of 2 coats of a varnish made by dissolving shellac in methylated spirits of wine.

#### **13.6.4.1 PAINTING WITH ENAMAL PAINT**

Enamel paint shall conform to IS 2933. Paint of approved brand, manufacturer and colour only shall be used. The preparation of surface for painting etc all shall be as in the case of other painting works above.

#### **13.6.4.2 PAINTING WITH SYNTHETIC ENAMEL PAINT**

Synthetic enamel paint shall conform to IS 2932 paint of approved brand, manufacturer and colour only shall be used. Preparation of surface shall be similar to that for enamel painting. One coat of the specified ordinary paint of shade suited to the shade of top coat shall be applied and allowed to dry over night. 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. The top coat of synthetic enamel paint of desired shade shall be applied after the under coat is thoroughly dry. Additional finishing coat shall be applied if found necessary to ensure properly uniform surface. All other details shall be generally as per that for enamel painting.

#### **13.6.4.3 PAINTING WITH ALUMINUM PAINT**

The aluminium painting shall conform to IS 2339. Paint of approved brand and manufacturer only shall be used. The paint comes in compact dual container with the paste and medium separately which shall be mixed together to proper consistency for use.

When applied for steel work, all rust and scale shall be removed by scraping, brushing with steel wire etc and smoothened with sand paper and thoroughly cleaned of dust. Each coat of painting shall be allowed to dry for atleast 24 hours and lightly rubbed down with fine grade sand paper and dusted off prior to next coat. The paint container should be frequently stirred to avoid settling of aluminium paste. The paint shall be applied quickly otherwise it is difficult to finish the surface.

#### **13.6.5 PAINTING WITH ANTICORROSIVE BITUMASTIC PAINT**

Ready mixed paint conforming to IS 158 of approved brand and manufacturer shall be used. It shall be black, lead free; acid; alkali; heat water resistant. The

drying time between alternate courses shall not be less than 3 hours. All other specifications shall be generally as per other painting works.

### **13.7 WASHABLE DISTEMPER**

a) Washable distemper of approved make, colour and shade shall be used, It shall conform to IS-427.

- \* The surface to be distempered shall be cleaned and all cracks, holes and surface defects shall be repaired with gypsum and allowed to set hard. All irregularities shall be sand papered smooth and wiped clean. The surface so prepared must be completely dry and free from dust before distempering is commenced. The priming coat shall be applied over the completely dry surface in the manner recommended by the makers in the case of patent distempers.

### **b) WASHABLE OIL BOUND DISTEMPER**

- \* The specifications for this item shall be same as for washable distemper except that washable oil bound distemper of the approved shade of colour conforming to IS 428. This shall be used after applying priming coat of petrifying liquid or other primer as may be recommended by the manufacturer of the distemper. Cement primer or distemper primer as described, of the same manufacture as distemper, as described in the items may also be adopted.

Only quantity of distemper required for days work shall be prepared. The distemper and primer shall be brought by the contractor in sealed tins in sufficient quantities at a time for the work and the same shall be kept in the joint custody of the contractor and Engineer-in-Charge. The empty tins shall not be removed from the site of work till the painting work is completed, consumption of painting material assessed, painting work passed by the EIC and removal of empty tins permitted by Engineer-in-charge.

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

If the wall surface plaster has not dried, completely, cement primer shall be applied before distempering the wall. But if distempering is done after the wall surface has dried completely, distemper primer shall be applied. Oil bound distemper is not recommended to be applied within six months of the completion of the wall plaster. However newly plastered surface is required to be distempered before a period of six months, it shall be given a coat of alkali

resistant priming paint conforming to IS 109 and allowed to dry for atleast 48 hours before distempering is commenced.

Unless otherwise stated for old works no primer coat is necessary

### **13.8 WHITE WASH / COLOUR WASH**

The surface shall be prepared by removing all mortar droppings and foreign matter and thoroughly cleaned with wire of fibre brush and other means as may be ordered by the Engineer-in-charge to reproduce an approved clean and even surface. All loose pieces and scales shall be scrapped off and holes stopped with mortar which shall be cured afterwards.

On the surface so prepared, the white wash shall be laid, each coat shall be laid on with a brush. The first stroke of the brush shall be from the top downwards, another from bottom upwards over the first stroke, and similarly, one stroke from the right and another from the left over the first brush before it dries. This will form one coat. In all, three such coats of white wash shall be applied. Each coat must be allowed to dry and shall be subject to inspection before the next coat is applied. When dry the surface shall show no signs of crackings. It shall present a smooth and uniform finish free from brush marks and it should not come off easily when rubbed with a finger.

Doors, windows, floors etc shall be protected from being splashed upon. Splashing and droppings if any, shall be removed and the surface cleaned.

#### **13.8.1 COLOUR WASH**

The base coat shall be a white wash as described above. The colour wash shall be prepared by adding necessary colouring matter of approved make to the white wash which has been strained. The colour shall be as approved by Engineer-in-Charge.

The contents of the drum or tin shall be stirred well before use. Thinning of paint shall not be permitted without the specific permission of the Engineer-in-Charge.

#### **13.8.2 WHITE WASH**

White wash shall be prepared from fresh burnt white lime stone or shell lime. The lime shall be of C type as mentioned in IS-712. The lime shall be dissolved in a tub with sufficient quantity of water (about 4.5 litres / 1 kg of lime) and the whole thoroughly mixed and stirred until it attains the consistency of thin cream. The wash shall be taken out in small quantities and strained through a clean course cloth. Alternatively ready made whiting complying



with IS 63 may also be used. Clean gum dissolved in hot water shall then be added in suitable proportion of 2 gm of gum to 1 cft of lime to prevent the white wash coming off easily when rubbed.

### **13.9 WALL PAINTING WITH PLASTIC EMULSION PAINT**

Wall painting with plastic Emulsion paint on New work.

#### **GENERAL**

Plastic emulsion paints are not suitable for application on external wood and iron surfaces and surfaces which are liable to heavy condensation and are to be used generally on masonry or plastered surfaces. Suitable primer as per manufacturer shall be provided.

#### **PAINT**

Plastic emulsion paint of approved brand and manufacture and of the required shade shall be used.

#### **PREPARATION OF SURFACE**

The surface shall be thoroughly cleaned of dust, old white or colour wash by washing and scrubbing. The surface shall then be allowed to dry for atleast 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 undulation and then sand papering the same after it is dry.

#### **APPLICATION**

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

The paint will be applied in the usual manner with brush 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 surfaces to 20 to 3 hours on non-absorbent surfaces.

The thinning of emulsion is to be done with water and not with turpentine.

Thinning with water will be particularly required for the undercoat which is applied on the absorbent surface. The quantity of thinner to be added shall be as per manufacturer's instructions.

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.

## PRECAUTIONS

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

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.

- b) In the preparation of walls for plastic emulsion painting, no oil base putties shall be used in filling cracks, holes etc.
- c) Splashes on floors etc. shall be cleaned out without delays as they will be difficult to remove after hardening.
- d) Washing of surfaces treated with emulsion paints shall not be done within 3 to 4 weeks of application.

## OTHER DETAILS

These shall be as per specification for "painting" as far as they are applicable.

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## CHAPTER 14

### REPAIRS TO BUILDINGS

#### 14.0 REPAIRS TO PLASTER

- 14.1 Repairs to plaster includes cutting the patch and preparing the wall surface with respect to patches of 2.50 square metres and less in area. Plastering in patches over 2.5 square metres in area shall be considered as regular plastering and shall be paid for accordingly.

#### 14.1.1 SCAFFOLDING

Scaffolding as required for the proper execution of the work shall be erected. If work can be done safely with the ladder of jhoola with the approval of EIC in writing, these will be permitted in place of scaffolding.

#### 14.1.2 CUTTING

The mortar of the patch, where the existing plaster has cracked, crumbled or sounds hollow when gently tapped on the surface shall be removed. The patch shall be cut to a square or rectangular shape at position marked on the wall as directed by the departmental staff. The edges shall be slightly under cut to provide a neat joint.

#### 14.1.3 PREPARATION OF SURFACE

The masonry joints which become exposed after removal of old plaster shall be raked out to a minimum depth of 10mm in the case of brick work and 20mm in the case of stone work. The raking shall be carried out uniformly with a raking tool and not with a basuli, and loose mortar dusted off. The surface shall then be thoroughly washed with water, and kept wet till plastering is commenced.

In case of concrete surfaces, the same shall be thoroughly scrubbed with wire brushes after the plaster had been cut out and pock marked. The surface shall be washed and cleaned and kept wet till plastering is commenced.

#### 14.1.4 APPLICATION OF PLASTER

Mortar of specified mix with the specified sand shall be used. The method of application shall be as described for single coat plaster work of the specified

mix. The surface shall be finished even and flush and matching with the old surrounding plaster. All roundings necessary at junctions of walls ceilings etc. shall be carried out in a tidy manner specified.

All dismantled mortar etc. shall be disposed of as directed by the Engineer-in-Charge.

#### **14.1.5 PROTECTIVE MEASURE**

Doors, windows, floors, articles of furniture etc. and such other parts of the building shall be protected from being splashed upon. Splashing and droppings if any, shall be removed by the contractor at his own cost and the surface cleaned. Damages, if any, to furniture of fittings and fixtures shall be recoverable from the contractor.

#### **14.1.6 CURING**

Curing shall be done as for plaster work with special reference to the particular type of plaster mix as described under sub-head 'finishing'.

#### **14.1.7 FINISHING**

After the plaster is thoroughly cured and dried the surface shall be finished with white washed or colour washed etc. to suit the existing finishing as required unless specified otherwise.

#### **14.1.8 MEASUREMENTS**

Length and breadth shall be measured correct to a cm. The area shall be calculated in square meter correct to two places of decimal. Patches below 0.05 square meter in area shall not be measured for payment.

Pre-measurements of the patches to be plastered shall be recorded after the old plaster has been cut and wall surface prepared.

#### **14.1.9 RATE**

The rate includes the cost of all the materials and labour involved in all the operations described above including lead for disposal of old dismantled plaster.

#### **14.2 MAKING OPENING IN THE MASONRY CONSTRUCTION AND FIXING CHOWKHATS FOR DOORS, WINDOWS AND CLERESTORY WINDOWS**

**14.2.0** Before making opening it is necessary to examine that the wall exclusive of opening is adequate to take the load coming on the structure. All the structural

members supported on the walls which have direct bearing over the area in which opening is to be made, shall be properly supported with props to relieve the load from masonry wall till the lintel over the opening is strong enough to take the load. Care should also be taken not to disturb the adjoining masonry.

All Precautions as explained in Chapter 15 (Demolition and Dismantling) should be followed in case of dismantling the external walls. The portion to be dismantled may be clearly marked on both sides of the wall. Dismantling shall be carried out from top to bottom within the marked area. The sides of the opening shall be as far as possible, parallel and perpendicular to the plane of wall.

#### **14.2.1 MAKING OPENING**

The openings for fixing door/window frames shall be to the extent of accommodating the holdfast. The holdfasts shall be fixed in cement concrete 1:3:6 (1 cement : 3 coarse sand : 6 stone aggregate 20mm nominal size) or in masonry as required. Where only opening is to be made in the masonry, the width of the opening shall be such that the sides of the masonry can be built true to line and plumb and such masonry built shall conform to the specifications of the particular type of masonry in which the opening is made with particular reference to size of corner stones etc. In order to get continuity with old masonry, proper key shall be provided. The height of the opening shall be such that it can accommodate the required depth of the RCC lintel also.

14.2.1.1 The sides of opening in masonry shall be cleaned of all dust, mortar, brick/bats. Loose stones, chips etc. and the surface left rough and thoroughly wetted.

14.2.1.2 The lintel shall be invariably cast first in the opening made for the purpose. One side of the shuttering shall be kept open in the beginning till the concrete is laid. The shuttering shall then be fixed for half of the opening and concreting completed.

14.2.1.3 Curing of lintel cast shall be done for a minimum period of 7 days.

14.2.1.4 Precast RCC lintel or R.S. Joist may also be used when directed by the Engineer-in-Charge.

#### **14.2.2 FIXING CHOWKHATS**

The sides of chowkhats of door, window or clerestory window abutting against or to be embedded in masonry shall be painted with two coats of tar

before being placed in position. The chowkhats shall then be inserted in position with their hold fast bolted tight. The chowkhats shall then be adjusted to proper line plumb and secured in position by temporary bracing which shall not be disturbed or removed until the hold fast are embedded in the masonry and the concrete block has set. The concrete to be used for embedding the hold fast shall be cement concrete 1:3:6 (1 cement : 3 coarse sand : 6 graded stone aggregate of 20mm nominal size).

The minimum size of concrete block in which the hold fasts will be embedded shall be 30 x 10 x 15 cm for 35 cm long hold fasts. The concrete of the block shall completely fill the holes made in the masonry for the purpose. The chowk cut in the floor shall be cut square and construction joint shall be provided filled with cement concrete 1:2:4 (1 cement : 2 coarse sand : 4 graded stone aggregate of 20mm nominal size) and rendered smooth at the top and finished to match the existing type of floor.

### **14.2.3 FINISHING**

14.2.3.1 After the surface of the sides of masonry opening and lintel are sufficiently dry and set, it shall be cleaned free of dust, loose mortar etc. and wetted thoroughly. It shall then be plastered or pointed as required flush with the surrounding masonry work. Any other portion of the wall if damaged shall be finished in similar manner at no extra cost.

14.2.3.2 After the cement plaster/pointing has been thoroughly cured and have dried the surface shall be either white or colour washed/painted as required. The surface of the wall which is spoiled due to splashing of mortar shall be cleaned.

### **14.2.4 MEASUREMENTS**

The opening made for doors, windows, clerestory windows shall be counted by numbers separately

### **14.2.5 RATE**

The rate shall apply irrespective of the size of the opening upto a maximum area of 3.75 square metres for doors, 2.50 square meters for windows and 1.20 square meters for clerestory windows. The rate is inclusive of labour and material involved in all the operations described above.

Cost of Chowkhats, cost of CC blocks, cost of supplying the hold-fasts bolts cost of RCC lintel or R.S. Joist which shall be paid for separately unless otherwise stipulated.

### **14.3 REPAIRS / REPLACEMENT OF DOORS AND WINDOWS SHUTTERS**

- 14.3.1 The damaged shutter shall be carefully examined by the Engineer-in-Charge to decide whether entire shutter along with panels and fittings is to be replaced or only a part of the shutter is required to be replaced. Keeping in view the condition and remaining life of the portions to be retained.
- 14.3.2 If the entire shutter is to be replaced, the shutter in question should be removed from the existing frame without damage to the frame and the hinges and fittings should be removed for reuse in the new shutter proposed to be fixed.
- 14.3.3 The new shutter shall be of the same class of timber as the dismantled one unless otherwise decided by the Engineer-in-Charge. The specifications for manufacture and fixing of the new shutter shall be as per that for new work.
- 14.3.4 At the time of fixing the shutter in the frame any minor adjustment required to the rebates in the frame shall be attended to ensure proper fitting of the shutter and fixing of hinges may be done with new wood screws in new locations. Slightly away from the original location to ensure proper fixing of the hinges to the frames.
- 14.3.5 Any old fitting of the dismantled door which are worn out or damaged may be replaced with new one as directed by the Engineer-in-Charge.
- 14.3.6 When so directed by the Engineer-in-Charge only a portion of the shutter viz. rails or styles may be replaced with new member of the same class of timber with shape and size matching the portions retained. The dismantling of the member shall be done with care so that mortar or tennon of the existing member is not damaged and the new member fixed carefully and properly as in the case of new work.

### **14.3.7 MEASUREMENTS**

Unless otherwise specified Measurements shall be made for total replaced shutter, if entire shutter has been replaced. If only paneling or part of paneling has been replaced, measurements shall be made for the portion replaced. If styles and rails are only to be replaced, measurements shall be made for the replaced styles and rails.

### **14.3.8 RATE**

The rate shall include the cost of all operations mentioned above.

#### **14.4 RENEWING GLASS PANES WITH PUTTY AND NAILS**

##### **14.4.1 REMOVING BROKEN GLASS PANES**

Old putty shall be raked out with hack knife. The brad (small nails without head) and pieces of broken glass shall be removed from the rebates of the sash bars. The pieces of glass panes as found useful shall be handed over to the Engineer-in-Charge of the work. No glass shall be inserted in frames until they have been primed and prepared for painting so that the wood may not draw oil out of putty.

##### **14.4.2 GLASS PANES**

The glass panes shall conform detailed specifications for the same.

##### **14.4.3 FIXING**

The glass panes shall be so cut that it fits slightly loose in the frame. A thin layer of Putty conforming to IS:419 shall be prepared by mixing one part of white lead with three parts of finely powdered chalk and then adding the boiled linseed oil to the mixture to form a stiff paste and adding varnish to the paste @ 1ltr of varnish to 18kg of paste. The putty so prepared in the form of a stiff paste shall be drawn along the inner edge of the rebate, for bedding the back of the glass panes. The glass pane shall then be put in position, pressed home against the thin layer of the putty, and secured in rebate by new brads. The brads shall not be spaced more than 7.5cm from each corner and not more than 15cm apart. The putty shall then be applied in the rebate uniformly, sloping from the inner edge of the rebate. In doing this care shall be taken to keep the putty a little within the inner edge of the rebate and surplus putty removed so that none of it is seen through the glass from the inside. The putty so filled in the rebates shall be leveled smooth and finished in a straight line. When dried the putty shall be covered with a coat of paint of approved quality and shade to match the existing finish of joinery work.

The glass panes shall be cleaned with methylated spirit. All splashing or droppings of washing and paints shall be removed. All rubbish and unserviceable materials shall be disposed off of the dumping ground.

**NOTE:** Frosted glass panes should be replaced with frosted glass panes. These shall be fixed with frosted face on the inside.

##### **14.4.4 MEASUREMENTS**

Length and breadth of glass panes shall be measured correct to a cm. The area of the glass panes as fixed shall be calculated in square meter correct to two places of decimal.



#### **14.4.5 RATE**

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

#### **14.5 RENEWING GLASS PANES WITH WOODEN FILLETS**

##### **14.5.1 REMOVING BROKEN GLASS PANES**

The Specifications shall be the same as in para 14.6.1 except the wooden fillets including nails shall be taken out carefully.

##### **14.5.2 GLAZING**

The specifications for glass panes and their fixing shall be the same as given in Chapter 9 of this booklet. The fillet shall either be fixed flush or projected uniformly to match with the existing work.

The new fillet provided shall be painted or finished otherwise to match with the existing finish of the joinery work.

The glass panes shall be cleaned with methylated spirit of all sorts of splashing and droppings of wash and paints.

All rubbish and unserviceable materials shall be disposed off in the dumping ground.

##### **14.5.3 MEASUREMENTS**

Length and breadth of glass panes shall be measured correct to a cm. The area of the glass panes as fixed shall be calculated in square metre correct to two places of decimal including necessary nails (brads).

The new wooden fillets fixed shall be measured in running meters correct to a cm.

##### **14.5.4 RATE**

The rates shall include the cost of labour and material involved in all the operations described above extent that the cost of new wooden fillets used in the work and their finishing shall be paid for separately.

#### **14.6 PROVIDING NEW WOODEN FILLETS**

**14.6.1** The fillets shall be of wood as specified in the item of work. These shall be cut and planed smooth to the required shape and dimensions.

#### **14.6.2 FIXING**

The specifications for glass panes and their fixing shall be the same as that for original work. The fillet shall either be fixed flush or projected uniformly to match the existing work.

The fillet shall be painted or finished otherwise to match with the existing finish of the joinery work.

The glass panes shall be cleaned of all sorts of splashing and dropping of wash and paints with methylated spirit.

#### **14.6.3 MEASUREMENTS**

The fillets shall be measured in running meters. The lengths shall be measured correct to a cm.

#### **14.6.4 RATE**

The rate shall include the cost of all labour and materials involved in all the operations described above. The rate shall also include the cost of removal of worn out fillets, when these are met with in old work. The rate shall vary according to the class of wood used.

#### **14.7 RENEWAL OF OLD PUTTY OF GLASS PANES**

14.7.1 The old putty shall be removed as specified in 14.4.1 and new putty fixed as specified in 14.4.3.

#### **14.7.2 MEASUREMENTS**

The work shall be measured in running meters. The length along the rebate shall be measured correct to a cm.

#### **14.7.3 RATE**

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

#### **14.8 GUNITING TO DAMAGED RCC COLUMNS AND BEAMS**

14.8.1 RCC columns and beams which have cracked or where reinforcements have deteriorated shall be repaired by guniting. Where necessary centering for the beams and slab and shoring for the columns in both the planes shall be provided before guniting is started.

Sequence of strengthening work shall be as under:

- 14.8.1.1 Strengthening of first floor beams and column from the footings upto the middle, of the second storey.
- 14.8.1.2 Strengthening of beams of second floor and columns from the middle of second storey to middle of third storey.
- 14.8.1.3 Strengthening of beams of 3<sup>rd</sup> floor and terrace beams and columns from the middle of 3<sup>rd</sup> storey upto terrace level.
- 14.8.1.4 At least 7days strength shall be attained by the gunited beams before any load from top floor is transferred to the floor beams. The members which are to be strengthened shall be relieved of the dead load. The repair work shall be done from ground floor upward.

#### **14.8.2 PREPARATION OF SURFACE**

Before strengthening the structural members by guniting the surface of the existing members shall be prepared as under:

##### **14.8.2.1 CONCRETE SURFACE**

Any existing plaster on RCC work shall be removed and RCC surfaces shall be roughened with footmarks at least 6mm deep at close intervals not more than 1cm centers to form a bond for the cement gunite plaster. In case of masonry walls, plaster, if any, shall be completely removed and joints raked out to a depth of 20mm. All cracks shall be opened out to maximum depth possible in V shape and the surface shall be cleaned of all loose mortar and foreign matter.

##### **14.8.2.2 REINFORCEMENT**

The reinforcement bars shall be cleaned properly to remove all the scales and rust by wire brushing and by rubbing with emery paper. A coat of neat cement slurry shall be applied on the existing reinforcement after cleaning it as mentioned above just before the guniting is done.

##### **14.8.3 PLACING ADDITIONAL REINFORCEMENT**

The additional reinforcement based on actual design shall be placed in position by fixing it to the existing concrete by fastening with wires tied to nails driven into the concrete and secured rigidly and supported so that reinforcement does not get displaced when guniting is done. In any case clear spacing between the reinforcement bars shall not be less than 50mm.

#### **14.8.4 PRECAUTION**

Gunite shall be continuously inspected to check the materials. Forms, reinforcement running of equipment, application of guniting and curing. Any defective area found shall be removed and got redone.

- 14.8.5 Gunite is a mixture of cement and sand deposited in the form of cement paster ranging from 12 to 50 mm thick for walls and 100mm for floors ejected under a pressure fo 2 to 3 kg/square cm from a machine called cement gun. The cement and sand are mixed almost dry and screened through a sieve of specified designation, and mixture is blown dry through a hose and water just sufficient for the purpose of hydration added at the nozzle. A separate hose carries the water to the nozzle. Under a pressure of 1 to 1.5kg/square cm unless otherwise specified by the manufacturer of the gun and the nozzleman regulates the quantity by means of a hand operated valve.

#### **14.8.6 MEASUREMENTS**

Breadth and length of face repaired/ gunited surface shall be measured correct to a cm and area shall be calculated in sqm correct to two places of decimal.

#### **14.8.7 RATE**

The rate shall include the cost of all operations, described above including the cost of additional reinforcements described which shall be paid separately unless otherwise specified.

#### **14.9 REPAIR TO CEMENT CONCRETE FLOORING**

- 14.9.1 The flooring to be replaced should be dismantled carefully without damaging the base and the dismantled material disposed off as directed by the Engineer-in-Charge.
- 14.9.2 The panels of the flooring to be repaired shall be adjusted according to the existing pattern and proper slope as per the existing floor slope shall be maintained. No damage shall be done to the existing floor panels. Edges of the adjoining panels shall be repaired and strengthened and surface shall be made smooth to get straight vertical joint.
- 14.9.3 The specification for concrete shall generally apply for flooring concrete also.
- 14.9.4 Length and breadth shall be measured correct to a cm and its area as laid shall be calculated in sqm correct to two places of decimal. Length and breadth shall be measured before laying skirting dado or wall plaster. No deduction shall be made nor extra paid for any opening in the floor of area upto 0.10 sqm.

14.9.5 The rate shall include the work of dismantling the existing flooring unless otherwise specified.

**14.10 REPAIRS TO CEMENT CONCRETE FLOORING (OF RED OXIDE OF IRON)**

14.10.1 The flooring to be replaced should be dismantled carefully without damaging the base and the dismantled material disposed off as directed by the Engineer-in-Charge.

14.10.2 The panels of the flooring to be repaired shall be adjusted according to the existing pattern and proper slope as per existing floor shall be maintained, edges of the adjoining panels shall be repaired and strengthened and surface shall be made smooth to get straight vertical joints.

14.10.3 If directed, for ensuring that the repaired floor matches with existing flooring sample of cement concrete flooring shall be prepared and got approved from the Engineer-in-Charge before laying the cement concrete flooring.

14.10.4 The specification given for original concrete flooring shall generally apply for repairs also.

14.10.5 Length and breadth shall be measured correct to a cm and its area laid shall be calculated sqm correct to two places of decimal, length and breadth shall be measured before laying skirting, dado or wall plaster. No deduction shall be made nor extra paid for any opening in the floor of area upto 0.10 sqm.

14.10.6 The rate shall include the work of dismantling the existing flooring unless otherwise specified.

**14.11 REPAIRS TO TERRAZZO (MARBLE CHIPS) FLOORING LAID IN SITU**

14.11.1 The flooring to be replaced should be dismantled carefully without damage to the base and dismantled materials disposed off as directed by the Engineer-in-Charge.

14.11.2 The Panels of the flooring to be repaired shall be adjusted according to the existing pattern and proper slope as per existing floor shall be maintained. Edges of the adjoining panels shall be repaired and strengthened and surface shall be made smooth to get straight vertical joints.

14.11.3 Samples of terrazzo (marble chips) flooring conforming to shade texture and pattern of the existing flooring shall be prepared and got approved from the Engineer-in-Charge before commencing the work.

14.11.4 Cement slurry shall be applied to the edge of existing flooring before fixing of glass strips.

14.11.5 Terrazzo tile flooring shall be laid higher than the level of existing flooring to make allowance for rubbing and polishing.

14.11.6 The specification given for cast in situ terrazzo flooring shall generally apply.

#### **14.11.7 MEASUREMENTS**

Measurements shall be made for the surface area of floor repaired longitudinal measurement shall be made correct to cm and area is sqmt to two decimal digits.

14.11.8 Unless otherwise specified the rate shall include all labour and material charges.

#### **14.12 REPAIR TO TERRAZZO TILE FLOORING**

14.12.1 The flooring to be replaced should be dismantled carefully without damage to the base and the dismantled materials disposed off as directed by the Engineer-in-Charge.

14.12.2 The patches of terrazzo tile flooring to be repaired shall be adjusted according to the existing pattern and proper slope as per existing floor shall be maintained.

14.12.3 Samples of terrazzo tile shall be got approved from Engineer-in-Charge before the start of the work to match the shade texture and pattern of the existing terrazzo tile flooring.

14.12.4 The specifications for terrazzo tile flooring shall generally apply.

#### **14.12.5 MEASUREMENTS**

Measurements shall be made for the area more than 0.40 sqm as per original terrazzo flooring work and shall be measured in number for the area equal to or less than 0.40 sqmt.

14.12.6 Specified in work order the rate shall include the work of dismantling the existing flooring in addition to what is specified unless otherwise specified.

#### **14.13 REPAIRS TO TERRAZZO TILES/ GLAZED TILE WORK IN DADO**

14.13.1 The portion of dado to be replaces should be dismantled carefully without damage to the base and the dismantled materials disposed off as directed by the Engineer-in-Charge.

14.13.2 Samples of terrazzo tile/glazed tile matching the existing tiles in dado in respect of texture shade size and pattern may be got approved by the Engineer-in-Charge before starting the work.

14.13.3 The specification for terrazzo tiles and glazed tile works in dado shall generally apply.

#### **14.13.4 MEASUREMENTS**

Measurements shall be done as per that for original dado work for the area more than 0.40 sqmtr and will be measured in number for the area equal to or less than 0.40 sqmtr unless otherwise specified.

14.13.5 The rate shall include the work of dismantling the existing dado and disposal of the dismantled material in addition to what is specified unless otherwise specified.

#### **14.14 PRECAUTIONS TO PREVENT CRACKS IN BUILDINGS**

14.14.0 In order to minimise cracks in building the following measures shall be adopted subject to the approval of the Engineer-in-Charge.

14.14.1 Cracks in General.

14.14.1.1 Masonry work shall be proceeded systematically and uniformly at all levels.

14.14.1.2 The plaster work in wall shall be deferred as much as possible so as to let shrinkage in RCC and masonry take place before plastering.

14.14.1.3 Where required as per working drawings 12mm wide gap shall be provided and filled with impregnated fiber base or bituminous filler as specified when two slabs butt against each other and bear on an internal wall. Such expansion joints should always be provided at ridges (and not in valleys).

14.14.1.4 Ceiling plaster shall be done first and then the wall plaster. When the ceiling plaster is done, it shall be finished with a chamfered edge at an angle at its junction with the wall at bearings with a trowel while the plaster is still green. Similarly when the wall plaster is being done, it shall be kept separate from the ceiling plaster by a thin straight groove drawn with a trowel at an angle with the wall, while the plaster is still green.

14.14.1.5 RCC or plain cement concrete 1:2:4 bed plate with smooth surface and a thick coat of lime wash or kraft paper shall be provided under the beams. The plaster of wall and the bed plate kept separated from that of the beam. Minimum thickness of bed plate shall be 10cm and that of plain concrete 20 cm.

#### 14.14.2 Horizontal crack in masonry & plaster.

- (i) At floor or roof slab level.
- (ii) At junction of sun shade and wall.

14.14.2.1 A smooth bearing for RCC slabs and beams on the wall with 6mm cement plaster 1:3 (1 cement : 3 fine sand), finished with a floating coat of neat cement shall be provided and then finished with a thick coat of lime wash or craft paper. The sides of top of slabs and beams in contact with walls shall be painted with thick coat of hot bitumen.

#### 14.14.3 TRANSVERSE CRACKS IN RCC SLAB OF SUN-SHADES, VERANDAHS AND ROOMS

Expansion joints shall be allowed at 5 to 6 mtrs intervals in case of sun shades 12 to 15mtrs in case of covered verandah slabs and 12 to 15 mtr in case of slab continuous over rooms in a row of quarters. To prevent cracks in the masonry below or above the expansion joints, the following measures shall be taken.

##### 14.14.3.1 SUN SHADES

In this case, the expansion joints shall not extend to the portion embedded in masonry but shall start from 5cm from the face of the wall and the distribution reinforcement in the embedded portion and in the 5cm portion of the chajja slab where there is no expansion joint, shall be increased to 40% of main reinforcement. The gap of the expansion joint in the projected portion shall not be filled with any materials.

##### 14.14.3.2 VERANDAH SLAB

In this case, the expansion joint shall be neat butt joint which shall be finished straight. The joint shall be carried right through the portion embedded in the masonry also. It is desirable to provide a vertical butt joint in the masonry supporting the verandah slab at the expansion joints right from plinth level. Where this is not possible RCC or plain cement concrete bed plates shall be provided on the bearing. To prevent cracks in the masonry above, the longitudinal wall shall also have a butt joint with gap running in the same vertical plane as the joint in the slab. The gap in the case of roof slabs can be sealed by aluminum cradles as shown in drawings.

##### 14.14.3.3 ROOM SLABS

In load bearing structures expansion joint in room slabs shall be similar to that in verandah slabs. Where slab is combined with T-beams, the expansion joint



shall be provided by substitution one of the T-beams, with rectangular beam and slabs.

- 14.14.3.4 In RCC framed structure, the expansion joint is generally provided in conjunction with twin beams and twin columns. The expansion joint shall be provided with aluminum cradle and its top filled with bituminous material. The underside of the beam shall be provided with sheet of asbestos or any other suitable materials, which shall be fixed on one side and shall be free to move on the other side within oval shaped holes, in case of twin-columns, the expansion joint is similarly covered on the inside and outside.

If not specified the gap between the twin columns and the gap below aluminum cradle twin beams need not be filled. However before, the joints are covered on the outside with asbestos or other suitable material as specified, the gap should be cleaned thoroughly of all rubbish or mortar dropping etc., in case of larger expansion joints (Generally more than 10 cm).

In case of gap between the twin columns and gap below aluminum (cradle) in twin beams may be filled up with impregnated fiber board or any approved filler in all the floors so that rubbish or mortar droppings etc., may not enter into the expansion joints.

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## CHAPTER 15

### DISMANTLING AND DEMOLITION

#### 15.0 TERMINOLOGY

##### 15.0 (A) DISMANTLING

The term 'Demolition' implies breaking up. This shall consist of demolishing whole or part of work including all relevant terms as specified or shown on the drawings.

#### 15.1 GENERAL

This chapter relates to building only.

- 15.1.1.1 All materials obtained from dismantling or demolition shall be the property of the Government unless otherwise specified and shall be kept in safe custody until they are handed over to the Engineer-in-Charge.
- 15.1.1.2 Due care shall be taken to maintain the safety measures prescribed in IS:4130 and CED construction safety manual of CED /DOS.
- 15.1.1.3 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 Engineer-in-charge.
- 15.1.1.4 Necessary precautions shall be taken to keep down the dust nuisance to the minimum.
- 15.1.1.5 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 Engineer-in-Charge.
- 15.1.1.6 Any serviceable material, obtained during dismantling or demolition, shall be separated out and stacked properly as directed by the Engineer-in-Charge within a lead of 50 metres. All unserviceable materials rubbish etc shall be disposed off as directed by the Engineer-in-Charge.

- 15.1.1.7 The contractor shall maintain / disconnect existing services, whether temporary or permanent, where required by the Engineer-in-Charge.

## **15.1.2 MEASUREMENTS**

- 15.1.2.1 All work shall be measured net in the decimal system, as fixed in its place, subject to the following limits, unless otherwise stated herewith.

- a) Dimensions shall be measured correct to a cm
- b) Areas shall be worked out in sqm correct to two places of decimal
- c) Cubical contents shall be worked out to the nearest 0.01 cum

- 15.1.2.2 Measurements of all work except hidden work shall be taken before demolition or dismantling and no allowance for increase in bulk shall be allowed.

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

- 15.1.2.4 Work executed in the following conditions shall be measured separately

- a) Work in or under water and / or liquid mud.
- b) Work in or under foul position.

## **15.1.3 RATES**

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 of unserviceable materials within a distance of 50 meters. The rate shall also include for temporary shoring for the safety of portions not required to be pulled down or of adjoining properly, and providing temporary enclosures or partitions, where considered necessary.

## **15.2 ROOFS**

- 15.2.1 Roofs covering generally including battens boarding, mats, bamboo jaffari or other subsidiary supports shall be measured in square metres except lead sheet roof covering which shall be measured in quintals (15.2.3) and stone slab roof covering which shall be measured in cubic metres.
- 15.2.2 R B or R C C roofs shall be measured as specified in 15.7
- 15.2.3 Supporting members, such as rafters, purlins, beams, joists, trusses etc. Where of wood shall be measured in cubic metres and steel or iron sections in quintals.

### **15.3 CEILING**

The stripping of ceilings shall be measured in square metres.

15.3.1 Dismantling of supporting joists, beams, etc shall be measured in cubic metres or in quintals as specified in 15.2.3.

15.3.2 Height above floor level, if it exceeds 3.5m shall be paid for separately, unless otherwise specified.

### **15.4 FLOORING AND PAVINGS**

Dismantling of floors (except concrete and brick floors) shall be measured in square metres, stating the thickness. Supports such as joints, beams etc., if any shall be measured as per 15.2.3. Concrete and brick paving shall be measured as per 15.5.

### **15.5 CONCRETE AND BRICK ROOFS AND SUSPENDED FLOORS**

Demolition of floors and roofs of concrete or brick shall be measured in cubic meters. Beams cantilevers or other subsidiary supports of similar materials, shall be included in the item. In measuring thickness of roofs provided with water proofing treatments with bitumen felts, the thickness of water proofing treatment shall be ignored.

### **15.6 WALLS AND PIERS**

15.6.1 Taking down walls and independent piers or columns of brick, stone or concrete shall be measured in cubic metres. All copings, corbels cornices and other projections shall be included with the wall measurements.

In measuring thickness of plastered walls, the thickness of plaster shall be ignored.

15.6.2 Ashlar face stones, dressed stone work, precast concrete articles, etc if required to be taken down intact shall be so stated and measured separately in cubic metres.

15.6.3 Cleaning bricks stacking or measurements including all extra handling and removal and disposing off the rubbish as stated shall be enumerated in thousand of cleaned bricks.

15.6.4 Cleaning stone obtained from demolished / dismantling stone masonry of any description including ashlar facing dressed stone work, stone slabs or flagging and precast concrete blocks including all extra handling and disposing off the rubbish as stated shall be measured in cubic metres of cleaned stone.

15.6.5 Honey comb works or cavity walls of bricks stone or concrete shall be measured as solid.

#### **15.7 REINFORCED CONCRETE AND BRICK WORK**

Reinforced concrete structures and reinforced brick roofs and walls shall be measured in cubic metres and if reinforcement is required to be salvaged, it shall be so stated.

Where reinforcement is required to be separated, scrapped and cleaned, the work shall be measured separately in quintal of salvaged steel.

#### **15.8 PARTITIONS, TRELIS WORK ETC.**

Partitions or light walls, of lath and plaster, trellis work, expanded metal, thin concrete or terracotta slabs and other similar materials including frame work if any shall be measured in square metres stating the over all thickness.

#### **15.9 WOOD WORK**

All wood work including karries average 40 sq cm or over in section, shall be measured in cubic metres, while that under 40 sq cm in section, in running meters. Ballies shall be measured in running metres.

Boarding including wooden chajjas and sun shades along with supports shall be measured in square metres in its plane.

#### **15.10 STEEL AND IRON WORK**

- 15.10.1 All steel and ironwork shall be measured in quintals. The weight shall be computed from standard tables unless the actual weight can readily be determined.
- 15.10.2 Riveted work, where rivets are required to be re-erected shall be measured separately.
- 15.10.3 Marking of structural steel required to be re-erected shall be measured separately.
- 15.10.4 In framed steel items, the weight of any covering material or filling such as iron sheets and expanded metal shall be included in the weight of the main article unless such covering is not ordered to be taken out separately.

#### **15.11 DOORS AND WINDOWS**

Dismantling of doors, windows, clerestory windows, ventilators etc. (wood or metal) whether done separately or along with removal of wall by making recess in the wall shall be enumerated. Those exceeding 3 sqm each in area shall be measured separately unless otherwise specified. The item shall include removal of chowkhatas architraves, hold fasts and other attachments.

If only shutters are to be taken out is shall be measured separately.

### **15.12 PIPES AND SEWER LINES**

- 15.12.1 Water pipe lines including rain water pipes with clamps and specials, sewer lines (salt glazed ware or concrete) etc shall be described by their diameter and length measured in running metres inclusive of joints.
- 15.12.2 If the joints, special and fittings etc are required to be separated, it shall be so stated and enumerated.
- 15.12.3 Pucca drains shall be measured under relevant items.
- 15.12.4 Valve cistern, public fountain platform, fire hydrants, etc shall be enumerated.
- 15.12.5 Manholes and inspection chambers shall be enumerated stating the size and depth of manhole/ inspection chamber. They shall be classified into different groups depending upon the depth, in unit of half and one metre depth. The depth of the manhole shall be the distance between the top of manhole cover and invert level of the drain.
- 15.12.6 Ventilating shafts, gully traps, flushing cisterns and other appurtenant items of work shall be enumerated.

### **15.13 FENCING WIRE MESH**

Wire mesh fencing of any type with frame shall be measured in square metres.

### **15.14 GLAZING**

Taking out any portion of serviceable glass except polished plate, from old sashes, skylights, etc (any thickness, weight or size) raking out old putty etc shall be measured in square metres.

Irregular or circular panes shall be measured as rectangle or square enveloping the same. The width and height being measured correct to the nearest 0.5 cm.

### **15.15 ROAD WORK**

- 15.15.1 Different type of road surfaces shall be measured separately.
- 15.15.2 Road surfaces metalling or soling (base) shall be measured in square metres.
- 15.15.3 Concrete paving shall be measured as in 15.5 or 15.7 as the case may be.

## CHAPTER 16

### MISCELLANEOUS BUILDING WORKS

#### 16.1 DAMP-PROOFING BASEMENTS, SUMPS AND RESERVOIRS

##### 16.1.1 DAMP-PROOFING EXISTING STRUCTURES

Damp proof coursing shall be so designed that it shall be capable of withstanding the penetration of moisture and water from an external source at or below ground level or from one part of building or structure to another. Where there is pressure from sub-soil water the treatment should be strengthened by structural layers capable of withstanding the same.

Damp proofing shall be laid in such a way as to ensure an effective barrier against dampness all over. For this purpose the damp-proof course shall be continuous throughout and the overlapping of joints of felts, wherever they occur, shall be perfectly made.

#### (A) DAMP PROOF TREATMENT

The damp proofing shall consist of seven course treatment as given in the description of the item each layer of bonding and self finished bitumen felt counted as a course individually.

A seven course treatment shall consist of the following layers:

An initial treatment of primer of a bituminous solutions consistency applied to the dry and cleaned wall and/or floor surface including grouting of cracks to assist adhesion of bonding materials to the same, in suitable quantities subject to a minimum of 0.25 litre/m<sup>2</sup> depending on the condition and nature of the surface.

- (i) The first course of binding material applied hot at 1.6 kg/m<sup>2</sup>.
- (ii) Second course of self finished bitumen felt of specified brand and manufacture conforming to the type and grade given in the description of the item.
- (iii) Third course of bonding material at 1.6 kg/m<sup>2</sup>.
- (iv) Fourth course of self finished bitumen felt.
- (v) Fifth course of bonding material at 1.6 kg/m<sup>2</sup>.

- (vi) Sixth course of self finished bitumen felt and
- (vii) Seventh and final course of bonding material at 1.6 kg/m<sup>2</sup>.

The primer applied before the first course of bonding material shall not count against the number of courses specified but shall invariably be carried out as part of the damp-proofing treatment.

## **(B) MATERIALS**

### **PRIMARY COAT**

Primer for water proofing (Felt course) shall consist of a liquid bitumen of low viscosity and shall be capable of penetrating a prepared surface on application. Primer shall conform to the requirements of IS:3384 specification for bitumen primer for use in water proofing and shall be of grade 85/25.

### **BONDING MATERIALS**

This shall comprise of blown type petroleum bitumen conforming to IS:702. Suitable blown type petroleum bitumen is of approved quality of IS grade 85/25.

Where bonding materials are proposed to be supplied by the contractor they shall conform in all respect to the specifications in the preceding para.

### **SELF FINISHED FELT**

The self finished felts to be used shall be of the brand and manufacture conforming to the type and grade given in the description of the item for the several layers unless otherwise specified. Felts of type 3 (grade 1 or 2) which are hessian base felts, be used.

The felts shall conform in all respects to IS:1322 "Bitumen felts for water proofing and damp proofing".

### **PRIMER**

After grouting the cracks if any, the primer shall be brushed over the clean dried surface before bonding materials is applied. The primer shall be applied at a minimum rate of 0.25 litre/m<sup>2</sup>.

### **BONDING MATERIAL**

Bitumen bonding material shall be heated to the working temperature specified by the bitumen manufacturers, and conveyed in buckets or



pouring cans in weighed quantities. Working temperature for blown type petroleum bitumen of I.S. grade 85/25 is 180° C which shall be maintained.

#### **OPERATION OF LYING**

Where damp-proofing is done on outer face of wall, the laying shall commence on the floor and shall be completed before treatment is applied on the vertical surface of the wall.

When damp-proofing is to be done on the inner face of walls as in case of existing structures, each layer of felt shall be taken along the wall surface in continuation of the floor treatment before the next layer of felt is laid and bonded on the floor.

#### **ACTUAL LAYING OF FELT**

The felt shall be cut to the required length, brushed clean of dusting material and laid out flat on the floor surface to eliminate curls and subsequent stretching. The felt shall not be laid in single pieces of very long lengths as they are likely to shrink; 6 to 8m are suitable lengths. The surface shall be thoroughly cleaned, dried and primed and the fillets at junctions if any, protected by felt strips before the felt treatment is begun.

Care shall be taken to keep the site free of water by pumping out etc. till such time the damp-proof course and structural slab is completed.

Each length of felt shall be spread in position and rolled back for a distance of half of its length. The hot bonding material at the rate of 1.6kg/m<sup>2</sup> be spread across the primed surface to the full width of the rolled felt, as the latter is steadily unrolled and pressed down. The spreading of bitumen shall be so regulated that the correct weight of bonding material per unit area is spread uniformly over the surface. Excess bonding material that gets squeezed out at the ends shall be leveled up as laying proceeds. When first half of the strip of felt has been bonded to the horizontal surface, the other half shall be rolled up and then unrolled on to the hot bonding material in the same way. Each strip shall overlap the adjacent one by atleast ten cm at the edges and ends. All overlaps shall be firmly bonded with bitumen streaks and tailings of bitumen near the edges of laps shall be leveled up by heating the overlaps with a blow-lamp and leveling done to avoid the unevenness.

Subsequent layers of bonding materials or bitumen felts shall be laid in the same manner as already described, taking care that laps in the felt are staggered from those in the layers below:

After the damp-proof treatment of the floor has been laid, it shall be paved with one layer 1st class brick laid in cement mortar or as specified, to protect the surface from being punctured. Such protective course shall be paid for separately unless otherwise specified.

- (d) The treatment of wall and other vertical surfaces shall then be taken up. The felt shall be cut to the required length (from floor upto tucking groove including over laps) brushed clean of dusting materials, laid out flat on the floor, leveled and then rolled up. The roll of felt shall be held at floor level and then gradually unrolled up the wall face, as hot bitumen at the rate of 1.6 kg/m<sup>2</sup> is being pored between the roll and the wall face, and the felt pressed with circular wooden roller etc. The squeezed bonding material and overlaps shall be treated as specified for the flooring. In case bitumen felt does not adhere to the wall surface properly, initially support may be given by nailing the felt to the wall.

The ends of the felt shall be properly extended to the full length of the tucking grooves.

After completing the required number of courses these shall be protected by walls of specified types and sizes which shall be built in cement mortar upto the top of the treatment, abutting against the treatment. The gap in between these shall be grouted with cement so as to ensure that no air is tapped between the damp proof course and wall.

- (e) In case of deep basement sumps, it shall be convenient to apply damp-proof coursing on the outside of the walls in stages of convenient heights and complete construction of walls, water proofing treatment, protective walls, floor and back filling of earth progressively. This will enable removal of shuttering earlier and shall arrest tendency of slipping down of damp proof coursing.

## **16.2 CEMENT CONCRETE PLINTH PROTECTION**

- 16.2.1 Plinth protection shall be provided, as specified to required width. It comprises specified thickness of cement concrete 1:3:6 PC (1 cement : 3 coarse sand: 6 graded stone aggregate 20 mm nominal size) over PCC 1:5:10 bed of specified thickness. Plinth protection shall be laid with a minimum outward slope of 1 in 50. The sub grade for plinth protection shall be prepared to required slope, watered, properly & consolidated.
- 16.2.2 Cement concrete 1:3:6 (1 cement : 3 coarse sand : 6 graded stone aggregate 20 mm nominal size as detailed in the item) of specified thickness shall be laid in one operation. The outer edge shall be bent to 90° with full thickness and shall extend at least 20cm or as shown in the working drawing below ground

for protection against erosion and at wall edges there shall be coving between vertical and horizontal surfaces with a groove separating coving and external wall plaster. The top of the plinth protection finished with only wooden floats. The concrete surface shall not be finished with mortar. The length of any panel shall not be more than 3 sq mt. Each panel shall be separated by grooves of 10mm depth for a depth of 1/3 of thickness of pavement or 40mm whichever ever is more. The groove shall be filled with approved hot poured sealing compound conforming to grade A or B of IS:1834. The concrete to be adequately consolidated top finished with broom finish with marking parallel to slope of top finish to facilitate easy draining of rain water. The grooves / panel joints at turning locations of plinth protection shall be always in line with the adjoining walls and shall not be diagonal to plinth protection quadrilateral as it creates weak concrete at outer corner of the quadrilateral.

### **16.2.3 CURING**

Curing shall be as specified under chapter 4 (concrete works).

### **16.2.4 MEASUREMENT**

The linear dimensions shall be measured correct to cm including depth and quantity in cubic meter correct to two decimal places. No deductions shall be made nor extra paid for any opening upto 0.1sq m.

### **16.2.5 RATE**

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

## **16.3 PROVIDING AND FIXING ALUMINIUM STRIP EDGING TO STAIRS**

### **16.3.1 ALUMINIUM SECTIONS**

Size and shape of aluminium sections shall be as specified in the relevant items of work/drawings.

### **16.3.2 FIXING**

A Suitable recess shall be provided in the step, both in tread and riser portions, to receive the step edging so that, after fixing, the top surface of the edging and the top surface of the tread shall be perfectly in one level. Similarly the outer of the vertical leg of the edging shall be flush with the finished surface of the riser.

In cases where the finish over the risers and treads consists of plain cement flooring and cement / lime cement mortar respectively, the edging shall be fixed

after the flooring/plastering are completed. Where the finish consist of marble chip flooring, marble chips plastering, the edging shall be fixed after the polishing of the flooring / plastering.

The recess shall be thoroughly cleaned of all loose material, mortar drippings etc. before fixing the edging. The surface of the recess shall be given a coat of cement slurry and thin layer of cement mortar 1:3 (1 cement :3 coarse sand). Holes shall be drilled in the leg of the edging coming on the tread to receive the screw of specified size. The edging shall be kept in position, tapped gently to make it sit firmly on the mortar bedding and then fixed in position with necessary 25 mm size wood screw. Each edging shall be in one piece only. After the work is completed and the mortar has set, no hollow sound shall be given when the edging tapped. Any edging giving hollow sound shall be taken out and refixed properly. Wooden plugs of suitable size at approximately 20mm apart shall be fixed at desired level during laying of cement concrete in steps for fixing the edging. The fixing may be done using rawl plugs/detefix also, instead of wooden plugs.

#### **16.4 SHELVES**

The plank for the shelves shall be planned on all faces and edges. These shall be supported on the angle irons which shall be built in the walls at least 15cm. deep in cement concrete 1:3:6 using stone aggregate 20mm nominal size when the shelves are upto 30cm. Width, the supports shall be spaced not more than 75cm. apart. When the shelves are wider, this spacing shall be suitably decreased as directed by the Engineer-in-Charge. The shelves shall be grooved to rest squarely on the supports to which these shall be fixed with iron, wood screws from below. The finished work with a tolerance of  $\pm 1$ mm in thickness and  $\pm 2$ mm in width may be allowed.

#### **16.5 PELMETS**

Sides, front and top of the pelmet shall be 12mm planks or boards of specified width unless otherwise specified. These shall project from wall face by 15cm. or as specified and shall be securely fixed to wall with wood screws by means of wooden plugs and 10cm x 25 x 3mm MS flat bend in the form of an angle or any other device indicated in the drawing and approved by Engineer-in-Charge. The pelmets shall be provided with curtain rods and brackets or curtain rails with rollers, stop ends and brackets as specified. Intermediate wooden brackets shall be provided, if the length of pelmet exceeds 1.5 metres.

#### **16.6 MS BARS AND MS GRILLS**

MS bars and MS grills shall be as per detailed drawing or as directed by the Engineer-in-Charge.

## **FIXING**

For MS bars to be fixed in wooden frames of windows etc. through holes shall be drilled in one frame, and in the other frame, holes shall be drilled 5 cm. deep. The bars shall be passed into the frame from one side and these shall be of the correct length to fit in at one end and to flush with out side of the frame at the other end. Where there are MS flats provided along with the bars, these shall be fixed at the ends of the wooden frame with wood screws. Holes for passing MS bars shall be punched in the flats at proper position. The grills shall be fabricated as per design and fixed to the frame by round headed bolts and nuts in new work and by wood screws in the old work.

### **16.7 EXPANDED METAL, HARD DRAWN STEEL WIRE FABRIC AND WIRE GAUZE**

These shall be fixed as detailed in the drawing. These shall be free from rust and other defects.

#### **EXPANDED METAL**

This shall be in the form of rhombus unless otherwise specified with its opening diagonal 20 x 60 mm and stands 3.25mm wide and 1.6mm thick weighing not less than 4.078 kg/m<sup>2</sup>.

#### **WELDED STEEL DRAWN WIRE FABRIC**

This shall have rectangular mesh 75 x 25mm size and its weight shall be not less than 7.75 kg/m<sup>2</sup> unless otherwise specified.

### **16.8 WIRE GAUZE**

This shall, unless otherwise specified shall be galvanized MS wire and of IS gauge designation 85 with wire diameter 0.56mm and 140 G with dia of 0.71mm.

#### **16.8.1 FIXING**

Unless otherwise specified the Expanded metal, Hard drawn steel wire fabric and Wire gauze shall be fixed as below. They shall be in one piece to the size of frame (out to out). Expanded metal and hard drawn steel wire fabric shall be fixed on to the frame with staples over which wooden beading 60 x 20 mm shall be fixed with wood screws. Wire gauze shall be turned back at 180° to the full width of frame and fixed tight with blue tacks, over which wooden beading of 62 x 19 mm shall be fixed with wood screws unless otherwise specified.

**16.9 ALLUMINIUM DOORS AND COMPOSITE UNITS OF DOORS AND FIXED GAZING FRAMES AND DOUBLE GLAZED PARTITION**

**MATERIALS**

All the frames work shall be large range extruded INDAL or equivalent aluminium sections structurally sound and rigid.

For aluminium doors and wall-glazing frames, the best material as of date is the treatable alloy HE9-WP. This alloy corresponds to INDAL 50 produced by M/s Indian Aluminium Co. The main alloying elements in this alloy are magnesium (0.4 to 0.9%) and silicon (0.3 to 0.7%). The symbol HE is the alloy designation denotes that heat treatable extruded.

The Mechanical strength of the alloy greatly improves with heat-treatment water quenching from a selected temperature and cooling it at a lower temperature in order to obtain the full benefit of precipitation hardening by Mg<sub>2</sub> Si.

**DIMENSIONS**

All the doors windows, and composite units shall be made to suit the exact dimensions of respective openings, measurements which shall be checked at site before manufacture. The contractor shall produce, shop drawings showing various sections and systems of operation for the approval of Engineer In-Charge before starting manufacturing.

**WORKMANSHIP**

Corners of door, window, composite units shall be accurately mitred, jointed and fitted to produce flush joints and welded along the concealed line of connections. All welding shall be on the unexposed sides in order to prevent pitting, discolouration and other surface imperfections after finishing. The weld shall thoroughly penetrate the metal, resulting in complete fusion between the frames, corners developed by external tie rods and/or superficial surfaces welding shall not be permitted. All welded joints shall be electrically flash welded. All cut-outs, recesses, mortising or milling operations required for hardware shall be accurately made and reinforced with backing plates as required to ensure adequate strength of connections.

No field fabrication of frame shall be permitted.

Screws, nuts, washers, bolts, lugs wherever necessary shall be of steel with cadmium plating and as directed by Engineer-in-Charge.

**FINISH**

The finish of all the members shall be dull matt anodized of approved colour.

## **ANODIZING**

It is necessary to anodize the sections for protection against corrosion especially in marine atmospheres. A relatively thick anodic coating of 25 microns from a sulphuric acid bath will improve its corrosion resistance. Further, the anodized sections should be double sealed or in the alternative sealed by exposure to steam. This treatment assists in closing the pores in the oxide layer. Double sealing involves a preseal in allayla polyethylene glycol or in a solution of nickel acetate and last seal in sodium dichromate solution.

## **LOCKING ARRANGEMENTS**

All doors shall have concealed locking arrangements, push plate cum handle on the lines as indicated. The doors shall have double action floor springs with oil check wherever indicated in the schedule of quantities/drawings.

## **RATES**

The rates quoted shall be inclusive of supply of all fixing accessories, frames, shutters, mullions, fixtures like handles, stays, lugs, locking arrangements, beading and rubber lining for glazing and necessary cadmium plated steel screws etc. complete.

## **GLAZING**

Glazing shall be carried out using glass of selected quality of thickness/type specified in schedule. Rubber lining and beading required to fix the glass in position shall be provided by the contractor.

## **DOUBLE GLAZED PARTITION**

The gap between the glass panes of the partition with double glazing shall be devoid of any air. This condition shall be created by approved method recommended by the specialist in the field. Further, the junctions of the glass panes with the aluminium frame work shall also be rendered air-tight to maintain the condition thereafter.

## **16.10 WOODEN FLOORING**

### **SUPPORTING JOISTS**

Main beams and joists of the class of wood and sections specified in the description of the item for beams and joists shall be fixed as per drawing and as instructed by the Engineer-in-Charge to dead levels. The width of the joists shall not be less than 50mm. The arrangements and spacing of beams, joists

etc. shall be as per design drawing furnished. The beams, joists etc., shall be painted or treated with wood preservative as directed by the Engineer-in-Charge. The beams and joists and the painting thereof shall be paid for separately unless specifically included in the description of the item.

## **BOARDS**

It shall be of the class of timber and thickness specified in the description of the item. The timber shall be as specified. Only selected approved boards of uniform width shall be used. Unless otherwise specified or shown in the drawings, the width of boards selected shall not less than 100 mm nor more than 150mm. The same width of boards shall be maintained throughout except where the width of the room is not an exact multiple of the boards. In the latter case, the difference shall be equally placed adjacent to walls. The length of the boards shall not exceed 3 metres anywhere. Ordinarily the minimum length of boards shall be such that the boards shall rest at least on these supports, except where otherwise required by the pattern specified in the drawings or as directed by the Engineer In-Charge.

The boards shall be planned true on the top face unless otherwise specified in the description of the item. Where the bottom face is to be painted or required to be planned, as specified in the item the same will have to be done as described for top surface.

Unless otherwise described in the item, the longitudinal joints of planks shall be tongued and grooved to a minimum depth of 12mm while the heading joints shall be of the square butt type and shall occur over the centre line of the supporting joists. Heading joists in adjacent boards shall not be placed over the same joists.

## **IRON SCREWS**

The joists on which the planks shall be fixed shall be checked and corrected to levels. The ends boards shall be accurately fixed with the sides parallel and close to the walls. Each adjoining boards shall be carefully jointed and shall be tightened in position and screwed. For fixing the boards to the joists two screws shall be used at each end of the boards and one screw at each of the intermediate joists in a zigzag manner. The screws shall be countersunk and screw holes filled with approved stopping.

Unless otherwise specified the junction between timber flooring and adjacent flooring shall be formed by inserting a metal strip (brass or aluminium) at the junction. The metal strip shall be fixed to the end of the planks by screws.



The flooring shall be truly level and plane. The joists shall be truly parallel and or perpendicular to the walls, unless otherwise specified.

The floor shall be planned in both directions and made perfectly even, true and smooth.

**NOTE:** No wood work of any kind shall be placed within 60cms of any fire place or flue. Provisions shall be made for ventilating the space below the floor in case of ground floor and between wooden floor and floor slab in the case of upper floors, as indicated in the drawing.

#### **FINISHING**

The surface of the floor shall be bees waxed or finished otherwise as specified or directed by the Engineer-in-Charge. The lower face shall be painted or treated with wood preservative as directed.

#### **16.11 DETAILED SPECIFICATION FOR CAVITY FLOOR (RAISED MODULAR FLOOR OR FALSE FLOOR) CONSTRUCTED IN SQUARE GRID PANELS OF DIMENSION 600 X 600 MM WITH STRAIGHT JOINTS**

The work to be carried out in respect of "Cavity Floor" includes provision of the entire floor comprising of vertical adjustable jack supports, M.S. runners consisting of INST 40 or any other approved system providing 35mm thick Novateak panel boards, 3mm thick PVC topping, TW lipping or specified floor panels all as per item specification and drawing etc. Complete, all arranged in position to the designed grid patterns, adjusted, leveled and finished. The rate accepted shall include cost of all materials, adjustable constituents, labour for manufacturing and setting the components to predetermined design, providing and fixing angle cleats, clips, welding, fabrication etc., complete and the floor finally laid in position and adjusted to proper line and level. The finished work including materials shall be guaranteed for a period of atleast 1 year.

#### **MS JACKS**

(a) Unless otherwise specified MS stools/vertical supporting jacks shall comprise of 25mm, solid MS rod studs with MS base and head plates each of size 100 x 100 x 6mm welded, around the periphery of the stud rod at bottom, and sleeve of stud welded to top jack plate and the pedestal provided with suitable arrangements consisting of MS coupling and check nut for level adjustments.

The various components involved in the vertical jack system shall be welded, machined threaded, adjusted and fitted together as per design requirements. The sleeve, collar, check nut and rod stud shall be provided with matching machine made threads.

The base plate of the jack shall be fixed to the base floor with araldite epoxy based adhesive set in position to conform exactly to the predetermined grid pattern of specified size say 600mm x 600 mm.

#### **MS FRAME WORK**

The cavity floor frame work shall comprise unless otherwise indicated MS Tee sections of size 40 x 40 x 6mm in main and cross runners (INST 40) arranged in the required grid pattern and suitably centered over the top plate of the supporting jack in between pairs of MS flat chairs/MS angle cleats welded to top plate of jack to receive 'T'; section from both directions so as to retain the frame work in position and to prevent lateral shift. Joints shall be as far as possible avoided in main runners, unavoidable joint shall be adjusted to occur over the supporting jacks. After the main runners are accurately positioned and leveled over the screw jacks, the cross runner shall be fixed, placed to correct modular size duly held in position by means of MS chairs/cleats welded to the top jack plate. The top surface of main and cross runners when finally aligned and adjusted shall remain in a single plane and offer uniform level seating for the floor panels.

#### **FLOOR PANELS**

The floor panels unless otherwise specified shall consists of 35mm novateak super particle boards (made out of novateak super phenolic formaldehyde adhesive bonded teak wood particle boards) with edges cut to slightly tapered section for facilitating easy removal of panels and of specified size say 600mmx 600mm, provided with 12mm thick solid teak wood liping on the edges fixed all round the particle board with fevicol or equivalent adhesive. Unless otherwise specified the top of novateack floor boards shall be finished with 3mm thick PVC flooring tiles of approved design, shade and colour, the PVC tiles being fixed using niloflex synthetic adhesive. The PVC sheets shall be sufficiently aged before fixing so as to take care of initial shrinking and to prevent unsightly gaps developing at joints and along the edges. The panels shall be cut to special shapes as required at site against protruding columns etc. carried out at no extra cost. The panels shall be truly square, level and uniform. The Novateak floor boards resting on MS Tee frame work shall be provided with a strip of a 1 to 2mm thick insulating felt fixed with suitable adhesive for providing cushioning effect for the floor panels and to act as shock absorbers. The particle boards used on the job shall be of best variety fire resistant, vermin and moisture proof quality. A coat of fire resistant paint shall be applied to the under side of floor boards. Each floor board shall be easily removable and remain in position without screwing or bolting.

All steel work in supporting jacks bottom and top plates and false floor frame works shall be prepared and neatly painted with two coats of approved paint over base coat of suitable primer.

The total height of the cavity floor from the base floor shall range from 325mm to 360mm as per actual requirement at site, however ensuring to provide a minimum free clearance of 250mm in between base floor and bottom of frame work.

#### **LOAD CRITERIA TO BE SATISFIED**

- (a) Unless otherwise specified the floor shall be suitable to withstand a point load of 450 kgs. On each panel and/or a super imposed uniformly distributed load of 1250 kgs/m<sup>2</sup>.
- (b) The floor shall not deflect by more than 1/650<sup>th</sup> of span under maximum point load.
- (c) The PVC facing tiles and flooring cover shall withstand a punching stress of 35 kg per cm<sup>2</sup>.

#### **GENERAL**

The workmanship shall be of the highest order. The entire work including materials involved and workmanship shall be guaranteed for a period of 1 year from the date of handing over. The finished job shall present a neat appearance without gaps between panels. All panels shall be interchangeable. The joint lines shall be truly straight, uniform and the finished floor shall be laid true to level. All panel boards and corresponding frame work shall be marked on the underside with distinguishing identification marks to indicate their position and orientation.

#### **DRAWING TO BE FURNISHED**

Detailed working drawings indicative of the general arrangements, fabrication and fixing details shall be furnished by the contractor for verification and guidance during execution.

Sample of all elements of the false flooring, panel board with TW lipping, and PVC edging shall be furnished for inspection and approval by the Engineer-in-Charge.

Sample of jacks, with machine made matching screw threads with coupling and sleeve shall be submitted for inspection and approval.

Sample elements of false flooring viz., jacks, panel boards etc. shall be tested for its strength and other specification requirements prior to approval.

## 16.12 RAILING FOR STAIRCASE AND BALCONIES

Hand railing for staircases and balconies shall be as per item description viz. steel, PVC hand rail, etc. as shown in the relevant drawings and as specified in the schedule of quantities. The balusters will be welded to anchor bars or inserts, embedded in the concrete steps. For hand rails with G.I. pipes, the pipes will be supported by G.I. pipe vertical supports fixed in RCC as indicated in drawings. All steel work and wood work for hand rails shall be painted two coats over a coat of approved primer. Payment will be made on running metre basis for the lengths of the hand rail which includes manufacture, supply and fixing in position complete railing including balusters. Samples hand rail has to be got approved by Engineer In-Charge prior to bulk procurement.

16-16-16-16-16-16

## CHAPTER 17

### ROAD WORK

#### 17.1 MATERIAL

##### 17.1.1 STONE AND COARSE AGGREGATE

Stone for soling, road metal, coarse aggregate, chipping etc shall be obtained from the approved quarries. Stone for soling shall be of granite trap, basalt, limestone, sandstone, laterite, or any other rock as specified. Stone shall be clean hard free from laminations, unsound fragments, decay and weathered stuff. Smaller stones for filling voids shall be of the same quality of larger stones. Stone for soling shall be of height almost equal to the thickness of soling with a tolerance of  $\pm 10\text{mm}$  and should have base area not less than 250 sqcm nor more than 500 sqcm. The smallest dimension of any stone shall not be less than half the largest dimension.

When crushed broken stones are used for soling these shall be of gauge not exceeding 80mm.

When boulders are used for soling these shall not be less than 13cm when measured across the proudest part in any direction.

##### 17.1.2 COARSE AGGREGATE FOR WATER BOUND MACADAM

Coarse aggregate and screenings shall be of crushed or broken stone, laterite or kankar etc. as indicated unless otherwise specified. Screenings shall be of the same material as coarse aggregate. Crushed or broken stone shall be hard and durable and shall be free from excess of flat, elongated, soft and disintegrated particles, dirt and other objectionable matter. Crushed or naturally occurring aggregate shall meet the following requirements.

Sl. No.	Type of Construction	Test	Requirement
1	Subbase	(i) Los Angles Abrasion value* Or	60% max
		ii) Aggregate impact value*	50% max
2	Base	i) Los Angles Abrasion value* Or	50% max
		ii) Aggregate impact value*	40% max
		iii) Flakiness index *	15% max
3	Surface course	i) Los angles Abrasion value* Or	40% max
		ii) Aggregate impact value*	30% max
		iii) Flakiness index	15% max

\* Aggregate may satisfy requirements of either of the two tests.

### **17.1.3 FILLER MATERIAL / BINDING MATERIAL**

The plasticity index of the filler material in the screenings shall be 4 to 9 in the case of unsurfaced water bound macadam course or where traffic is to be permitted on compacted water bound macadam before surfacing is laid and 4 to 6 in the case of surface treated water bound macadam. Where lime stone formations exist nearby, lime stone dust or kankar nodules may preferably be used.

Coarse aggregate for bituminous work, shall consist of broken/crushed stone, crushed gravel (Shingle) or other stones or cubical fragments free from disintegrated pieces, salt, alkali, organic or other deleterious matter. The aggregate shall preferably be hydrophobic in nature and of low porosity. Flakiness index of the aggregates shall not exceed 25 percent.

Shingle shall be clean and free from foreign matter and obtained from approved nullah or river beds. Shingle of all in size shall contain a sufficient proportion of fine material to fill all interstices and to ensure binding when consolidated.

Gravel shall be composed of large coarse, silicious grains, sharp and gritty to the touch and free from impurities and dirt. Laterite gravel may be used if the excess of clay is separated by screening. All in size shall contain a sufficient proportion of fine material to fill all interstices and to ensure binding when consolidated.

Laterite when ordered for use as soling or breaking into metal shall be hard compact heavy and of a dark colour. Light coloured sandy laterite and that containing much clay shall not be used on the work.

Kankar shall be clean tough free from moorum sand and shall not contain any clay in the cavities between the modules and shall not disintegrate on exposure to sun and rain.

Moorum shall be clean, of good binding quality and obtained from approved pits/ quarries of disintegrated rocks which contain silicious material and natural mixture of clay of calcareous origin.

Sand for binding tarred or bituminised surface or for mixing with tar or bitumen shall be clean, hard, sharp, gritty, coarse dry particles, free from earth, silt and other deleterious matter.

### **17.1.4 PREFORMED FILLERS FOR EXPANSION JOINTS (PREMOULDED JOINT FILLER)**

Prefomed fillers for expansion joints shall comply with the requirements of IS: 1838 specifications for preformed fillers, for expansion joints in concrete, non extruding and resilient type (Bitumen impregnated). Fibre used may be

of soft board, fibre board, or other suitable fibres, (natural or artificial) of cellular nature and shall be securely bond together and uniformly impregnated with bitumen.

The thickness shall be 20mm or 25mm as specified and shall be of maximum available standard length. The filler shall remain 20mm below the top surface of the pavement and shall extend upto the sub grade.

Prejoined strips of expansion joint filler shall not be deformed by hoisting, bending or other handling, or when exposed to atmospheric conditions. Pieces of the joint filler that have been damaged shall be rejected. Tolerances of  $\pm 1.5\text{mm}$  in thickness and  $\pm 3\text{mm}$  in depth shall be permitted.

Sealing compound for joints in concrete pavement shall conform to IS: 1834. Specifications for hot applied sealing compounds for joints in concrete. Sealing compounds shall be either Grade A (nominal) or Grade B jet fuel resistant as indicated. Grade 'A' sealing compound shall be used for concrete constructions other than those which are subjected to spillage of kerosene or other heavy petroleum oils and Grade 'B' (Jet fuel resistant) for concrete constructions of run ways for jet air crafts conforming to IS :1834.

Binder Tar and Bitumen shall be as indicated.

#### **17.1.5 COLLECTION AND STACKING OF MATERIALS**

The materials shall be stacked on the side of the road and clear of the road way. Stacks shall be uniformly distributed along the road. The collection of materials shall be completed for the entire work or for a complete stretch as directed by EIC. Aggregates shall not be stacked unless they have been screened to gauge and freed from all earth rubbish etc., or any rejected materials. The rejected materials shall be removed from the site immediately. Measurements shall not be taken until sufficient materials have been collected and all rejected stuff have been removed. The contractor shall ensure that his transport vehicles do not drop any aggregate etc. on the road and shall keep screens or sieves of proper sizes at the sizes at the site of stacks to enable EIC to exercise checking regarding size etc. if desired.

#### **17.2 WORKMANSHIP**

The Contractor at all times shall be responsible for the proper lighting, watching, provision of barriers and protection of all unfinished sections of the road and for the safety of the travelling public.

Only so much length shall be taken up at a time as can be consolidated on the same day.

### **17.3 SETTING OUT AND JUNGLE CLEARANCE**

The line and levels of foundation side slopes, drainage, carriage ways, foot paths and shoulders etc. shall be carefully set out and frequently checked, care being taken to ensure that correct gradient and cross sections are obtained at all places. The finished surface of the carriage ways and foot paths shall be formed so as to provide adequate fall and satisfactory run off at all surface water outlets, gullies etc.

Side drains / catch water drains, cross drainage culverts etc. shall be provided as indicated and shall be paid for under the respective sections of the contract schedule.

#### **17.3.1 JUNGLE CLEARANCE**

The term jungle applies to heavy vegetation, shrubs, trees etc. which cannot be cut or removed with the ordinary application of a showrah or a shovel. Jungle shall be cleared inclusive of roots and removed and deposited at least 50cm clear of the formation. Subsequent disposal shall be as indicated and paid for separately. Cavities formed by grubbing up of roots shall be filled in and well rammed.

### **17.4 EARTH WORK IN ROAD CONSTRUCTION**

Earth work for Road falls broadly under three categories viz.

- 1) Earth work in cutting including burrow pits.
- 2) Earth work in filling with out optimum moisture conditions
- 3) Earth work in filling in embankments under optimum moisture conditions.

The detailed specification for earthwork under Chapter 2 of this book will hold good for earthwork for road to the extent applicable. In addition certain special requirements of earthwork for road constructions, especially under embankments and excavations from borrow pits. These shall broadly conform to

- a) IRC : 36 Recommended practice for construction of earthen embankments for road works.
- b) IRC :10 Recommended practice for borrow pits for road embankments by manual operations.

### **17.5 EMBANKMENT CONSTRUCTION UNDER OPTIMUM MOISTURE CONDITIONS**

In addition to the specification for earthwork said above, following shall apply. Only approved material shall be allowed. The filling shall be so planned



that the best available material shall be used for top. The foundation of embankment shall be ploughed to a depth of 15 to 25cms and surface shall be well watered before earthwork is started.

The embankment shall be laid in 20cms layers, which shall be continuous and parallel to the finished grade. The clots shall be broken and all organic/inorganic matters shall be removed and disposed off. Joining of old and new embankments shall be done by stepping in an overall slope of about 1 to 5. Each layer of earth should be adequately watered to aid compaction. Consolidation of each layer to be done by road roller of 8 to 10 tonnes weight, rolled not less than 5 times, till the soil behaves as an elastic material and gets compressed only elastically under the weight of roller. The embankment shall be dressed neatly.

The quantity of earth work shall be calculated by measuring the volume of earth work from borrow pits, cuttings etc. When it is not possible to arrive the volume by cutting, the filling shall be measured and quantity computed. A reduction of 5% shall be made from the quantity of filling measured to arrive at the quantity for payment.

In case of earthwork consolidated under optimum moisture conditions (OPC) each layer of earth shall be carefully moistured to give field moisture content of about +1% to -2% of the OPC. Required amount of water shall be added during consolidation to keep the moisture content of the soil at the optimum as per test. The density to be achieved for each layer of the material shall not be less than 95% of the density obtained in the laboratory by proctor method. Each layer shall be tested for density prior to laying next layer. A systematic record of this shall be maintained. Unless otherwise stated one density measurement shall be made for each 500 sqm of compacted area. Each measurement shall consist at least 5 density determinations, average of which shall be field density. The determination of density shall be as per IS: 2720 (Part XXVIII). For the top 40cm thick the above measurements shall be for each 250 sqm and less and minimum 10 determination of density to be done for each measurement.

The soil suitable for consolidation under OMC preferably shall have

- |                               |     |
|-------------------------------|-----|
| a) Minimum percentage of clay | 10% |
| b) Liquid limit               | 14  |
| c) Plasticity index           | 4   |
| d) Maximum silt content       | 50% |

## 17.6 PREPARING FORMATION

The ground shall be formed to the proper gradient, camber, super elevation etc. corresponding to the required finished surface by trimming the surface. If

indicated all soft spots shall be excavated and filled in with approved soil and well rammed. Surplus soils if any shall be thrown clear of the road formation. The formation shall be watered and rolled if indicated.

Rolling shall progress from edges towards the centre (or from lower to higher edge in case of super elevated curves) parallel to the centre line of road and lapping uniformly each preceding rear wheel track by one half width of such track. The roller shall not be stopped or reversed in the working length. These operations being carried either over completed surface behind or over the incompleting surface ahead. Rolling shall be continued till a closely knit compacted surface is obtained. The surface shall be checked by templates, hollows corrected with spalls and consolidated.

## **17.7 STONE SOLING**

Soling shall be constructed on the prepared sub-grade in conformity with lines, grade, thicknesses and cross sections shown on drawings as directed by the EIC.

### **MARKING OUT**

The edges of soling shall be marked out by strings or stakes. The lines shall be carefully ranged.

### **LAYING**

Stones shall be hand packed carefully to the required cambers of the top surface by laying correct to the templates placed 15 metres apart. Stone shall be laid resting on their broad bases with their height equal to the thickness of the soling and the largest dimension at right angles to the centre line of the road. Stones shall be laid breaking joint in close contact with each other but not leaning against each other. Large size stones shall be arranged at the edges and centre of road.

**Wedging and packing:** All interstices between soling stones shall be wedged in with smaller stones of suitable size and well driven in by hammers to ensure tight packing and complete filling of interstices. Wedging shall be carried out simultaneously with laying of soling stones. After the hand packing has been completed, inequalities in the surface shall be checked with by templates and carefully set right.

The soiling shall then be consolidated by a road roller of 8 to 10 tonne weight as directed by EIC depending upon the type of soling stones and the nature of subgrade. Finally a layer of moorum or sandy soil of thickness not less than 25mm shall be spread and watered and rolled with a light roller. Particular care shall be taken to use only sufficient quantity of water so as not to soften the surface.

Soling with crushed broken stone aggregate shall be constructed in the same manner as for stone soling except laying and wedging. The coarse aggregate shall be spread uniformly and evenly upon the prepared base in required quantities from stock piles along the side of the road way. The surface of the aggregate spread shall be carefully levelled up and all high or low spots corrected by removing or adding aggregate as may be required. The surface shall be checked from time to time during the spreading and rolling of the aggregate to ensure a finished surface without variations greater than 15mm when a 3 meter long straight edge is laid parallel to centre line of road.

#### **LIGHT WEARING SURFACE OF KANKAR, SHINGLE, GARVEL, MOORUM ETC.**

The material shall be of grading containing a proportion of all sizes as obtained from quarry, pit, river bed etc. screened to remove sizes in excess of half the spread thickness and shall be spread evenly on the formation or base, thoroughly consolidated by means of a roller weighing not more than 5 tonnes. Rolling shall continue until a closely knit thoroughly compacted surface conforming to required levels is obtained, any settlement being made up by rolling in fresh material. In areas where rolling is impracticable consolidation may be effected to a similar extent by ramming.

#### **17.8 WATER BOUND MACADAM**

Where the road side strips do not confine the spread metal well tempered clay bunds or fillets about 15cm wide and to height required shall be formed on each side of the metal to prevent its spreading out during consolidation. These shall be laid true and parallel, having a clear distance between them equal to the width to be metalled.

#### **PREPARATION OF SUBGRADE, SUBBASE OR BASE**

Subgrade-subbase or base shall be well drained and cleaned of all foreign substances. Any ruts or soft yielding places that appear due to improper drainage conditions, traffic or handling or from any other cause shall be corrected to required grade, camber, shape and finish, and thoroughly compacted before coarse aggregate is spread. In the case of existing road surfaces where new material is to be laid, it shall be scarified and reshaped to the required grade camber and shape if necessary. Weak places shall be strengthened, corrugations removed and depressions and pot holes made good with suitable material before laying the water bound macadam course on it.

#### **SPREADING OF COARSE AGGREGATE**

The coarse aggregate shall be spread uniformly and evenly upon the prepared base in required quantities from stockpiles along the side of the roadway. But

in no case shall the aggregate be damped in heaps directly on the base with in the area over which it is to be spread nor over the partly completed base, be permitted. The aggregate shall be spread uniformly to proper profile by using templates placed across the road about 6 meters apart. Wherever possible approved mechanical devices shall be used to spread the aggregate uniformly so as to minimize the need for manipulation by hand.

The surface of the aggregate spread shall be carefully turned up and all high or low spots connected by removing or adding aggregate as may be required. The surface shall be checked from time to time during the spreading and rolling of the coarse aggregate to ensure a finished surface without variation greater than 12.5mm when a 3mtr long straight edge is laid parallel to entire line of road.

The coarse aggregate shall not normally be spread in lengths more than three days average work, in advance of the rolling screening and bonding of the preceding section. When spread thickness exceeds 11.5 cm the metal shall be spread and consolidated in layers not exceeding 11.5cm but not less than 5cm.

#### **DRY ROLLING**

Immediately following the spreading of the coarse aggregate it shall be compacted to full width by rolling with 8 to 10 tonne power roller. Rolling shall continue until the aggregate is thoroughly keyed and the creeping of the aggregate ahead of roller is no longer visible, slight sprinkling of water may be done if required.

The layer shall not be rolled when the subgrade is soft or yielding or when the rolling causes a wave like motion in the base course or subgrade. When rolling develops irregularities that exceed 12mm when tested with a 3mtr straight edge the irregular surface shall be loosened and then aggregate added to or removed from it as required and the area rolled until it gives a uniform surface conforming to the desired cross section and grade. The surface shall also be checked transversely by template and any irregularities corrected in the manner described above. Screenings shall not be allowed to make up depressions.

#### **APPLICATION OF SCREENING AFTER THE COARSE AGGREGATE HAS BEEN THOROUGHLY KEYED AND SET BY ROLLING**

Screenings to completely fill the interstices shall be applied gradually over the surface. Dry rolling shall be continued while the screenings are being spread so that the jarring effect of the roller will cause them to settle into the voids in the coarse aggregate. The screenings shall be spread uniformly in successive thin layers in three or more applications to fill all voids. Screenings shall not be applied so fast and thickly as to cake or bridge on the surface. Rolling and brooming shall continue with the spreading of the screening until no more

screenings can be forced into the voids. Damp and wet screenings shall not be used. The spreading rolling and brooming of screenings shall be performed on sections which can be completed with in one days operation.

#### **WET ROLLING**

When all possible voids have been filled with screenings the surface shall then be copiously sprinkled with water, swept and rolled. Hand brooms shall be used to sweep the wet screenings into the unfilled voids and then distribute them evenly. The sprinkling sweeping and rolling shall be continued and additional screenings applied where necessary until the coarse aggregate is well bonded and firmly set for its entire depth and until a grout has been formed or screenings and water that will fill all voids and form a wave of grout ahead of the wheels of the roller.

Care shall be taken to see that the base or subgrade does not get damaged due to the use of excessive quantities of water during construction. Finally the WBM surface is to be kept wet for 7 days. Quarry dust of sand layer may also be used.

### **17.9 SURFACE DRESSING**

#### **PRIMING WITH BITUMINOUS PRIMERS**

##### **PREPARATION OF SURFACES**

The surface to be primed shall be swept clean, free from dust, dirt or other deleterious matter by hand brushing with wire brushes; bass brooms and finally by fanning the cleaned surface with gunny bags to remove all loose dirt. Large irregularities pot holes depressions etc. shall be repaired before priming as indicated.

##### **APPLICATION OF BITUMINOUS PRIMER**

Bituminous primer shall be sprayed uniformly at the rate indicated over the prepared dry surface using preferably mechanical sprayers. Temperature of application of the primer to be 350°F or as recommended by the bitumen manufacturer to permit the primer to be sprayed effectively through the jets of spray bar and to cover the surface effectively. The edges of the surface to be treated shall be defined by ropelines stretched in position.

Depression or pot holes if any shall be repaired as indicated. The surface shall be thoroughly dried before application of binder.

##### **APPLICATION OF BINDER**

After the surface, to be treated has been prepared as indicated above in a perfectly dry condition, the binder heated to temperature as recommended by

the manufacturer shall be sprayed over the surface preferably using mechanical sprayers. The sprayer shall be operated in such a way as will ensure an even and uniform distribution of the binder on the road surface. Excessive deposit of binder on the road surface caused by stopping and starting the sprayer or distributor or by leakage shall be avoided. Spraying shall be carried out parallel to centre line of the road.

#### **APPLICATION OF COVERING MATERIAL (CHIPPINGS)**

Immediately following application of binder, stone chipping of size indicated in a perfectly dry condition shall be uniformly and evenly spread at the rate indicated over the entire surface which has been sprayed. The surface shall be checked by means of a chamber board laid across the road and a three metre straight edge laid parallel to centre line of the road and the irregularity if any shall be corrected by removal or addition of blindage.

#### **ROLLING**

The blinded or grided surface shall be rolled with a 8 to 10 tonne roller. Rolling shall be continued until the chippings are firmly embedded in the bituminous material and present a uniform closed surface. Excessive rolling which results in the crushing of the aggregate shall be avoided.

#### **FINISHING**

The finished surface shall be uniform and conform to the lines grades and cross sections indicated and when tested with a template and straight edge shall show no variation greater than 6mm over a three meter length.

#### **OPENING TO TRAFFIC WHERE STRAIGHT RUN BITUMEN OR ROAD TAR IS USED AS BINDER**

The finished surface shall be thrown open to traffic the following day. Where cutback bitumen and emulsion is used, the finished surface shall be kept closed to traffic until it has sufficiently cured to hold the cover aggregate in place.

### **17.10 PREMIXED CHIPPING THIN CARPET: PREPARATION OF BASE**

Before the carpet is applied on the existing base the surface shall be absolutely free from dust or caked mud. Pot holes or ruts if any in the existing surface shall be filled with premixed chippings and well rammed about a week before the carpet is laid.

#### **PRIMING / TACK COAT**

The bituminous primer shall be heated to the temperature as recommended by the manufacturer and applied uniformly to the base by means of a sprayer. The tack coat shall be applied just ahead of the spreading of the premix.

## **PREPARATION OF PREMIX**

Mechanical mixers shall be employed for mixing. For small quantities of work improvised hand mixing drums may be used, as directed by EIC. The binder shall be heated to the temperature as recommended by the manufacturer and mixed until the chippings are thoroughly coated with the binder.

## **SPREADING OF PREMIX**

Immediately after the application of the priming/tack coat the premix shall be spread with rakes to the desired thickness and to the correct camber or distribute evenly by means of a drag spreader. The surface shall then be checked for camber by means of a camber board and any inequalities found shall be corrected.

## **ROLLING**

As soon as sufficient length has been spread with the premix the surface shall be rolled with 8 to 10 tonne power roller. When the roller has passed once over the area any high spot or depression which becomes apparent shall be corrected by removing or adding premix. When this has been done the surface shall be rolled to compaction.

Seal coat if indicated shall be applied immediately after laying the carpet and rolled.

Surface dressing with one coat of paving bitumen shall be with 2.85 kg of bitumen per one sqm and 1.65cum of graded hard stone aggregate 12mm size per 100 sqm of road surface.

Surface dressing with two coats of paving bitumen shall be 2.0kg of bitumen per one sqm and 1.15cum of graded hard granite stone aggregate of 12mm size per 100sqm of road surface for first coat and 1kg of bitumen per sqm and 0.90cum of graded hard granite stone aggregate of 10mm size per 100sqm of road surface for the second coat.

20mm premix carpet shall be with 2.40 cum of IRC graded metal of 10mm nominal size for 100sqm of road surface comprising of hot cut back bitumen at 65kgs per cum of stone aggregate laid over a tack coat of hot cut back bitumen at 75 kg/100sqm of road surface complete.

### **17.11 FULL GROUT MACADAM**

Full grout macadam 50mm thick shall consist of spreading 40mm size IRC graded hard broken granite stone metal at 6.00 cum per 100 sqm rolled lightly. Spreading bitumen at 5.00 kg/sqm and blinding the surface with 12mm graded granite stone chips at 1.50 cum/per 100s qm and consolidating with 8 to 10

tonne power roller. Applying final seal coat with 80/100 grade bitumen at 0.98 kg/sqm and 6mm graded granite stone chips at 1.20 cum per 100 sqm and final consolidation with 8 to 10 tonne power roller.

## **SPECIFICATIONS FOR FULL GROUT BITUMINOUS MACADAM SURFACE**

(Bituminous Penetration Macadam Base/ Binder Course)

### **A) PREPARATION OF WATER BOUND MACADAM SURFACE**

The existing water bound macadam surface shall be brushed and cleaned properly so as to be free from all loose materials, murrum, earth, silt etc. and should be shaped and conditioned to the specified lines, grades and sections as directed by the Engineer-in-Charge. Any depression or potholes shall be properly made up and thoroughly compacted sufficiently in advance. The surface shall be thoroughly swept and scrapped clean of dust and other foreign matter and priming if needed may be applied in accordance with IRC specification for priming of base course with bituminous primers. During the process of cleaning the sub grade (water bound macadam) soft spots pockets, hollows etc., are found, such spots will be filled with approved metal, consolidated and finished to proper level, rolled with power roller if found necessary, by the Engineer-in-Charge, or consolidated as directed by the Engineer-in-Charge. It shall be the responsibility of the contractor to ensure that the subgrade is even and finished to camber and slope as specified. The surface of the subgrade shall be checked for its trueness by means of a scratch template resting on side forms having scratch points placed not more than 200mm apart and set to the exact profile of the base course. The template shall be drawn along the forms at right angles to the centre line of the road.

The unevenness of the surface as indicated shall not exceed the limits given in the table No. 1 given here under. The surface irregularities in excess of this shall be rectified all as directed by the Engineer-in-Charge.

No full grout macadam work shall be commenced unless the thus prepared surface is approved by the Engineer-in-Charge.

The Contractor shall ensure that he inspects the road and collects all relevant data pertaining to the preparation of subgrade and unless otherwise specified rate quoted by him shall be deemed to be inclusive of all charges required for the preparation of the base as detailed above and no compensation whatsoever shall arise from these works.



TABLE 1

**PERMITTED TOLERANCES OF SURFACE REGULARITIES FOR PAVEMENT COURSES**

Sl. No.	Type of Construction	Max. Permissible undulation in mm	Longitudinal Profile with 3 mtr template				
			Straight edge Max. No. of undulations permitted in any 3mtrs length				Cross profile Max permissible variation from specified profile under camber
			18mm	12mm	10mm	6mm	
1	2	3	4	5	6	7	8
1	Earthen Subgrade	24	30	-	-	-	15
2	Granular/lime cement stabilised sub base	15	-	30	-	-	12
3	Water bound macadam with big size metal (40-90 mm size)	15	-	30	-	-	12
4	Water bound macadam with normal size metal (20-50 mm & 40-63 mm size)	12	-	-	30	-	8
5	Macadam or built-up spray grout	12	-	-	20	-	8
6	Surface dressing (two coats)* over WBM (20-50 mm or 40-63 mm size metal)	10	-	-	-	30	6
7	Bituminous penetration macadam or built-up spray grout	10	-	-	-	20**	6
8	Open graded premix carpet mix seal surfacing	10	-	-	-	20**	6
9	Bituminous macadam Semi dense Carpet* Asphaltic concrete	8	-	-	-	10**	4

- Note :** 1)\* For surface dressing in all other cases the standards of surface evenness will be the same as these for surface receiving the surface dressing.
- 2)\*\* These are for machine laid surfaces, if laid manually due to unavoidable reasons tolerance upto 50% above these values in this column may be permitted at the discretion of the Engineer-in-Charge. However this relaxation does not apply to the value of maximum undulations for longitudinal and across profiles mentioned in column 3 and 8 on the table.
- 3) The surface evenness requirements in respect of both the longitudinal and cross profiles should be simultaneously satisfied.

**b) COLLECTION OF METAL**

The metal required for full grout bituminous macadam shall conform to IRC specifications in all respects and should conform to the physical requirement as given in Table 2 here below and also should conform to the grading as given in Table 3 here below:

**TABLE 2**

**PHYSICAL REQUIREMENTS OF AGGREGATE FOR BITUMINOUS MACADAM**

Sl. No.	Test	Test Method	Requirements
1	Los Angles* abrasion value	IS: 2386 (Part IV)	35% Maximum
2	Aggregate impact value	IS: 2386 (Part IV)	30% Maximum
3	Flackiness Index	IS: 2386 (Part I)	35% Maximum
4	Stripping value	IS: 6241	25% Maximum
5	Water absorption	IS: 2386 (Part III)	2% Maximum

**Note :** \* Aggregates may satisfy requirements of either of the two tests.

**TABLE-3**

**GRADING REQUIREMENT OF COARSE AGGREGATES AND KEY AGGREGATES**

% By Weight Passing the Sieve				
SEIVE Designation	For 50mm thickness	Compacted	For 75mm thickness	Compacted
	Coarse aggregate	Key aggregated	Coarse aggregate	Key aggregate
63mm	—	—	100	—
50mm	100	—	—	—
38mm	—	—	35-70	—
25mm	35-70	—	—	100
19mm	—	100	0-15	35-70
12mm	0-15	35-75	—	0-15
9mm	—	—	—	0-15

Metal shall be collected in stacks on level ground and stacked on the sides of the road as directed. The metal shall consist of crushed stone, clean, strong, durable, fairly cubical shape free from all earth, rubbish and vegetable matter disintegrated pieces, salt, alkali, adherent coating and graded, before stacking and closely packed in stacks. The aggregates shall be hydrophobic and low porosity. The measurements shall be taken for the collected metal before spreading. No deductions will be made for the voids. The size of the stack may be 1.0m wide at top, 2.0m wide at bottom and 0.50m high or as per the approval template size. The length shall be as directed by the Engineer-in-Charge. The Contractor shall provide the template required to ensure the compliance with the size of the stack stipulated.

**(c) BINDER**

Binder shall be of grade specified in the schedule of quantity such as straight run bitumen 80/100, 60/70, 30/40 road tar grade RT4/RT5 or approved cut backs satisfying the requirements of IS 73, 215, 217 or 454.

The quantities of aggregate and binder requirements for 10 sqm or road surface is as per Table 3 given below.

**TABLE**

**QUANTITIES OF MATERIAL REQUIRED FOR 10 SQM OF ROAD SURFACE FOR BITUMINOUS PENETRATION MACADAM BASE/ BINDER COURSE**

<b>Binder</b>				
<b>Compacted Thickness</b>	<b>Straight run bitumen</b>	<b>Road for RT4/RT5</b>	<b>Coarse aggregate</b>	<b>Key aggregate</b>
50mm	50kg	60-65 kg	0-60 M <sup>3</sup>	0-15 M <sup>3</sup>
75mm	68kg	82-88 kg	0-90 M <sup>3</sup>	0-18 M <sup>3</sup>

**CONSTRUCTIONAL OPERATIONS**

**WEATHER AND SEASONAL LIMITATIONS**

The bituminous penetration macadam course shall not be constructed during foggy or rainy weather. When the underlying course is damp or wet or during dust storm or when the atmospheric temperature in shade is 16°C below.

**PREPARATION OF UNDERLAYING COURSE**

The under laying course should be prepared as laid down above and protected from dust or any other foreign material till the laying of coarse aggregate.

## **FORM WORK**

Necessary form work of design approved by the Engineer-in-Charge shall be used to retain the aggregate and bitumen etc., in position at sides, to required lines, levels and gradients during the entire progress of work.

## **SPREADING AND COMPACTING COARSE AGGREGATE**

The coarse aggregate in dry and clean form shall then be spread over the prepared bed uniformly and evenly, without segregation of coarse and fine fragments at the rate specified in the table 3 above in such a manner so as to produce the required line, grade and cross section as directed by the Engineer-in-Charge. Template, depth gauges, spirit levels, shall be used to ensure proper spreading of material to required thickness, camber etc.

## **ROLLING THE COARSE AGGREGATE**

After spreading the coarse aggregate it shall be dry rolled so as to give a firm even surface which will allow a uniform penetration of bituminous material using 10 tonnes smooth wheeled steel roller. The dry rolling shall be commenced as soon as the coarse aggregate has been spread to camber, profile, thickness etc., and has been duly verified. The rolling shall progress gradually from each side towards the centre of the road (over lapping at least 30 cms) except at super elevated curves where it shall progress from the inner to the outer edge, over lapping approximately one third the width of the rear wheel each trip. The trueness of the surface shall be checked frequently by means of camber boards and 3 metre straight edge. The surface should not vary more than 12mm from the template or straight edge. Uneven area that develop during rolling shall be loosened and recompacted adding fresh material or removing as may be necessary. Rolling shall be stopped immediately where there are signs of stones crushing as the rolling is not meant for consolidating but merely to provide an even surface to the satisfaction of the Engineer-in-Charge. The speed of the roller should be sufficiently slow to prevent any pushing under the wheels. Generally rolling shall be done until the compacted coarse aggregate has a firm surface true to the cross section shown on the plan/ specified and that it has a texture will allow free and uniform penetration of the asphaltic material.

## **APPLICATION OF BITUMINOUS MATERIAL**

The bitumen shall be heated in a bitumen boiler to the specified temperature. In case of R-90 it may be heated between 163°C-177°C. At no time the bitumen materials be allowed to attain a temperature above the maximum temperature specified.

The temperature to which different grades of bitumen shall be heated is as below:

GRADE	Temperature to which it shall be heated
<b>A) For Surface dressing (For Painting)</b> 1. Paving bitumen from Assam Petroleum A90 2. Paving bitumen from other sources 80/100-S90 3. Bitumen Emulsion min 50% bitumen Content: RS Grage IS 8837 4. Cut backs RC (Rapid Curing) IS 217	177°c. to 190°c.  177°c. to 190°c.  Cold application  Cold application
<b>B) For Premix Carpeting</b> 1) Paving asphalt 30/40, S-35, or 80/100 S-90 2) Bitumen Emulsion min 60% bitumen contents RS grage IS 8837 3) Cutback MC( Medium curing) IS 4545	149°c. to 177°c.  Cold application  Cold application
<b>C) For asphaltic concrete straight run bitumen 60/70 (S-65) conforming to IS 73</b>	150°c. to 177°c.

After heating the bitumen shall be applied over the coarse aggregate laid and compacted as specified herein before, by pressure spraying machine at the rate specified in table 3 above. The pump and spraying equipment shall be provided with suitable devices to ensure flow of bitumen under constant pressure. Spraying machine shall be provided with an accurate thermometer for temperature control. The bituminous material shall be applied to the surface uniformly in quantities specified and the sprayer shall be operated in such a manner as to avoid missing or over lapping of the surface which would make for a non uniform application. It should be ensured that the aggregate are perfectly dry to the full depth of the layer prior to the application of the bitumen.

**(e) APPLICATION OF KEY AGGREGATE AND SECOND ROLLING**

Immediately after the first penetration of the bitumen, key aggregate in a clean and dry state shall be spread uniformly over the surface by means of an approved mechanical spreader or by approved manual method at the rate specified in Table 3 herein above.

The surface shall be broomed to ensure the uniform application of key aggregates. The entire surface shall then be rolled with a 8-10 tonne smooth steel wheeled roller (along with vibratory roller if available) to the specification conforming to para above.

As soon as the chippings are spread and while the bitumen is still soft the surface shall be rolled by a power roller to thorough compaction and to all even finish. This rolling shall be continued until the bitumen hardness and there is no movement under the roller.

After rolling as specified above, the surface shall be cleaned without disturbing the chippings and irregularities if any, corrected by painting with bitumen and blinding with chippings.

#### **(F) SEAL COATS**

The penetrations macadam shall then be opened for traffic for seven days or such other period as the Engineer-in-Charge may specify and a seal coat applied as below:

Seal coat work shall consists of application of seal coat for sealing the voids in the bituminous surface laid to the specified levels, grade and camber by application of a layer of bituminous binder followed by a cover of stone chippings.

All potholes and depressions should be repaired and the surface cleaned of all mud, matted earth, dust and other foreign materials. If there is any matted material not definitely bonded to the surface it shall be scrapped away. All traces of dust which get dislodged while brushing and brooming shall be removed by dusting the surface with clean gunny bags.

The binder shall be bitumen of a suitable grade as specified or directed by Engineer-in-Charge and conforming to the requirement of IS 73,217 or 454 as applicable or any other approved cut back. The quantity in terms of straight run bitumen shall be 9.8 kg per 10 m<sup>2</sup> area. The bitumen to be heated to the specified temperature for R-90 (80/100 grade) 160°C to 177°C and applied by pressure sprayers uniformly at the rates specified herein above.

The stone chippings shall consists of angular fragments of clean, hard, tough and durable rock of uniform quality through out. They should be free of elongated or flaky pieces soft or disintegrated stone, vegetable or other deleterious matter. Stone chippings shall be of 6mm size defined as 100% passing through 10mm sieve and retained on 2.36mm sieve. The quantity used for spreading shall be 0.12M<sup>3</sup> per 10M<sup>2</sup> of area. The chipping shall satisfy the quality requirement spelled out in Table 2 given herein above except that the upper limit for flakiness index shall be 30. The application of aggregate shall be followed by light brooming of the surface till a uniform surface, free from waveiness, depressions, and other irregularities is achieved. Additional materials shall be added in required quantities to cover bare spots.

Where bitumen material has become sufficiently stiff to hold the aggregate in place but not sufficiently cured to become hard and brittle the surface shall be lightly rolled. Excessive rolling shall be avoided to prevent crushing of aggregate.

**(G) SURFACE FINISH AND QUALITY**

All works performed should confirm to the lines, grades, cross sections, and dimensions shown on the drawings or as directed by the Engineer-in-Charge subject to the permitted tolerances described hereinafter.

Horizontal alignment shall be reckoned with respect to the centre line of the carriage way as shown on the drawings. The edges of the carriage way as constructed shall be correct within a tolerance of  $\pm 25\text{mm}$  therefrom. The corresponding tolerance for the edges of the road way and lower layers of pavement shall be  $\pm 40\text{mm}$ .

As regards longitudinal profile, the levels, of subgrade and different pavement courses as constructed shall not vary from those calculated with reference to the longitudinal and cross profile of the road shown on the drawings or as directed by the Engineer-in-Charge, beyond the tolerance mentioned below:

Sub grade	...	$\pm 25\text{mm}$
Sub base	...	$\pm 20\text{mm}$
Base course	...	$\pm 15\text{mm}$
Wearing course	...	$\pm 10\text{mm}$

Provided however that the negative tolerance of wearing course shall not be permitted in conjunction with positive tolerance for base course if the thickness of the former is thereby reduced by more than 6mm.

The surface regularity of completed sub base, base courses and wearing surfaces in longitudinal and traverse directions shall be within the tolerance indicated in table 1 herein above.

The longitudinal profile shall be checked with a 3m long straight edge at the middle of each traffic lane, along a line parallel to the centre line of the road. The transverse profile shall be checked with a set of three camber boards at intervals of 10mtrs.

Where the surface irregularities of subgrade and various pavement courses fall outside the specified tolerances the contractor shall be liable to rectify these in the manner as specified under clause 900 of IRC publication on specification for road and bridge works to the satisfaction of the Engineer-in-Charge.

#### **(H) OPENING TO TRAFFIC**

Traffic shall not permitted to run on any newly surface dressed area until the following day. In special circumstances however the Engineer-in-Charge may open the road to traffic immediately after rolling but in such cases its speed shall be limited to 16km per hour till the following day.

The work involves the following in addition to the specification laid down:

- 1) Making arrangements for traffic during construction as laid down in IRC specification such as the contractor shall at all times carry out the work on road in a manner creating least interference to the flow of traffic while consistent with satisfactory execution of the same etc.
- 2) Preparation of base (except for laying of levelling course) but including filling of potholes.
- 3) Providing all materials to be incorporated in the work, including all royalties, fees, rents, where necessary and all leads and lifts.
- 4) All labour, tools, equipment and incidentals to complete the work to the specifications.
- 5) Carrying out the work in part widths where directed.
- 6) Inclusive of all operations, form work etc; for the successful completion of work in a workman like manner to the entire satisfaction of the Engineer-in-Charge generally consistent with specifications stated herein above.

#### **17.12 DENSE BITUMINOUS MACADAM**

##### **MATERIALS**

Coarse aggregate shall be from crushed / broken hard stone conforming the requirements of IS 2386, IS 6241 and ASTM-D. The fine aggregate shall be the fraction passing 2.36mm sieve and retained on 75 micron sieve, consisting of crusher run screenings, natural sand or mixture of both. The aggregate shall be clean and conforming to the requirements. The filler shall consists of finally graded particles of stone dust, hydrated lime, cement, flyash, or any other non plastic mineral approved by the Engineer-in-Charge. The plasticity index shall not be greater than 4. The gradation requirement is as below:

<b>Sieve designation</b>	<b>Percentage passing by dry weight</b>
60 microns	100
300 microns	95-100
75 microns	85-100



The paving bitumen of penetration value 60/70 grade S65 or A65 conforming to IS73 shall be used. Alternatively with the approval of EIC bitumen of grade S90 may be used.

Apart from conformity with grading and quality requirements of individual ingredients, the mix shall meet the requirement set out below:

1) Marshall stability (ASTM Designation D-1559)	820kg
2) Marshall flow (mm)	2-4
3) Percent air voids	3-5
4) Minimum voids in mineral aggregates (VMA)	10% - 12%
5) Percent voids in mineral aggregated filled by bitumen (VFA)	65-75
6) Binder content percent by weight of total mix	not less than 4%

The contractor shall intimate at least 20 days before the start of the work the job mix formula inter alia giving the following details and get it approved.

- a) Source and location of all materials
- b) Proportion of all materials
- c) A single definite percentage passing each sieve for the mixed aggregate.
- d) Results of tests of meeting Marshall stability, Marshall flow, and percent air voids, VMA, VFA binder content etc.
- e) Test results of physical characteristics of aggregates.
- f) Mixing and compacting temperature.

The work of laying should not be taken up during rainy or foggy weather or when the base course is damp or wet or during dust storm or when the atmospheric temperature in shade is 10°C or less.

The preparation of base shall be generally as in the case of any bituminous macadam surface.

Tack coat shall be applied over base as specified.

Bituminous macadam mix shall be prepared in a hot mix plant of adequate capacity and capable of yielding a mix of proper and uniform quality with thoroughly coated aggregates. The hot mix plant shall preferably be of batch mix type. The plant shall have essential features as specified in MOST specification clause 504.

The temperature of the binder at the time of mixing shall be in the range of 150°C to 163°C and that of the aggregate in the range of 155°C to 163°C provided

that the difference in temperature between the binder and aggregate shall at no time exceed 14 °c. The mixing shall be thorough approved tipper vehicles to be used for transporting the mix to the point of use.

The spreading of the mixture shall be by self-propelled paver with suitable screeds capable of spreading, specified quantity / thickness, tamping and finishing the mix to specified grade lines and cross section. The paver finisher shall conform to that stipulated under clause 504.3.5 of MOST specifications. For smaller jobs with the approval of EIC mechanical paver may be used and restricted locations where equipment cannot be operated manual laying of mix may be approved by EIC.

The temperature of mix at the time of laying shall be 120°C to 160°C.

Compacting shall be done by smooth wheeled 8T to 10T vibratory roller or 15 to 25 T weight pneumatic tyred roller moving at a speed not more than 5km/h. Finishing shall be done by 6 to 8 tonnes smooth wheeled tandem roller. For initial breakdown rolling and finishing rolling, no vibratory compaction shall be resorted to. Trial compaction to be done and exact pattern of rolling shall be got approved by EIC. No foreign matter shall be allowed to be dropped on the pavement during rolling operation or roller is standing. The wheels of the roller shall be kept moist to prevent any adherence fuel / lubricating oil shall not be used for this nor excess water poured. Rolling shall proceed as per rolling of other macadam surfaces specified above. Rolling shall be done till the density achieved is 98% of laboratory Marshall specimen (compacted) and completed before the temperature of the mix falls below 100°C.

After completion of rolling and mix cools down to ambient temperature, traffic may be allowed. Prior to regular opening to normal traffic/rainy season appropriate wearing course shall be provided.

All work shall be executed generally as specification under clause 507 of specification of Ministry of Surface Transport (Roads wing) (MOST RW).

#### **17.13 BUILT-UP SPRAY GROUT MACADAM**

Work shall consist two layers of composite construction of compacted crushed stone aggregates with application of bituminous binder after each layer and key aggregates on top for the second layer, in accordance with the requirement of specifications and in conformity with the lines, grades and cross sections shown on drawings or as directed by Engineer of specified thickness.

The materials, weather and seasonal limitations, preparation of base, tack coat shall all be as specified for macadam road works above.

Immediately after application of tack coat, the coarse aggregate in dry and clean form shall be spread uniformly evenly, and to template preferably by mechanical means at specified rate.

Immediately on spreading the aggregates the entire surface shall be rolled with a 8 to 10 tonnes smooth wheeled roller. The rolling and checking the top surface etc. shall be attended as in the case of rolling of aggregates for other bituminous surfaces specified above. The rolling shall be stopped before voids in the aggregate layer are closed to such an extent as to prevent free and uniform penetration of binder.

For application of the binder for the first spray, the binder shall be heated to the temperature appropriate to grade of bitumen and sprayed on aggregate layer at the specified rate and at specified temperature in uniform manner with mechanical sprayer excessive deposits of binder caused during spraying due to any reason should be corrected promptly.

Immediately after first application of the binder the second layer of course aggregate shall be spread and rolled. Rolling shall be done as detailed above.

On rolling the second aggregate layer second spray of binder shall be attended at specified rate and temperature. Immediately, key aggregate is clean and dry state shall be spread uniformly and evenly preferably by mechanical means at specified rate to cover the surface completely duly brooming whenever required to ensure uniform application. The surface shall again be rolled with 8 to 10 tonne smooth wheeled roller as said above adding additional key aggregate wherever required until the entire course is thoroughly compacted and the key aggregates are firmly in position. On satisfactory completion of work and the surface has set the road may be opened for traffic.

#### **17.14 ROUGH STONE DRY PACKING FOR REVETMENT/PITCHING**

Wherever revetment is proposed for earthwork embankment, 150mm gravel backing shall be provided.

The thickness of revetment/pitching slope, toe wall etc shall be as shown in the respective working drawings.

The revetment stones shall be hard and may be mixed size exceeding 63mm and not exceeding 300mm in dimensions. The smaller sizes shall be carefully selected to the required shape and packed by hand to required levels grades, camber etc. The revetment shall be with as few and small voids as possible duly filling the interstices with similar hard spalls and finished in an acceptable workman like manner. Before start of work, profiles at 3m intervals along the length are to be marked with strings and got approved by EIC.

## 17.15 LETTERING WITH PAINT

Unless otherwise specified, black Japan paint (conforming to IS 341) or ready mixed paint of approved brand/ manufacture and shade as ordered by the Engineer-in-Charge shall be used.

The letters and figures shall be to the height and width as in drawing or as directed by EIC. They shall be stenciled or drawn in pencil and got approved before painting. Required number of coats shall be applied till uniform colour and finish are obtained.

## 17.16 REMOVING OLD PAINT

Patent paint remover of approved brand and manufacturer shall be used. It shall be free from alkaline matter and non caustic so that it can be handled by workman without injury. As far as possible it shall be non inflammable quality paint removers may be used where burning off with blow lamp is not suitable. The paint remover shall be applied liberally with brush, and allowed to remain for a period recommended by manufacturer depending upon brand of paint remover thickness of paint coating to be removed etc. If the paint is not thoroughly removed second coat may be applied with the approval of EIC. Finally the paint shall be thoroughly scrapped, washed with mineral turpentine and surface made suitable for application fresh paint or any other finish.

When the paint remover used is of inflammable type suitable precautions should be taken. Neighboring paint surface which is not to be removed shall be suitably protected from contact with paint remover. When permitted, paint may be removed by caustic soda solution. As it contains alkali, after the paint is removed by caustic soda solution, it should be cleaned thoroughly with clean water and all traces of alkali should be got removed, if required a little acetic acid or vinegar may be added to the final rinsing water, while cleaning which helps to neutralize any remaining alkali. As alkali will spoil the new paint, thorough removal of the same should be ensured. Precaution should be taken to ensure that no liquid spills over skin or clothing as it is corrosive liquid.

Blow lamp or air acetylene equipment may also be used for removal of paint. The flame shall be allowed to play upon the paint just enough to soften it without charring either the paint or the background. The softened paint shall then be removed with a stripping knife following the flame as it is moved upto the surface. Burning off shall begin at the bottom of the vertical surface and shall proceed upwards. Removal of paint with blow lamp shall not be done on narrow or carved under cut surfaces or where there is risk of damages to the neighbouring materials such as panes in glazed windows etc.

**LIST OF MATERIALS BEARING ISI CERTIFICATION  
(WITH REFERENCE FROM THE BUYER'S GUIDE OF BUREAU OF INDIA  
STANDARDS)**

Sl. No.	IS:NO	PRODUCT
		<b>EARTH WORK</b>
1	IS:8944-1978	Chlorpyrifos emulifiable concentrate
		<b>CONCRETE WORKS</b>
2	IS:2645-1975	Integral Cement Water Proofing compounds
	IS:9103-1979	Admixture for concrete
		<b>RCC WORKS</b>
3	IS:1566-1982	Hard drawn steel wire fabric for concrete reinforcement
4	IS:1786-1985	High strength deformed steel bars and wires for concrete reinforcement
5	IS:7887-1992	MS Wire Rods for general Engineering purposes
6	IS:6522-1972	Specification for precast RCC door and window frames
		<b>WOOD WORK</b>
7	IS:303-1989	Plywood for general purpose
8	IS:1328-1996	Veneered decorative ply wood
9	IS:3087-1985	Wood particle boards (medium density) for general purposes
10	IS:1659-1990	Block boards
11	IS:1658-1977	Fibre Hard boards
12	IS:2191-(Part-1) 1983	Wooden flush door shutters (Cellular & hollow core type), ply wood face panels.
13	IS:2202-(Part-1) 1991	Wooden flush doors shutters (Solid core type) ply wood face panels
14	IS:1341-1992	Steel butt Hinges
15	IS:205-1992	Non ferrous metal butt hinges
16	IS:362-1992	Parliament hinges
17	IS:3818-1992	Continuous (Piano) hinges

SI. No.	IS:NO	PRODUCT
18	IS:206-1992	Teel & strap hinges
19	IS:208-1996	Door handles
20	IS:281-1991	Mild Steel sliding door bolts for use with padlocks
21	IS:2681-1993	Non-ferrous metal sliding door bolts (aldrops) for use with padlocks
22	IS:204 (Part I)1991	Tower bolts (ferrous metals)
23	IS:204(Part II)1992	Tower bolts (Non ferrous metals)
24	IS:3564-1995	Door closures (hydraulically regulated)
25	IS:7452-1990	Hot rolled steel section for doors, windows and ventilators
26	IS:1083-1983	Steel doors, windows and ventilators
27	IS:6248-1979	Metal rolling shutters and rolling grills
28	IS:1161-1979	Steel tubes for structural purposes
29	IS:1331-1971	Cut size timber
30	IS:2191 (Part II) 1983	Cellular and hollow core type particle board and hard board face panels
31	IS:2202 (Part II) 1983	Solid core type wooden flush door shutters, particle board face panels and hard board face panels
32	IS:4021-1995	Timber door window and ventilator frames
33	IS:4962-1968	Specification for wooden sliding doors
34	IS:5100-1992	Ledged, braced and battoned timber door shutters
35	IS:5509-1980	Fire retardant plywood
36	IS:5539-1969	Specification for preservative treated plywood
37	IS:10394-1982	Wooden sleepers for railway track
38	IS:10701-1983	Structural plywood
39	IS:190-1991	Specification for coniferous sawn timber (bulks and scantings)
40	IS:209-1996	Door handles
41	IS:452-1973	Door springs rat tail type
42	IS:453-1993	Double acting spring hinges

Sl. No.	IS:NO	PRODUCT
43	IS:729-1979	Specification for drawer locks cup-board lock and box locks
44	IS:823-1980	Floor door stoppers
45	IS:4992-1975	Specification for door handles for mortice locks
46	IS:6315-1992	Specification for floor springs (hydraulically regulated) for heavy doors
47	IS:6343-1982	Specification for door closet (pneumatically regulated) for light doors with weighing upto 40 kgs.
48	IS:7196-1974	Hold fasts
49	IS:7197	Double acting floor springs for heavy doors
50	IS:1018-1982	Pad locks brass lever type machine made
51	IS:1019-1974	Rim latches
52	IS:2209-1976	Mortice locks
53	IS:3843-1995	Steel black flap hinges
54	IS:3847-1992	Mortice night latches
55	IS:5899-1970	Bathroom latches
56	IS:5930-1970	Mortice latch (verticle type)
57	IS:5999-1971	Swing latches
58	IS:6318-1971	Specification for plastic window stays and fasteners
59	IS:6607-1972	Specification for rebated mortice locks (vertical type)
60	IS:7540-1974	Mortice dead locks
61	IS:8760-1978	Mortice sliding door locks with lever mechanism
62	IS:9106-1979	Rising butt hinges
63	IS:10019-1981	Mild steel stays and fasteners
64	IS:12197-1987	Pad locks pin tumbler type
65	IS:12303-1987	Criteria for design of RCC hinges
66	IS:12817-1989	Stainless steel butt hinges
67	IS:8756-1978	Mortice ball catches for use in wooden almirah
68	IS:9460-1980	Specification for flush drop handles for drawer

Sl. No.	IS:NO	PRODUCT
69	IS:207-1964	Gate and shutter hooks and eyes
70	IS:275-1992	Pad locks lever type hand made
71	IS:363-1993	Hasps and staples
		<b>FLOORING</b>
72	IS:1237-1980	Cement concrete flooring tiles
73	IS:1195-1978	Bituminum mastic for flooring
74	IS:1196-1978	Code of practice for laying bitumen mastic flooring
75	IS:1197-1970	Code of practice for laying rubber floors
76	IS:1198-1982	Code of practice for laying, fixing and maintenance of linoleum flooring
77	IS:5398-1969	Code of practice for laying of hard wood parquet and wood block floors
78	IS:5481-1992	Floor polish liquid
79	IS:653-1992	Linoleum sheets and tiles
80	IS:809-1992	Rubber flooring materials for general purpose
81	IS:1128-1974	Lime stone (Slabs and tiles)
82	IS:1130-1969	Marble (block, slabs and tiles)
83	IS:1478-1992	Clay flooring tiles
84	IS:3461-1980	Specification for PVC asbestos floor tiles
85	IS:3462-1986	Specification for un-backed flexible PVC flooring
86	IS:3464-1986	Methods of test for plastic flooring and wall tiles
87	IS:3583-1988	Burnt clay paving bricks
88	IS:3622-1977	Specification for sand stone slab and tiles
89	IS:3670-1989	Code of practice for construction of timber floors
90	IS:4457-1982	Ceramic unglazed vitreous acid resisting tiles
91	IS:13753-1993	Dust pressed ceramic tiles with water absorption of E 10% (group B-111)
92	IS:13754-1993	Dust pressed ceramic tiles with water absorption of 6% E 10% (group B11b)
93	IS:13755-1993	Dust pressed ceramic tiles with low water absorption 3% E 6% (group B-11a)



Sl. No.	IS:NO	PRODUCT
94	IS:13756-1993	Dust pressed ceramic tiles with low water absorption of E 3% (Group B-1)
95	IS:9704-1980	Methods of test for linoleum sheets and tiles
96	IS:13630-(Part 0-sec 3 part 15)-1994	Ceramic tiles Methods of test
97	IS:13801-1993	Chequered cement concrete tiles
98	IS:657-1982	Materials for use in the manufacture of magnesium oxychloride flooring compositions
99	IS:658-1982	Code of practice for magnesium oxychloride composition floors
		<b>ROOFING</b>
100	IS:1322-1933	Bitumen felts for water proofing and damp proofing
101	IS:1626 (Part1) 1994	Asbestos cement building pipes and pipe fitting, gutters and gutter fittings, roofing – (Part 1) pipe and pipe fittings
102	IS:1230-1979	Cast iron rain water pipes and fittings
103	IS:5390-1984	Code of practice for construction of timber ceiling
104	IS:277-1992	Galvanised and steel sheet (Plain and corrugated)
105	IS:459-1992	Corrugated and semi-corrugated asbestos cement sheets
106	IS:730-1978	Hook bolts for corrugated sheet roofing
107	IS:1239 (part 1) 1990	Mild steel tubes tubular and other wrought steel fittings, mild steel tubes
108	IS:1239 (Part II) 1992	Mild steel tubes tubular and other wrought steel fittings and other wrought steel pipe fittings
109	IS:1254-1991	Corrugated aluminium sheets
110	IS:1346-1991	Code of practice for water proofing of roofs with bitumen felt
111	IS:2690 (Part 1) 1993	Burnt clay flat terracing tiles (machine made)
112	IS:2690 (Part II) – (Part 2)	Burnt clay flat terracing tiles (hand made)

Sl. No.	IS:NO	PRODUCT
113	IS:3951 (Part 1) 1975	Specification for hollow clay tiles for floors and roofs filler type
114	IS:3951 (Part 2) 1976	Specification for hollow clay tiles for floors and roofs, structure type
115	IS:6073-1971	Specification for autoclaved reinforce cellular concrete floor and roof slabs
116	IS:7193-1994	Glass fibre based bitumen pitch and bitumen felts
117	IS:8869-1978	Washers for corrugated sheet roofing
118	IS:10388-1982	Corrugated coir wood wool cement roofing sheet
119	IS:1580-1991	Bituminous compounds for water proofing and caulking purposes
120	IS:1626 (Part 2) 1994	Asbestos cement building pipes and pipe fittings, gutter and gutter fittings and roofing fittings.
121	IS:2096-1992	Asbestos cement flat sheets
122	IS:2098-1964	Asbestos cement building boards
123	IS:2700-1987	Code of practice for roofing with wooden fittings
124	IS:2858-1984	Code of practice for roofing with Mangalore tiles
125	IS:3087-1985	Wood particle boards for general purposes
126	IS:3097-1980	Veneered particle board
127	IS:3308-1981	Wood wool building slabs
128	IS:6520-1981	Specification for roofing slate tiles
129	IS:6332-1984	Guide of practice for construction of floor and roofs using pre-cast doubly curved shell units
130	IS:7290-1979	Recommendation for use of polythene film for water proofing of roofs
131	IS:10505-1983	Code of practice for construction of floors and roofs using pre-cast concrete waffle units
132	IS:13008-1990	Shallow corrugated asbestos cement sheets
133	IS:3348-1965	Specification for fibre insulation board
134	IS:12506-1988	Code of practice for improved thatching of roof with rot and fire retardant treatment

Sl. No.	IS:NO	PRODUCT
135	IS:13000-1990	Silica asbestos cement flat sheet
		<b>FINISHING</b>
136	IS:341-1973	Black Japan type A,B&C
137	IS:419-1967	Putty for use on window frames
138	IS:5410-1992	Cement paint colour as required
139	IS:104-1979	Ready mixed paint, brushing, zinc chrome priming
140	IS:123-1962	Ready mixed paint brushing, finishing, semi-gloss for general purposes to Indian Standard colour No.445, 448, 449, 451, 473 and red oxide (Colour unspecified)
141	IS:158-1981	Ready mixed paint brushing, bituminous black, lead free, acid, alkali and heat resisting
142	IS:164-1981	Ready mixed paint for road marking
143	IS:168-1993	Ready mixed paint, air drying for general purpose
144	IS:9862-1981	Ready mixed paint, brushing, bituminous black, lead free, acid alkali, water and chlorine resisting
145	IS:3537-1996	Ready mixed paint, finishing, interior for general purpose Indian Standard colours No.101, 216, 217, 219, 275, 281, 353, 358 to 361, 363, 364, 388, 410, 442, 444, 628, 631, 632, 634, 693, 697 white and black
146	IS:3536-1996	Ready mixed paint, brushing, wood pink primer
147	IS:2339-1963	Aluminium paint for general purpose in dual container
148	IS:525-1968	Varnish, finishing exterior and general purposes
149	IS:5411 (Part 1) 1974	Plastic emulsion paint (Part 1) for interior use
150	IS:2932-1993	Enamel, synthetic exterior (a) under coating (b) finishing
151	IS:2933-1975	Enamel exterior (a) under coating (b) finishing
152	IS:133-1993	Enamel interior (a) under coating (b) finishing

Sl. No.	IS:NO	PRODUCT
153	IS:427-1965	Distemper, dry, colour as required
154	IS:428-1969	Distemper, oil emulsion, colour as required
155	IS:3709-1966	Mastic cement bedding of metal windows
156	IS:1232-1964	Ready mixed paint, brushing, yellow ochre semi-gloss for general purpose
157	IS:5411 (Part 2)1992	Plastic elumson paint for exterior use
158	IS:2074-1992	Ready mixed paint air drying, red-oxide zinc chrome, priming
159	IS:2075-1979	Ready mixed paint, storing red oxide zinc chrome, priming
160	IS:3539-1996	Ready mixed paint undercoating for use under oil finishes to Indian Standard colours as required
161	IS:3585-1966	Ready mixed paint aluminium brushing, priming, water resistant for wood work
162	IS:3678-1966	Ready mixed paint, thick white, for lettering
163	IS:5660-1970	Ready mixed paint, brushing, aluminium red-oxide primer
164	IS:11883-1986	Ready mixed paint, brushing, red oxide primer for metals
165	IS:13183-1991	Aluminium paint heat resistant
166	IS:14314-1995	Thinner, general purpose for synthetic paints and varnishes
167	IS:14355-1996	Zinc dust pigment for paints
168	IS:44-1991	Iron oxide pigment for paints
169	IS:38-1976	Antimony oxide for paints
170	IS:40-1971	Carbon black for paints
171	IS:53-1988	Brunswick green for paints
172	IS:54-1988	Green oxide for chromium for paint
173	IS:55-1970	Ultramarine blue for paints
174	IS:56-1993	Prusian blue (iron blue) for paints
175	IS:57-1989	Red lead for paints and other purposes
176	IS:58-1976	Litharge

Sl. No.	IS:NO	PRODUCT
177	IS:62-1950	Graphite for paints
178	IS:63-1978	Whitening for paints and putty
179	IS:64-1972	Barium sulphate pigments for paints
180	IS:66-1972	Magnesium silicate pigments for paints
181	IS:67-1979	Silica for paints
182	IS:68-1979	China clay (Kaolin) for paints
183	IS:70-1980	Cuprous oxide for paint
184	IS:75-1973	Linseed oil raw and refined
185	IS:77-1976	Linseed oil boiled for paints
186	IS:79-1975	Linseed stand oil for paints
187	IS:80-1989	Tung oil for paint
188	IS:81-1989	Dehydrated castor oil for paint
189	IS:102-1962	Ready mixed paint, brushing red lead non-setting priming
190	IS:109-1969	Ready mixed paint, brushing, priming plaster to Indian Standard colour Nos. 361 and 631 white and off whiteq
191	IS:110-1983	Ready mixed paint, brushing, grey filler for enamels for use over primers
192	IS:117-1964	Ready mixed paint, brushing, finishing exterior semi gloss for general purposes to Indian Standard colour Nos. 101 to 104, 169, 174, 216, 217, 219, 275, 278, 280, 281, 283, 352 to 354, 358 to 365, 384 to 388, 397, 410, 442 to 444
193	IS: 120-1982	Ready mixed paint, brushing, finishing, semi-gloss for general purposes standard colour Nos. 537, 538, 540, 541, 570 and 574.
194	IS:121-1962	Ready mixed paint, brushing, finishing semi-gloss for general purpose to Indian Standard colour Nos. 414
195	IS:122-1962	Ready mixed paint, brushing, finishing semi-gloss for general purpose to Indian Standard colours nos. 411, 412 and 413

Sl. No.	IS:NO	PRODUCT
196	IS:124 (Part 1) 1976	Ready mixed paint, brushing, finishing semi-gloss for general purpose (Part 1)
197	IS:124 (Part 2) 1979	Ready mixed paint, brushing, finishing semi-gloss for general purpose (Part 2)
198	IS:124 (Part 3) 1979	Ready mixed paint, brushing, finishing semi-gloss for general purpose (Part 3)
199	IS:126-1962	Ready mixed paint, brushing, finishing semi-gloss for general purpose to Indian Standard colour NO. 671
200	IS:127-1962	Ready mixed paint, brushing, finishing exterior semi-gloss for general purpose white
201	IS:128-1962	Ready mixed paint, brushing, finishing semi-gloss for general purpose black
202	IS:137-1965	Ready mixed paint, brushing mat or egg shell, flat finishing interior to Indian Standard colour as required
203	IS:144-1950	Ready mixed paint, brushing, petrol resisting air drying for interior painting of tanks and containers red oxide (Colour unspecified)
204	IS:145-1950	Ready mixed paint brushing, petrol resisting, air drying for interior painting of tanks and containers, red oxide (Colour un specified)
205	IS:146-1950	Ready mixed paint brushing, petrol resisting, air drying for interior painting of tanks and containers, red oxide (Colour un specified)
206	IS:147-1950	Ready mixed paint brushing, petrol resisting, air drying for interior painting of tanks and containers, red oxide (Colour un specified)
207	IS:148-1950	Ready mixed paint, brushing, under coating, storing for enamels and general purposes colour as specified
208	IS:149-1950	Ready mixed paint spraying, under coating, storing for enamels and general purposes colour as required
209	IS:150-1950	Ready mixed paint, brushing, finishing, storing for general colour as required.
210	IS:151-1986	Ready mixed paint, spraying, finishing storing enamel for general purposes colour as required

Sl. No.	IS:NO	PRODUCT
211	IS:152-1950	Ready mixed paint, brushing, storing lead free for general purposes colour as required
212	IS:153-1950	Ready mixed paint spraying, storing lead free for general purpose colour as required
213	IS:155-1950	Ready mixed paint brushing mat black for use on wood
214	IS:159-1981	Ready mixed paint brushing acid resisting
215	IS:162-1950	Ready mixed paint brushing fire resisting silicate type for use on wood colour as required
216	IS 163-1978	Ready mixed paint, dipping fire resisting
217	IS:290-1961	Coal tar black paint
218	IS:337-1975	Varnish finishing interior
219	IS:342-1976	Varnish acid resisting
220	IS:344-1976	Varnish storing
221	IS:347-1975	Varnish shellac for general purposes
222	IS:348-1968	French polish
223	IS:430-1972	Paint-remover solvent type non flammable
224	IS:524-1983	Varnish, finishing, exterior, synthetic air drying
225	IS:533-1973	Gum-spirit of turpentine (oil turpentine)
226	IS:870-1962	Ready mixed paint brushing, finishing, egg shell gloss for interior use to Indian Standard colours No. 101, 216, 217, 219, 275, 281 & 358.
		<b>SANITARY INSTALLATIONS</b>
227	IS:4984-1987	HDPE pipes for potable water supplies, sewage and industrial effluents.
228	IS:3989-1984	Centrifugal cast (spun) iron, spigot and sockets soil, waste and ventilating pipes, fitting and accessories
229	IS:1729-1979	Sand cast iron spigot and socket soil, waste and ventilation pipes fittings and accessories
230	IS:771 (Part 2) 1985	Glazed fire clay sanitary appliance (part 2) specific requirements of kitchen and laboratory sinks.

Sl. No.	IS:NO	PRODUCT
231	IS:774-1984	Flushing cistern for water closet and urinals (other than plastic cistern)
232	IS:2326-1987	Automatic flushing cisterns for urinals
233	IS:2548 (Part 1) 1996	Plastic seats and covers for water closets (Part 1) Thermoset seats and covers.
234	IS:2548 (Part 2) 1996	Plastic seats and covers for water closets (Part 2) Thermoplastic seats and covers.
235	IS:1795-1982	Pillar taps for water supply purposes
236	IS:771 (Part 1) 1979	Glazed fire clay sanitary appliances part 1 general requirements
237	IS:771-(Part 3/sec. 1) 1979	Glazed fire clay sanitary appliances, part 3 specific requirements for urinals section 1 slab urinals
238	IS:771 (Part 3/sec. 2) 1985	Glazed fire clay sanitary appliances, part 3 specific requirement for urinals section 2 stall urinals
239	IS:771(Part 4) 1979	Glazed fire clay sanitary appliances, part 4 specific requirement of post mortar slabs
240	IS:775-1970	Cast iron brackets and supports for wash basins
241	IS:777-1988	Glazed earthen wire wall tiles
242	IS:2556 (Part 1) 1994	Vitreous sanitary appliances (Vitreous china) general requirements
243	IS:2556 (Part 2) 1994	Vitreous sanitary appliances (Vitreous china) part 2 specific requirements of wash down water closets
244	IS:2556 (Part 3) 1994	Vitreous sanitary appliances (Vitreous china) part 3 specific requirements pans
245	IS:2556 (Part 4) 1994	Vitreous sanitary appliances (Vitreous china) part 4 specific requirements basins
246	IS:2556 (Part 5) 1994	Vitreous sanitary appliances (Vitreous china) part 5 specific requirements laboratory sinks
247	IS:2556 (Part 6) 1995	Vitreous sanitary appliances (Vitreous china) part 6 specific requirements of urinals and partition plates



Sl. No.	IS:NO	PRODUCT
248	IS:2556 (Part 7) 1995	Vitreous sanitary appliances (Vitreous china) part 7 specific requirements of accessories for sanitary appliances
249	IS:2556 (Part 8) 1995	Vitreous sanitary appliances (Vitreous china) part 8 specific requirements of pedestal close coupled wash down and symphonic water closets
250	IS:2556 (Part 9) 1995	Vitreous sanitary appliances (Vitreous china) part 9 specific requirements of pedestal type bidets
251	IS:2556 (Part 14) 1995	Vitreous sanitary appliances (Vitreous china) part 14 specific requirements integrated squatting pans
252	IS:2556 (Part 15) 1995	Vitreous sanitary appliances (Vitreous china) part 15 specific requirements universal water closets
253	IS:9758-1981	Flush valves and fittings for water closets and urinals
254	IS:1701-1960	Mixing valves for ablutionary and domestic purposes
256	IS:2963-1979	Specification for copper alloy waste fittings for wash basins and sinks
257	IS:3311-1979	Waste plug and its accessories for sinks and wash basins
258	IS:4267-1967	Stands, wash hand basins
259	IS:7231-1984	Specification for plastic flushing cisterns for water closets and urinals
260	IS:8718-1978	Vitreous enameled steel kitchen sinks
261	IS:8727-1978	Vitreous enameled steel wash basins
262	IS:3489-1985	Specification for enameled bath tubs
263	IS:6411-1985	Specification for gel coated glass fibre reinforced polyester resin bath tubs
264	IS:13983-1994	Stainless steel sinks for domestic purposes
		<b>WATER SUPPLY</b>
265	IS:1592-1989	Asbestos cement pressure pipes

Sl. No.	IS:NO	PRODUCT
266	IS:4985-1988	Unplasticised PVC pipes for potable water supplies
267	IS:1536-1989	Centrifugal cast (spun) iron pressure pipes for water, gas and sewage
268	IS:1537-1976	Vertically cast iron pressure pipes for water, gas and sewage.
269	IS:1538 (Part 1 to 24) 1993	Cast iron fittings for pressure pipes for water, gas and sewage
270	IS:778-1984	Copper alloy gate, globe and check valves for water works purposes
271	IS:780-1984	Sluice valve for water works purposes (50 mm to 300 mm size)
272	IS:781-1984'	Cast copper alloy screw down bib taps and stop valves for water services)
273	IS:2906-1984	Specification for sluice valves for water works purpose (350 to 120 mm size)
274	IS:6163-1978	Centrifugally cast (spun) iron pressure pipes for water, gas and sewage
275	IS:7181-1986	Horizontally cast iron double flanged pipes for water, gas and sewage
276	IS:5531-1988	Cast iron specials for asbestos cement pressure pipes for water, gas and sewage
277	IS:8794-1988	Cast iron detachable joints for use with asbestos cement pressure pipes
278	IS:10299-1982	Cast iron saddle pieces for service connection from asbestos cement pressure pipes
279	I:S12987-1991	Cast iron detachable joints for use with asbestos cement pressure pipes (light duty)
280	IS:1701-1960	Mixing valves for ablutionary and domestic purposes
281	IS:1703-1989	Copper alloy float valves (horizontal plunger type) for water supply fittings
282	IS:1879-1987	Malleable cast iron fittings
283	IS:3004-1979	Specification for plug locks for water supply

Sl. No.	IS:NO	PRODUCT
284	IS:3076-1985	Low density polythene pipes for potable water supplies
285	IS:3589-1991	Seamless or electrically welded steel pipes for water, gas and sewage
286	IS:3950-1979	Surface boxes for sluice valves
287	IS:IS:4038-1986	Foot valves for water-works purpose
288	IS:4346-1982	Specification for washers for use with fittings for water services
289	IS:4621-1975	Indicating bolts for use in public baths and lavatories
290	IS:4984-1995	High density polyethylene pipes for water supply
291	IS:5312 (Part 1) 1984	Swing check type reflux valves – single door pattern
292	IS:5312 (Part II) 1986	Swing check type reflux (non-return valves, multi-door pattern)
293	IS:6392-1971	Steel pipe flanges
294	IS:6418-1971	Cast iron and malleable cast iron flanges for general engineering purposes
295	IS:6631-1972	Steel pipes for hydraulic purposes
296	IS:7520-1974	Corrosion resistant high silicon iron castings
297	IS:7634 (Part 1) 1975	Practice for plastic pipe work for portable water supplies part 1 choice of materials and general recommendations
298	IS:7834 (Part II) 1987	Injection moulded PVC fittings with solvent cement joints for water supplies part 1 general requirements
299	IS:7834 (Part II) 1987	Injection moulded PVC fittings with solvent cement joints for water supplies part 2 specific requirements for 45° elbows
300	IS:7834 (Part III) 1987	Injection moulded PVC socket fittings with solvent cement joints for water supplies part 3 specific requirements for 90° elbow
301	IS:7834 (Part IV) 1987	Injection moulded PVC socket fittings with solvent cement joints for water supplies part 4 specific requirements 90° tees

SI. No.	IS:NO	PRODUCT
302	IS:7834 (Part V) 1987	Injection moulded PVC socket fittings with solvent cement joints for water supplies part 5 specific requirements for 45° tees
303	IS:7834 (Part VI) 1987	Injection moulded PVC socket fittings with solvent cement joints for water supplies part 6 specific requirements for sockets
304	IS:7834 (Part VII) 1987	Injection moulded PVC socket fittings with solvent cement joints for water supplies part 7 specific requirements for unions
305	IS:7834 (Part VIII) 1987	Injection moulded PVC socket fittings with solvent cement joints for water supplies part 8 specific requirements for caps
306	IS:8008 (Part 1) 1976	Injection moulded HDPE fittings for potable water supplies part 1, general requirements
307	IS:8008 (Part II) 1976	Injection moulded HDPE fittings for potable water supplies part 2, specific requirements for 90° bends.
308	IS:8008 (Part III) 1976	Injection moulded HDPE fittings for potable water supplies part 3, specific requirements 90° tees
309	IS:8008 (Part IV) 1976	Injection moulded HDPE fittings for potable water supplies part 4, specific requirements for reducers
310	IS:8008 (Part V) 1976	Injection moulded HDPE fittings for potable water supplies part 5, specific requirements for reffule reducers
311	IS:8008 (Part VI) 1976	Injection moulded HDPE fittings for potable water supplies part 6, specific requirements for pipe ends
312	IS:8008 (Part VII) 1976	Injection moulded HDPE fittings for potable water supplies part 7, specific requirements for sandwich flanges.
313	IS:8329-1994	Centrifugally cast (Spun) ductile iron pressure pipes for water gas and sewage
314	IS:8360 (Part 1) 1977	Fabricated high density polythylene HDPE fitting for potable water supplies part 1 general requirements

Sl. No.	IS:NO	PRODUCT
315	IS:8360 (Part II) 1977	Fabricated high density polythylene HDPE fitting for potable water supplies part 2 for 90° tees
316	IS:8360 (Part III) 1977	Fabricated high density polythylene HDPE fitting for potable water supplies part 3 for 90° bends
317	IS:8931-1993	Copper alloy fancy single tap assembly and stop valves for water services
318	IS:9338-1984	Cast iron screw down stop valves and stop & check valves for water works purposes
319	IS:9520-1980	Nominal sizes for valves
320	IS:9523-1980	Ductile iron fittings for pressure pipes for water, gas and sewage
321	IS:9739-1981	Pressure reducing valves for domestic water supply system
322	IS:9762-1994	Polythylene floats (Spherical) for float valves
323	IS:9890-1981	General purpose ball valves
324	IS:10124 (Part I) 1988	Fabricated PVC fittings for potable water supplies part I general requirements.
325	IS:10124 (Part II) 1988	Fabricated PVC fittings for potable water supplies part 2 specific requirements for sockets
326	IS:10124 (Part III) 1988	Fabricated PVC fittings for potable water supplies part 3 specific requirements for straight reducers
327	IS:10124 (Part IV) 1988	Fabricated PVC fittings for potable water supplies part 4 specific requirements for caps
328	IS:10124 (Part V) 1988	Fabricated PVC fittings for potable water supplies part 5 specific requirements for equal tees.
329	IS:10124 (Part VI)	Fabricated PVC fittings for potable water supplies part 6 specific requirements for flanged tail piece with metallic flanges
330	IS:10124 (Part VII) 1988	Fabricated PVC fittings for potable water supplies part 7 specific requirements for threaded adopters

Sl. No.	IS:NO	PRODUCT
331	IS:10124 (Part VIII)	Fabricated PVC fittings for potable water supplies part 8 specific requirements for 90° bends
332	IS:10124 (Part IX) 1988	Fabricated PVC fittings for potable water supplies part 9 specific requirements 60° bends
333	IS:10124 (Part X) 1988	Fabricated PVC fittings for potable water supplies part 10 specific requirements for 45° bends
334	IS:10124 (Part XI) 1988	Fabricated PVC fittings for potable water supplies part 11 specific requirements 30° bends
335	IS:10124 (Part XII) 1988	Fabricated PVC fittings for potable water supplies part 12 specific requirements for 22½° bends
336	IS:10124 (Part XIII) 1988	Fabricated PVC fittings for potable water supplies part 13 specific requirements 11¼° bends
337	IS:10292-1988	Dimensional requirements for rubber sealing rings for C1/D joints in cement piping
338	IS:12234-1988	Plastic equilibrium float valve for cold water services
339	IS:12701-1996	Rotational moulded polyethylene water storage tanks
340	IS:12709-1994	Glass fibre reinforced plastic (GRP) pipes, joints and fittings for use for water supplies.
341	IS:13095-1991	Butterfly valves for general purposes.
342	IS13114-1991	Forged brass gate globe and check valves for water works purposes.
343	IS13159(Part1)1993	Pipe flanges and flanged fittings part-1 dimensions
344	IS:14182-1994	Solvent cement for use with unplasticized polyvinyl chloride plastic pipe fittings
345	IS:14329-1995	Malleable iron castings
346	IS:1795-1982	Specification for pillar taps for water supply purpose

Sl. No.	IS:NO	PRODUCT
347	IS:2692-1989	Ferrules for water services
348	IS:9763-1988	Plastic bib taps and stop valves (rising spindle) for cold water services
		<b>DRAINAGE</b>
349	IS:458-1989	Pre-cast concrete pipes (with and without reinforcement)
350	IS:651-1992	Salt glazed stone ware pipes and fittings
351	IS:1726-1991 (Part 1 to 6)	Cast iron manhole cover and frames
352	IS:784-1978	Prestressed concrete pipes (including fittings)
353	IS:1729-1979	Sand cast iron spigot and socket soil, waste and ventilating pipes, fittings and accessories
354	IS:3486-1966	Cast iron spigot and socket drain pipes.
355	IS:3989-1984	Centrifugally cast (Spun) iron spigot and socket soil, waste and ventilating pipes and accessories
356	IS:4350-1976	Specification for concrete porous pipes for under drainage
357	IS:4885-1988	Sewer bricks
358	IS:5455-1969	Cast iron steps for man holes
359	IS:5600-1970	Sewage and drainage pumps
360	IS:5961-1970	Specification for cast iron grating for drainage
361	IS:6908-1991	Asbestos cement pipes and fittings for sewage and drainage
362	IS:7319-1974	Perforated concrete pipes
363	IS:3006-1979	Specification for chemically resistant glazed stone water pipes and fittings
364	IS:3271-1966	General requirements of steel cowl ventilators with detectable component
365	IS:3272-1966	Dimensions for over head steel cowl ventilators
366	IS:3273-1966	Dimension for circular head steel cowl ventilators
367	IS:3274-1966	Goose neck ventilators-welded type
368	IS:3275-1966	Dimensions for steel cowl ventilators accessories

Sl. No.	IS:NO	PRODUCT
369	IS:3278-1966	Dimensions for detachable coaming covers and wire mesh grids for steel cowl ventilators
370	IS:IS:6280-1971	Specification for sewage screens
371	IS:11925-1987	Specification for pitch impregnated fibre pipes and fittings for drainage purposes
372	IS:12592 (Part 1) 1988	Specification for pre-cast concrete manhole covers and frames part 1 covers
373	IS:12592 (Part II) 1988	Specification for pre-cast concrete manhole covers and frames part 2 frames
374	IS:14333-1996	High density polyethylene pipes for sewerage
375	IS:14402-1996	Glass fibre reinforced plastics (GRP) pipes, joints and fittings for use for sewerage industrial waste water (other than potable)
376	IS:13592-1992	Unplasticized polyvinylchloride (UPVC) pipes for soil and waste discharges system inside building including ventilation and rain water system
<b>STEEL WORK &amp; GLAZING</b>		
377	IS:1730-1989	Steel plates, sheets, strips and flats for structural and general engineering purposes
378	IS:3614 (Part I) 1996	Specification for fire check doors, plate metal covered and rolling type
379	IS:3641 (Part II) 1992	Specification for metallic and non-metallic fire check doors resistance test and performance criteria
380	IS:4351-1976	Specification for steel door frames
381	IS:4384-1967	Steel water tight & weather tight doors
382	IS:7152-1992	Book room doors specification
383	IS:9796-1981	Non-weather tight steel doors
384	IS:10521-1983	Collapsible gates
385	IS:806-1968	Code of practice for use of steel tubes for general building construction
386	IS:808-1989	Dimensions for hot rolled steel beam, column, channel and angle sections



Sl. No.	IS:NO	PRODUCT
387	IS:1081-1960	Code of practice for fixing and glazing of metal (steel and aluminium) doors with ventilators
388	IS:1361-1978	Steel windows for industrial buildings
389	IS:2835-1987	Flat transparent sheet glass
390	IS:3954-1991	Hot rolled steel channel sections for general engineering purposes
391	IS:4923-1985	Hollow steel sections for structural use.
392	IS:5437:1994	Figured, rolled and wired glass
393	IS:10451-1983	Steel sliding shutters (top huge type)
394	IS:11188 (Part 1) 1991	Vault (Strong room) doors part 1 specification
395	IS:11188 (Part 2) 1991	Vault (Strong room) doors part II test for burglary resistance
396	IS:1188 (Part 3) 1991	Vault (Strong room) doors part III test for fire resistance
397	IS:1977-1996	Low tension structural steel
398	IS:2062-1992	Steel for general structural purposes

**SAFETY IN CONSTRUCTION**

The contractor shall employ only such methods of construction, tools and plants as are appropriate for the type of work or as approved by Engineer-in-Charge in writing.

The contractor shall take all precautions and measures to ensure safety during execution of works and shall be fully responsible for the same. Safety pertaining to construction works such as excavation, centering and shuttering, trenching, blasting demolition, electric connections, scaffolds, ladders, platforms, gangway, mixing of bituminous materials. Electric and gas welding, use of hoist and other construction machinery shall be governed by CED safety code; CPWD safety code, construction safety manual of DOS, (DOS:ISRO:TR:105) relevant IS safety codes and also direction of Engineer In-charge.

SL. NO.	STAGE AND NATURE OF CONSTRUCTION HAZARD	SAFETY MEASURES EXPECTED TO BE TAKEN BY THE CONTRACTOR AND SITE ENGINEERS
1	Excavation in soft loose and slushy soil more than 2.00m depth sliding of earth of collapsing of sides.	The excavation beyond 1.5m to be done in steps of minimum 500 mm offsets as in relevant clause. Planking and strutting should be done as in relevant clause/drawing, as per direction of EIC, based on site condition.
2	Excavation in slippery area (water logged) – The labour may fall or machinery on site may slip.	Try to dewater the area and spread minimum 150 mm thick sand layer to avoid slipping.
3	Excavation in Rock where chiseling is involved – The fall of hammer may injure the hand, small rock pieces may injure the eyes and legs.	For hammer work, only experienced and skilled labour should be employed. Chisel should not be allowed to be held by hand while hammering but chisel holding clamp should be provided. The labour should be provided with goggles and leg coving to protect eyes and legs, from injuries due to small rock pieces.
4	Excavation in Rock where blasting is involved – Careless handling may lead to injury to main worker or passers by.	The work of blasting should be entrusted to only experienced persons. Provide sufficient length of fuse to give ample margin of time from the time of lighting to the time of explosion. A danger zone atleast 180m diameter is to be flagged off 10 minutes before actual firing. All workmen should be sent away from danger zone except the firing man, who should be provided with a whistle.

SL. NO.	STAGE AND NATURE OF CONSTRUCTION HAZARD	SAFETY MEASURES EXPECTED TO BE TAKEN BY THE CONTRACTOR AND SITE ENGINEERS
5	Excavation for drain across road or manhole adjacent to a road - chances of a passer by falling into the excavated portion.	The area should be well barricaded and a red lamp provided at night. A watchman should be deputed to prevent any movement of persons, or vehicles.
6	During Excavation or some times even while concreting – snake bites or scorpion stings-	In places where the movements of snakes are more the contractor should provide the labour with gumboots gloves etc and also make snake ant/dotes available on site. A particular care that has to be taken on such site is to always keep a vehicle available on site to rush the patient to a doctor.
7	Centering (form-work) and scaffolding – form work collapse while concreting or just before concreting especially when wooden ballies are used.	Many a times ballies joined together give way due to weak joint, use of ballies should be discouraged. If for any reason it is used, the use of joined ballies should be restricted. Only 2 joined ballies out of 8 ballies should be allowed. In case of double staging for a slab at a height, utmost care should be taken to see that the top balli rests on the bottom balli. A particular care that should be taken during concreting operation of slabs and beams is that, one carepenter and two helpers with spare ballies, nails etc should be deputed below the slab/beam that is being concreted to watch any disturbances in the supports of the form work below during concreting. In case of any doubt the concreting should be stopped immediately and the form work strengthened. Never allow bricks below a ballie to make up the required height. This is most dangerous.
8	Form-work for beams and slabs: The bottom of beam collapses and many times brings down the slab as well injuring the labour and supervision staff.	This case is noticed when slender ballies are used without bracing. In fact, no concreting should be allowed without bracing at 300 mm above ground, and at mid way, in normal beams and slabs. The bracing should be for the support of beams as well as slabs.
9	Form-work for sides of a slab: The labour just rests his foot on the plank and looses balance and falls resulting a fatal accident.	This is noticed when the carpenter fixed the side shuttering of a slab with a plank just tied by binding wire to the steel reinforcement and by wooden pieces nailed in wall and plank. This is so weak a portion that with little pressure the plank gives way.

SL. NO.	STAGE AND NATURE OF CONSTRUCTION HAZARD	SAFETY MEASURES EXPECTED TO BE TAKEN BY THE CONTRACTOR AND SITE ENGINEERS
		Hence side shuttering should be done with a direct balli support from ground or floor, and the practice of typing planks reinforcement should be totally avoided. A temporary railing along the periphery of slab will guard the life of labour and supervision staff.
10	Form-work for beams and slabs – Opening the form work – Accident due to fall of materials during removing the forms.	In fact, this is a most dangerous work. One should be very careful while form work is removed. Only trained carpenters should be deputed for the work. A safe resting place outside the area of slab as a temporary measure should be constructed from where the slab can be removed safely. Removal of form work during night should not be permitted under any circumstances.
11	Scaffolding – Fall of workman, supervision staff, standing on chalis not tied properly or tied only at one end. (Chalis made of Bamboo)	This is a very common negligence on the part of labour who do scaffolding work. The chalis on which they work span over it's complete length or is tied loosely and many times at one end only. Hence, care must be taken that the chali do not psna over the full length but some middle supports are provided and also the same is tied properly on both ends.
12	Ladders – Balli or bamboo ladders. The horizontal member breaks and the person falls. Some times the top face just rests on wall and the whole ladder tilts causing an accident.	The ladder should be strong enough to bear the weight of a labour with materials on head. As far as possible a hand rail should be provided at least one side. The horizontal member should be preferably fixed with bolt and nuts or strong nails. When the ladder is placed across a wall the top portion should be tied firmly to a strong support so that the ladder does not move laterally.
13	Column reinforcement – Column reinforcement mainly in independent footing collapses – injury to persons working nearby	The tendency of bar – benders is to tie the vertical steel with coir rope or 8 mm steel rods as ties on all four sides of the column reinforcement. This method of upporting the column reinforcement should be supported by strong ballies on all four sides of reinforcements and as far as possible a combined platform should be constructed out of ballies over which the reinforcement can be supported.

SL. NO.	STAGE AND NATURE OF CONSTRUCTION HAZARD	SAFETY MEASURES EXPECTED TO BE TAKEN BY THE CONTRACTOR AND SITE ENGINEERS
14	Concreting chejjas – When chajjas are concreted without care and on opening the form work the chajja would damage, causing injury to labour on top or bottom of chajja.	While concreting chajjas care must be taken that the labour do not stand on the reinforcement and disturb the position. A separate scaffolding must be tied, over which the labour can stand and work without disturbing the reinforcements. The main reason is in chajja the steel has to be positioned at top and if labour stands on the steel, it will bend and come to bottom face and the chajja will be weakened which will fall when form work is removed. Thus causing injury to labour working on top or bottom.
15	Dismantling – Dismantled materials may fall on passers by. The person engaged in dismantling work may fall due to slipping. The dismantled materials may fall on persons below.	When work of demolition is to be taken up the area should be closed for all outsiders. No one should be allowed up to 50 m or as per the requirement of site, from the place of demolition. The workers engaged in demolition should be asked to wear safety belts. Helmets must be worn by all the workers engaged in dismantling work. The place should be strictly guarded at night with red lights at prominent places and watchman should be posted.
16	Electric – connection/ cables etc. High tension /LT. Electric wire passing near the slab structure- while bending, lifting or tying reinforcements the bar benders may sustain the electric shock, causing fatal injury.	The work in such places must be executed under the strict supervision of a responsible foreman or a supervisor.
17	Electric Connection /Cables etc. Cables below ground may get punctured during excavation and thus electrocute the labour working. Similarly when concreting is in progress the punctured cable may prone to be fatal to the labour.	Before taking up the work all available drawing shall be studied, local enquiry to be made to know the position of cables and work in such area should be got executed under strict supervision of an experienced foreman or a supervisor.
18	Electric Connection / Cables etc: Temporary Electric lines near damp walls, near joinery stretched on a considerable length – There is every chance that the wire may get cut due to usage and may develop short circuits / leakages etc. and may electrocute the person touching the wire accidently.	The electric wires should be maintained by an electricians also he should regularly check up the insulation of wires especially placed near steel items and damp areas. The temporary, wiring should be supported properly. As far as possible a good quality wire should be used which may not get damaged easily.

SL. NO.	STAGE AND NATURE OF CONSTRUCTION HAZARD	SAFETY MEASURES EXPECTED TO BE TAKEN BY THE CONTRACTOR AND SITE ENGINEERS
19	Electric and gas welding work – Drilling, polishing work – Done by temporary cables used on a number of works – Due to the fact that the wires are old and when they come in contact with water even in the process of curing the surrounding area may get affected due to leakage in the electric current thus causing damage to the workers and supervision staff.	All wiring works to be inspected by experienced electrician. All wires to be properly insulated and fixed at height on temporary poles. No welding work should be permitted near damp area. The welders to be provided with welders goggles and gloves. As far as possible machine in good condition should be used.
20	Construction Machinery and Lifts – Concrete mixers – Safety precautions. A mixer with hopper tried to be operated by an helper could not release brake in time thus causing injury to the person near hopper – some times fatal one.	The mixers with hopper should be operated by an experienced mixer operator and such mixers should not be allowed to be handled by a helper or a labour.
21	Construction Machinery and lifts – lifts – safety precautions. (1) The lift pit if left unguarded the children of workers may fall in the pit resulting in fatal accident.  (2) The manually operated brakes of the lift failed or the communication between the labour at the top and the liftman failed and thus, the lift was not controlled and resulted in fatal accident.	(1) A brick protection wall of minimum 1.00m height should be constructed around the lift pit, thus, preventing the children going near the pit. A special care should be taken to see that the children are not allowed to come near the machine.  (2) The condition of the lift must be maintained properly. The lift operator should be well trained. The labour receiving the bucket at top should be smart and active enough to convey the message of stopping and releasing the lift to lift operator properly.
22	Water Storage Tank for general use and curing – chances of children of workers falling in the tank with fatal accident.	The water tank constructed on site should be protected by at least 1.00 m high walls on four sides, so that the children do not fall.
23	Misuse of lift by labour and some times supervision staff. The lifts that are meant for lifting materials used by labour to go to upper floors. The labour thus travelling may times get injured.	No persons should be allowed to go to upper floors by lifts that are mainly meant for conveying the building materials. Fatal accidents have taken place due to above action of workers

SL. NO.	STAGE AND NATURE OF CONSTRUCTION HAZARD	SAFETY MEASURES EXPECTED TO BE TAKEN BY THE CONTRACTOR AND SITE ENGINEERS
24	Site Cleaning – Cleaning top floors of building – Upper portion of any structure – Throwing waste materials broken concrete pieces, brick bats, sand etc. straightway from top to ground injuring person below or even a passer by.	This dangerous practice should not be allowed at all. The materials should be brought to the ground with the help of lift or use of rope over pulley with a bucket, thus bringing down the material safely.
25	Bar bending work – Helpers of bar benders resort to short cut methods of throwing surplus steel pieces from top floors to ground which may cause fatal injuries	This is a very bad practice. The helpers should bring the rods to ground with the help of lift or rope and pulley.

# PUBLIC HEALTH ENGINEERING SPECIFICATION



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SECTION I  
**INTERNAL PUBLIC HEALTH WORKS**

**SECTION – I**  
**SPECIFICATION FOR INSTALLATION OF SANITARY FIXTURES :**  
**INTERNAL P. H. WORKS**

**SCOPE:**

The work covered under these specifications includes the supplying and installing of sanitary fixtures, for the building water supply and drainage system and laying CI soil and waste pipes. This specification includes (1) General specifications for sanitary fixtures and installations of (2) European water closet suite (3) Orissa pattern/Indian water closet suite (4) Wash Basin suite (5) Flushing cistern and Urinals (6) Fire clay kitchen sink (7) Laboratory sink (8) Granite sink and other toilet fixtures like liquid soap holder, toilet paper holder etc.

**1 General Specifications of Sanitary Fixtures:**

1.1 All sanitary fixtures shall be conforming to relevant ISI specification and approved by the Engineer-in-Charge prior to installation of fixtures and the approved samples shall be maintained at site till the completion of the work.

1.2 Vitreous sanitary ware fixtures shall be of strong high grade ceramic ware made from the mixture of clays and finely ground minerals such as quartz and felspar. After firing at a high temperature, the ware shall not, even when unglazed, have a mean value of water absorption greater than 0.5 percent of the ware when dry. The fixture shall be coated on all exposed surfaces with an impervious non - crazing vitreous glaze giving white or coloured finish as required. The thickness at any place in an appliance shall not be less than 6 mm.

1.3 All visible surfaces of the body shall have uniform glazing, free from craze and discolouration and shall possess an impervious surface. The fixtures shall be free from blisters, bubbles, craze (fine crack in the glaze), dull finish, dunt (hairline fracture), fire check or fire crack. (fine shallow crack in the body not covered with glaze).

1.4 Vitreous chinaware sanitary appliances - European water closets, Indian/Orissa pattern water closets wash hand basins, kitchen sinks, soap tray, lab sink, urinals etc., shall satisfy the general requirements with regard to quality as specified in IS: 2556.

1.5 All rates for fixing shall provide for making holes in walls, providing screws, wooden plugs and cleats wherever necessary, cutting floors, chasing in walls and floors etc., and making good and restoring to original conditions. The rates shall be for the completed work as laid down in the schedule and the contractor is not entitled for any payment on this account except in case of any dismantling or reconstruction of any brick masonry or concrete structures which are of special nature in the opinion of the Engineer-in-Charge for which payment shall be made in accordance with the relevant rates as in schedule of approved rates.

1.6 The sanitary fittings and fixtures shall be handed over to the Engineer-in-Charge complete in all respects on the completion of work and no incomplete items will be taken over. Any loss or damage of these due to any reason whatsoever before the handing over shall be at the contractor's cost and charges.

1.7 All exposed pipes and specials shall be painted with *three coats* of approved paint of required shade to match with the adjacent wall surface colour. All concealed pipes shall be



painted with three coats of anti-corrosive black bitumastic paint. The rate for all piping shall be inclusive of the cost of such painting.

1.8 All materials used in the work shall conform to the relevant latest Indian Standard Specification.

1.9 The specification for items of main civil works shall apply equally for this work also wherever such items of civil works are involved.

1.10 Certified licensed plumbers should be employed by the contractor on the work of internal sanitary installation, building water supply, drainage and sewers. The work shall be carried out in workmanship like manner and the contractor shall also process the application for obtaining water and sewage municipal service connection & expedite the same wherever necessary.

## 2 European Water Closet Suite :

2.1 The best quality single syphonic European water closet pan shall be fixed to the floor with C. P. brass screws of required gauge and length screwed on to teak wood plugs embedded in the floor and jointed to the soil system.

2.2 The flushing cistern to be used for the EWC shall be low level cistern made of pressed steel. The body of pressed steel cistern shall be of seamless or welded construction of thickness not less than 1.6 mm before coating and shall be porcelain enamelled and free from any manufacturing defects. Cistern shall be mosquito proof and shall be conforming to the requirements specified in IS:774-1971. The cistern shall discharge at an average rate of 5 ltrs. in 3 secs. and satisfy the test for discharge capacity as specified in IS:774-1971. The flush pipe shall have a nominal internal dia of 40mm for low level cistern and shall be of seamless or welded steel tube not less than 1.00mm thick and inside and outside hot galvanised.

2.3 The cistern shall be fixed to the wall with white enamelled CI brackets with necessary teak wood plugs and screws. The flushing cistern shall be connected to the water closet inlet with matching chromium plated flush bend, over flow for the cistern with 15 mm CP brass mosquito proof jalli and shall be as specified in the schedule.

2.4 Plastic seat cover for the EWC used shall be made out of any one of the plastic material conforming to IS : 2548-1967. The underside of the seat may be flat and shall be of solid moulding. The seat shall be fixed with a hinging device made of brass electroplated with chromium. The dimensions of seats and covers shall conform to IS : 2548-1967.

2.5 The EWC suite has to be tested for satisfactory functioning as suggested vide para 2.4 of IS : 2556-Part VIII-1973.

2.6 The Plastic seat and lid supplied shall have ISI certification mark and shall be assembled and fixed to the water closet in an approved manner and as per manufacturer's specifications. The installation of EWC shall be done as per the detailed installation **fig. No. 1.1**.

2.7 The inlet to the flushing cistern shall be arranged through a 15mm n.b. PVC or polyethylene inlet pipe connection, heavy approved quality with CP brass unions at both ends.

The entire suite shall be tested for leakages and satisfactory functioning, flushing and commissioned.

The rate for the item shall provide all aspects of works mentioned above and works specified in the schedule of quantities.

### **3 Orissa Pattern IWC/Indian Closet Suite :**

3.1 The best quality Orissa Pattern IWC/the Indian water closet pan with trap shall be fixed in lime concrete 1:5:10 using brick bats of 40 mm size as course aggregate to proper line and levels with necessary excavation where-ever required and jointed to the soil pipe system including fixing of foot rests where required in CM 1:1. Details of installation shall be as per **fig.No.1.2** for Orissa Pan and **fig.No.1.3** for IWC with foot rests.

3.2 The Indian style water closet (long squatting pan), and Orissa pattern water closet shall conform with regard to dimensions and other specifications to IS : 2556 (Part-III)-1967. The size of the pan will be as specified in the tender schedule. Each pan shall be provided with a trap either 'P' or 'S' with or without inspection vent as specified in the schedule. Generally 'S' traps are preferred for ground floor installations and 'P' trap for upper floors. The trap shall be glazed inside. The squatting pans and traps on installation shall satisfy the flushing tests given in para 6.1.1 of IS : 2556-(Part-III)-1967 to ensure satisfactory flushing using a high level flushing cistern of capacity 12.5 Ltrs.

3.3 The flushing cistern to be used for the Indian/Orissa pan water closet shall be high level cistern made of cast iron grade 15 of IS : 210-1962, 12.50 Ltrs. capacity and the construction of the cistern conforming to IS : 774-1971 complying with the requirements specified under para 3.4

3.4 The flushing pipe shall have a nominal internal diameter of 40 mm for high level cistern and shall be of seamless or welded steel tube not less than 1.00mm thick and inside and outside hot galvanised. The cistern shall discharge at an average rate of 5 Ltrs. in 3 secs. when installed at a height of 125 cms, above the top of the pan. The cistern shall be marked with the manufacturers name and also with the ISI certification mark. The cistern shall be fixed to the wall with painted white synthetic enamelled CI brackets with necessary teakwood plugs and screws. The flushing cistern shall be connected to the water closet inlet with 32mm GI telescopic flush pipe. Overflow for the cistern shall be connected with 15 mm n.b. PVC or polythene pipe connection as specified in the schedule.

3.5 The inlet to the flushing cistern shall be provided by a 15 mm n.b. PVC or polyethylene inlet pipe connection, heavy quality with CP brass unions at both ends as specified.

3.6 The entire suite shall be tested for leakages, satisfactory functioning, flushing and commisioned.

3.7 The rate for the item shall provide all aspects of work mentioned above and works specified in the schedule of quantities.

### **4 Wash Basin Suite :**

4.1 The wash hand basins to be installed shall be of flat back type of sizes as specified in the schedule conforming to IS : 2256 (Part IV)-1972 and also shall have the ISI certification mark. The basins shall have either single tap or double tap hole as specified in the schedule suitable for fixing pillar taps. The construction details of the wash hand basin shall be as specified in IS : 2556. The wash basin pan shall be mounted on a pair of cast iron wall fixing single rail type brackets for wash hand basin of minimum weight 2 kg., heavy quality, painted as specified, screwed on to the teak wood plugs fixed in the wall. The wash basin shall be provided with 32 mm size CP brass waste coupling, heavy quality with rubber plug, CP brass chain along with CP brass bottle trap, heavy quality at the outlet. The outlet of the trap shall be connected to the

32 mm n.b. GI waste pipe, medium quality with specials such as GI sockets, elbows, tees, unions, plugs, hexagonal nipples, pillar cock, stop cock etc. Which shall be fixed in the wall/ floor concealed and made to discharge into the floor trap below the floor grating. The pipe shall be painted as specified.

4.2 The inlet to the wash basin shall be arranged through a 15 mm n. b. PVC or polyethylene inlet connection, heavy quality with CP brass unions at both ends as specified. The wash basins may be provided either with PVC waste pipe or GI waste pipe with bottle trap as the case may be as specified in the schedule of quantities.

4.3 The entire suite shall be tested for leakages, satisfactory functioning and commissioned. The rate for the item shall provide for all aspects of work mentioned above and in the schedule of quantities. Details of installation will be as specified in the **fig.1.4**.

#### **5 Flushing Cistern and Urinals :**

5.1 The urinal pans to be installed shall be of flat back bowl type urinal of sizes as specified in the schedule and the construction details conforming to IS : 2556 (Part-VI)-1967. The automatic cistern and capacity shall be as specified in the schedule supported on a pair of synthetic enamel painted CI brackets fixed to wall, complete assembly painted as directed and the rate shall include the following fittings in addition to the cistern :

1. 12 mm CP common brass distributor pipe for urinals fixed to wall with CP brass clamps.
2. 12 mm CP spreader of approved type for each urinal.
3. 15 mm GI overflow pipe with specials from cistern upto 15mm above floor level terminated with 15 mm CP brass mosquito proof jalli screwed fitting.
4. 15 mm heavy quality PVC or polyethylene inlet connection with brass unions at both ends.
5. 15 mm n. b. heavy type approved make CP brass stop cock easy clean variety on inlet connection piece.
6. 32 mm heavy quality CP brass bottle trap with extension piece and wall flange wherever required.
7. 32 dia GI/PVC waste pipe with specials.

5.2 The capacity of flushing cistern, number of urinals shall be as specified in the schedule. The entire suite shall be tested for leakages and satisfactory functioning. The rate for the item shall provide for all the aspects of work covered above and as per schedule of quantities. The installation shall be carried out as per **fig.1.5**.

#### **6 Fire Clay Kitchen Sink & Drain Board :**

6.1 The kitchen sink and drain board shall be of vitreous china ware and sizes as mentioned in schedule of quantities. Normal size of sink used are 600 X 450 X 250 mm and 600 X 450 X 200 mm.

6.2 Cast iron brackets of suitable size, enamel painted shall be supplied and fixed on wall by teak wood plug & brass screws. Height of fixing from finished floor level will be suitable to kitchen platform, and when fixed independently without a platform the height will be 800 mm above finished floor level to the top of rim of sink. The waste pipe connection for kitchen sinks shall be of CP brass waste coupling and coupling of 32mm n. b. with rubber plug and chain and

PVC/GI waste pipe length not exceeding 1m to discharge into floor trap. Fixing details are shown in **fig. 1.6a** which shall be followed for construction.

6.3 The rate for the item shall provide for all aspects of works mentioned above and in the schedule of quantities including cost of waste coupling & piping.

6.4 The drain board shall have flutes which will permit smooth flow of water and easy cleaning without any sharp edges. The drain board shall be fixed with a slope of 25 mm towards the sink and shall be kept with sufficient over lap on sink to allow the drained water to fall freely into sink.

6.5 The entire installation shall be tested for leakages and satisfactory functioning and commissioned.

## **7 Laboratory Sinks**

7.1 The laboratory sink shall be of vitreous china ware with internal overflow arrangement and of sizes mentioned in schedule of quantities. Standard sizes of sinks available are 450 X 300 X 150 mm, 300 X 250 X 150 mm and 500 X 350 X 150 mm. The size of sink as specified in the schedule of quantities shall be supplied by the Contractor. **Ref. fig.1.6.**

7.2 Cast iron brackets of suitable size, enamel painted shall be supplied and fixed on wall by teak wood plug and brass screws. The lab sink shall be fixed 800 mm above FFL to the top rim of sink. When fixed with laboratory work tables, sink shall be fixed flush with the top surface of work table. The waste pipe connection for laboratory sinks shall be of CP brass waste and coupling 32 mm n. b. with rubber plug and chain and PVC/GI pipe length not exceeding 1m to discharge into floor trap.

## **8 Granite Sink and Other Toilet Fixtures :**

### **8.1 Granite Kitchen Sink and Drain Board :**

8.1.1 The granite used for Kitchen sink shall be of uniform texture, colour and grains and shall be free from flaws, cracks and from selected black granite stone.

8.1.2 The dimensions of sink and drain board shall be as per schedule of quantities. The granite sink and drain board shall be made out of a single stone as shown in **fig.1.7.**

8.1.3 As the granite sink is very heavy necessary reinforcement bars are to be provided in floor slabs while fixing in upper floors and hence locations as indicated in the construction drawings are to be followed.

8.1.4 The waste pipe connection for kitchen sink shall be of CP brass waste coupling of 32 mm n. b. The waste pipe shall be of PVC/GI pipe not exceeding 1m to discharge into floor trap. The sink shall be fixed on suitable masonry or RCC supports as shown in construction drawings.

8.1.5 The rate for the item shall provide for all aspects of work as mentioned above in the schedule of quantities including cost of waste coupling.

### **8.2 Recess Type Toilet Paper Roll Holder :**

8.2.1 The recess type toilet paper roll holder shall be of best approved quality and of size as specified in the schedule of quantities, in white glazed vitreous chinaware. The rate shall include chasing the wall, fixing the toilet paper roll holder and making good the surface to the original condition etc. complete.

### **8.3 Marble Partitions :**

8.3.1 The marble partitions shall be 25 mm thick, best Indian white marble, machine cut and polished with rounded corners and the sizes as specified, fixed in the groove of depth 75 mm in the wall including cutting grooves in the wall where required and fixing and making good the surface to original condition etc. complete.

### **8.4 Mirror :**

8.4.1 The mirror shall be of superior glass, free from flaws, specks and bubbles and of 6 mm thickness and the glass of the mirror shall be uniformly silver plated at the back and shall be free from silvering defects. Silvering shall have a protective uniform covering of red lead paint. Size shall be as specified with bevelled edges and mounted on 6 mm thick plywood or asbestos sheet backing as indicated in the schedule fixed to walls with CP brass screws over teak wood plugs with detachable CP brass. The rate includes for making necessary holes in wall, providing and fixing TW plugs etc. complete.

### **8.5 Liquid Soap Holder :**

8.5.1 The liquid soap holder shall be of best approved quality container as specified in the schedule with CP brackets, CP screws, washers etc. The contractor shall supply and fix the necessary screws, washers, plugs etc., along with the liquid soap holder.

### **8.6 Towel Rails :**

8.6.1 Towel rails shall be of CP brass/anodised aluminium tube with CP brass aluminium brackets, best quality and of sizes as specified in the schedule. The rate shall include fixing the towel rail to wall with necessary chromium plated brass screws including provision of rawl plugs and CP brass screws for fixing the same.

### **8.7 Coat and Hat Hooks :**

8.7.1 Coat and hat hooks shall be of CP brass and best Indian make. They shall be of approved quality and size. The contractor shall supply coat and hat hook and fix them with the necessary screws, plugs, washers as directed by Engineer-in-Charge.

### **8.8 Bib Taps, Stop Cocks :**

8.8.1 Bib taps and stop cocks shall be of chromium plated brass and shall be of best approved Indian make conforming to IS : 781 bearing ISI certification mark. The size and minimum weight shall be as specified in the schedule and when tested it should withstand internal hydraulic pressure of 20 kg/cm<sup>2</sup> for atleast two minutes during which it shall neither leak nor sweat.

### **8.9 Gate Valves**

8.9.1 Gate valves shall be of best Indian make of heavy approved quality of screw down type made of gun metal and fitted with a handwheel and conform to IS : 778 and bearing ISI certification mark. GI unions and GI flanges as specified shall be provided adjacent to gate valve to facilitate easy removal of valve for maintenance purpose. The valves shall be tested hydraulically along with the pipeline.

### **8.10 Nahani Trap :**

8.10.1 The Nahani trap shall be of cast iron material conforming to IS : 3989-1970 dimensions

conforming to IS: 1729-1979 **fig.1.8** may be referred. The rate shall include fixing the trap in cement concrete 1 : 2 : 4 as shown in drawing and for providing a chromium plated brass hinged heavy type grating of size 165mm dia on the top of trap and jointed to C.I waste pipe. As may be seen from **fig.1.8** the outlet of Nahani is constricted at the trap whereas floor trap provides free flow without obstruction. It is preferable to restrict the usage of Nahani traps for waste waters not containing any solids such as Urinal outlet, bath waste.

8.10.2 As the trap shall be invariably fixed with the top at a level lower than the finished floor level sloping towards the nahani trap, the inlet to the trap shall be formed in cement concrete 1 : 2 : 4 over the trap and the internal surfaces plastered with water proof cement plaster. The grating shall be fixed flush with the floor. To prevent seepage of water around the nahani trap, CM 1 : 1 shall be filled and compacted flush with nahani trap.

8.10.3 No holes shall be punched in the grating of Nahani trap and waste pipe connection shall be made as shown in **fig.1.8**.

8.10.4 The rate for this item shall provide all aspects of work mentioned above and in the schedule of quantities.

#### **8.11 Floor Trap :**

8.11.1 The floor trap shall be of cast iron material conforming to IS: 1729-1979 **fig.1.8** may be referred. The floor trap provides free flow to the full section of outlet pipe and shall be preferable for waste water containing solids such as kitchen sink waste and wash hand basins. For kitchen sinks of canteens and wash platforms floor trap of size DN 100 mm shall be preferable.

8.11.2 The gratings may be hinged or screwed down and hinges shall be of galvanized iron.

8.11.3 The thickness of fittings higher than that specified in **fig.1.8** may be accepted.

8.11.4 The rate shall include fixing the trap in cement concrete 1 : 2 : 4 as shown in drawing and for providing a chromium plated brass hinged heavy type grating of size 100 mm/200 mm as the case may be on the top of trap and jointed to C.I. soil pipe.

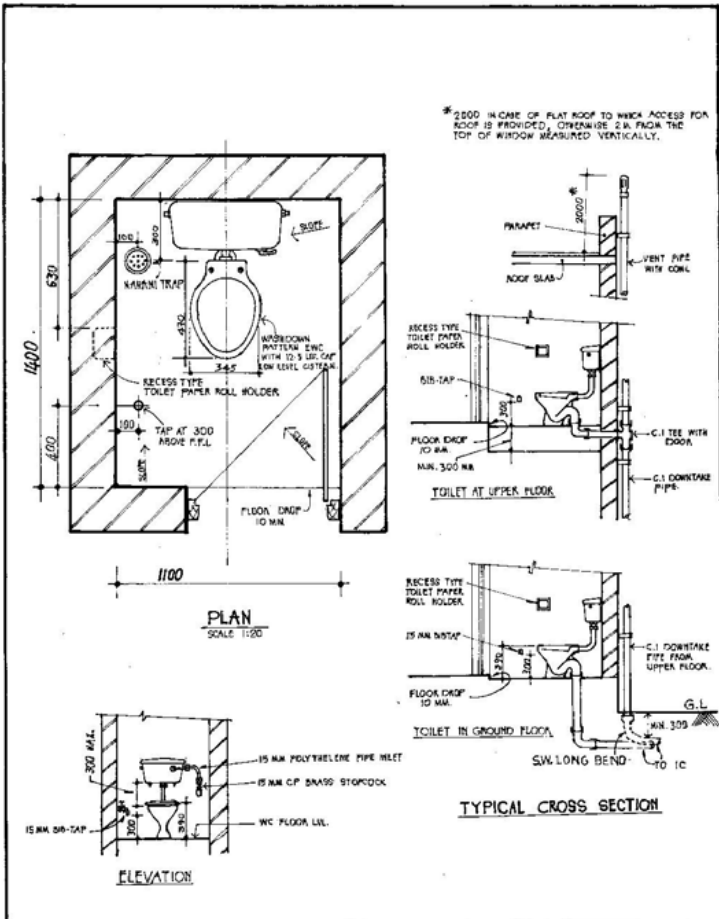
8.11.5 As the trap shall be invariably fixed with the top at a level lower than the finished floor level sloping towards the floor trap, the inlet to the trap shall be formed in cement concrete 1 : 2 : 4 over the trap and the internal surfaces plastered with water proof cement plaster. The grating shall be fixed flush with the floor. To prevent seepage of water around the floor trap CM 1 : 1 shall be filled and compacted flush with floor trap.

8.11.6 No holes shall be punched in the grating and waste pipe connection shall be carried out as shown in **fig.1.8**.

8.11.7 The rate for this item shall provide all aspects of work mentioned above and in the schedule of quantities.

#### **8.12 White Glazed Half Round Channel :**

8.12.1 The half round channels used shall be of best Indian make white glazed vitreous chinaware and of the specified size with or without dead ends as per site condition. They shall be bedded on 75 mm thick cement concrete bed (1 : 2 : 4) laid to proper slope and alignment and shall be fixed over a bed of cement mortar 1 : 3, 20 mm thick. The joints shall be painted with white cement. The running metre cost for channels shall be with dead ends if required as per construction drawings.



\* 2000 IN CASE OF FLAT ROOF TO WHICH ACCESS FOR ROOF IS PROVIDED, OTHERWISE 200 FROM THE TOP OF WINDOW MEASURED VERTICALLY.

PLAN  
SCALE 1:50

TYPICAL CROSS SECTION

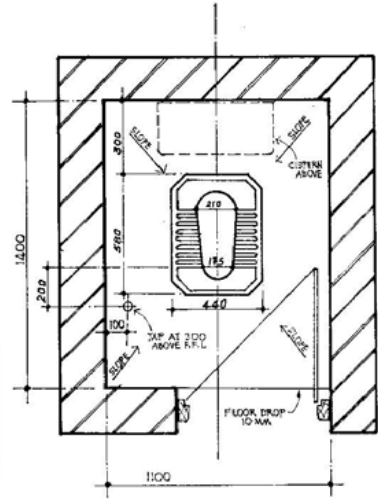
- NOTE
- 1 ALL DIMENSIONS ARE IN MILLIMETRES.
  - 2 ONLY FIGURED DIMENSIONS ARE TO BE FOLLOWED
  - 3 FLOOR SHALL BE SLOPED TOWARDS MANHOLE TRAP IN FLOOR FINISHING INSIDE THE WATER CLOSET BY 10 MM.
  - 4 TANKING TREATMENT SHALL BE PROVIDED FOR COUNTER SURFACE FLOOR IN UPPER FLOOR AS PER THIS OFFICE CIRCULAR NO. CED/M/4/9/493 DATED 3-6-1980.

TYPICAL FIXING DETAILS OF EUROPEAN WATER CLOSET

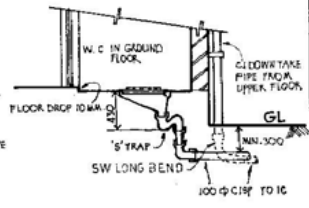
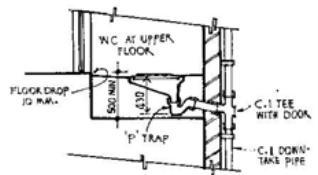
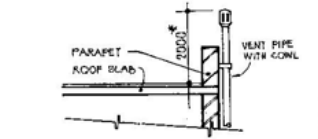
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RECORDED • <i>[Signature]</i>		SCALE • 1:20, 1:50	
APPROVED <i>[Signature]</i>		FIG. NO.	
CHIEF ENGINEER		CED:PH: 1-1	

CIVIL ENGINEERING DIVISION  
DEPARTMENT OF SPACE BANGALORE

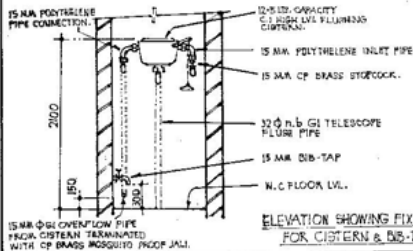
\* 2000 IN CASE OF FLAT ROOF TO WHICH ACCESS FOR ROOF IS PROVIDED, OTHERWISE 2M FROM THE TOP OF THE WINDOW MEASURED VERTICALLY.



PLAN  
SCALE 1:20



TYPICAL CROSS SECTION



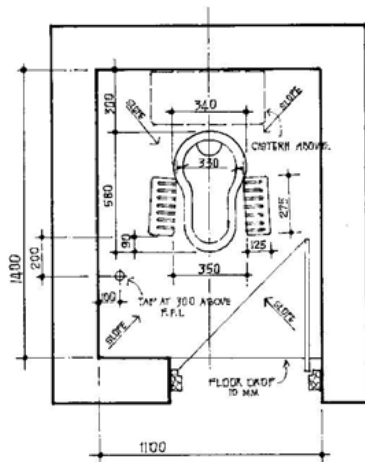
ELEVATION SHOWING FIXING HT.  
FOR CISTERN & DIS-TAP

- NOTE
1. ALL DIMENSIONS ARE IN MILLIMETRES.
  2. ONLY FIGURED DIMENSIONS ARE TO BE FOLLOWED.
  3. FLOOR SHALL BE SLOPED TOWARDS PAN IN FLOOR FINISHING INSIDE THE WATER CLOSET BY JOINT.
  4. TARFELT TREATMENT SHALL BE PROVIDED FOR COUNTER-SUNK FLOOR IN UPPER FLOORS AS PER THIS OFFICE CIRCULAR NO. CWO/PN/G/C/495 DATED 3-6-1960.

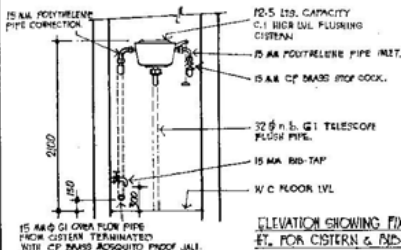
TYPICAL FIXING DETAILS OF 'ORISSA' PATTERN INDIAN WATER CLOSET	
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RECORDED • <i>[Signature]</i>	SCALE = 1:20, 1:50
APPROVED <i>[Signature]</i> CHIEF ENGINEER	FIG. NO. CED:PH: 1:2
CIVIL ENGINEERING DIVISION DEPARTMENT OF SPACE, BANGALORE	



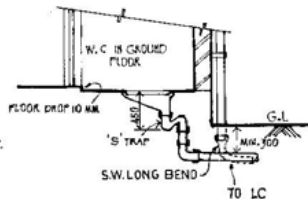
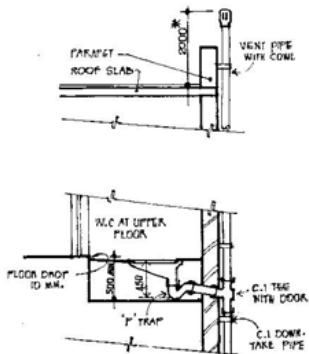
\* 2000 IN CASE OF FLAT ROOF TO WHICH ACCESS FOR ROOF IS PROVIDED, OTHERWISE 2.5M FROM THE TOP OF WINDOW MEASURED VERTICALLY.



**PLAN**  
SCALE 1:20



**ELEVATION SHOWING FIXING**  
ET. FOR CISTERN & BID-TAP.



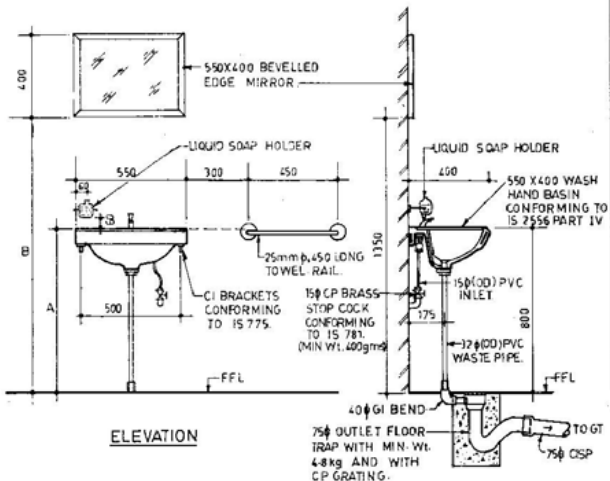
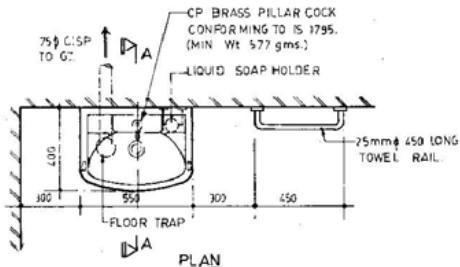
**TYPICAL CROSS SECTION**

**NOTE**

1. ALL DIMENSIONS ARE IN MILLIMETRES.
2. ONLY FIGURED DIMENSIONS ARE TO BE FOLLOWED.
3. FLOOR SHALL BE SLOPED TOWARDS PAN IN FLOOR FINISHING INSIDE THE WATER CLOSET BY 10 MM.
4. SANITARY TREATMENT SHALL BE PROVIDED FOR CISTERN, SUNK FLOOR IN UPPER FLOOR AS PER THIS OFFICE CIRCULAR NO. CED/PM/G/C/493 DATED 5-4-1980.

**TYPICAL FIXING DETAILS OF  
INDIAN WATER CLOSET WITH FOOT RESTS**

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RECORDED • <i>[Signature]</i>	DATE • 10/1/82	SCALE • 1:20, 1:50
APPROVED CHIEF ENGINEER	<i>[Signature]</i>	FIG. NO. <b>CED:PH: 1-3</b>
CIVIL ENGINEERING DIVISION DEPARTMENT OF SPACE, BANGALORE		



AGE IN YEARS	A	B
BELOW 5	580	1130
5 to 10	630	1180
ABOVE 10	800	1350

TITLE

TYPICAL FIXING DETAILS OF WASH HAND BASIN.(SIZE 550X400)

DRAWN

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28/11/09

RECOMMENDED

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10.11.09  
HEAD - PH

APPROVED

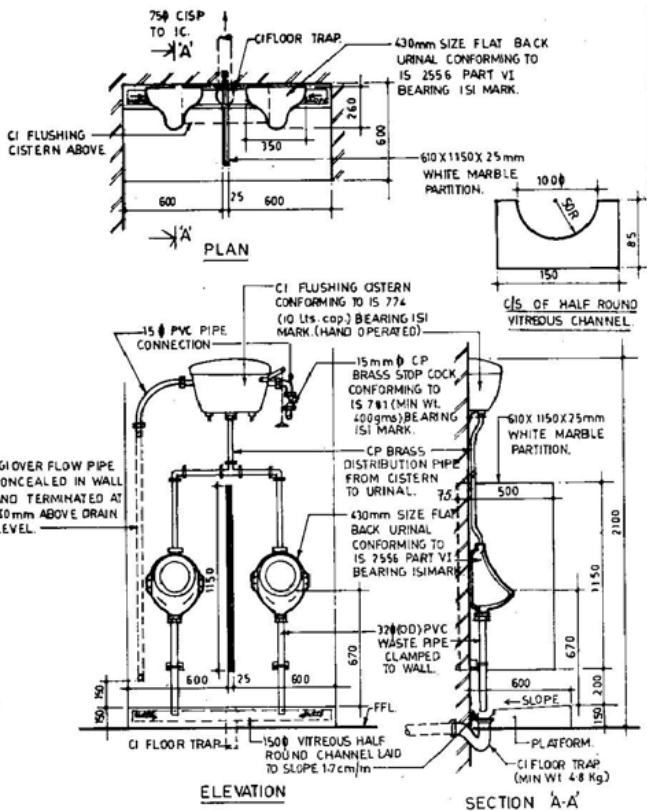
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CHIEF ENGINEER

SCALE

1:20  
DATE  
DEC 1984

FIG NO

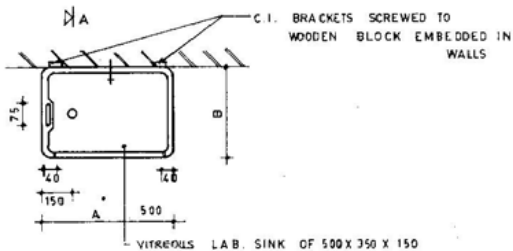
CED:PH:1-4



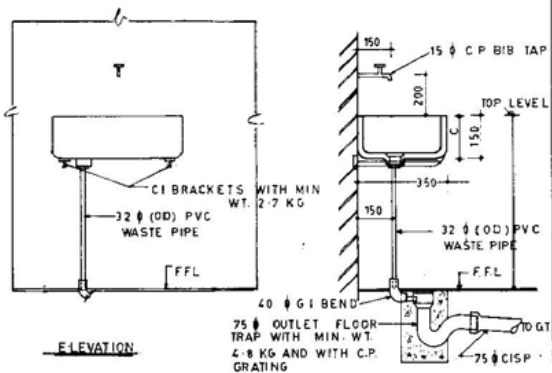
TITLE \*

TYPICAL FIXING DETAIL OF FLAT BACK URINAL. (SIZE 430mm)

DRAWN *	CHECKED *	RECOMMND *	APPROVED *	SCALE : 1:25	FIG NO.
MEENAKSHI SARANASAK 12-12-84	S.M. 12/12	19.12 HEAD.PH	12 CHIEF ENGINEER	DATE : DEC 1984	CED:PH:15



PLAN



ELEVATION

SECTION A-A

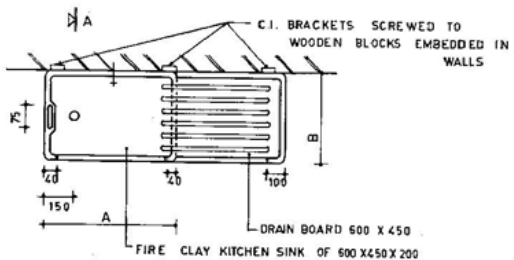
NOTE: TOP LEVEL VARIES AS PER  
WORK TABLE.

A	B	C
500	350	150
450	300	150

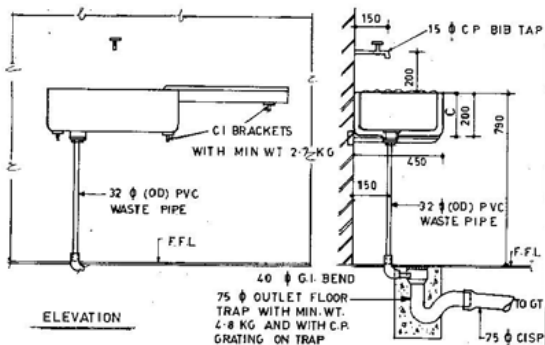
TITLE

TYPICAL FIXING DETAILS OF VITREOUS LAB SINK.

DRAWN	CHECKED	RECOMM D	APPROVED	SCALE	FIG. NO.
				N T S	
				DATE	CED:PH:1:6
		HEAD PH	CHIEF ENGINEER	APR 85	



PLAN



ELEVATION

SECTION A - A

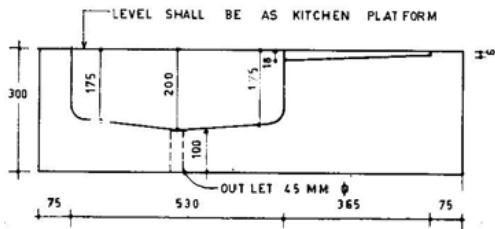
A	B	C
600	450	250
600	400	200

NOTE: TOP LEVEL VARIES AS PER  
KITCHEN PLATFORM HEIGHT.

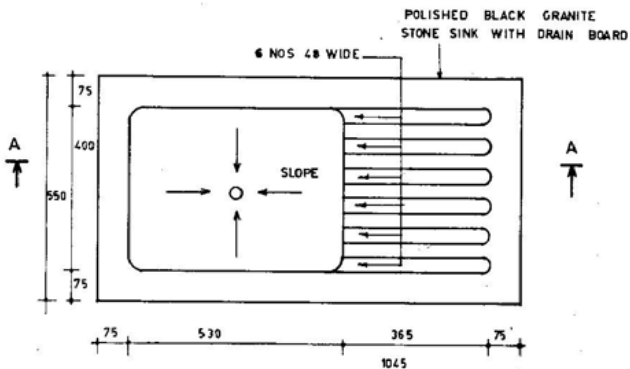
TITLE

TYPICAL FIXING DETAILS OF FIRE CLAY KITCHEN SINK.

DRAWN	CHECKED <i>[Signature]</i> 30/1/85	RECOMM D <i>[Signature]</i> 30/1/85 HEAD PH	APPROVED <i>[Signature]</i> CHIEF ENGINEER	SCALE N T S DATE 4 - 85	FIG. NO: CED.PH.16a
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SECTION A-A

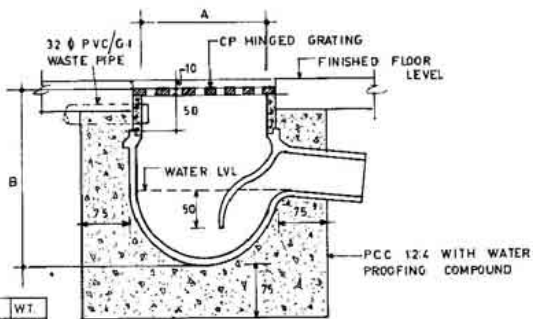


- NOTE : • DIMENSIONS WILL VARY AS PER  
CONSTRUCTION DRAWING AS PER  
LOCATION OF KITCHEN PLATFORM.
- GRANITE STONE SHOULD BE BLACK IN COLOR  
WITHOUT ANY CRACK OR FLAW IN STONE.

TITLE

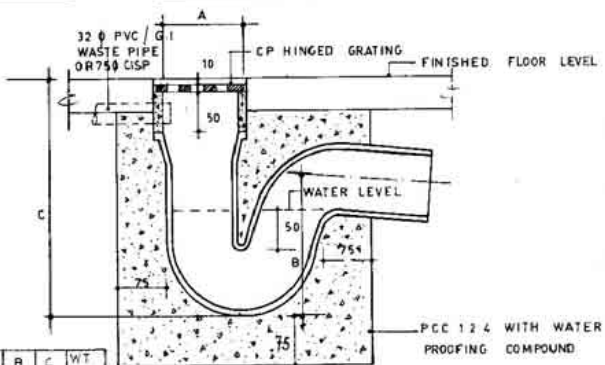
TYPICAL DETAILS OF GRANITE SINK.

DRAWN	CHECKED <i>R</i> 27/9/05	RECOMM <i>R</i> 30/9/05 HEAD PH	APPROVED <i>R</i> CHIEF ENGINEER	SCALE N T S DATE MAR 05	FIG NO CED-PH-1-7
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C.I. NAHANI TRAP

N. DIA	A	B	WT
50	165	175	5.5 kg
75	165	225	6.6 kg



C.I. FLOOR TRAP

N. DIA	A	B	C	WT
50	110	133	95	25 kg
75	100	165	225	68 kg
100	200	206	296	75 kg

TITLE : TYPICAL DETAILS OF FLOOR TRAP AND NAHANI TRAP

DRAWN	CHECKED <i>P. S.</i> 2/9/85	RECOMM <i>[Signature]</i> HEAD PH	APPROVED <i>[Signature]</i> CHIEF ENGINEER	SCALE	FIG NO
				DATE MAR #5	CED. PH. 1-8

SECTION II  
**GALVANISED IRON PIPES**



**SECTION – II**  
**SPECIFICATION FOR LAYING GI PIPES**

**Scope :**

This specification covers the methods of laying GI pipes for internal and external public health works. The specification includes laying GI pipes: (1) Specifications of pipes and fittings (2) Earth work excavation and preparation of trench for external works (3) Marking (4) Checking the quality of pipes before laying (5) Jointing of pipes (6) Laying for external works (7) Installation of water meters (8) Laying for internal works (9) Provision of anchor blocks and thrust blocks (10) Hydrostatic pressure testing for external works (11) Hydrostatic pressure testing for internal works (12) Commissioning the system and disinfection of internal public health fittings (13) Disinfection of external mains before commissioning (14) Back filling the pipe trenches (15) Restoration of road surfaces.

**Specification of GI Pipes and Fittings :**

**1 G.I. Pipes and Sockets :**

**1.1 Materials :**

The pipes shall be galvanised mild steel welded pipes and seamless, screwed and socketed tubes conforming to the requirements of IS: 1239-1968 for medium grade. They shall be of the nominal diameter (nominal bore) specified in the description of the item. The sockets shall be designated by the respective nominal bores of the pipes for which they are intended.

The pipes and sockets shall be cleanly finished, well galvanised in and out and free from cracks, surface flaws, laminations, and other defects. The ends shall be cut cleanly and square with the axis of the tube.

The details of pipes and sockets regarding nominal bore, thickness and weight in kg/m are given in the table below:

Table  
(Particulars of medium grade GI pipes)

Nominal bore mm	Dimensions of pipes		Thickness mm	Dimensions of ordinary socket		
	Outside Maximum mm	Diameter Minimum mm		Approximate outside diameter mm	Minimum length mm	Weight of pipe Kg/m
15	21.8	21.0	2.65	27.0	33	1.23
20	27.3	26.5	2.65	32.5	39	1.59
25	34.2	33.3	3.25	39.5	46	2.46
32	42.9	42.0	3.25	49.0	51	3.17
40	48.8	47.9	3.25	56.0	51	3.65
50	60.8	59.7	3.65	68.0	60	5.17
65	76.6	75.3	3.65	84.0	69	6.63
80	89.9	88.0	4.05	98.0	75	8.64

The following manufacturing tolerance shall be permitted on tubes and sockets in addition to those indicated in the table above.

(a) *Tube:*

1. Thickness:

- i) Medium Tubes butt welded: + Not limited  
- 10 percent
- ii) Medium tubes seamless: + Not limited  
- 12.5 percent

2. Weight:

- i) For quantities of 150m and over of one size:  $\pm$  4 percent
- ii) Single tube: + 10 percent  
- 8 percent

(b) *Sockets:*

Outside diameter:  $\pm$  2.5 percent

All screwed tubes and sockets shall have pipe threads conforming to the requirements of IS:554-1955 (or revised). Screwed tubes shall have taper threads while the sockets shall have parallel threads.

**1.2 Pipe Fittings:**

The fittings shall be of malleable cast iron or mild steel tubes complying with all the appropriate requirements given in para 1.1 or as specified. The fittings shall be designated by the respective nominal bores of the pipes for which they are intended.

The fittings shall have screw threads at the ends conforming to the requirement of IS:554-1955 (or revised). Female threads on fittings shall be parallel and male threads (except on running nipples and collars of unions) shall be tapered.

1.3 The dimensions of specials to be used shall be as per tables 1 to 29 of IS:1239 part-II.

**2 Earth Work Excavation and Preparation of Trench for External Works:**

The galvanised iron pipes and fittings shall be laid in excavated trenches. The widths and depths of the trenches for different diameters of the pipes shall be as in the table given below:

Table

Dia of Pipe	Width of Trench	Depth of Trench
15mm to 50mm	30cm	60cm
65mm to 100mm	45cm	75cm

The work of excavation and refilling shall be done true to line and gradient in accordance with specifications. At joints the trench width shall be widened where necessary for earth work in trenches as described in paras 2.2, 2.7, 2.9, 2.10, 2.11, 2.13, 2.14, 2.15, 2.16, 3.8, 3.11, & 3.12 in section V. of specification for laying pipes.

When excavation is done in the rock bottom shall be excavated to extra depth of 10 cms to permit the pipes to be laid on a cushion of sand of minimum 10 cm thick.

### **3 Marking :**

The different classes of tubes shall be distinguished by colour bands which shall be as follows :-

- A – Light tubes – Yellow
- B – Medium tubes – Blue
- C – Heavy tubes – Red

Tubulars and fittings shall be suitably packed and threads protected from damages and marked with the following details :

1. Manufacturers name or trade mark
2. Size, Designation

Pipes and fittings shall also be marked with ISI certification mark.

### **4 Checking the Quality of Pipes before using on Works :**

The pipes and fittings shall be inspected at site before use to ascertain that they conform to the wall thickness and weight of pipe for one metre length of pipe shall be necessarily checked to ensure the appropriate class of pipe (medium class/heavy class) before acceptance of the pipe for use in the building. The wall thickness of pipe has to be checked accordingly to second decimal of a millimeter using a screw gauge and recorded in measurement book. The defective pipes shall be rejected. While cutting, laying and jointing for internal and external works, where the pipes have to be cut or rethreaded, the ends shall be carefully filed out so that no obstruction to bore is offered. The end of the pipes shall then be threaded conforming to the requirements of IS-554-1955 with pipe dies and taps carefully in such a manner as will not result in slackness of joints when the two pieces or screwed together. The taps and dies shall be used only for straightening screw threads which have become bent or damaged and shall not be used for turning of the threads so as to make them slack, as the later procedure may not result in a water tight joint. The screw threads of pipes and fittings shall be protected from damage until they are fitted.

### **5 Jointing of GI Pipes :**

The pipes shall be cleaned and cleared of all foreign matter before being laid. In jointing the pipes, pipes shall be oiled and rubbed over with white lead and a few turns of spun yarn wrapped round the screwed end of the pipe. The end shall then be screwed in the socket, tee etc., with the pipe wrench. Care should be taken that all pipes and fittings are properly jointed so as to make the joints completely water tight and pipes are kept at all times free from dust and dirt during fixing. Burr from the joint shall be removed after screwing. After laying, the open ends of the pipes shall be temporarily plugged to prevent access of water, soil or any other foreign matter.

Any threads exposed after jointing shall be painted or in the case of under ground piping thickly coated with approved anticorrosive paint to prevent corrosion.

### **6 Laying for External Works :**

6.1 The pipes shall be painted with two coats of anticorrosive bitumastic paint of approved

quality. The pipes shall be laid and jointed on a layer of 7.5 cms sand and filled upto 15 cms above the pipes. In case of sandy soil not containing sulphates and chlorides more than provision of layer of sand is not required. The remaining portion of the trench shall then be back filled with excavated earth as described in section III para 7 of CI pipes specifications. The surplus earth shall be disposed off as directed.

6.2 When CI pipes are laid below ground level they shall not be laid parallel and close to electrical cable. Using GI water pipes for earthing of electrical wiring shall not be done as it may induce galvanic corrosion in pipes, and also may result in electrocution.

### **6.3 Protection Against Aggressive Soils :**

In case soil contains high sulphates and chlorides and peaty matter special precaution shall be taken to prevent corrosion as directed by Engineer-in-Charge.

### **6.4 Vertical and Horizontal Separation Between Sewer and GI Pipe Line :**

Care shall be taken to lay the GI water mains always above the sewer line. The minimum horizontal and vertical clearance between sewer line and water line shall be 500 mm. Joints shall be avoided in the water pipe and sewer pipe at the crossing of sewer line and water line if the crossing is perpendicular or angular to sewer line.

### **6.5 Laying Service Pipes:**

Service pipes of less than 50 mm bore may be connected to cast iron pipe mains by means of right angled screw down ferrule of non-ferrous metal conforming to IS : 2692-1964, but the ferrule itself shall not be more than 25 mm bore. Ferrule of 20 mm bore and above shall not be used in CI mains of less than 100 mm bore. The CI main is drilled and tapped and the ferrule screwed in.

## **7 Installation of Water Meters:**

The meter shall be installed in accordance with IS : 2401-1963. The meters shall be fitted beyond the stop cock with unions to facilitate the removing of the meter for repairs. If fitted in an exposed position outside the building the meter shall be housed in water meter boxes conforming to IS : 2104-1962. Care shall be taken that the factory seal of the meter is not disturbed. When the meter shall be fixed to a newly fitted pipe line, the pipe line shall have to be completely washed before fitting the meter. For this purpose a piece of pipe equal to the length of the meter shall be fixed in the proposed position of the meter in the new pipe line. The water shall be allowed to flow completely to wash the pipe line and then the meter installed as described above by replacing the connecting pipe.

## **8 Laying GI Pipes for Internal Works :**

### **8.1 General:**

All rates for fixing shall provide for making holes in walls, providing screws, wooden plugs and cleats wherever necessary, cutting floors, chasing in walls and floors etc., and making good and restoring to original conditions. The rates shall be for the completed work as laid down in the schedule and the contractor is not entitled for any payment on this account except in case of any dismantling or reconstruction of any brick masonry or concrete structures, which are of special nature in the opinion of the Engineer-in-Charge for which payment shall be made in accordance with the relevant rates as in schedule of approved rates.

### 8.2 Marking the Alignment of Pipes:

The alignment of pipes to be laid shall be neatly marked with thread and line strictly in accordance with plans and approval of the Engineer-in-Charge taken before commencing the laying of pipes. Any deviations from plan found necessary during laying shall be got approved by the Engineer-in-Charge. No water pipe is to be buried under flooring. Pipes shall be laid exposed or concealed in walls as prescribed in drawing and schedule of quantities.

### 8.3 Laying GI Pipes Exposed on Walls:

All exposed pipes and specials shall be painted with three coats of approved synthetic enamel paint of approved shade to match with the colour of wall surface.

The fixing shall be done by means of standard pattern holder bat clamps, keeping the pipes about 15mm clear of the wall. The clamps shall be spaced at regular intervals in straight lengths as shown in table given below: (Ref. fig. 2.1)

Size of pipe in mm	Intervals in meters	
	For horizontal run	For vertical run
15	2.0	2.5
20	2.5	3.0
25	2.5	3.0
32	2.5	3.0
40	3.0	3.5
50	3.0	3.5

### 8.4 GI Pipes Laid Concealed in Walls:

8.4.1 GI pipes shall be fixed in chases and be secured with approved MS pipe hooks at about 1.5 m intervals.

8.4.2 For GI pipes 15 mm to 25 mm diameter the holes in the walls and floors shall be made by drilling by pipe jumper and not by dismantling the brick work or concrete. However for bigger dimension pipes the holes shall be carefully made of the smallest size as directed by the Engineer in-Charge. After fixing the pipes the holes shall be made good with cement mortar 1:3 and properly finished to match the adjacent surface.

8.4.3 The chasing to be done in the wall shall be of minimum width equivalent to pipe diameter plus 20 mm on either side Ref. fig.2.1. The depth of chase shall be pipe diameter plus 20 mm to be cut in unplastered brick wall. Care shall be taken to do all chasing before plastering. Wherever pipes are intended to be concealed in wall chases, the pipes shall be painted with 3 coats of anticorrosive bituminous paints. The pipe shall be laid centrally along the centre line of chase leaving sufficient space for grouting. GI pipes shall be fixed in chases by means of MS pipe hooks driven in to the wall at every 1.5 M intervals securely clamping the pipe into wall. The front cover from the exterior pipe surface to the surface of unplastered brick wall shall be minimum 20 mm at all places. After pipe laying is completed, pressure testing shall be conducted as described in para 11 and water tightness of the entire piping system including all joints to be concealed got checked. After satisfactory testing the chases shall be grouted with cement

mortar of mix. 1:3 flush in line with the unplastered brick wall surface.

#### **9 Provision of Anchor and Thrust Blocks in Pipelines :**

Anchor and thrust blocks for external water pipes shall be provided as described in Section V para 5 for specifications for laying CI pipe lines. In case of GI pipes of dia 80 mm and above laid inside buildings subjected to high pressures suitable MS anchors grouted in walls shall be provided at all bends and free ends.

#### **10 Hydrostatic Testing for External Work :**

Hydrostatic testing for external work shall be done as described in section V para 6 of specifications for CI pipe line works.

#### **11 Hydrostatic Testing for Internal Works :**

After laying and jointing the GI pipe shall be slowly and carefully charged with water, so that all air is expelled from the main by providing a 25 mm inlet with a stop cock allowed to stand full of water for one day minimum and then tested under pressure. The test pressure shall be 5 kg/cm<sup>2</sup> or one and half times the maximum working pressure, whichever is greater. The pressure shall be applied by means of a manually operated test pump. Due precaution shall be taken to ensure that the required test pressure is not exceeded. Pressure gauge shall be accurate and shall preferably have been recalibrated before the test. The test pump having been stopped the test pressure shall maintain itself without measurable loss for atleast half an hour. The internal pipes shall be tested in sections as the work of laying proceeds. The GI pipes laid in chases have to be concealed with cement mortar only after the pressure testing is done satisfactorily and leakages if any are stopped and the test is passed by the Engineer-in-Charge. The open end of the main may be temporarily closed for testing under moderate pressure by fitting a water tight plug. The end of the main and the plug shall be secured by struts or otherwise, to resist the end thrust of the water pressure in the mains.

#### **12 Commissioning the System and Disinfection of IPH Pipes and Fittings :**

After completion of the entire internal plumbing system the overhead tank shall be filled with water mixed with filtered bleaching powder solution of 50 ppm chlorine. This water shall be filled to the entire system and kept for a contact period of 12 hours. All fittings like stop cocks, bib taps, shower rose, pillar cocks, flushing cistern etc., shall be operated with this water for effective disinfection. Disinfection shall be done to the satisfaction of Engineer-in-Charge and then only the work shall be taken over. Care shall be taken to see that this water is not used for drinking and other purposes. The system shall be flushed with potable water before commissioning.

#### **13 Disinfection of external Mains before Commissioning :**

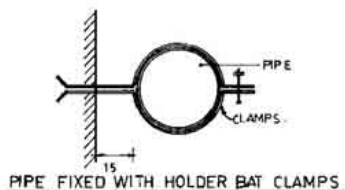
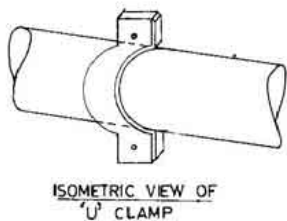
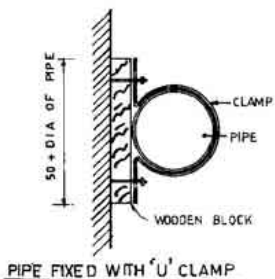
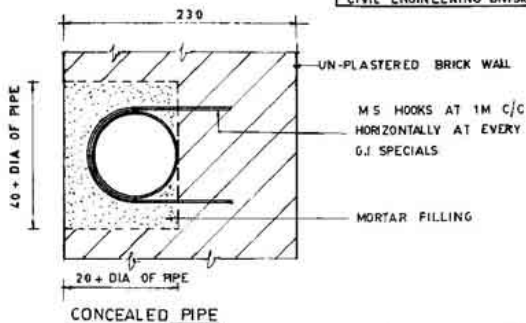
Disinfection of external works shall be done as described in para 8 in specifications for CI pipes.

#### **14 Back Filling the Pipe Trench :**

Back filling of the trenches shall be done as described in para 7 in specifications for CI pipes.

#### **15 Restoration of Road Surfaces, Pavements Etc.**

Restoration shall be done as described in para 9 in specifications for CI pipes.



TITLE

TYPICAL FIXING DETAILS OF G.I. PIPES EXPOSED AND CONCEALED

DRAWN	CHECKED <i>R</i> 2/9/85	RECOMM D <i>20/4</i> HEAD PH	APPROVED <i>1/2</i> CHIEF ENGINEER	SCALE N T S DATE MAR 85	FIG NO: CED. PH. 2-1
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SECTION III  
**SPECIFICATION FOR CAST IRON SOIL PIPES  
FOR DRAINAGE OF SANITARY  
INSTALLATIONS IN BUILDINGS -  
LAYING, JOINTING AND TESTING.**



## SECTION – III

### 1 CI SOIL PIPES FOR DRAINAGE OF SANITARY INSTALLATIONS :

**1.1 SCOPE:** This Specification includes:

- a) Specification for pipes and fittings
- b) Tests for acceptance of pipes and fittings
- c) Sizes, mass and tolerances,
- d) Coating
- e) Marking
- f) General procedure for layout of pipes and fittings
- g) Ventilating pipes.
- h) Inspection, testing and commissioning of pipes.

**1.2 Specification for pipes and fittings:**

1.2.1 General requirements of materials shall be as per IS:1387-1967.

1.2.2 The pipes and fittings shall be free from defects, other than any unavoidable surface imperfections which result from the method of manufacture and which do not affect the use of fittings.

**1.3 Tests for Acceptance :**

1.3.1 Hammer test : Each pipe and fitting shall be tested by striking with a light hand hammer and shall emit a clear ringing sound.

1.3.2 Hydrostatic Test:

Pipes and fittings must have been tested for a hydrostatic pressure of 0.07 N/mm<sup>2</sup> (0.7 kg/cm<sup>2</sup>). Manufacturer's certificate to this effect must be produced by the contractor in case of pipes of quantity exceeding 300 metres, and necessary fittings.

**1.4.1 Sizes:** The dimensions of pipes and fittings shall conform to the sizes as specified in tables 1 to 28 in IS:1729-1979.

1.4.1.1 Dimensions of straight pipes and sockets and spigots shall be as shown in IS:1729.

1.4.1.2 Ears : If pipes and fittings with ears are specified in schedule of quantities they shall have the following projections which are measured from the outer surface of the pipe or fitting to the face of the ears.

For 50 and 75 mm dia ... 32 mm

For 100 and 150 mm dia ... 38 mm

**1.4.2 Mass:** The nominal mass of pipes shall be as shown in table 1 of IS:1729.

Pipes weighing more than the nominal mass shall be accepted provided the dimensions and quality is of acceptable quality

**1.4.3 Tolerances :**

1.4.3.1 Tolerances in dimensions :

Tolerances on the external diameter of the barrel, the internal diameter of the socket and depth of socket shall be as follows :

Dimensions	Nominal Diameter (mm)	Tolerance (mm)
External diameter of barrel	50, 75	± 3.0
	100	± 3.5
	150	± 4.0
Internal diameter of socket	All diameters	± 3.0
Depth of socket	All diameters	± 10.0

1.4.3.2 Tolerance in Mass: The tolerance on mass shall be minus 10 percent.

**1.5 Coating :** Each pipe and fitting shall have coating of tar or other suitable base. This coating must have been done with pipes and fittings being preheated and in an immersion bath. The coating shall not chip off when scratched lightly with a pen knife.

**1.6 Marking :** Each pipe and fitting shall have cast, stamped or indelibly painted on it the following appropriate marks :

- a) Manufacturer's Name, initials or identification mark.
- b) The nominal diameter.
- c) ISI Marking.
- d) The last two digits of the year of manufacture

#### 1.7 General Procedure for layout of pipes

1.7.1 The pipe system shall be as shown in construction drawings either single stack system or double stack system. The quantities shall be as per schedule of quantities which is given in running metres for CI soil pipes, number of specials and making number of joints. The quantities specified are only approximate and may vary as per site conditions and directions of Engineer-in-Charge.

1.7.2 A schematic piping drawing shall be furnished in the Internal Public Health Works drawings for construction. Based on this construction drawing a detailed drawing for plumbing of CI soil pipes with all fittings indicated shall be prepared by contractor and got approved by Engineer-in-Charge before execution of works. The works shall follow the standard plumbing practices as per national building code and relevant IS specifications and rates shall include supplying and installing of all materials and fixtures to the extent specified in schedule of quantities used in the installation of the piping, specials and fittings, fixtures appliances and appurtenances in connection with sanitary drainage, the venting system etc., within the building premises. Prior to commencement of work the contractor shall furnish name and address of the licenced plumber by whom the plumbing works shall be executed and take approval of Engineer-in-Charge. The licenced plumber shall possess valid licence issued by local municipal authority under whose jurisdiction the site of building is located.

1.7.3 Some of the precautions to be taken by contractor are given below.

1.7.3.1 Branches and stacks which receive discharges from WC pans should not be less than 100mm. For outlets of floor traps, nahani traps 75 mm or 100 mm dia pipes may be used as shown in drawing for construction.

1.7.3.2 The gradient of a horizontally laid CI soil pipe for drainage should not be flatter than 1 in 50 and not steeper than 1 : 10.

1.7.3.3 Layout of Pipes : Pipe work and appliances should be done as per layout shown in the construction drawings. Soil outlet from water closet connected to the main soil pipe shall have an access door for cleaning. The access door must not be concealed in walls. The soil pipe shall be situated outside the building or in suitably designed pipe shaft. The waste pipe shall be continued upwards without any diminution in its diameter and without any bend or angle to such a height and position as to afford effective ventilation by means of the open end of the waste pipe of safe outlet for foul air. The position of the open end shall be as described in clauses 1.7.3.21, (d).

1.7.3.4 The waste pipe shall be firmly attached in the wall at least 5 cms clear of it. Cast iron waste pipes shall be fixed with holder bats as described in the specifications for rain water pipes.

1.7.3.5 The pipe work in branch connections should always be arranged to allow free drainage of the system. Connections to main or branch pipes should be so arranged as to prevent cross flow from one appliance to another. Connections should be made with an easy sweep in the direction of flow particularly in the single stack system.

1.7.3.6 Two pipe system of soil pipes is to be provided for discharging of

- (i) Soil waste waters from water closets and Urinals in one pipe and
- (ii) Waste waters from wash basins, sinks and baths in the second pipe

1.7.3.7 The vertical CI soil pipes shall be extended up above the roof slab and provided with a ventilating cowl as shown in **fig. 3.1**.

1.7.3.8 Anti siphon pipes shall be provided wherever specified in the IPH drawing, which is usually proposed for multistoreyed buildings more than three storey.

1.7.3.9 In rows of toilets where more than one vertical soil pipe is shown in IPH drawing one main soil pipe may be fixed centrally with branches to connect other water closets. Similar system of branching may be followed for waste water having one main waste pipe stack with branches for wash basins, bath etc., where necessary.

1.7.3.10 When the pipes are concealed, inaccessible or laid exposed along with the internal face of the walls, they should preferably be of cast iron. In the ground floor all the pipes, including those laid on the external face of the walls upto the first inspection chamber or gully trap should be of cast iron soil pipe of appropriate size.

1.7.3.11 All joints in pipe work and of pipe work to appliance should be made in such a manner as to be air tight and water tight and to remain so during use. Care should be taken to ensure that no jointing material projects inside the bore of the pipe.

1.7.3.12 The joint shall be made of neat cement paste and hemp yarn soaked with cement well caulked (with water content not exceeding 30 percent).

1.7.3.13 Bends should be of long radius where practicable. In the case of bends in the bottom most pipes they should necessarily be of long radius and should preferably be made of 92<sup>o</sup> bend or 135<sup>o</sup> (1/8)bends.

1.7.3.14 Ample provision should be made for access to all pipe work and the embedding of joints in walls should be avoided.

1.7.3.15 Fixtures shall be connected to the stack or inspection chamber only through any trap.

1.7.3.16 **Traps** : Special care shall be taken by contractor in locating the traps, size and type of trap conforming to the construction drawings and where site conditions warrant a change same shall be done as per the directions of Engineer-in-Charge.

1.7.3.17 Traps should always be of self cleaning pattern. Each trap shall be inspected and passed by Engineer-in-Charge.

1.7.3.18 Traps used should be conveniently accessible and provided with cleaning eyes bends, tees in upper floors. In domestic buildings, traps shall be located in such a place where-in it is easily accessible for cleaning by in-mates.

1.7.3.19 Soil pipes whether inside or outside the building, shall not be connected with any rain water pipe.

1.7.3.20 **Ventilating Pipes** : Ventilating pipes should be so installed that water cannot be retained in them. They should be fixed vertically. Whenever possible horizontal runs should be avoided.

1.7.3.21 Ventilating pipe or shaft shall be carried to a height of atleast 60 cms above the outer covering of the roof of the building or in the case of the window in a gable wall or a dormer window, it shall be carried upto the ridge of the roof or atleast 2 m above the top of the window. Refer **fig. 3.1**.

1.7.3.22 In the case of a flat roof to which access is provided, it shall be carried upto a height of atleast 120 cm above the parapet and not less than 2m above the head of any window within a horizontal distance of 3m from the vent pipe and in no case, shall it be carried to a height less than 3 m above plinth level. Refer **Fig.3.1**.

1.7.3.23 Local condition, like wind directions, adjacent building opening etc. are to be taken into account. The upper and of every ventilating pipe should be protected by means of a cowl.

## **1.8 Inspection, Testing and Commissioning :**

1.8.1 **Inspection** : Work should be inspected during installation and tests carried out on completion, care being taken that all work which is to be encased or concealed is tested before it is finally encased.

1.8.1.1 Pipe systems should be tested for gas tightness and for hydraulic performance as described in 1.8.2. Record shall be done about the inspection to ensure the following :

- a) Work accords with the drawings and specification.
- b) All pipe brackets, clips etc. are securely fixed.
- c) Fixtures are correctly spaced.
- d) Embedded pipe work is properly protected and tested before concealing.

- e) All access covers; caps or plugs, cleaning eyes are accessible and fixed in position as per drawing.
- f) The interior of NT/GT etc. are so made that the internal faces are finished neatly as per drawing and all loose mortar debris etc. removed to provide free passage of waste water, without causing any obstruction in the pipe bore.

### 1.8.2 Testing Systems :

**1.8.2.1 Water Test :** The water test may be applied before the appliances are connected and may be carried out in sections so as to limit the static head to 4.5m. In order to restrict the static level to 4.5m vertical pipe shall be tested by filling up with water every 4.5m and after testing further laying of stack continued. It is necessary to seal all openings affected by the test and provide support to the plugs used as stoppers. All the joints in soil pipes and waste pipes shall be got inspected by the Engineer-in-Charge including the joints within sanitary ducts and water filled in CI soil pipes shall be retained atleast for 15 minutes without dropping level at top. Then the test may be deemed to have passed.

**1.8.2.2 Hydraulic performance :** Discharge test should be made from all the appliances singly and collectively. Obstruction in any of the pipe lines should be traced and the whole system examined for proper hydraulic performance, including retention of an adequate water level in each trap. Any defects revealed by the tests should be made good and the tests repeated until a satisfactory result is obtained and then only the system shall be commissioned.

**1.8.2.3** Complete records shall be kept of all tests carried out of sewers and drains both during the construction and after being put into service and testing and passing of test recorded in Measurement Book in remarks column, before paying final bill.

### 2. Laying Building Drains upto Main Sewer - Manholes and Inspection Chambers :

**2.1** SW pipes or CI soil pipes shall be supplied and laid as per relevant specifications in public health engineering works and civil works. Specifications for construction of inspection chambers, gully traps and manholes if any shall be constructed as specified under specification for external sewerage works and as per schedule of works and conformity with the detailed drawings for manholes, inspection chambers and gully traps of appropriate size and depth.

**2.2** The discharge of water through a domestic drain is intermittent and limited in quantity and therefore, small accumulations of solid matter are liable to form in the drains between the building and the main gravity sewer. To prevent these temporary accumulations and which may lead to blockage of drains sufficient gradients shall be given as indicated in table in clause No. 2.4.

**2.3 Gradient :** Normally, the sewers are designed for discharging three times the dry weather flow flowing half-full with a minimum self cleansing velocity of 0.75 m/sec. In cases where it is practically not possible to conform to the ruling gradient due to site conditions like connecting to existing gravity sewer system etc., a flatter gradient may be used but the minimum velocity in such cases shall be on no account be less than 0.61 m/sec. and adequate flushing is to be done. In hilly terrain it may be unavoidable to provide steeper gradient. The limiting velocity in any case should not be more than 2.4 m/sec. In such cases cast iron pipes shall be used in place of stone ware pipes. The table in 2.4 gives gradients for 0.61 m/sec., 0.75 m/sec and 2.4 m/sec for different diameter of pipes with discharge. Steeper gradients may be provided wherever site

conditions permit the same and the network of sewer system can accommodate the same.

#### 2.4 Gradients for different velocities :

Diameter	Velocity m/sec.	Gradient	Discharge m <sup>3</sup> /mm
100 mm	0.61	1 in 135	0.30
-do-	0.75	1 in 57	0.18
-do-	2.40	1 in 5.6	0.59
150 mm	0.61	1 in 250	0.72
-do-	0.75	1 in 100	0.42
-do-	2.40	1 in 9.7	1.32
200 mm	0.61	1 in 350	1.08
-do-	0.75	1 in 145	0.73
-do-	2.40	1 in 14	2.40
230 mm	0.61	1 in 400	1.50
-do-	0.75	1 in 175	0.93
-do-	2.40	1 in 17	2.98

2.5 The minimum size of pipe shall be 100 mm. Due to site conditions in no case pipe size shall be provided less than 100 mm. Any deviations from construction drawings shall be done on approval of Chief Engineer on obtaining revised drawings.

#### 2.6 Man Holes and Inspection Chambers :

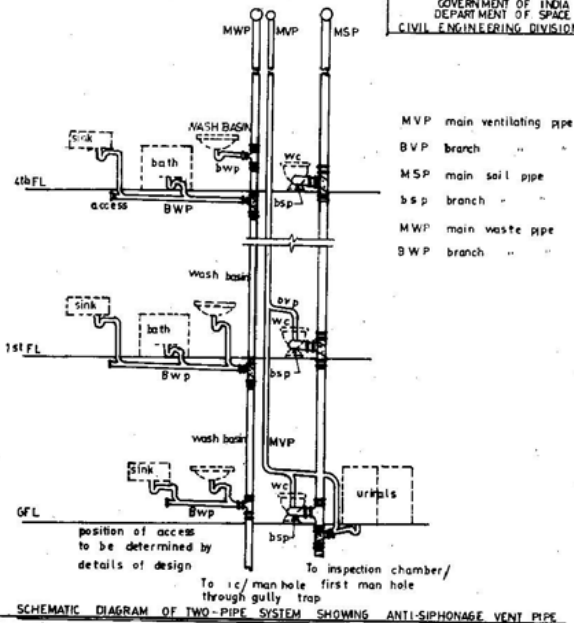
Shall be provided as shown in construction drawings. The maximum distance between man holes shall be 30 m.

2.7 Chambers shall be of such size as will allow necessary examination or clearance of drains. The minimum internal sizes of chambers for different depths are as follows.

- for depths of 1m or less ... 450 x 450, 600 x 600 or 800 x 800 mm
- for depths between 1 m and 1.5 m. ... 900 x 1200 mm.
- for depths 1.5 m and above ... Circular chambers with a minimum diameter of 1200 mm.

2.8 The invert levels shown in construction drawings are theoretical. Engineer-in-Charge shall take levels along alignments of sewers and appropriate invert levels are to be fixed with reference to plinth level of building and these levels shall be recorded in level books duly signed by contractor and Engineer-in-Charge.

2.9 Testing, Inspection and Commissioning shall be done as described in relevant clauses of specifications for stone ware pipes.

**NOTE**

- 1 IN CASE OF 4 FLOORS AND MORE SEPERATE VENT SYSTEM AS SHOWN IN SKETCH IS TO BE LAID
- 2 IN CASE OF ONLY 2 & 3 FLOORS THE SOIL STACK ITSELF SHALL BE ACTING AS VENT AND EXTENDED ABOVE PARAPET WALL OF ROOF
- 3 IN CASE OF ONLY GROUND FLOOR ONE VENT PIPE SHALL BE PROVIDED ATTACHED TO THE BUILDING TAKING OFF FROM THE MOST ELEVATED INSPECTION CHAMBER ONE FOR EACH BRANCH SEWERS.
- 4 SEPERATE VENT PIPE MAY BE PROVIDED FOR WATER CLOSETS.

**TITLE SCHEMATIC DIAGRAM OF TWO PIPE SYSTEM ANTI SIPHONAGE VENT PIPE**

DRAWN G.USHA	CHECKED <i>[Signature]</i> 16/7/85	RECOMM D <i>[Signature]</i> HEAD PH 16-7-85	APPROVED <i>[Signature]</i> CHIEF ENGINEER	SCALE N T S DATE JULY 85	FIG.NO CED PH 3-1
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**SECTION IV  
SPECIFICATION FOR LAYING  
RAIN WATER PIPES.**



## SECTION – IV

### SPECIFICATIONS FOR LAYING RAIN WATER PIPES

#### SCOPE:

This specification covers the methods of laying cast iron and asbestos cement rain water pipes. The specifications include (1) Specification of pipes to be used for rain water (2) Fixing pipe size for roof drainage and location of pipes. (3) Laying and jointing (4) Gradients to be given in and laying weathering course (5) Tar felt flashing, grating fixing details, and gola & Khura details for rain water pipes (the scope of specifications does not include laying of weather proof course and tar felt laying).

#### 1 Specifications for Pipes :

1.1 Cast iron and asbestos cement pipes are used for rain water pipes. wherever rain water pipes are to be concealed in RCC columns or RCC members MS pipes are to be used.

#### 1.2 Materials specification for cast iron rain water pipes (CI) :

1.2.1 Cast iron rain water pipes shall be sand cast or spun pipe of approved quality, even surface and truly cylindrical, their inner and outer surfaces being as nearly as practicable concentric and shall conform to IS : 1230-1968 for cast iron rain water pipes and fittings and also have ISI certification mark. The metal used for the CI rain water pipes and fittings shall be of quality not lower than grade-15 of IS : 210-1962. The holder bats may however be of cast iron or mild steel.

#### 1.3 Dimensions and tolerances :

Straight pipes shall comply with the dimensions given in Fig.4.1. They shall have an overall length of 1800mm subject to the following tolerances.

Dimensions mm	Nominal Diameter mm	Tolerance mm
a) External diameter of barrel (B)	50, 75	± 3.0
	100, 125	± 3.5
	150	± 4.0
b) Internal diameter of socket (F)	All diameters	± 3.0
c) Depth of socket (J)	All diameters	± 10.0
d) Thickness (C)	All diameters	± 1.0
e) Length	All diameters	± 13.0

1.3.1 Pipe fittings and their sockets and spigots shall conform to the thickness and other dimensions specified for the corresponding parts of the straight pipes subject to the following tolerance :

Thickness : ± 1 mm

Length : ± 3 mm

#### 1.4 Weights and tolerances:

Nominal weight of 1800 mm length without ears in Kg.

Nominal inside Diameter in mm	50	75	100	125	150
External dia in mm	53	79	104	130	156
Weight in Kgs.	7.5	11.0	14.0	20.0	26.0

The tolerance on weight shall be - 10 percent.

**1.4.1 Ears:** Unless and otherwise specified pipes and fittings shall be supplied without ears. When ears are required as per drawing or as per site conditions Engineer - in - charge shall order for the same. The dimensions of ear shall be as shown in **fig. 4.1**. They shall have following projections measured from outer surface of the pipe or fitting to face the ears.

Nominal fittings. mm	Projection from back of ear to back of pipe. mm
50 and 75	30
100, 125 and 150	40

**1.4.2 Fittings:** Dimensions of different fittings to be used in CI rain water pipe line shall conform to table 2 to table 6 of IS:1230-1968.

1.4.2.1 Weights of different sizes of CI rain water pipe fittings:

**Table 1**

Sl. No.	Description	75 mm dia weight in Kgs.	100 mm dia weight in Kgs.	150 mm dia weight in Kgs.	Unit
1.	Bends (Plains)	3.20	4.50	9.10	Each
2.	Off - sets (Plain):	2.70	5.00	8.20	"
	a) 55 mm projection	2.70	5.00	8.20	"
	b) 75 mm projection	3.20	5.50	9.10	"
	c) 115 mm projection	4.10	5.90	5.90	"
	d) 150 mm projection	4.50	6.40	10.40	"
	e) 225 mm projection	5.00	7.30	11.80	"
	f) 300 mm projection	6.00	8.60	12.70	"
3.	Branches (plain) Single	5.00	7.30	14.50	"
	" " Double	6.80	10.00	19.10	"
4.	Standard shoes (plain)	3.20	4.10	8.60	"
5.	Longer shoes (plain):				
	a) 300 mm	3.20	5.00	-	"
	b) 375 mm	4.10	6.40	-	"
	c) 450 mm	5.50	5.50	-	"
	d) 600 mm	7.30	8.60	-	"
6.	Heads	6.40	6.80	11.30	"
7.	Extras: a) For ears case on any fittings & short pipes	0.90	0.90	1.35	"
	b) For inspection door & fitted on any fittings	1.80	1.80	2.25	"

NOTE : 1. The above table applies only to rain water fittings which are part of pipe lines fixed on wall face, permissible tolerance in weight of fittings shall be  $\pm 5\%$

2. For fittings to be used with pipe lines to be embedded in masonry, specifications shall correspond with those of pipe fittings for soil, waste and vent pipes. For their weights, specifications under CI soil, waste and vent pipes may be referred to.

#### **1.5 Inspection of quality of pipes and fittings before laying :**

Pipes and fittings shall be cylindrical, reasonably circular as practicable. The outer surfaces shall be smooth and shall, in all respects, be sound and free from pinholes, projections or other imperfections which may affect their utility and shall be neatly dressed. The ends shall be finished reasonably right angle to their axis.

1.5.1 **Hammer test :** Each pipe when tested for soundness by striking with a light hand hammer shall emit a clear ringing sound.

1.5.2 The pipes supplied shall be factory painted with a tar based composition both inside and outside which shall be smooth and tenacious and hard enough not to flow when exposed, to a temperature of 77° C but not so brittle at a temperature of 0° C as to chip off when scribed lightly with a pen knife.

1.5.3 **Marking :** Each pipe and fittings shall have nominal diameter, manufacturer's trade mark and ISI certification mark stamped suitably on it. Every spun pipe shall have marking 'S' on it.

#### **1.6 Material specification for Asbestos Cement rain water pipes (AC) :**

1.6.1 **Composition :** The materials used in the manufacture of the asbestos cement building and sanitary pipes and pipe fittings shall be composed of an inert aggregate consisting of clean asbestos fibre cemented together by ordinary portland cement conforming to IS : 269 - 1976, portland slag cement conforming to IS : 455 - 1976 or portland pozzolana cement conforming to IS : 1489 - 1976.

#### **1.6.2 General quality and workmanship :**

The materials used in the manufacture of the pipes and pipe fittings shall be intimately mixed. The interior surface of the pipes and pipe fittings should be regular and smooth.

#### **1.6.3 Dimensional and physical requirement :**

1.6.3.1 **Dimensional requirements - nominal diameter :** The nominal diameter of the pipes and pipe fittings corresponds to the internal diameter (bore) tolerance not being taken into account. The series of the nominal diameters shall be 50, 60, 80, 100, and 150 mm.

1.6.3.2 **Thickness :** The nominal thickness of pipes and pipe fittings shall not be less than the values given in the following **Table-II** for different values of nominal diameter.

#### **1.6.3.4 Length :**

**Nominal length :** The nominal lengths of pipes correspond to the useful lengths of the socketed pipes exclusive of internal depths of socket not taking tolerances into account, and shall be 0.5, 1, 1.5, 2 and 3 m.

#### **1.6.3.3 Over all length :**

The overall length is the sum of nominal length of socket (Dimensions 'C' in table given below).

**Table-II** Thickness of pipes and pipe fittings and tolerances of thickness:

Sl. No.	Nominal Diameter of pipe or pipe fittings (mm)	Thickness of pipe fittings (mm)	Tolerance on thickness (mm)
(1)	(2)	(3)	(4)
1.	50	6.5	± 1.0
2.	60	6.5	± 1.0
3.	80	8.0	± 1.0
4.	100	8.0	± 1.0
5.	150	9.5	± 1.5

other dimensions of pipes and pipe fittings shall be according to the details in **table-2** given in IS: 1626 (part-I)-1980 and table nos. referred therein.

**Table-III**

Dimensions of single socketed pipes and details of socket for accessories.  
All dimensions in millimeters.

Nominal size of pipe dia mm	A	B	D	E	G
50	50	6.5	76	8.0	70
60	60	6.5	86	8.0	70
80	80	8.0	109	8.0	70
100	100	8.0	129	9.5	75
150	150	9.5	185	9.5	75

1.6.3.5 Tolerances on dimensions on internal diameters and actual diameter (maximum or minimum bore of pipes, pipe fittings or sockets measured over a given section) and the nominal diameter (bore of pipes, pipe fittings or sockets) should be between 0.95 and 1.05 mm for all diameters of pipes and pipe fittings.

1.6.3.6 **On Thickness:** The tolerances on thickness of pipes and fittings shall be in accordance with table-I.

**On the nominal length:** The tolerances on nominal lengths of pipes and pipe fittings shall be ± 10 mm and ± 5 mm respectively.

**On the overall length:** The tolerance on the overall lengths of pipes shall be ± 10 mm.

**On the depth of sockets:** The tolerance on the depth of the sockets of pipe fittings shall be ± 5 mm.

#### 1.6.3.7 Physical Requirements:

The deviation in straightness of pipes determined in accordance with IS: 5913-1970 (methods of test for asbestos cement products) shall not exceed the following:

Nominal diameter mm	Maximum deviation mm
50 to 60	5.5 'l
80 to 150	4.5 'l

Note: 'l' is the nominal length of the pipe in meters.

### 1.6.3.8 Tests to be done at manufacturer's factory :

When the requirement of AC pipes in work is more than 300 m or more then the contractor shall obtain a certificate from the manufacturers stating that the pipes are tested and the quality of pipes satisfy the requirements of IS: 1626 - part -1 - 1980.

The following tests shall be done at manufacturers factory premises as per procedure laid down in IS: 5913 - 1970.

**Hydraulic pressure test :** The hydraulic pressure test shall be carried out in pipes and pipe fittings except on items core cap cowl, slotted vent cowl and pipe fittings provided with access doors. The internal hydraulic pressure should be raised gradually to  $0.1 \text{ MN/m}^2$  and maintained for 30 seconds such that there is no fissure or visible sweating on the outside surface of the fittings.

**Hydraulic bursting test (for pipes only):**

The pipes shall indicate a minimum bursting stress of  $5 \text{ MN/m}^2$ .

**Transverse crushing test : (for pipes only ):** The unit transverse crushing stress at failure shall not be lower than  $14 \text{ MN/m}^2$ .

**Longitudinal bending test (for pipes only):** The unit longitudinal stress shall not be less than  $12.5 \text{ MN/m}^2$ .

**Water absorption test:** The mean water absorption of specimen shall not be more than 28 percent of the dry mass of the material.

**Acid resistance test:** The mean amount of acetic acid used in testing shall not exceed  $1150 \text{ g/m}^2$ .

**Sampling and testing:** The method of sampling of pipes and pipe fittings shall be as per IS: 7639 - 1975 and in case of doubtful quality of pipes supplied in bulk of quantity exceeding 300 mm, the Engineer-in-Charge will get three samples of pipes selected at random and get them tested as specified above.

### 1.6.4 Marking:

1.6.4.1 Pipes and fittings shall be clearly and indelibly marked suitably with the following :

- Manufacturer's name or trade mark;
- Size of the pipe or pipe fittings and
- Date of manufacture.

Each pipe or pipe fittings shall be marked with ISI certification mark.

### 2. Fixing Pipe Size for Roof Drainage and Location of Pipe :

2.1 Pipe sizing: The sizes of rain water pipes and the sectional area of rain water pipes used for roof area shall satisfy the following requirements :

Sl. No.	Pipe size dia, cm	Pipe area $\text{cm}^2$	Roof area $\text{M}^2$		Roof area/pipe area	
			Min.	Max.	Min.	Max.
1.	7.5	44.2	Upto	35	—	0.8
2.	10	78.5	36	63	0.39	0.8
3.	15	176.7	64	141	0.36	0.8
4.	20	314.2	142	251	0.45	0.8

2.2 The rain water pipes shall be fixed to the outside of the external walls of the buildings or in recesses or chases cut or fixed in such external wall or in such other manner as shown in drawings.

2.3 A rain water pipe conveying rainwater shall discharge directly or by means of a channel into or over an inlet to a surface drain or shall discharge freely in a compound, drained to surface drain but in no case shall it discharge directly into any sewer pipe or closed drain.

2.4 A rain water pipe shall not discharge into or connect with any soil pipes or its ventilating pipe or any waste pipe or its ventilating pipe nor shall it discharge into a sewer unless specifically permitted to do so by the written approval of Chief Engineer or in which case such discharge into a sewer shall be intercepted by means of gully trap.

2.5 The location, size and spacing of pipes shall be executed as per construction drawings. However if any deviations are felt necessary due to the site conditions the same shall be got approved by Chief Engineer.

### 3. Laying and Jointing :

#### 3.1 Laying and jointing cast iron rainwater pipes :

3.1.1 Rainwater pipes and fittings unless otherwise directed by the Engineer-in-Charge or drawing shall be fixed in vertical alignment. They shall be kept clear of any falling debris to avoid choking. All holes etc, made for fixing the pipes shall be made good to match the existing surfaces.

3.1.2 Pipes without ears shall be secured to the walls by means of brackets/heavy pattern MS or CI holder bat weighing 1½ to 2½ Kgs each according to the size of the pipe and hinged in two parts. The holder bat shall be solidly built or pinned into wall in CM 1:2. Pipes with ears shall be fixed 30 mm clear of walls with steel or iron barrel distance pieces or bobbins and stout galvanised iron nails to run 75 mm into wall, including necessary hardwood plugs.

3.1.3 Dimensions of holderbats : The dimensions of holder bats shall be as per the table - V given below.

**Table - V** - Dimensions of holderbats

Dimensions mm	Nominal size of Pipes, mm				
	50	75	100	125	150
A	75	100	125	150	180
B	100	125	150	180	205
C	140	165	190	220	245
D	60	70	90	105	115
E	30	30	40	40	40

#### 3.1.4 Jointing-cement joints :

3.1.4.1 Quality of cement to be used for jointing shall conform to IS:456-1978.

3.1.4.2 Making cement joints : The annular gap between the spigot and socket shall be first packed with strands of spun yarn to 1/3 depth. One piece of strand soaked in cement paste shall be wound round and packed with caulking tool and hammered. When more than one

single strand of yarning material is used it shall have an over lap at the top of not more than 5 cms. The packing of spun yarn to correct depth shall be got checked by the Engineer-in-Charge, with a wooden gauge before filling with cement mortar. The remaining 2/3rd depth of socket shall be packed with 1 : 1 cement mortar. Fine sieved sand free from stones and pebbles shall be used for jointing. The cement mortar shall be solidly rammed using caulking tool and hammer. The outer face of joint shall be finished smooth, with 45° slope using cement. Pipe laid with cement joints shall not be filled with water until lapse of twelve hours after leakage till after 36 hours have lapsed thereafter. The cement joints shall be cured with water after a period of 12 hours and curing of joints done for minimum 7 days by covering the joint with a thin gunny cloth and watering.

3.1.5 Details of tar felt flashing grating fixing gola and khurra details shall be done as described in the following clause-5.

### **3.2 Laying and jointing asbestos cement rain water pipes and fittings :**

Laying and jointing shall be done all as described in clause 3.1.1 to 3.1.4 of Specification for CI pipes except that holder bats shall weigh about 1 to 1½ kgs each. In AC pipes the arrangement of fixing pipes with ears is not applicable since AC pipes are not manufactured with ears. Fixing with holder bats only will be applicable.

### **4. Gradient to be given in Roof and Laying Weathering Course :**

4.1 Irrespective of top finish for weathering either tar felt treatment water proof plastering, burnt clay flat terracing tiles or Mangalore tiles the protection against water penetration for the roof finish is enhanced by efficient drainage of surface water which shall be ensured by Engineer-in-Charge by complying with the following guide lines.

4.2 The slope of the terrace with lime concrete and tile finish shall not be less than 1 : 60 and the slope in the case of plain lime concrete finish shall not be less than 1 : 50.

4.3 The detailed Specifications for laying weathering course with lime concrete, tile finish and tar felt laying in relevant civil work specifications shall be followed. But the following clauses shall be ensured by Engineer-in-Charge with reference to proper roof drainage.

4.3.1 The minimum compacted thickness of brick bat coba in lime at all places of roof shall be not less than 7.5 cms. In case the thickness is more than 10 cms each layer of brick bat coba shall not be more than 10 to 12.5 cms.

4.3.2 If the roof is flat the slope required for drainage in lime concrete layer shall be as per clause 4.2. But the minimum compacted thickness of the concrete layer shall nowhere be less than 7.5 cms.

4.3.3 The brick bat coba in lime layer shall be kept wet up to the time of laying the tiles.

4.3.4 RCC flat slabs shall be tested and accepted by Engineer-in-Charge before providing weather proof course in the following manner ; water shall be ponded to a depth of 75 mm to 150 mm for a period of three days over the slab and checked for any leakage and dampness below the slab. Leakages if any shall be attended and again the ponding of water repeated to check the water tightness of slab before passing for providing weather proof course. (ref. CE's circular No. CED/Q/18/243 dated 16-12-1975).

4.3.5 RCC flat slab shall be applied with bitumen 85/ 25 grade after testing as specified in clause 4.3.4 at the rate of 1.5 Kg/sq.m after cleaning the surface with wire brush etc.,

## 5. Tar Felt Flashing Grating fixing details, Gola details and Khurra details for Rainwater Pipes :

### 5.1 Specification for tar felt treatment at outlets of rainwater down take pipe :

#### 5.1.1 Preparation of surface :

The surfaces around the rain water outlet shall be cleaned with wire brushes, cotton or gunny cloth and properly dusted off all loose scales and shall be further cleaned with a piece of cloth, lightly soaked in kerosene oil over an area of 75 cm radius around the mouth of the rainwater down take pipe including grouting cracks if any with CM 1 : 4 slurry or blown type petroleum bitumen of IS grade 85/25. The roof surface shall be absolutely dry before felt treatment is begun.

5.1.2 **Treatment :** On the prepared roof surface as detailed above, one primer coat of approved bitumen primer. (SHALIKOT water bound emulsion or equivalent primer) has to be applied at 1.5 kgs/m<sup>2</sup>. The primer should be brought to site in its original packing and shall be opened and used in the presence of the Engineer-in-Charge has time to satisfy himself regarding the quality of bitumen primer actually used and given his permission to remove the same. (The above procedure shall be followed in case of hot bitumen 85/25 grade, specified for 1st and 3rd course of tar felt flashing detailed here below).

The tarfelt flashing treatment shall be four course treatment (excluding primer coat) consisting first and third layer of hot bitumen of IS grade 85/25 applied at 1.5 kg/m<sup>2</sup> of the area, applied uniformly over already laid primer coat, without leaving any blank patches using bitumen heated to working temperature of 180°C as specified in IS : 702, 2nd and 4th layer of self finished bitumen felt type 3, grade - 1, conforming to IS : 1322. Bitumen felts will be of size one meter square and shall be placed one above the other at an angle such that the edges make 45°/135° with each other. Care should be taken to see that bitumen binding materials is spread evenly below the triangular corners of the tarfelt at all round outer edges of the treated area. Each layer of self finished felt shall be cut radially as shown in the sketch for tucking inside the rainwater pipe for a depth of approximately 5 cms as shown in the fig.4.2. The cuts in each layer of the tarfelt shall be so adjusted such that the gaps inside the pipe after tucking to first layer are fully covered by the top layer tucking. The pouring of bitumen shall be so regulated that the correct quantity is spread uniformly over the surface. Excess bonding materials that gets squeezed out at the ends shall be levelled up. Each layer of the felt shall be a single piece and no jointing of felt shall be permitted. Each course of felt shall be firmly bonded with hot bitumen. Streaks and trailings of bitumen near edges of laps shall be levelled by heating the over lap with a blow lamp and levelling down unevenness. Care shall be taken to see that the felt beyond the periphery of the pipe is not damaged or cracked and will not have any curls. The overlaps 2nd and 4th course of felt shall be made perfectly and properly sealed with blow lamp as specified above not to admit/increase ingress of moisture. The entire treatment shall generally be attended as indicated in fig. 4.2 and conforming to IS : 1346 for tarfelt flashing (weather proof course of brick bat coba and clay tile laying etc., will be measured and paid separately) 200 mm square cast iron grating for 100 mm dia rainwater pipe and 250 mm square cast iron grating for 150 mm dia rainwater pipe will be fixed at the top of weather proof course. While finishing the weather proof course at the mouth of the rainwater pipe outlet, it shall be ensured that the brick bat coba at the entrance have been eased and rounded off properly with a coat of 12 mm thick CM 1 : 3 for easy flow of water into the rain water pipe.



#### **5.1.2.1 Measurement :**

The measurement for tarfelt flashing shall be for each number of flashing for 100 mm dia RWP and 150 mm dia RWP. The rate shall include all work and materials excluding CI grating and weather proof course which shall be measured under respective items.

#### **5.1.3 Detailed specifications for Gola at junction of weather proof course with parapet :**

##### **5.1.3.1 Preparation and work :**

A chase of 75 mm wide and 75 mm deep shall be cut in the parapet wall at the junction of weather proof concrete and parapet wall and it shall be filled with CC 1 : 2 : 4 with a slope of 1 : 0.75 and exposed surface of gola shall be plastered with CM 1 : 3 properly overlapping with the parapet plastering and weather proof course not less than 75 mm on both sides. The expansion joints at every 3.5 M to 4.5 M length of gola shall be provided and filled with bitumen filler. The bitumen filler shall be prepared by mixing bitumen and course sand in the ratio of 80 : 1 : 0.25 (80 kgs of hot bitumen : 1 kg of cement : 0.25 cum of course sand).

All work shall be executed as per **fig.no. 4.3.**

**5.1.3.2 Curing :** The finished work shall be cured for at least 7 days.

**5.1.3.3 Measurements :** The length of the finished gola shall be measured at its junction with the wall face correct to a cm. No deduction shall be made in measurement for gaps for water outlets.

**5.1.3.4 Rate :** The rates shall include labour and materials involved in the operations described above including bitumen filler in expansion joints. The rate includes all turning and roundings at all the corners and risers.

#### **5.1.4 Detailed specifications for Khurras sequence of work and material :**

**5.1.4.1** The Khurras shall be constructed before the brick masonry work in parapet wall is taken up and it shall be generally of size 45 cm x 45 cm size and shall be formed of cement concrete 1 : 2 : 4.

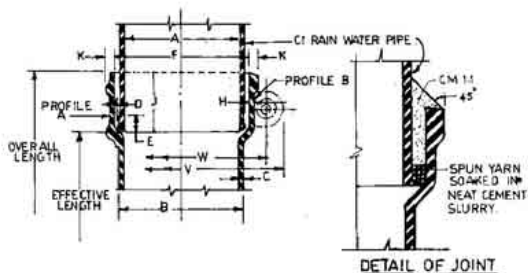
**5.1.4.2 Laying :** APVC sheet/tarfelt 1m x 1m shall be laid under the khurra using binding materials below and then cement concrete shall be laid over to a minimum thickness of 3 cm at the outlet and 4 cms at the other three edges, uniformly sloping towards the outlet point. The top surface shall be lower than the level of the adjoining finished roof surface by not less than 70 mm for easy flow of water from roof surface.

The concrete shall be laid to 60 cms x 53 cms size excluding parapet portion wall such that there will be an offset minimum 75 mm on all three sides for plaster for khurra. The top surface of the concrete shall be continued at the same slope throughout the width of the wall, into the outlet opening to ensure a water tight joint.

The khurra and the sides of the outlet shall then be rendered with 12 mm thick coat of cement plaster 1 : 3. This shall be done when the concrete is still wet and shall be finished with a floating coat of neat cement. The sides of the khurras and sides of the outlet opening shall be well rounded. The size of the finished outlet opening shall be 10 cms/15 cm wide by 20 cm high or as required for particular situation. Appropriate size of iron gratings shall be provided at the outlet as a safe guard against choking of rainwater down take pipes.

5.1.4.3 **Measurement:** Khurras shall be counted in number.

5.1.4.4 **Rate:** The rate for each completed khurra is inclusive of the cost of all materials and labour involved in forming the khurras and outlet opening as described above excluding iron grating.



DIMENSION		NOMINAL SIZE 'A'				
PIPE	EXTERNAL DIAMETER, B	50	75	100	125	150
	THICKNESS, C*	3.0	3.0	3.0	3.0	3.0
	PROJECTION OF SPIGOT BEAD, D	1.0	1.0	1.0	1.0	1.0
	WIDTH OF SPIGOT BEAD, E	2.0	2.0	2.0	2.0	2.0
	INTERNAL DIAMETER, F	63	88	114	139	167
SOCKET	THICKNESS MIN, H	4.0	4.0	4.0	4.0	4.0
	INTERNAL DEPTH, J	60	65	65	75	75
	THICKNESS OF BEADS, K	7	7	7	8	9
NOMINAL WEIGHT OF 1800mm PIPE WITHOUT EARS, kg		7.5	11.0	14.0	20.0	26.0
EARS	LENGTH OF FLANGE OVERALL, MN, V	130	162	190	216	254
	CENTRE TO CENTRE HOLE, W	98	130	159	184	216

NOTE • OPTIONAL FEATURES ARE

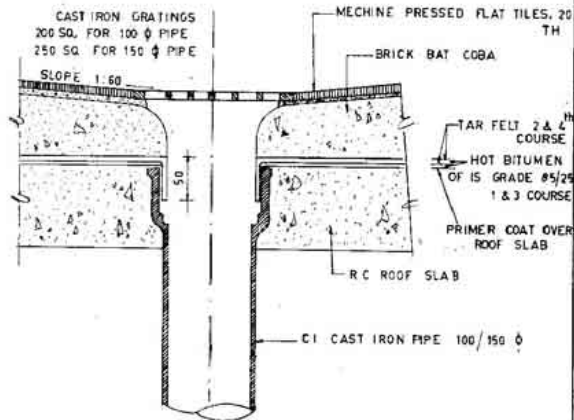
- ALTERNATE SOCKET PROFILE
- SPIGOT THICKENING ON 1800mm LENGTH.
- INTERNAL TAPER OF SOCKET

\* OPTIONAL

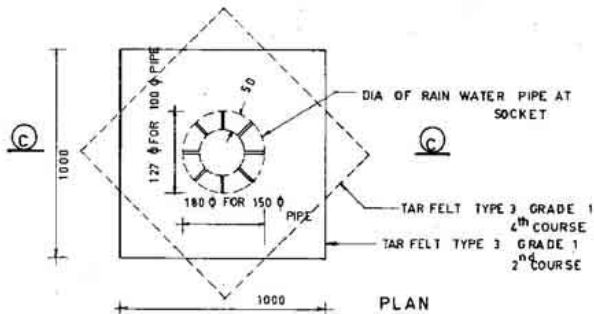
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## DIMENSIONS AND WEIGHT OF CI PIPES SOCKETS AND EARS.

DRAWN. <i>Shankar</i>	CHECKED • <i>P. S.</i> 20/1/85	RECOMM'D. <i>Shankar</i> 20/1/85 HEAD-PH	APPROVED • <i>M. S.</i> CHIEF ENGINEER	SCALE • NTS DATE • DEC 1984	FIG NO • CED:PH:4:1
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SECTION C-C



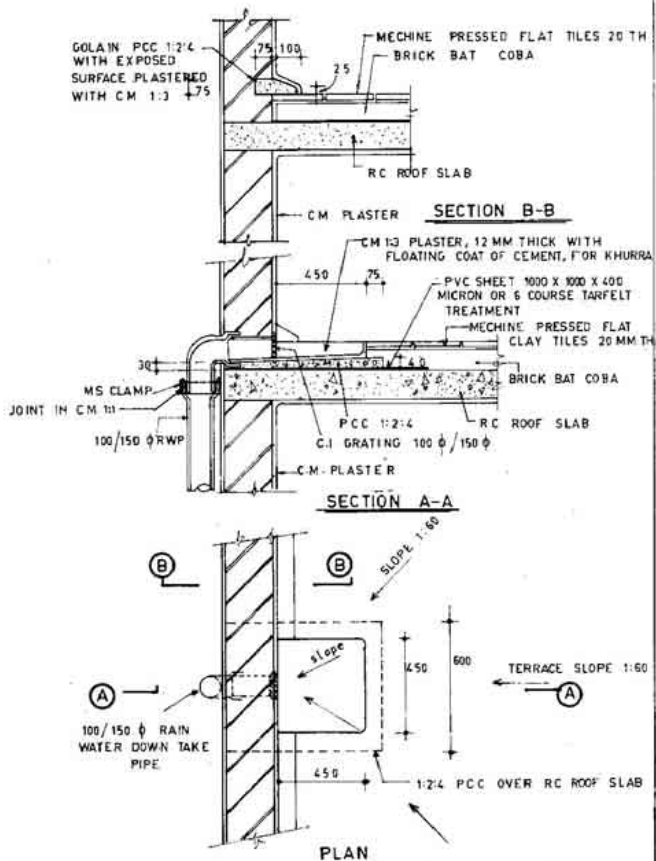
PLAN

TITLE:

TYPICAL DETAILS AT RAIN WATER OUTLETS / PURGOLA

DRAWN	CHECKED <i>R</i> 15/3/85	RECOMM D <i>Chaitanya</i> 30.14 HEAD PH	APPROVED <i>[Signature]</i> CHIEF ENGINEER	SCALE N.T.S	FIG NO. CED. PH.42
				DATE: MAR 85	

GOVERNMENT OF INDIA  
DEPARTMENT OF SPACE  
CIVIL ENGINEERING DIVISION.



TITLE TYPICAL DETAILS AT RAIN WATER OUTLETS / PURGOLA

DRAWN	CHECKED	RECOMMDD	APPROVED	SCALE	FIG NO
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**SECTION V**  
**SPECIFICATION FOR CASTIRON**  
**PRESSURE PIPES. (CI PIPES)**  
**LAYING, JOINTING AND TESTING.**

## SECTION – V

### SPECIFICATION FOR LAYING OF CAST IRON PIPES

#### SCOPE:

This specification covers the methods of laying cast iron pipes below ground level for water supply and drainage works. Specifications for laying cast iron pipes for fire fighting systems are furnished separately. The specifications includes (1) specification for pipes and fittings (2) earth work excavation and preparation of pipe trench (3) laying (4) jointing (5) provision of anchor and thrust blocks (6) hydraulic pressure testing of pipes (7) back filling the pipe trench (8) disinfection of mains before commissioning and (9) restoration of road surfaces.

#### 1. Specification of Pipes:

Cast iron pipes to be used on work shall conform to IS: 1536-1976 for centrifugally cast (Spun) iron pressure pipes and IS: 1537 - 1976 for vertically cast iron pressure pipes and cast iron fittings conforming to IS: 1538 - 1976. Centrifugally cast (Spun) iron pressure pipes of following classes are available upto 750 mm dia.

Sl. No.	Class of pipe.	Manufacturer's test pressure	Maximum test pressure after laying and jointing
1.	Class L A	3.5 N/mm <sup>2</sup> (35 kgf/cm <sup>2</sup> )	1.2 N/mm <sup>2</sup> (12 kgf/cm <sup>2</sup> )
2.	Class A	3.5 N/mm <sup>2</sup> (35 kgf/cm <sup>2</sup> )	1.8 N/mm <sup>2</sup> (18 kgf/cm <sup>2</sup> )
3.	Class B	3.5 N/mm <sup>2</sup> (35 kgf/cm <sup>2</sup> )	2.4 N/mm <sup>2</sup> (24 kgf/cm <sup>2</sup> )

1.1 Vertically cast iron pressure pipes of following classes are available upto 1500 mm dia conforming to IS: 1537 - 1976.

Class of pipe	Manufacturer's test pressure	Maximum test pressure after laying & jointing
1. Class-A upto 600 mm dia	2.0 N/mm <sup>2</sup> (20 kgf/cm <sup>2</sup> )	2/3rd of manufacturer's test pressure.
600 mm to 1000 mm	1.5 N/mm <sup>2</sup> (15 kgf/cm <sup>2</sup> )	
1000 mm to 1500 mm	1.0 N/mm <sup>2</sup> (10 kgf/cm <sup>2</sup> )	
2. Class-B upto 600 mm dia	2.5 N/mm <sup>2</sup> (25 kgf/cm <sup>2</sup> )	2/3rd of manufacturer's test pressure.
600 mm to 1000 mm	2.0 N/mm <sup>2</sup> (20 kgf/cm <sup>2</sup> )	
1000 mm to 1500 mm	1.5 N/mm <sup>2</sup> (15 kgf/cm <sup>2</sup> )	

1.2 Pipes of appropriate class shall be used on work depending on the maximum working pressure at field which will include static pressure or operating pressure whichever is maximum plus pressure due to water hammer.

1.3 Satisfactory quality of pipes and fittings may be found by checking thickness of pipe, standard weight of pipes and careful examination for absence of cracks, blowholes etc.

1.4 **CI fittings**: Cast iron fittings to be used on works shall conform to IS: 1538-1978.

1.5 **Hydrostatic Test Pressure for Fittings**:

Table-I - Hydrostatic Test Pressure for fittings:

Nominal Diameter	Test Pressure	
	Fittings without branches or with branches not greater than half the principal diameter N/mm <sup>2</sup> (kgf/cm <sup>2</sup> )	Fittings with branches greater than half the principal diameter N/mm <sup>2</sup> (kgf/cm <sup>2</sup> )
Upto and including 300 mm	2.5 (25)	2.5 (25)
Over 300 mm upto and including 600 mm	2.0 (20)	2.0 (20)
Over 600 mm upto and including 1500	1.5 (15)	1.0 (10)

**2. Earth Work Excavation & Preparation of Pipe Trench :**

2.1 **Alignment and Grade :**

The proposed alignment and grade of pipeline has to be marked at site as per construction drawing (but subject to such modifications as shall be ordered by the Engineer-in-Charge from time to time to meet the requirements of the works) with the help of sight rails made out of timber of ample size set at intervals of 15 Mtrs. and at all changes in levels and grades. Atleast four sight rails shall be maintained at site at approved levels and the excavation to required depth only carried out using boring rod and sight rails. Any extra depth excavated than required depth shall be filled in by cement concrete 1:4:8 at the cost of contractor.

2.2 When the pipeline is under a roadway, a minimum cover of 1.0 m is to be provided and for other places minimum cover shall be 900 mm. But it may be modified to suit local conditions as may be decided by the Engineer-in-Charge. The trench shall be provided with shoring by wooden planks and struts with timber scantlings wherever necessary to ensure safety of workmen and pedestrians.

The discharge of the trench dewatering pumps shall be conveyed either to drainage channels or to natural drains. The rate quoted by the contractor for excavation of trenches shall include the above.

2.3 **Width of Trench :**

(For water pipe laid at depth upto 1M)

Width of the trench at bottom between sides of trench shall be such as to provide not less than



20 cm clearance on either side of the pipe. Trenches shall be of such extra width, when required as will permit the convenient placing of timber supports shoring and shuttering.

#### **2.4 Excavation of Deep Trenches for Water/Sewer Lines :**

The following trench widths are proposed for deep trenches for water supply and sewerage works using CI pipes.

- a) Trenches upto depth of 90 cms, width of trenches = dia of pipe plus 40 cms, but minimum width to be 55 cms.
- b) Trenches of depth exceeding 90 cms, and upto 2 Mtr. width of trench = diameter of pipe plus 40 cms, but minimum width to be 75 cms.
- c) Trenches exceeding 2M depth :-

Width of trench shall be widened by allowing steps minimum of 50 cms, on either side after every 2M depth from the bottom, so as to give virtual side slopes of 1/4 to 1. Where soil is soft, loose or slushy, width of steps are to be suitably increased or the sides shored up as may be necessary to prevent collapse of sides of trench and as directed by the Engineer-in-Charge.

#### **2.5 Socket Pits or Joint Pits to be Excavated in the Trench Bottom :**

Additional 10 cm - 15 cm width shall be provided at positions of sockets and flanges to a length of 30 - 40 cm for jointing to be made properly. Depths of pits at such places shall be 15 cms - 30 cms from the bottom of trench to permit making of joints at the bottom side ; excavation of joint pits is necessary to ensure resting of pipe barrel evenly on the trench bed and to prevent resting of socket or flanges on trench bed. Figures 5.1 may be referred, **fig.5.1** also shows incorrect method of laying and jointing without excavating socket pits and jointing. In this method after the trench is refilled with earth there is likely hood of hollow space below the pipe and the pipe being subjected to bending due to weight of earth. Hence this kind of laying and jointing should not be done. **Fig.5.1** shows correct method of laying and jointing.

2.5.1 Before laying the pipe the bottom of the trench shall be properly trimmed off to present a plain surface and all irregularities shall be levelled. Where rock and large stones or boulders are encountered, the trench shall be trimmed to a depth of atleast 8 cm below the level at which the bottom of the barrel of the pipe is to be laid, and filled to a like depth with broken stone to pass through a sieve of 12.5 mm aperture size (see IS : 2405 -1963) and well rammed to form a fair and clean bed for pipes. Joint holes shall be excavated to such dimension which will allow the joints to be conveniently and thoroughly made and finished.

#### **2.6 Preparing Trench Bottom When Poor Soil/Unstable Soil is met with :**

Where the bottom of trench is found to consist of materials which is unstable to such a degree that it cannot be removed and replaced with an approved material thoroughly compacted in place to support the pipe properly a suitable foundation for the pipe with timber piles or other materials may be provided as directed by the Engineer - in - Charge. **Fig.5.3** shows arrangement of timber pile supports for CI pipes in sandy soil saturated with ground water.

2.7 The bottom and sides of excavation shall be trimmed to the required profile. The bottom shall be watered and thoroughly compacted using iron rammers.

2.8 All water which may get accumulated in the trench under excavation during the progress

of work, from whatever source shall be bailed or pumped out by the contractor. No separate charge shall be paid towards this account.

2.9 Shoring, strutting and timbering to excavation shall be provided, wherever required as may be necessary to protect life and property on the work. In cases of deep trenches, trenches having surcharge load due to adjoining structures, trenches having high seepage of water, continuous shoring and strutting may be provided as may be necessary to protect life of workmen and property.

2.10 The rates for excavation shall also include the following :

- i) Excavation in soil, murrum (soft or hard), sandy soil mixed with boulders, kanker, disintegrated rock and excavation of such other materials which are not classified as hard rock upto depths as specified. (Excavation in hard rock shall be measured and paid for separately).
- ii) Excavating trenches dressing sides and bottom.
- iii) Clearing away all shrubs, roots etc.,
- iv) Bailing, pumping out or otherwise removing cleaning of site from water which may accumulate in the excavation during the progress of work.
- v) Setting out the work profile etc.,
- vi) Timbering to excavations where required.
- vii) Removing surplus excavated materials to a lead specified and disposing off as directed by the Engineer-in-Charge.

2.11 Excavation shall always be done in open excavation, even if tunnelling is possible at certain portion unless otherwise ordered by the Engineer-in-Charge.

2.12 The excavated soil shall preferably be deposited on one side of the trench, leaving a bench of about 0.50 m to facilitate the workers to move along the trench without any difficulty.

2.13 In places having vehicular traffic the excavated soil shall be dumped on the traffic side for the protection of the traffic from accidents. The other side of the trench may be used for placing pipes and other accessories.

#### **2.14 Stacking of Surface Materials for Re-Use :**

All surface materials which in the opinion of the Engineer-in-Charge suitable for re-use in restoring the surface shall be stacked separate from the general excavated materials as directed by the Engineer-in-Charge.

#### **2.15 Stacking Excavated Materials :**

All excavated materials shall be stacked in such a manner that it will not endanger the work or workman or obstruct foot-paths, roads and drive-ways. Hydrants under pressure, surface boxes, or other utility controls shall be left unobstructed and accessible until the work is completed. Storm drains shall be kept free from excavated earth and natural water course shall not be obstructed, by the excavated earth.

#### **2.16 Provision of Barricades, Danger Lights and Safety Provisions :**

To protect persons from injury and to avoid damage to property adequate barricades, caution

boards, red lanterns and guards as required shall be placed and maintained during the progress of the construction work and until it is safe for traffic to use the roadway. All material piles, equipments and pipe which may serve as obstructions to traffic shall be enclosed by fences or barricades and shall be protected by proper lights when the visibility is poor. The rules and regulations of the local authorities in respect of safety provisions shall be observed.

#### **2.17 Maintenance of Traffic :**

The work shall be carried in such a manner not to cause any interruption to traffic, and the road/street may be closed in such a manner that it causes the least interruption to the traffic.

#### **2.18 Protection of Property and Surface Structures :**

No trees shrubbery, fences, poles and any other structures shall be removed unless their removal is shown specifically in the drawings or authorised by the Engineer-in-Charge when it is necessary to cut trees and tree branches, such cutting shall be done with the express permission and under the supervision and direction of the Engineer-in-Charge.

#### **2.19 Approval of Excavated Trench :**

The excavated trench shall be got inspected by the Engineer-in-Charge to check the correct grade, alignment, watering and compaction of trench bottom, preparation of trench with special foundation where necessary and on approval by the Engineer-in-Charge laying of pipe commenced.

#### **3. Laying :**

The contractors shall take delivery of the pipes and fittings from the departmental stores, if stipulated in schedule of quantity and schedule-A. for issue after fully satisfying himself as to the soundness and condition of the stores issued. The contractor shall be responsible thereafter for the safe custody of the pipes and specials till the pipe line is laid, back filled and handed over to the satisfaction of the Engineer-in-Charge. Surplus materials shall be returned to the stores of supply at contractor's expense.

#### **3.1 Responsibility for Damage to Materials :**

Any pipes or other articles which shall have been handed over to the contractor in good condition and which thereafter shall be damaged before or after being placed in the work and before being returned, to stores in case of surplus shall be paid for by the contractor at cost there of market rate plus 15 % in excess of such rate.

#### **3.2 Preventing Damages to Pipes and Fittings During Unloading :**

While unloading, pipes shall not be thrown down from the trucks on hard roads, unloading them on timber skids without a steady rope and thus allowing the pipes to bump hard against one another should not be allowed. In order to avoid damage to the pipes and specially to the spigot end, pipe should not be dragged along concrete and similar pavements with hard surfaces.

#### **3.3 Lowering of Pipes, Fittings and Valves into Trenches :**

Proper implements, tools and facilities satisfactory to the Engineer-in-Charge shall be provided and used for the safe and convenient execution of work. All pipes, fittings, valves and hydrants

shall be carefully lowered into the trench, piece by piece, by means of derrick ropes or other suitable tools or equipments, in such a manner not to cause any damage to the pipes and other materials and protective coatings and linings. Under no circumstances shall pipe materials be dropped or thrown into the trench. Pipes over 300 mm diameter shall be handled and lowered into trenches with the help of chain pulley blocks. Tripod supports used for this purpose shall be regularly checked to prevent all risks of accidents.

#### **3.4 Detection of Cracks in Pipes :**

The pipes and fittings shall be inspected for any visible cracks, blow holes and other defects. Pipes can be rung with a light hammer preferably while suspended to detect cracks. Cracks can be easily detected by smearing the outside with chalk dust. In doubtful cases presence of crack can be ensured by pouring a little kerosene on the inside of the pipe at the suspected spot; if a crack is present the kerosene seeps through and shows on the outer surface.

3.4.1 If a pipe is accidentally mis-handled it should be thoroughly inspected before laying and if used, be laid as the last pipe of test section where its removal, if necessary is neither expensive nor tedious.

#### **3.5 Cleaning Pipes and Fittings :**

All lumps, blisters and excess coating materials shall be removed from the socket and spigot end of each pipe and the outside of the spigot and the inside of the socket shall be wire-brushed and wiped clean and dry and free from oil and grease before the pipe is laid.

#### **3.6 Closing the Ends of Pipe to Prevent Entry of Foreign Materials while Laying Pipe :**

Every precaution shall be taken to prevent foreign materials from entering the pipe while it is being placed in the line. If the pipe laying team cannot put the pipe into the trench and in place without getting earth into it, the Engineer-in-Charge may require that before lowering the pipe into the trench, a heavy, tightly woven canvas bag of suitable size shall be placed over each end and left there until the connection is to be made to the adjacent pipe. During laying operations, no debris, tools, clothing or other materials shall be placed in the pipe. After laying and jointing of a reach is completed the two free ends shall be kept closed to prevent entry of foreign materials, rodents and other animals.

#### **3.7 Cutting of Pipe :**

The cutting of pipe for inserting valves, fittings or closure pieces shall be done in a neat and workman like manner without damage to the pipe so as to leave a smooth end at right angles to the axis of the pipe. For this purpose use of a pipe cutter is recommended. Pipe cutting machine is recommended for large pipes. When pipe cutting machine is not available for cutting pipes for large diameters, the electric arc cutting method may be permitted using a carbon or steel electrode. Only qualified and experienced workmen shall be employed on this work. When the pipe cutting machine is not available and the site conditions do not permit pipe cutting by machines, the pipe can be cut using chisel. The flame cutting of pipe by means of an oxy-acetylene torch shall not be allowed.

#### **3.8 Direction of Laying of Socket End :**

On level ground, the socket ends should face the upstream. When the line runs uphill the socket ends should face the upgrade.

3.9 The permitted tolerance for deflection may be as following:

For lead joints –  $2\frac{1}{2}^\circ$

For rubber joints – 80 mm to 300 mm –  $5^\circ$

For rubber joints – 350 mm to 400 mm –  $4^\circ$

For rubber joints – 450 mm to 750 mm –  $3^\circ$

### **3.10 Pipelines Crossing Railway Line, National Highways – Highways:**

The Engineer-in-Charge should consult the concerned department before preparing plans and specifications for this part of the work, and arrange to execute the work either by Railway/Highway department or under their supervision as specified by them.

### **3.11 Conditions Unsuitable for Laying of Pipe:**

No pipe shall be laid when, in the opinion of the Engineer-in-Charge trench conditions are unsuitable.

### **3.12 Casing Pipes:**

The water/sewer main or carrier pipe may be laid in a casing pipe when laid across corridors of buildings, important high ways/railways etc., to facilitate removal and replacement of pipe without resorting to excavation. The casing pipe should be 150 to 200 mm larger than the outside diameter of the cast iron pipe sockets to facilitate the carrier pipe to be pushed or pulled through the completed casing pipe. Spacers should be placed around the carrier pipe to ensure centering it within the casing pipe and to prevent damage during installation. Care must be exercised in order to avoid metal to metal contact. In order to avoid transfer of earth and live loads to the carrier pipe, the space between the carrier and casing pipe should be of sufficient structural strength to withstand live loads and dead loads.

### **3.13 Clearance to Existing Pipes, Cable etc:**

When crossing existing pipe lines, cables or other structures, alignment and grade shall be adjusted as necessary, with the approval of the Engineer-in-Charge to provide clearance as required by state or local regulations or as deemed necessary by the Engineer-in-Charge to prevent further damage or contamination of either structure.

## **4. Jointing:**

Jointing to socket and spigot pipes may be done with any one of the following methods.

1. Tyton joints with rubber ring joints.
2. Molten lead (under dry conditions) and lead wool joints.
3. Cement joints.
4. Flanged joints.

### **4.1 Tyton Joints:**

#### **4.1.1 Rubber Rings for Tyton Joints:**

The quality and composition of rubber ring to be used for tyton joints shall conform to IS:5382-1969.

#### 4.1.2 Making Tyton Joints :

Joint using rubber gasket for spigot and socket pipes shall only be adopted when pipes cast with spigot and socket of modified design suitable for the purpose. Spigot of pipes and portion of sockets engaging the bulb seating of rubber ring shall be scrubbed of all dirt, dust, loose scales, etc., and wiped clean. A thin film of any approved lubricant shall be applied to the bulb seating inside the socket. The rubber ring after wiping clean, shall be fixed and placed inside the socket with the bulb towards back of the socket, ensuring that the groove in the ring is located on the retaining head in the socket and retaining heel of the ring is firmly bedded in its seating. (Ref. fig. 5.5). The chamfered portion of the spigot and the inside surface of gasket shall be lightly smeared with a thin film of lubricant. Spigot of the pipe shall be aligned and carefully entered into the socket until it makes contact with the rubber ring and the joint assembly completed by forcing the spigot and past the rubber ring (which is thus compressed) until the spigot reaches bottom of the socket. If the spigot cannot be forced home with the use of reasonable force the spigot shall be removed and the rubber ring in position, examined for any bulges or displacement.

4.1.3 Forcing home the spigot shall be done by using appropriate tools and tackle suitable for the purpose.

4.1.4 Spigots, in pipes to be used when rubber joints are adopted, shall have chamfered ends ; When it is found necessary to cut a pipe on site, the cut end shall be chamfered carefully removing burrs and sharp edges before using.

#### 4.2 Molten Lead Joints :

Pig lead — pig lead for jointing purpose should conform to IS : 782—1978. Spun yarn used as jointing material shall be of sterilized quality. It shall have been exposed to vapours of 40 percent formaldehyde in air tight chamber for three hours before using it in water main.

##### 4.2.1 Making of Lead Joints :

The interior of socket and spigot end are cleaned with a brush. The spigot end is inserted into the socket till it touches the bottom of the socket. Strands of twisted spun yarn of suitable thickness shall be driven tightly in the annular gap between the socket and spigot till the spun yarn touches the bottom of socket with, suitable yarning tool. Bits of spun yarn less than one circumference of spigot end shall not be used. Yarn packing should result in ensuring annular gap of uniform thickness allround for pouring of lead to make the joints water tight. Clean hemp yarn shall be used (tarred hemp yarn shall be used only for sewerage works).

4.2.2 The approximate depth of yarn packing and lead caulking for different diameters of CI pipes are given below in **table-I**. Correct depth of yarn packing and thickness in each point has to be checked by means of a wooden gauge by inserting it around the annular gap (refer fig 5.2 wooden gauges with grooves to show the depth of yarn and lead caulking shall be prepared with reference to **table-I** for each diameter of pipe).

##### 4.2.3 Lead Wool Joints :

Joints are made with lead wool in place of molten lead when it is impracticable or dangerous to use molten lead for joints e.g. in cases such as inverted joints or in wet conditions or in exceptional cases. Lead wool joints may be done only with the approval of Engineer-in-Charge. Lead wool used shall have strings not less than 6 mm thick, and thoroughly caulked.

**Table-I**

Dia of pipe in mm	Total depth of socket mm	Depth of yarn caulking mm	Depth of lead caulking mm	Approx.Qty. of yarn jointing Kg/joint	Approx.Qty. of lead in Kg/joint
80	84	39	45	0.10	1.8
100	88	43	45	0.18	2.2
125	91	46	45	0.20	2.6
150	94	49	45	0.20	3.4
200	100	55	45	0.30	5.0
250	103	55	45	0.35	6.1
300	105	55	50	0.48	7.2
350	107	57	50	0.60	8.4
440	110	60	50	0.75	9.5

NOTE :  $\pm 20\%$  variation in quantities of lead and spun yarn stated above can be permitted for a single joint. Average consumption of lead per joint should be matching to the above standard with a tolerance of 5%. For overall reduction in quantity of lead used for a given number of joints from the above standard corresponding cost of lead shall be deducted from the bill of contractor. Quantity of lead used in work shall be weighed. Lead removed while caulking at the joint also be weighed and accounted for arriving at the net quantity of lead consumed for jointing.

Joints made with the lead wool shall comply with all the requirements specified for molten lead joints unless otherwise indicated, the quantity of lead wool and spun yarn for each joint shall be as under. (Use of less quantities of lead wool and spun yarn upto the extent of 5 percent may be allowed with proportional adjustment in rates).

**Table-II**

Nominal dia of pipes in mm	Lead wool required per joint in Kg.	Spun yarn requirement for joints in Kg.
80	0.85	0.10
100	0.95	0.15
150	1.60	0.25
250	3.05	0.55
300	3.80	0.70

#### 4.2.4 Heating and Pouring of Lead :

Lead shall be heated in a melting pot kept in easy reach of the joint to be poured so that the molten metal will not get chilled in being carried from the melting pot to the joint.

#### Preparation of Clay Mould for Pouring Lead Joint :

Mould for pouring lead joints shall be prepared using well kneaded clay, using a thick rope of size little larger than the annular groove. The rope is damped with water and watery clay and shall be wound around the edge of the spigot end snugly fitting around the annular gap in between spigot end and socket face and the clay is flashed around to form the mould. The way for pouring lead in the mould shall be formed by carefully with drawing the rope without dislodging the

clay mould. A pouring lip shall be formed in the clay mould for pouring the lead.

When the molten lead is stirred it will show a rapid change of colour. Before pouring, all scum shall be removed. Each joint shall be made with one continuous pour, filling the entire joint space with solid lead. After few minutes of cooling clay mould can be removed and the continuity of lead poured examined. Spongy or imperfectly filled joints shall be removed and repoured.

#### **4.3 Cement Joint:**

Cement joints are used for cast iron sewers under low pressure (upto 30 M head) whenever so specified. The quality of cement to be used for jointing shall conform to IS: 456-1978.

##### **4.3.1 Making Cement Joints:**

Cement jointing shall be done only if it is specifically provided for in the schedule of work or in drawing. The annular gap between the spigot and socket shall be first packed with strands of spun yarn (tarred spun yarn for sewers) to 1/3rd depth. One piece of strand soaked in cement paste shall be wound round and packed with caulking tool and hammer. When one single length of strand of spun yarn is not used suitable over laps of yarn shall be provided. The remaining 2/3rd depth of socket shall be packed with CM 1:1. Fine sieved sand free from stones and pebbles shall be used for jointing. The cement mortar shall be solidly rammed using caulking tool and hammer. The outer face of joint shall be finished smooth with 45° slope using cement. Pipe laid with cement joints shall not be filled with water until a lapse of twelve hours after the last joint. It shall not be subjected to hydrostatic pressure, inspected and tested for leakage till at least 36 hours have lapsed thereafter. Six or more lengths of pipe shall be laid in place, ahead of each joint before finishing the joint. The cement joints may be cured with water after a period of 12 hours and curing of joints done for minimum 7 days by covering the joint with a thin layer of earth and watering.

#### **4.4 Flanged Joints:**

Cast iron pipes may also be jointed by means of flanges cast on or with cast iron screwed flanges.

4.4.1 The joining materials used between flanges of pipes shall be compressed fibre board or rubber conforming to IS: 638-1979 of thickness between 1.5 mm to 3 mm. The fibre board shall be impregnated with chemically natural mineral oil and shall have a smooth and hard surface. Its weight per M<sup>2</sup> shall be not less than 112 g/mm thickness.

4.4.2 Each bolt should be tightened a little at a time taking care to tighten diametrically opposite bolts alternatively. The practice of fully tightening the bolts one after another is highly undesirable.

#### **5. Usage of Anchor and Thrust Blocks in Pipelines:**

Pressure mains need anchorages at dead ends and bends, as appreciable thrust occur which tend to cause 'Draw' and even complete 'Blow-out' of joints. Where the thrust is appreciable, concrete blocks should be installed at all points where movement may occur. To ensure anchorage, flanged pipes are preferred for over ground mains but socket and spigot pipes could also be used by external clamps. The anchor blocks/thrust blocks should be designed as per IS 5330-1969.

5.1 Suitable anchorages shall be provided to resist the tendency of the pipes to pull apart:



- a) At bends or other points of unbalanced pressure, or
- b) When they are laid on steep gradients and the resistance of their joints to longitudinal (shearing) stresses is either exceeded or inadequate. They are also used to restrain or direct and expansion and contraction of rigidly joined pipes under the influence of temperature changes. Provision of anchor blocks though not shown in drawings are to be provided as warranted due to site conditions at all salient places, as per directions of Engineer-in-Charge.

5.2 It is advisable to avoid sharp bends above 45° and in soft ground it is better not to put two bends together but to separate them by atleast a length of straight pipe. If the pressures are high enough to move it and sleeve joints are being used, the joints of the bends and on two pipes either side of them should be fully welded inside and outside, and the trench, refilled with concrete to 150 mm above these pipes and bends. Pipes laid on steep inclines should be anchored or transverse blocks or other precautions taken to prevent slippage and measures to overcome unbalanced pressure provided.

5.3 Spacing of Transverse anchors for steeply inclined pipelines:

Gradient	Spacing
1 in 2 and steeper	5.5 mts
below 1 in 2 to 1 in 4	11.0 mts
below 1 in 4 to 1 in 5	16.5 mts
below 1 in 5 to 1 in 6	22.0 mts
flatter than 1 in 6	Not usually required.

Anchor blocks to resist horizontal thrust, vertical thrust and gradient thrust for buried mains are illustrated in fig. 5.4. Wts. of such anchor blocks have to be worked out for the actual pressure head of water as per IS : 5330-1969.

## 6. Hydrostatic Testing of CI Pipes Laid and Jointed :

### Types of Tests :

After a new pipe has been laid and jointed it shall be subjected to the following pressure tests :

6.1 Pressure test at a pressure to be specified by the Engineer-in-Charge. Pipe and joints shall be absolutely water tight under the test.

6.1.1 Leakage test (to be conducted after the satisfactory completion of the pressure test) at a pressure to be specified by the Engineer-in-Charge for a duration of two hours.

6.2 Where any section of a main is provided with concrete thrust blocks or anchorage in accordance with para-5, the pressure test shall not be made until atleast five days have elapsed after the concrete was cast. If rapid hardening cement has been used in these blocks or anchorage, the test shall not be made until atleast two days have elapsed.

### 6.3 Partial Back-Filling of Pipe Trench Before Testing :

Before testing, the trench shall be partially back-filled except at the joints in accordance with provision of clause-7.

### 6.4 Procedure for Pressure Test :

Testing of pressure pipes - The field test pressure to be imposed should be not less than the greatest of the following :

- i) 1½ times the maximum sustained operating pressure.
- ii) 1½ times the maximum pipeline static pressure.
- iii) Sum of the maximum sustained operating pressure or the maximum pipeline static pressure and the maximum calculated surge pressure subject to a maximum equal to the works test pressure for any pipes and fittings incorporated in the pipeline.
- iv) The minimum test pressure in any case be not less than 10 kg/cm<sup>2</sup>.

6.5 If the pressure measurements are not made at the lowest point of the section, an allowance should be made for the static head between the lowest point, and the point of measurement to ensure, that the maximum pressure is not exceeded at the lowest point. If a drop in pressure occurs, the quantity of water added in order to re-establish the test pressure should be carefully measured. This should not exceed 0.1 litre per mm of pipe dia per km of pipe line per day for each 30 meters head of pressure applied. The field test pressure shall be conducted for the maximum pressure as stipulated in para 6.4 above for a duration of four hours.

#### **6.6 Pressurization :**

Each valved section of pipe shall be filled with water slowly and the specified test pressure, based on the elevation of lowest point of linear section under test and correct to the elevation of the test gauge, shall be applied by means of a pump connected to the pipe in a manner satisfactory to the Engineer-in-Charge.

#### **6.7 Examination Under Pressure :**

All exposed pipes, fittings, valves, hydrants and joints should be carefully examined during the open trench test. When the joints are made with lead, all such joints showing visible leaks shall be recaulked until tight. When the joints are made with cement and show seepage or slight leakage, such joints shall be cut out and replaced as directed by the Engineer-in-Charge. Any cracked or defective pipes, fittings, valves or hydrants discovered in consequence of this pressure test shall be removed and replaced by sound materials and the test shall be repeated until it is satisfactory to the Engineer-in-Charge.

The final pressure test duration shall be at least one hour. Examination under pressure and passing of the test shall be done by the Engineer-in-Charge for all tests and only when Engineer-in-Charge is not available by any other Engineer specifically authorised by the Engineer-in-Charge.

#### **6.8 Procedure for Leakage Test :**

A leakage test shall be conducted concurrently with the pressure test. Leakage is defined as the quantity of water to be supplied into the newly laid pipe, or any valved section thereof within 0.035 N/mm<sup>2</sup> or 0.35 kgf/cm<sup>2</sup>, of the specified leakage test pressure after the air in the pipeline has been expelled and the pipe has been filled with water (in case of test pressure 10 kgf/cm<sup>2</sup> the leakage test pressure will be 3.5 kgf/cm<sup>2</sup>).

6.9 No pipe installation shall be accepted until the leakage is less than the number of cm<sup>3</sup>/h as determined by the formula :

$$q_L = NP D/33$$

where  $q_L$  – the allowable leakage in cm<sup>3</sup>/h, N – number of joints in the length of the pipeline, D – Diameter in mm, and P – the average test pressure during the leakage test in kg/cm<sup>2</sup>.

#### **6.10 Variation from Permissible Leakage :**

Should any test of pipe laid disclose leakage greater than the specified in clause 6.9 the defective joints shall be repaired until the leakage is within the specified allowance.

#### **7. Back Filling of Trench :**

7.1 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, for the purpose of refill materials to be used.

ZONE 'A' - From the bottom of the trench to the level of the centre line of the pipe.

ZONE 'B' - From the level of the centre line of the pipe to a level 30 cm above the top of the pipe, and

ZONE 'C' - From a level 30 cm above the top of the pipe to the top of the trench.

#### **7.2 Back Fill Materials :**

All back fill materials shall be free from cinders, ashes, slag, refuse, rubbish, vegetable or organic materials, lumpy or frozen materials, boulders, rocks or stone or other material which in the opinion of the Engineer-in-Charge, is unsuitable or deleterious. Fine excavated earth which shall pass through a sieve of aperture size 20 mm can be used for filling in zones A and B. However, material containing stones upto 20 mm as their greatest dimension may be used in zone C only unless otherwise specified by the Engineer-in-Charge. Where excavated material is considered by the Engineer-in-Charge not suitable for back filling, clean river sand shall be used for the same.

#### **7.2.1 Back Fill Sand :**

River sand used for back fill shall be a natural sand complying with para 7.1 graded from fine to coarse. The total weight of clay in it shall not exceed 10 percent. All materials shall pass through a sieve of aperture size 20 mm (IS:2405 - 1980) and not more than 5 percent shall remain on IS sieve of aperture size 6.30 mm.

#### **7.3 Back-Fill Gravel :**

Gravel used for back fill shall be natural gravel, complying with para 7.2 and having durable particles graded from fine to coarse in a reasonably uniform combination with no boulders or stone larger than 50 mm in size. It shall not contain excessive amount of loam and clay and not more than 15 percent shall remain on a sieve of aperture size 75 micron.

7.4 Back filling in zone A shall be done by hand with fine excavated material or river sand, fine gravel or other approved materials placed in layers of 8 cm and compacted by tamping. The back filling material shall be deposited in the trench for its full width of each side of the pipe, fittings and appurtenances simultaneously.

7.5 Back filling in zone B using fine excavated material shall be done by hand or approved mechanical methods using the fine excavated material special care being taken to tamping and to avoid injuring or moving the pipe. If excavated material is not suitable the type of backfill material to be used and the method of placing and consolidating shall be prescribed by the Engineer-in-Charge to suit individual locations.

7.6 Back filling in zone C shall be done by hand or approved mechanical methods and well

compacted. Excavated earth having stones of size not exceeding 20 cm can be used for Zone C. If the excavated earth is unsuitable for back fill the filling material shall be specified by Engineer-in-Charge.

#### **7.7 Backfill with Excavated Materials :**

Where the excavation is made through permanent pavements, curbs, paved foot paths, or where such structures are undercut by the excavation, the entire back fill to the sub-grade of the structures shall be made with sand or cement concrete in accordance with para 7.2.1. The method of placing and consolidating the back fill material shall be prescribed by the Engineer-in-Charge.

#### **7.8 Concrete Slabs over Pipes :**

When pipes are laid under roads and pavements subjected to heavy traffic loads, the trenches may be covered with reinforced concrete slabs of suitable dimension, supported on edges to relieve the load on pipes to the adjoining earth.

### **8. Disinfection of Mains before Commissioning :**

#### **8.1 General :**

Pipe lines laid for transmission of water for drinking purposes shall be disinfected before commissioning.

#### **8.2 Initial Flushing :**

The main shall be flushed prior to disinfection. The flushing velocity shall be not less than 0.75 m/s. Care should be taken to prevent contamination entering the pipe line during laying operations.

#### **8.3 Chlorination :**

As a disinfectant, liquid chlorine should be used only when suitable equipment is available and only under the direct supervision of a person familiar with its use.

8.4 For out of way places and where equipment for injecting liquid chlorine is not available, the main may be disinfected by using chlorinated lime, calcium or sodium hypochlorite. A solution in which the concentration of chlorine is 50 mg should be prepared by mixing the chemical in water and then fed into the pipe line. Chlorine application shall continue until the entire section of the main to be treated is filled with chlorine solution. The chlorinated water shall be retained in the main for atleast 24 hours during which time all valves hydrants, etc., attached to the pipe line may be operated to disinfect the appurtenances. If at the end of 24 hours period the residual concentration of chlorine is less than 10 mg of chlorine, the operation shall be repeated.

#### **8.5 Final Flushing :**

After the retention period is over, the heavily chlorinated water shall be flushed from the main and clean water introduced until the chlorine concentration in the water leaving the main is not higher than the generally prevailing chlorine concentration in the system. Residual chlorine tests shall be carried out throughout the test period. The highly chlorinated water shall be discharged at such places and in such a manner as not to cause any damage to life and property on the down stream of the point of discharge.

### **8.6 Bacteriological Tests :**

After final flushing and before the water main is commissioned, samples shall be collected from the end of the pipe line and tested for bacteriological quality and shall ensure the absence of coliform organisms.

### **8.7 Communications :**

During all phases of cleaning, testing, disinfecting, flushing, and commissioning, reliable communication system between the field staff at both ends and in between the section of the pipe line being disinfected should be established. Highchlorinated water used for disinfection should be prevented from being supplied to any consumer and necessary precautions shall be taken in this regard.

### **9. Removal, Restoration of Paved Foot Paths and Roads after Laying of Pipe and Back Fillings of Trenches :**

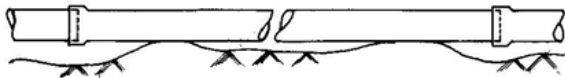
9.1 The width of pavements and road surfaces removed along the normal trench for the installation of the pipe shall not exceed the width of the trench specified by more than 15 cm on each side of the trench. The width and lengths of the area of pavement removed for the installation of gate valves, specials, manholes or other structure shall not exceed the maximum linear dimensions of such structures by more than 15 cms on each side. Wherever, in the opinion of the Engineer-in-Charge existing conditions make it necessary to remove additional pavement it shall be removed as directed by the Engineer-in-Charge.

### **9.2 Replacement of Pavement and Structures :**

All pavements, paved foot-paths, curbing, gutters, shrubbery, fences, polars or other property and surface structure removed, or disturbed as a part of the work shall be restored to a condition equal to that before the work began, furnishing all labour and materials incidental thereto. In restoring the pavements, sound granite blocks, sound brick or asphalt paving blocks as may be necessary as directed by Engineer-in-Charge, may be reused. No permanent pavement shall be restored unless and until, in the opinion of the Engineer-in-Charge, the condition of the back fill is such as to properly support the pavement.

### **9.3 Site Cleaning on Completion of Work :**

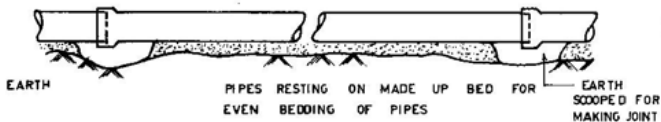
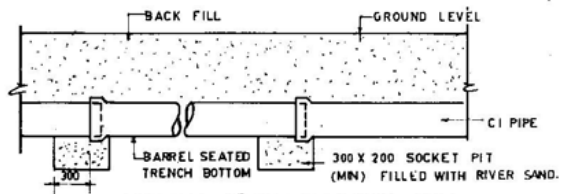
All surplus pipes and fittings, valves etc., and all tools and temporary structures shall be removed from the site as directed by the Engineer-in-Charge. All dirt rubbish and excess earth from the excavation shall be removed and transported and disposed at a suitable place as directed by Engineer-in-Charge and the construction site left clean to the satisfaction of the Engineer-in-Charge.



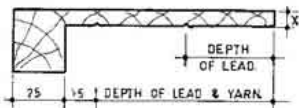
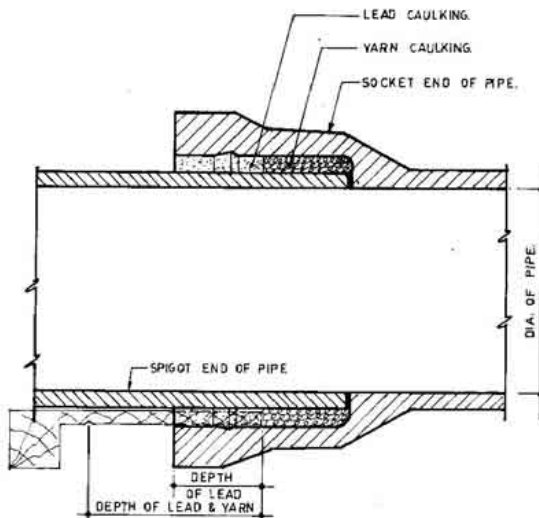
PIPES RESTING ON HUMPS IN BED

2A FAULTY LAYINGPIPES RESTING ON JOINTS OR ON  
EARTHEN MOUNDS2B FAULTY LAYING

SAND GRAVEL FILLING

PIPES RESTING ON MADE UP BED FOR  
EVEN BEDDING OF PIPESEARTH  
SCOOPED FOR  
MAKING JOINT2C CORRECT LAYINGCORRECT METHOD OF LAYING AND  
JOINTING OF C.I. PIPES
 TITLE  
 LAYING OF C I PRESSURE PIPES IN TRENCHES

DRAWN	CHECKED	RECOMMND	APPROVED	SCALE N T S. DATE	FIG NO.
	<i>P. S.</i> 2/6/85	<i>...</i> HEAD PH	<i>...</i> CHIEF ENGINEER		CED: PH: 5:1



WOODEN GAUGE TO SUIT ANNULAR  
GAP FOR CHECKING DEPTH OF  
YARN FILLING

## NOTE\*

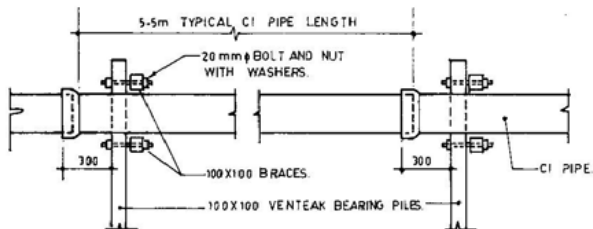
- \* TO CHECK DEPTH OF LEAD AND YARN PACKING DIMENSION 'X' TO SUIT EACH DIA. OF PIPE.

TITLE\*

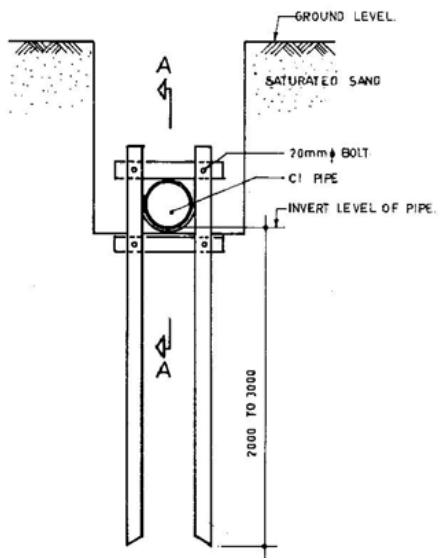
LEAD JOINT IN CAST IRON PIPE.

DRAWN* <i>Handwritten signature</i>	CHECKED* • <i>Handwritten signature</i> • 28/12/84	RECOMM* <i>Handwritten signature</i> 10.1.85 HEAD-PH	APPROVED* <i>Handwritten signature</i> CHIEF ENGINEER	SCALE* NTS DATE* OCT 1984	FIG NO* <b>FIG:PH:52</b>
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GOVERNMENT OF INDIA  
DEPARTMENT OF SPACE  
CIVIL ENGINEERING DIVISION



SECTION 'A-A'



TITLE\*

TIMBER PILE SUPPORTS FOR CI PIPES IN  
SANDY SOIL SATURATED WITH GROUND WATER.

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20/10/04

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CHIEF ENGINEER

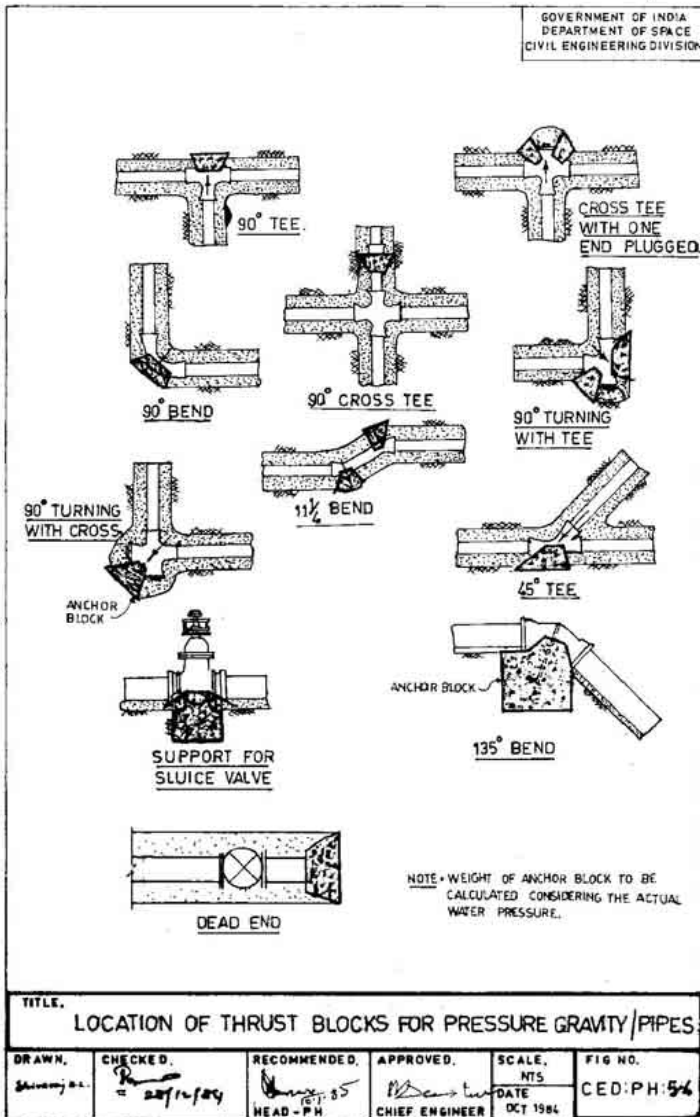
SCALE\*

DATE\*  
NOV 1984

FIG NO\*

FIG: PH:53





TITLE.

LOCATION OF THRUST BLOCKS FOR PRESSURE GRAVITY PIPES

DRAWN.	CHECKED.	RECOMMENDED.	APPROVED.	SCALE.	FIG NO.
Shivraj S.S.	R. S. S. S. S.	Head - PH	Chief Engineer	M/S DATE OCT 1984	CED:PH:54



1. CLEANING THE SOCKET



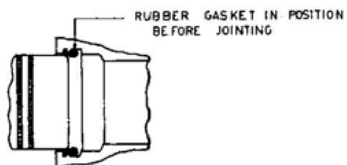
2. INSERTING THE GASKET



3. GASKET IN POSITION



4. GASKET COMPLETELY SEATED



5. SECTIONAL VIEW BEFORE COMPLETION OF JOINT

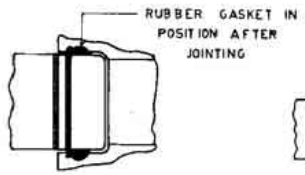


6. CROW - BAR METHOD FOR UPTO 200 MM (8")

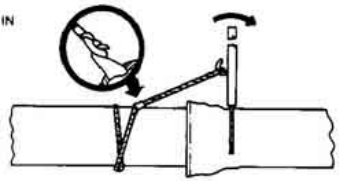
TITLE

DETAILS SHOWING TYTON JOINTING.

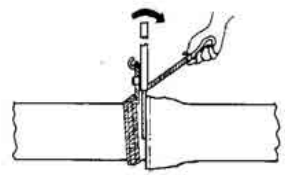
DRAWN	CHECKED  R 2/4/85	RECOMM D  HEAD PH	APPROVED  CHIEF ENGINEER	SCALE N T S	FIG NO.
				DATE MAR 85	CED. PH. 5-5



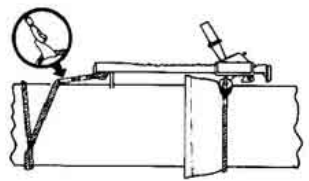
7. SECTIONAL VIEW AFTER  
COMPLETION OF JOINT



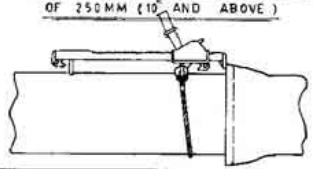
8. FORK TOOL METHOD FOR PIPE  
UPTO 200 MM (8")



9. FORK TOOL METHOD OF DISASSEMBLY



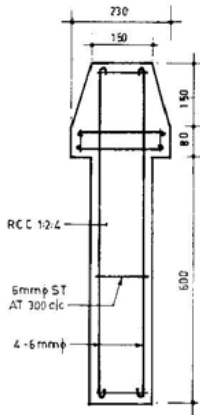
JACK METHOD OF ASSEMBLY FOR PIPES  
OF 250 MM (10" AND ABOVE)



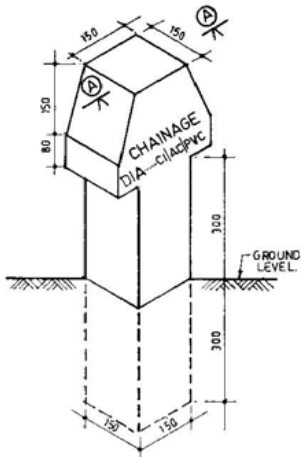
JACK METHOD OF  
DISASSEMBLY

TITLE  
DETAILS SHOWING TYTON JOINTING

DRAWN	CHECKED	RECOMM D	APPROVED	SCALE	FIG NO.
	<i>P</i>	<i>[Signature]</i>	<i>[Signature]</i>	N T S	CED.PH.5-5(a)
	2/4/85	HEAD PH	CHIEF ENGINEER	DATE MAR 85	



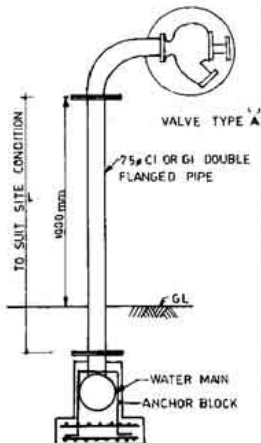
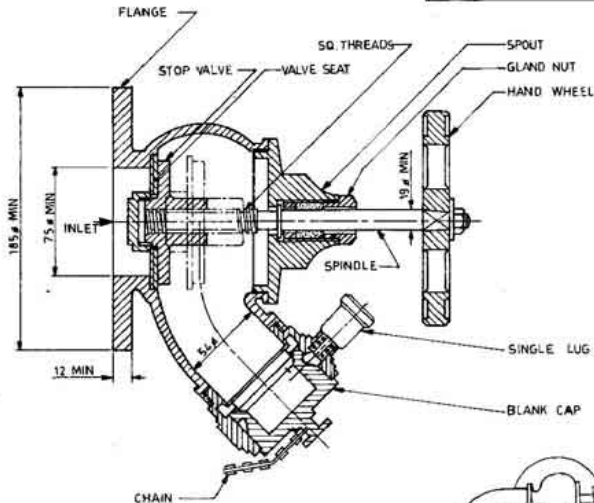
SECTION (A-A)



ISOMETRIC VIEW

TITLE • PIPE ALIGNMENT MARKER STONE-TYPICAL DETAIL.  
BLUE BACKGROUND WITH WHITE LETTERING.

DRAWN • <i>M. Srinivasulu Reddy</i>	CHECKED • <i>M. Srinivasulu Reddy</i> 22/12/84	RECOMM'D • <i>M. Srinivasulu Reddy</i> HEAD PH	APPROVED • <i>M. Srinivasulu Reddy</i> CHIEF ENGINEER	SCALE • NTS DATE • NOV 1984	FIG NO • FIG:PH:5.6
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**NOTE:**

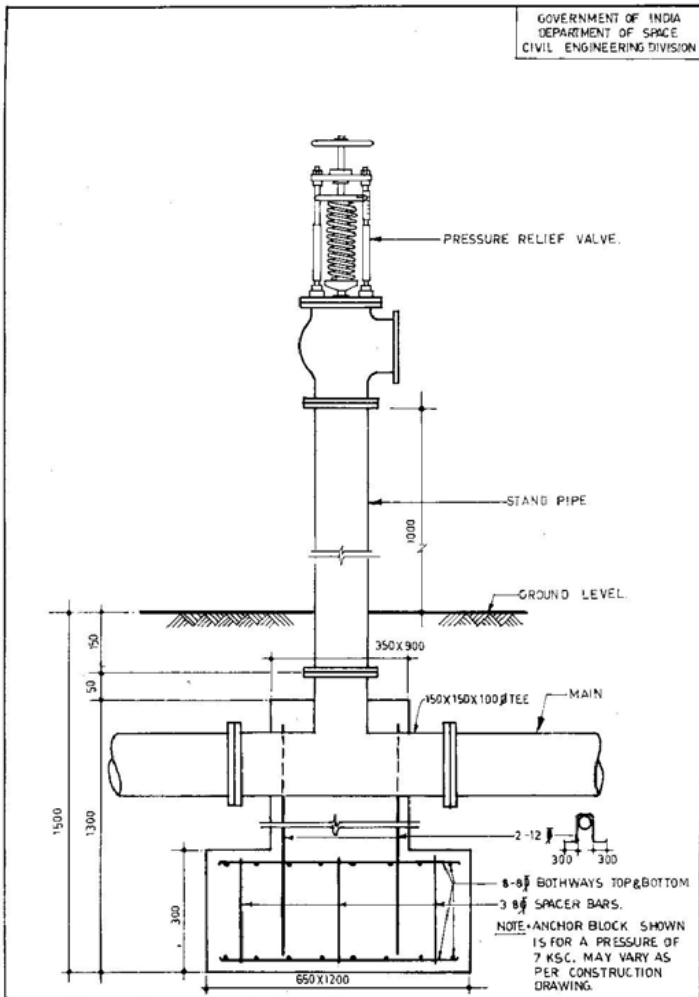
WHEN HYDRANT LANDING VALVE IS TO BE FIXED AT THE DEAD END OF PIPE LINE, DUCK FOOT BEND TO BE USED IN PLACE OF TEE, WHEN FH IS TO BE FIXED OVER THE FIRE FIGHTING MAIN ITSELF, TEE HAS TO BE USED AS SHOWN IN SKETCH.

\* AS PER IS 5290-1969.

**TITLE.****TYPICAL INSTALLATION OF FIRE HYDRANT LANDING VALVE TYPE-A**

DRAWN -	CHECKED -	RECOMM'D -	APPROVED -	SCALE -	FIG NO -
<i>H. S. Bhatnagar</i>	<i>[Signature]</i>	<i>[Signature]</i>	<i>[Signature]</i>	NTS	FIG-PH-57
		HEAD - PH	CHIEF ENGINEER	DATE, NOV 1984	

SECTION VI  
**SPECIFICATIONS FOR ASBESTOS CEMENT  
PRESSURE PIPES. (AC PRESSURE PIPES)  
LAYING, JOINTING AND TESTING.**



TITLE\*

### DETAIL OF FIXING PRESSURE RELIEF VALVE.

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*H. S. Bhatnagar*

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*P. S. 28/11/54*

RECOMM\*

*P. S. 28/11/54*  
HEAD-PH

APPROVED\*

*M. S. 28/11/54*  
CHIEF ENGINEER

SCALE\*

NIS  
DATE\*  
NOV 1984

FIG NO\*

FIG:PH:5-8

## SECTION – VI

### ASBESTOS CEMENT PRESSURE PIPES (AC PRESSURE PIPES)

#### 1. Supply of Pipes :

Asbestos Cement Pressure pipes shall conform to IS: 1592-1970.

#### Composition :

Asbestos cement pressure pipes and couplings shall be made from a thorough and homogeneous mixture of ordinary and rapid hardening portland cement conforming to IS: 269-1967, portland blast furnace slag cement conforming to IS: 455-1967 or portland-pozzolana cement conforming to IS: 1489-1967 and asbestos fibre. Addition of silica is also permissible.

#### Classification :

The pipes shall be classified with respect to the hydraulic test pressure and the hydraulic working pressure shall normally be not more than 50 percent of the pressure defining the class.

Table - 1

Class of Pipes	Hydraulic Test pressure as per manufacturer	Maximum Field Test Pressure	Max Working pressure
Class 5	5 kgf/cm <sup>2</sup>	3.75 kgf/cm <sup>2</sup>	2.5 kgf/cm <sup>2</sup>
Class 10	10 kgf/cm <sup>2</sup>	7.50 kgf/cm <sup>2</sup>	5.0 kgf/cm <sup>2</sup>
Class 15	15 kgf/cm <sup>2</sup>	11.25 kgf/cm <sup>2</sup>	7.5 kgf/cm <sup>2</sup>
Class 20	20 kgf/cm <sup>2</sup>	15.00 kgf/cm <sup>2</sup>	10.0 kgf/cm <sup>2</sup>
Class 25	25 kgf/cm <sup>2</sup>	18.75 kgf/cm <sup>2</sup>	12.5 kgf/cm <sup>2</sup>

1.1 The nominal length shall be 3 m or 4 m for pipes of nominal diameters of 100 mm or less and 4 m for pipes of nominal diameters greater than 100 mm.

1.2 Wall thickness of pipes shall be as per Table-2. IS: 1592-1970 for diameter 80 to 200 mm for classes 5, 10, 15 and for other classes and sizes are to be as per relevant IS specifications.

Table - 2

Dimensions of Asbestos Cement Pressure Pipes.

Sl. No.	Nominal Diameter (internal diameter) mm	Wall thickness in mm		
		Class 5	Class 10	Class 15
1.	80	9.75	9.75	9.75
2.	100	10.0	10.0	10.0
3.	125	10.0	10.0	11.0
4.	150	10.5	10.5	12.0
5.	200	10.5	12.5	15.5



1.3 Tolerance shall be as per IS :1592 -1970. All internal surface of the pipes should be regular and smooth, since the pipes are laid with water tight jointing rings, the rest of the pipes where the rings are located should satisfy the tolerance of the external diameter set out for length, appropriate to the type of joint adopted and should be free from any local irregularity which could affect the water tightness.

1.4 The shape of the finished ends should be as fixed by the manufacturer to suit the type of joint specified in the schedule.

1.5 Two types of joints are normally provided with asbestos cement pressure pipes and they are :

- a) Asbestos cement couplings with rubber sealing rings, and
- b) Cast iron detachable joints with rubber sealing rings and bolts and nuts.

1.6 Cast iron of the cast iron detachable joints shall conform to IS: 5531 -1979. The cast iron detachable joints shall be suitably protected by a bituminous coating.

1.7 Rubber rings used in jointing shall comply with the requirements of IS: 5382 -1969. The rubber shall be free from extractable substances which impart taste, smell or toxicity to water.

The rings shall be homogeneous, free from porosity, grit, excessive blooms, blisters or other visible surface imperfections. The fin or flash shall be reduced as much as possible and in any case the thickness of it shall not exceed 0.4 mm and the width 0.8 mm.

#### **1.7.1 Stretch test:**

Stretch gaskets till the circumference is increased by 50% then the surface shall be smooth, free from pitting cracks, blisters, air marks and any other imperfections.

Sealing rings shall not absorb more than 10% of water.

#### **1.7.2 Marking:**

Each sealing ring shall be marked indelibly with :

- a) Manufacturer's name or trade mark if any
- b) The month and year of manufacture,
- c) The type followed by a word such as GAS or WATER or SEWERS with ISI mark.

1.8 The assembled joints shall be flexible and capable of withstanding the specified hydraulic pressure of pipes on which they are to be used, when the pipes are set at the maximum permissible angular deviation indicated by the manufacturer/supplier of pipes.

1.9 All cast iron fittings/specials shall be plain ended conforming to the requirements of IS:5531-1969.

#### **1.10 Manufacturer's Certificate:**

The supplier/contractor shall satisfy himself that the pipes suitable to the types of jointing specified and conform to the requirements of IS :1592 and if required shall furnish a certificate to this effect to the Department/Engineer-in-Charge or his representative clearly stating the class of the pipe.

#### **1.11 Marking:**

The pipes shall be legibly and indelibly marked with the following information.

- manufacturer's name,
- trade mark if any,
- Date of manufacture,
- Nominal diameter and
- Class of pipe.

Each pipe may also be marked with ISI certification of pipe.

## **2. Receipt, Transport and Custody of Materials :**

The contractor shall take delivery of the pipes, specials, saddle pieces and detachable joints, couplings etc., from the departmental stores after fully satisfying himself as to the soundness and condition of the stores issued.

The contractor shall be responsible thereafter for the safe custody of the pipes and other materials till the pipe line is laid, tested back filled and handed over to the Engineer-in-Charge. Surplus materials if drawn by the contractor shall be returned in sound condition to the departmental stores at the expense of the contractor.

### **2.1 Responsibility and Damage to the Materials Issued :**

Any pipe or other articles, which shall have been handed over to the contractor in good condition and which thereafter shall be damaged before, when or after being placed in the work and before being returned to stores in case of surplus shall be paid for by the contractor at the departmental issue rate or market rate whichever is higher plus 15 % in excess of such rate.

### **2.2 Cleaning and Examining of Pipes and Materials at Site :**

Each pipe before lowering into the trench must be carefully examined for defects such as cracks, chipped ends, crushing of the sides etc., Defective pipes must be removed and placed away from trenches. The pipes to be laid in trench must be clean inside. After a day's laying work is completed, the ends of the pipe line must be closed so that no foreign materials can enter and no animals take refuge inside.

Different parts of the joints will have to be laid near the pipe ends and must also be checked and cleaned. The bolts and nuts of CI detachable joints should be loosened and then tightened by hand after cleaning them. Rubber rings must be kept in the shade till they are needed.

### **3. Storage of Pipes and Accessories at Site of Works :**

- a) To avoid any costly manipulation of handling, the pipes shall be unloaded where they are required, if the trenches are ready to receive them. Unloading (except where mechanical handling facility are available) - pipes weighing upto 60 kgs. shall be handled by two persons by hand-passing. Heavier pipes shall be unloaded from the lorry or wagon by holding them in loops, formed with ropes and sliding over planks shall not be steeper than 45°. The planks shall be sufficiently strong and two ropes shall be used to roll the pipes down the planks. The ropes should be tied on the side opposite the unloading. Only one pipe shall be unloaded at a time.
- b) The pipes shall not be thrown down from the carriers or be dragged or rolled along hard surfaces.

- c) The pipes shall be checked for any visible damage such as broken edges, cracking or spalling of pipe while unloading and shall be sorted out for reclamation. Any pipe which shows sufficient damage to preclude it from being used shall be discarded.

### **3.2 Storing :**

- a) Each stack shall contain only pipes of same class and size, with consignment or batch number marked on it with particulars of suppliers.
- b) Storage shall be done on firm level and clean ground and wedges shall be provided at the bottom layer to keep the stack stable.
- c) The stack shall be in pyramid shape or the pipes laid lengthwise and crosswise in alternate layers. The pyramid stack is advisable in smaller diameter pipes for converting space in storing them. The height of the stack shall not be more than 1.5 m.
- d) Cast iron detachable joints and fittings shall be stacked under cover and separated from the asbestos cement pipes and fittings.
- e) Rubber rings shall be kept clean, free from grease, oil, heat and light.

### **3.3 Cutting of Pipes :**

- a) Cutting of pipes may be necessary when pipes are to be laid in lengths shorter than the standard lengths supplied such as while salvaging the pipes with damaged ends or while replacing cast iron accessories like tees, bends, etc., at required positions in the pipelines. In such cases it may also be necessary to reduce the cut ends of rasps to suit the inner diameter of central collar. The cutting of pipes shall be done as detailed in para (b) below.
- b) A line shall be marked around the pipe with a chalk piece at the point where the cut is required to be made. The line shall be so marked that the cut is truly at right angle to the longitudinal axis of the pipe. The pipe shall be properly held on two parallel rafters nailed to cross beams, taking care that the portion to be cut does not overhang and the cut mark is in between the two rafters. The pipe shall be neatly cut at the chalk mark with carpenter's new saw or hack-saw having a long blade, by slowly rotating the pipe around its longitudinal axis so as to have the uncut portion on top for cutting. Cutting of the pipe at the overhang should be avoided as it is dangerous as an overhanging end is liable to tear off due to its weight before the cut is completed.

### **4. Earth Work Excavation of Trenches for Laying Pipes :**

- a) The trenches shall be so dug that the pipes can be laid to the required alignment level and at required depth.
- b) Width - The width of the trench above pipe level shall be as small as possible but shall provide sufficient working space necessary for jointing the pipes. The trench width shall be such as to provide a space of 300 mm on either side of the pipe.
- c) Depth - The pipes shall have a minimum soil cover of 750 mm when laid under foot paths and side walks, 900 mm when laid under roads with light traffic or under cultivated soils and 1.25 m when laid under roads with heavy traffic. When the soil has a poor bearing capacity and is subject to heavy traffic, the pipe shall be laid on a concrete cradle. An extra trench depth of 100 mm shall be provided for each jointing pit. Cover shall be measured from top of pipe to the surface of the natural ground.

- d) The excavation of the trenches shall be so carried out that the digging of the trenches does not get far ahead (not more than 200 m) of the laying operations. By doing this, the risk of falling of sides and flooding of trenches can be avoided.
- e) If the trench bottom is extremely hard or rocky or loose stony soil, the trench should be excavated at least 150 mm below the trench grade. Rocks, stone or other hard substances from the bottom of the trench shall be removed and the trench brought back to the required grade by filling with selected fine earth or sand (or fine murrum if fine soil or sand is not available locally) and compacted so as to provide a smooth bedding for the pipe. Where excavation requires blasting operation it shall be ensured that no pipes have been stacked in the vicinity or completed pipe line in the vicinity have already been covered before starting of blasting operation; this is necessary to prevent damage to the exposed pipes in the vicinity by falling stones as a result of blasting.
- f) Roots of trees within a distance of about 0.5 m from the side of the pipeline shall be removed or killed.
- g) Paragraphs 2.3, 2.4, 2.5, 2.6, 2.7, 2.8, 2.9, 2.10, 2.11, 2.12, 2.13, 2.14, 2.15, 2.16, 2.17, 2.18. under earth work excavation and preparation of trenches of specifications for laying cast iron pipes shall be complied with.
- h) The bed of the trench shall be excavated to the pipe grades so that uniform support is assured for the full length of the pipe and to ensure the same joint pits may be excavated of suitable dimensions (50 cm long x 30 cm depth).

#### **5. Laying:**

- a) The pipes shall be lowered into the trenches either by hand passing or by means of two ropes. One end of each rope shall be tied to a wooden or steel peg driven into the ground and the other end shall be held by men which when slowly released will lower the pipe into the trench.
- b) The pipes shall rest continuously on the bottom of the trench. The pipes shall not rest on lumps of earth or on the joints. Four metre long wooden templates may be used to check the level of the bed. Clearance of approximately 100 mm in depth and width equal to length of the collar plus 30 mm on both sides shall be provided at the joint which shall be refilled from sides after the joint is made using fine excavated earth or fine sand.
- c) In unsuitable soil/soils, such as soft soils and dry lumpy soils it shall be checked whether the soils can support the pipelines and if required suitable foundation shall be provided.
- d) Some clay soils (for example black cotton soil) are drastically affected by extremes of saturation and dryness. In changing from totally saturated to a completely dry condition, these soils are subjected to extraordinary shrinkage. This shrinkage is usually seen in the form of wide and deep cracks in the earth surface and may result in damages to underground structures, including pipe materials. The clay forms a tight gripping bond with the pipe, subjecting it to excessive stresses as the clay shrinks. In such areas, the Engineer-in-Charge should establish whether the condition exists to a degree justifying special precautions. It is recommended that in such cases an envelope of a minimum 100 mm of tamped sand shall be made around the pipe line to avoid any bonding.

- e) In places where rock is encountered, cushion of fine earth or sand shall be provided for a depth of 150 mm by excavating extra depth of the trench, if necessary, and the pipes laid over the cushion. Where the gradient of the bed slopes is more than 30° it may be necessary to anchor a few pipes against their sliding downwards.

#### **6. Jointing :**

- a) Before commencing joints, the pipes shall be cleaned ; the joints and the ends of the pipe shall be cleaned, preferably with a hard wire brush to remove loose particles.
- b) Cast Iron Detachable joints - The joints shall consist of a central collar, two rubber rings, two flanges of cast iron and the required number of bolts and nuts.

One flange and rubber ring shall be placed on end of the pipe already laid, and the other flange, ring and central collar shall be slipped on to the pipe to be assembled.

The rubber ring shall be kept positioned at half the collar width less 2.5 mm from the end of the pipe already laid. A site gauge is to be used for convenience of making correct placement of rubber ring.

The other pipe shall be brought nearer leaving a gap of 5 mm between the two pipe ends. This gap will facilitate manoeuvring of deflection at joints after assembly and will take care of an expansion in the pipeline.

The collar shall be slid to sit square around the rubber ring on pipe 1 and then the rubber ring shall be rolled on pipe 2 to sit around the collar.

The flanges shall be moved on both ends to enclose rubber rings. The fastening bolts shall be inserted through the holes of the flanges and the bolts shall be tightened alternatively and evenly for proper sitting of the joint.

#### **c) Asbestos Cement Coupling (Hydrotite Joint) :**

This joint shall consist of three rubber rings and an asbestos cement coupling machine on the inside.

The rubber rings shall be sealed in their respective grooves, after cleaning the coupling and rubber rings. The machined ends of the pipe and end rings in the coupling shall be suitably lubricated with a soft soap solution or other lubricant which is not detrimental to rubber rings or drinking water. Then the assembly shall be made by pushing with a crow-bar or using a pipe puller.

The joints shall be made by keeping the pipes in one line. Any permissible deflection at the joint shall be made after completion of the joint only. The amount of deflection and the radius of curvature by successive deflection shall be as given in Table.

Wherever necessary change over from cast iron pipe to asbestos cement pipes and vice versa shall be done with the help of suitable adaptors.

#### **7. Thrust Blocks :**

- a) Thrust blocks are required to transfer the resulting hydraulic thrust from the fitting or pipe on to a larger load bearing soil section.
- b) Thrust blocks shall be installed whenever there is a change in the direction of the pipeline, size of the pipeline or when the pipelines end at a dead end. If necessary thrust blocks may

Table - 2  
Deflection and Radius of Curvature

Angle of Deflection	Displacement D in mm for Pipe Length				Radius R of Curvature for Pipe Length			
	1 m	2 m	3 m	4 m	1 m	2 m	3 m	4 m
1°	20	35	50	70	60	120	180	240
2°	35	70	100	135	30	60	90	120
3°	50	100	150	200	20	40	60	60
4°	70	135	200	270	15	30	45	60
5°	85	170	250	335	12	24	36	48

be constructed at valves also. Thrust blocks shall be constructed taking into account the pipe size, water pressure, type of fitting, gravity component, when laid on slopes and the type of soil. The location of thrust blocks for various types of fittings is given in **fig.5.4**, under C.I. Pipes.

When a fitting is used to make a vertical bend, it shall be anchored to a concrete thrust block designed to have enough weight to resist the upward and outward thrust. Similarly at joints, deflected in vertical plane, it shall be ensured that the weight of the pipe, the water in the pipe and the weight of the soil over the pipe provide resistance to upward movement. If it is not enough, ballast or concrete shall be placed around the pipe in sufficient weight to counteract the thrust.

When the line is under pressure there is an outward thrust at each coupling. Good soil, properly tamped is usually sufficient to hold pipe from lateral movement. However, if soft soil conditions are encountered, it is necessary to provide side thrust blocks or other means of anchoring. In such cases only the pipe on each side of the deflected coupling shall be anchored without restricting the coupling.

Pipes on slopes need to be anchored when there is a possibility of the backfill around the pipe sloping down the hill and carrying the pipe with it. Generally for slopes upto 30° good well drained soil, carefully tamped in layers of 100 mm under and over the pipe, right up to the top of the trench will not require anchoring.

For steeper slopes, one out of every three pipes shall be held by straps fastened to vertical supports anchored in concrete as in **fig.5.4**

### 8. Special Cast Iron Fitting and Accessories :

Normally when pipeline is laid, a certain number of cast iron fittings such as tees, bends, reducers etc. and special fittings such as air or sluice valves are required.

**Laying of Fittings** - All cast iron fittings shall be plain ended to suit the outside diameter of asbestos cement pressure pipes and to the class and diameter of pipe being used in the work. When using such cast iron fittings, they are jointed by cast iron detachable joints: for any cast iron specials having flanges, they are jointed in the pipelines with cast iron flanged adaptors having one end flanged and the other plain ended.

**Anchorage** - It should particularly be noted that the cast iron joints do not hold pipe ends or within it firmly. During working or test pressure, there will be the tendency for the pipe ends or

special ends to slip out of the joint, more so with the case of blank end cap used for closure of pipelines bends and tees. In order to keep them firmly in the pipeline, anchoring of these specials are necessary against the direction of thrust.

#### 9. Service Connections :

- a) When the pipe is used in distribution system, house service connections shall be provided through a saddle piece.
- b) The saddle piece consists of two straps which envelopes the portion of pipe from where connection is to be given. The hole of required size shall be drilled through the pipe and the boss provided in the top strap. Ferrule piece shall be connected after making threads in the boss and pipe. Suitable rubber packing shall be used between the straps and the pipe to provide cushioning as well as sealing against leakages.
- c) The size of the hole drilled in the pipe shall be limited as given below :

Max. size of drilled hole, in mm	Pipe size, in mm
20	80 and 100
25	125 and 150
35	200
50	250 and above.

#### 10. Testing :

- a) It is recommended to test the portions of the line by subjecting to pressure test as per para 10(c) as the laying progress before the entire line is completed. In this way any error of workmanship will be found immediately and can be corrected at a minimum cost.
- b) Usually the length of the section to be tested shall not exceed 500 m.
- c) The purpose of field testing is to check the quality of workmanship and also to check whether the pipes have been damaged in transit and laying. However, it may be noted that the test pressure during the field test shall not exceed the values given in Table - 3.

Table-3  
Test Pressure for Pipes

Class of pipe	Max. field test pressure kg/cm <sup>2</sup>
5	3.7
10	7.5
15	11.5
20	15.0
25	18.5

- d) Prior to testing, enough back fill as described in para 11 shall be placed over the pipeline to resist upward thrust. All thrust blocks forming part of the finished line shall have been sufficiently cured and no temporary bracing shall be used.

- e) The open end of the section can be sealed temporarily with an end cap having an outlet, which can serve as an air relief vent or for filling the line, as may be required.
- f) The blind face of the end cap shall be properly braced during testing by screw jacks and wooden planks or steep plate.
- g) The section of the line to be tested shall be filled with water manually or by a low pressure pump. Air shall be vented from all high spots in the pipeline before making the pressure strength test because entrapped air gets compressed and causes difficulty in raising the required pressure for the pressure strength test.
- h) Asbestos cement pipes always absorb a certain amount of water. Therefore, after the line is filled, it should be allowed to stand for 24 hours before pressure testing and the line shall be again filled.
- i) The test pressure shall be gradually raised at the rate of approximately one kg/cm<sup>2</sup>/minute.
- j) The duration of the test period shall be 4 hours to make a careful check on the pipeline section.
- k) Examination before pressure shall be done as per specification in para 6.7 specified under specifications for laying of cast iron pipes.

**11. Back filling of trench :** Back filling shall be done in accordance with para 7 of specification for laying cast iron pipes.

**12. Disinfection of Pipelines before Commissioning :**

12.1 Pipe lines carrying water for drinking purposes shall be disinfected before commissioning as per clause 8 vide paragraphs 8 to 8.7 of specification for laying cast iron pipes which shall be complied with.

13. For removal, restoration and maintenance of paved foot paths etc., after laying of pipe and back filling of trenches, paragraph 9 of the specification for laying cast iron pipes shall be complied with.



SECTION VII  
**SPECIFICATIONS FOR POLYVINYL  
CHLORIDE PIPES (PVC PIPES)  
LAYING, JOINTING AND TESTING.**

## SECTION – VII

### POLYVINYL CHLORIDE PIPES (PVC PIPES):

#### Scope:

This specification covers the methods of laying rigid PVC pipes below ground level for water supply and effluent pumping mains. The specification includes:

- 1) General application of PVC pipes,
- 2) Specification of pipes and fittings,
- 3) Earth work excavation and preparation of pipe trenches,
- 4) Storage and handling,
- 5) Installation and jointing,
- 6) Testing,
- 7) Back filling and restoration of old surfaces and
- 8) Disinfection of mains.

#### 1. General Applications of PVC Pipes:

Rigid PVC pipes are suitable for conveying water and effluents and have certain advantages over metal pipes, such as the resistance to corrosion, light weight, toughness, ease of joining, laying and flexibility. Suitability to convey each effluent has to be checked for each effluent.

#### 2. Specifications of Pipes:

##### 2.1 Classification of Pipes:

The rigid PVC pipes are available for the following maximum working pressures:

2.5, 4, 6 and 10 kgs/cm<sup>2</sup>.

##### 2.2 Visual Appearance:

The appearance of pipes shall be reasonably round. The internal and external surface of the pipe shall be smooth and clean, reasonably free from groovings and any other moulding defects. The end shall be cleanly cut and square with the axis of the pipe. The mechanical properties of PVC pipes shall conform to IS:4985-1968.

2.3 PVC pipes of different classes shall conform to the following dimensions and tolerances as given in Table-I.

##### 2.4 ISI Marking:

2.4.1 All pipes shall be indelibly marked at intervals of not more than 3 metres to show the following details:

- a) The manufacturer's name or trade-mark,
- b) The outside diameter and
- c) Maximum working pressure.

2.5 Each pipe shall also be marked with the ISI Certification Mark.

2.6 The pipe shall also be marked in colour as indicated below for different classes of pipes:

Class of Pipe	Colour
2.5 kgs/cm <sup>2</sup>	Red
4.0 kgs/cm <sup>2</sup>	Blue
6.0 kgs/cm <sup>2</sup>	Green
10.0 kgs/cm <sup>2</sup>	Brown

### 3. Earth Work Excavation :

#### 3.1 Pipe Trench Width & Depth :

Since pipes may be joined at the trench side and then lowered gently into the trench using guide ropes, the trench width can be narrower than for CI pipes and shall be of 300 mm over the diameter of the pipe. The depth of trenches can be normally a minimum of 0.75 m. In areas subject to extremely low winter temperature the depth of the trench should be atleast 0.3 metres below the minimum frost line.

3.2 Paragraphs 2.3.2, 2.7, 2.9, 2.11, 2.12, 2.13, 2.14, 2.15, 2.16, 3.1.1, 3.8, 3.11, 3.12, 3.13 under specifications for earth work for CI pipes shall also apply to trench excavation of PVC pipes. Pipe line alignment should be marked and cleared by Engineer-in-Charge before starting of excavation.

#### 3.3 Road Crossing :

Pipe casing for road crossing shall be carried out as described in paragraph 7.8 for specifications of CI pipes.

### 4. Storage and Handling :

4.1 The pipe shall be given adequate support at all times. Pipes shall be stored in a reasonably flat surface free from stones and sharp projections so that the pipe is supported throughout its length by the trench bed. In storage pipe racks shall be avoided. Pipes shall not be stacked in large piles, especially under warm temperature conditions as the bottom pipes may distort, thus giving rise to difficulty in jointing. Socket and spigoted pipes should be stacked in layers with sockets placed at alternate ends of the stacks to avoid lop sided stacks.

4.2 Pipes shall not be stored inside another pipe.

4.3 On no account shall pipes be stored in a stressed or bent conditions or near the sources of heat.

4.4 Pipes shall not be stacked more than 1.5 m high and pipes of different sizes and classes shall be stacked separately.

4.5 The ends of the pipe should be protected from abrasion particularly those specially prepared for jointing either by spigot or socket solvent welded joints or shouldered for use with couplings.

4.6 In tropical conditions pipes shall be stored in shade. In very cold weather, the impact strength of PVC is reduced making it brittle and more care in handling shall be exercised in winter conditions.

4.7 If due to unsatisfactory storage or handling a pipe becomes kinked, the damaged portion should be cut out completely. Kinking is likely to occur only on very thin walled pipes.

## **5. Installation :**

5.1 Plastic pipes in general need not be painted. Painting may disguise its character. Hazard might occur by mistaking this for metal pipe in using it for load bearing support, or for electrical grounding. Also use of certain paints can cause damage to PVC pipe.

5.2 Plastic pipes shall not be installed near hot water pipes or near any other heat sources.

### **5.3 Anchorage :**

5.3.1 Suitable anchor blocks as detailed in para 5 for specification for laying of cast iron pipes should be provided at all changes in direction of the pipe line and wherever else required to withstand thrust resulting from the internal water pressure at blank ends. Valves and hydrant tees should be supported in such a manner that the torque applied in operating a valve is not transmitted to the pipe line. Ref **fig.5.4**.

#### **5.3.2 Concrete Surrounds and Anchorage :**

When pipes are encased in concrete either as a protective surround or as an anchorage, membranes, such as felt or polyethylene film should be placed between the concrete and the PVC pipes.

5.3.3 The pipes shall be positioned in the trench so as to avoid any induced stress due to deflection. Since pipe may be joined at the trench side and then using guide ropes.

### **5.4 Jointing Techniques :**

5.4.1 The commonly used joints are as follows:

- 1) Solvent welded joints,
- 2) Flanged joints,
- 3) Rubber ring joints.

The specific jointing method to be followed shall be as per 1 and 2 above unless otherwise specified.

#### **5.4.2 Solvent Welded Joints :**

These are permanent in nature and strong in tension. They are used for service pipes of water mains. These joints are commonly used and economical for PVC pipe works.

This technique is used with both spigot and socket type joints, in which the socket is made specially to form a close fit on the pipe end and with injection moulded fittings.

Solvent cement of vinyl polymer or copolymer dissolved in a suitable volatile mixture or organic solvents shall be used with chemical resistance equal to that of the pipe of approved make. The full load shall be given only after 24 hours of jointing. Solvent to be used preferably may be of the quality recommended by the pipe manufacturer.

The solvent welded joint may be achieved either by heat application method or by non-heat application method. For water supply installations solvent welded joint shall be non-heat application method. A typical illustration of solvent welded joint is shown in **fig.7.1**.

#### **5.4.3 Non Heat Application Method :**

5.4.3.1 In this method, instead of forming a socket on one of the pipe ends by heat application,

an injection moulded socket fitting or coupler is used. This socket fitting has a provision to take in the pipe normally on either ends. The joint shall be made in ambient temperature. Cement on surface shall be applied only when temperature is favourable. The fabricated fittings are inferior to the injection moulded ones and only injection moulded fittings shall be used.

5.4.3.2 The pipe shall be cut perpendicular to the axis of the pipe length with a metal cutting saw or an ordinary hand-saw with a small teeth. Pipe ends have to be bevelled slightly with a bevelling tool (reamer) at an angle of about 30°. The total length of insertion of socket shall be marked on pipe by chalk mark to show how far the pipe end could be inserted into the fitting.

5.4.3.3 Dust, oil, water, grease, etc., shall be wiped out with dry cloth from the surfaces to be coated with solvent cements. The degreasing of surface shall be done with a suitable solvent such as methylene chloride. The coating of solvent cements shall be applied evenly on the inside of the fitting for full length of insertion and then on the outside of the pipe end upto the marked line. For hot and dry climate thicker coatings shall be applied. After application of cement the pipe shall be pushed into the fitting socket and held tight for 1 to 2 minutes to avoid the pipe end coming out of the fitting due to the slippery quality of cement and the tapering inside bore of the fitting. The surplus cement on the pipe surface shall be wiped out.

5.4.3.4 In most of the cases, the pipe inserted shall be upto the marked line and in no case shall be less than 2/3 of the length of the socket pipe and or upto marked line. When solvent welding the pipes, the spigot end should always be fully inserted into the socket. If this cannot be done either the solvent cement has dried too much or the tapering of the socket is too steep.

5.4.3.5 In hot climates with a larger temperature differences between day and night it is advised to make the joints early in the morning or in the evening when it is cooler. By this the joints are prevented from being pulled apart again when the pipe cools off at night. Once the joint sets the trench at these points shall be refilled and covered to avoid any damages due to temperature variations.

#### 5.4.3.6 Requirement of Solvent Cements :

Outside Dia of Pipe (mm)	Approximate No. of Joints per Kg of Solvent Cement
20	350
25	300
32	250
40	200
50	150
63	125
75	103
90	79
110	54
140	36
160	27
200	15
225	12
250	9
280	7
315	5

#### **5.4.4 Flanged Joints :**

These are used for jointing of PVC pipes particularly of larger sizes to valves and vessels and larger size metal pipes where strength in tension is required. The joint is made by the compression of a gasket or a ring seal set in the face of the flange. The flange may be formed in any one of the following manner.

5.4.4.1 By solvent cementing a plastic stub flange on to the pipe end and again using a backing ring. The pipe end may also be welded to the PVC flange. A typical illustration is shown in **fig.7.1**.

5.4.4.2 By solvent cementing a plastic full faced flange on to pipe end and bolting thus to the fitting face. For evenly distributing the bolt loads a backing ring or wide washers shall be provided which in turn prevents distortion of the PVC flange. A typical illustration of this type of connection is shown in **fig.7.1**.

#### **5.4.5 Union Joint :**

This is a form of flanged joint but the faces are held together by a screwed connection. A composite metal and PVC socket union is a very satisfactory method of jointing PVC to screwed metallic fittings. A typical illustration of union joint is shown in **fig.7.2**.

Short pieces of thick walled pipe may be threaded at one end and solvent cemented on to normal walled pipe at the other end to make the connector pieces to screwed metal fittings. This system may be used upto 50 mm in outside diameter and not on any pumping mains.

#### **5.4.6 Rubber Ring Joints :**

Rubber ring joints can provide a water tight seal but are not designed to resist pull. Rubber joints shall be used only when the fluid to be carried does not affect the rubber or the fluid is affected by rubber. The material of rubber rings should conform to IS : 5382 - 1969. Where aggressive soils are met with synthetic rubbers perform better. Rubber ring joints are used for large sized pipes (63 mm and above). Such joints may be provided on pipes which are buried in the ground and supported throughout on a bedding so that they are not subjected to movement and longitudinal pull.

The strength of a rubber ring joint to longitudinal forces is not high and for same joints a flange or a shoulder is made on the pipe end to provide the necessary strength in tension. In case of buried water supply mains the installed pipes and joints are supported by the continuous bed of the trench and no tensile strength in the joint itself is necessary. The anchor which shall be provided as described in para 5 for specification for laying cast iron pipe fittings, bends and at connections to valves. If used above ground, they shall be anchored to provide the required strength.

Un-plasticized PVC pipes may be jointed by methods employing a rubber ring to provide the water tight seal. The ring may be housed in a groove formed in a plastic or metallic housing. The rubber is compressed and makes a seal between the pipe and the housing. The ring shape and the method compressing the ring vary considerably in different types of joints. When rubber joints needs lubrication only lubricating paste prescribed by manufacturer shall be used. Strictly usage of mineral oils, petrol or grease is to be avoided as they are harmful for natural rubber.

The following are some of the types of rubber ring joints :

- a) Insertion joints.
  - 1) With spigot and socket or
  - 2) With separate collar pieces having two rubber rings, one at either end.
- b) Lip seal joints,
- c) Wedged joints and
- d) O-ring shrink joints.

At the times rubber rings and gaskets and all other fittings shall be stored so as to avoid damage of any kind to them or contamination by oil, petrol or greases.

All rubber items should be stored in a cool dry and dark place. When not in use, containers of lubricant should be kept closed tightly to avoid entry of dirt.

#### **5.4.7 Service Connections :**

PVC saddles can be used for the off take of service connections from larger bore pipes (50 mm diameter and above). The saddle shall consist of a half round moulded unplasticized PVC section which is solvent cemented to the pipe surface. The outside of the PVC section shall have a boss on to which the service connection may be screwed. Another type consists of two half round sections of metal or PVC which are bolted together or held round the pipe by wedge grips. A seal is formed between the pipe and the under surface of the upper section. The service connection is taken from a boss on the upper section. The specific type of saddle to be used for service connection shall be as specified in the schedule of quantities.

For giving service connections, conventional equipment for tapping under pressure or a special trepanning cutter to pierce the pipe wall ferrules with self contained cutter shall be used. Ferrules should not be screwed directly into unreinforced pipes without the introduction of a reinforcing saddle piece. A typical illustration of a ferrule connection is shown in **fig. 7.2**.

#### **6. Testing :**

6.1 Test pressure as described in para No. 6 of testing CI pipes shall be followed.

#### **6.2 Testing of Installations :**

After the completion of installation before starting the hydraulic test the system shall be visually inspected to ensure that the recommendations for the correct installation procedure have been complied with and that the pipe line together with appliances, valves and fittings are laid in the prescribed manner and anchor blocks are provided at all salient places. Solvent welded pipe lines should not be pressure tested until at least 24 hours after the last solvent welded joint has been made.

All control valves shall be positioned 'open' for the duration of the test and open ends temporarily closed with water-tight fittings.

The system should be slowly and carefully filled with water to avoid surge pressure of water hammer. Air vents should be open at all high points so that air may be expelled from the system during filling.

6.3 Air vents shall be closed when the system has been fully charged with water and air displaced from the line. The line may be initially inspected for seepage at joints and the firmness of

## 7. Back Filling :

As described in para 7 of specification for refilling for CI pipes shall be followed.

## 7.1 Restoration of Old Surfaces :

Shall be done as described in para 9 of specification for CI pipes.

## 8. Disinfection :

Shall be done as described in para 8 of specification for CI pipes.

Table - 1  
Dimensions of Unplasticized PVC Pipes  
(All dimensions in milli metres)

Outside diameter	Tolerance on outside	Wall thicknesses for working pressures							
		2.5 Kgf/cm <sup>2</sup>		4 Kgf/cm <sup>2</sup>		6 Kgf/cm <sup>2</sup>		10 Kgf/cm <sup>2</sup>	
		Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.
16	+0.3	-	-	-	-	-	-	1.1	1.5
20	+0.3	-	-	-	-	-	-	1.1	1.5
25	+0.3	-	-	-	-	-	-	1.4	1.8
32	+0.3	-	-	-	-	-	-	1.8	2.2
40	+0.3	-	-	-	-	1.4	1.8	2.2	2.7
50	+0.3	-	-	1.2	1.6	1.7	2.1	2.8	3.3
63	+0.3	-	-	1.5	1.9	2.2	2.7	3.5	4.1
75	+0.3	-	-	1.8	2.2	2.6	3.1	4.2	4.9
90	+0.3	1.3	1.7	2.1	2.6	3.1	3.7	5.0	5.7
110	+0.4	1.6	2.0	2.5	3.0	3.7	4.3	6.1	7.0
125	+0.4	1.8	2.2	2.9	3.4	4.3	5.0	6.9	7.7
140	+0.5	2.0	2.4	3.2	3.8	4.8	5.5	-	-
160	+0.5	2.3	2.8	3.7	4.3	5.4	6.2	-	-
180	+0.6	2.6	3.1	4.2	4.9	6.1	7.0	-	-
200	+0.6	2.9	3.4	4.6	5.3	6.8	7.7	-	-
225	+0.7	3.3	3.9	5.2	6.0	7.6	8.6	-	-
250	+0.8	3.6	4.2	5.7	6.5	8.5	9.6	-	-
280	+0.9	4.1	4.8	6.4	7.3	9.5	10.7	-	-
315	+1.0	4.6	5.3	7.2	8.2	10.7	12.0	-	-

**NOTE : 1.** Reference should be made to the code of practice for the use of plastic pipes of 2.5 kgf/cm<sup>2</sup> pressure rating.

**Note : 2.** The wall thickness of pipes are based on a safe working stress of 86 kgf/cm<sup>2</sup> at 27°C and working pressures get reduced at higher temperature.

**Note : 3.** The safe working stress at 20°C is 100 kgf/cm<sup>2</sup> and as a guide from 20°C to 40°C a reduction of 2 percent and from 40°C in to 49°C a reduction of 3.5 percent of the safe working stress of 100 kgf/cm<sup>2</sup> at 20°C should be assumed for arriving at the maximum working stress levels at different temperatures upto 49°C.



support under load. Pressure should be applied either by handpump or power driven pump. Pressure gauges should be correctly positioned and closely observed to ensure that at no time the test pressure is exceeded. Pressure increase may be applied thereafter until the required test pressure is reached (See note).

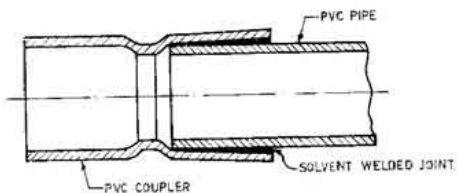
**Note:** Thermoplastic pipes expand under pressure to a greater extent than pipes of asbestos cement or cast iron due to low modules of elasticity of the material and results in initial fall of pressure even though there is no leakage. This applies to all the four pressure classification of pipes. The amount of water required to build up a steady test pressure for the plastic pipes is given in Table 2 and Table 3 for polyethylene and PVC pipes respectively. The values are only approximate to give a guideline as variations occur due to temperature fluctuation and variation in test pressure and wall thickness. The time taken to build up approximate steady pressure is 12 hours. Without any additional requirement of make up water the test pressure should not fall more than 0.2 kg/cm<sup>2</sup> at the end of one hour test duration. This extra quantity of water required is normally termed as make up water.

Table - 2  
Make Up Water Required While Testing Polyethylene Piping

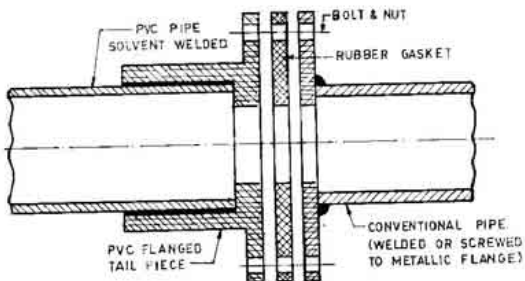
Nominal Size mm	Litre/100 M Line
25	1.1
32	1.6
40	2.6
50	4.0
63	5.9
80	8.5
110	16.4
125	26.9

Table - 3  
Make Up Water Required While Testing PVC Piping

Nominal Size mm	Litre/100 m Line
50	2.28
63	4.55
110	6.83
125	10.92
140	14.56
160	18.20
200	22.30



PVC SOLVENT WELDED JOINT.



FLANGED JOINT

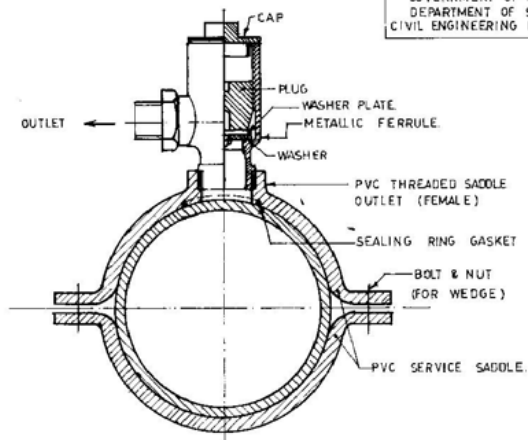
(Joining PVC pipes and other conventional pipes using pvc flanged tail piece)

TITLE\*

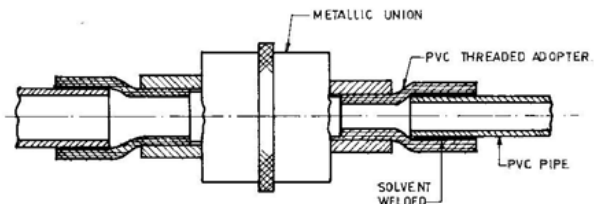
JOINTING TECHNIQUES FOR RIGID PVC PIPES.

DRAWN * <i>Manoj K. Singh</i>	CHECKED * <i>[Signature]</i> 28/11/84	RECOMMENDED * <i>[Signature]</i> HEAD - PH	APPROVED * <i>[Signature]</i> CHIEF ENGINEER	SCALE * NTS	FIG NO * CED. PH. 7-1
				DATE * OCT 1984	

SECTION VIII  
**SPECIFICATION FOR STONEWARE PIPES  
LAYING, JOINTING AND TESTING  
(SW PIPES)**



FERRULE CONNECTION  
(Using pvc service saddle)



UNION JOINT

TITLE

JOINTING TECHNIQUES FOR RIGID PVC PIPES.

DRAWN <i>U. Sankar</i>	CHECKED <i>P. Sankar</i> 25/12/89	RECOMM'D. <i>U. Sankar</i> HEAD-PH	APPROVED <i>M. Sankar</i> CHIEF ENGINEER	SCALE NTS DATE OCT 1984	FIG NO. CED. PH. 7-2
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## SECTION – VIII

### SPECIFICATION FOR LAYING, JOINTING AND TESTING OF STONEWARE PIPE SEWERS

#### Scope:

This specification for laying and jointing of the stoneware pipe covers the following:

- 1) Specifications for stoneware pipes and fittings.
- 2) Testing for acceptance of pipes and fittings.
- 3) Earth work excavation of pipe trenches.
- 4) Handling of stoneware pipes and fittings.
- 5) Laying of stoneware pipes.
- 6) Jointing of stoneware pipes.
- 7) Hydraulic testing.
- 8) Back filling of trenches.
- 9) Construction of manholes, inspection chambers, gully traps and grease traps.
- 10) Removal, restoration of roads and paved foot paths etc., and site cleaning.

#### 1. Specification for Stoneware Pipes and Fittings:

1.1 Stoneware pipes and fittings shall be of best quality stoneware, salt glazed, thoroughly burnt throughout the whole thickness, of a close and even texture, free from air blows, fire blisters, cracks and other imperfections. They shall conform to "Grade AA" of IS : 651 in all respects. The pipes and fittings shall give a sharp clear note when struck with a light hammer.

#### 1.2 Glazing:

The interior and the exterior surfaces of the pipes and fittings which remain exposed after jointing shall be glazed. The portions which remain covered after jointing may or may not be glazed. The glazing shall be obtained by the action of the fumes of volatilized common salt on the material of the pipes and fittings during process of burning.

#### 1.3 Internal Diameter of Pipes:

The internal diameter of the pipes shall be as specified in col. 1 of Table 1.

Permissible variation - The internal diameter of the barrel of a pipe shall not where deviate from the internal diameter specified in col. 1 of Table 1 by more than the following.

Internal Dia of Pipes in mm (1)	Permissible Deviation from Dia in mm (2)
100	3
150	5
200 to 230	6
250 to 350	8
400 to 450	10
500 to 600	12

#### 1.4 Thickness of Barrels, Sockets and Bends:

The mean thickness of the barrel and the socket of the pipes shall be not less than the mean thickness given in col 2 of Table 1. Such mean thickness of the barrels or sockets of any individual pipe

shall be ascertained by making several measurements and adding the measured least thickness (not in the groove) to the greatest thickness and dividing the sum by two. The mean thickness of the barrel and socket shall be determined separately.

**Permissible Variation** – The difference between the measured least thickness and the greatest mentioned in 1.4 shall not exceed the amounts given below.

Internal dia of pipe (mm)	Permissible variation in thickness of barrel and sockets. (mm)
not exceeding 450	2
500 to 600	3

### 1.5 Length and Straightness of Barrels and Taper Pipes :

The length of the barrels of straight and taper pipes ; junctions and half-section channels, exclusive of the internal depth of the socket, shall be 60, 75 or 90 cm.

**Permissible Tolerance on Length** : The permissible tolerance on length shall not be more than 10 mm for pipes of 60 cm and 75 cm of length and 15 mm for pipe of 90 cm length.

**Permissible Deviation from Straightness** : The maximum permissible deviation from straightness of the barrel of a pipe, measured on the inside of the curve and tested by means of a straight edge, for all diameters of pipe, shall be 5 mm for pipes 60 cm in length, 6 mm for pipes of 75 cm length and 7 mm for pipes of 90 cm length.

### 1.6 Dimensions of Barrels and Sockets :

Refer Fig. No.8.2

### 1.7 Grooving :

The interior of the sockets and the exterior of the spigots shall be grooved circumferentially and such grooving on the spigot shall be for a length equal to one and a half times the depth of sockets, and the depth of such grooves shall be between 1 mm and 2 mm.

## 2. IS Specifications :

### 2.1 Testing for accepting of pipes and fittings :

For accepting stoneware pipes to be used on the works sample stoneware pipes supplied by the contractor shall be got tested for (i) hydraulic test (ii) absorption test and (iii) crushing strength test. Brief test procedures are furnished. Detailed test procedure for carrying out these tests may be referred in latest IS : 651. Number of samples to be tested shall be 5 pipes per 1000 pipes or 3 pipes per 500 pipes drawn at random. These quality tests shall be carried out for all works involving use of 500 nos. or more stoneware pipes. The tests may be got done in any laboratories of Engineering Colleges, PWD, Highways etc., and results produced to the Engineer-in-Charge.

Besides the following parameters have to be checked at site at random on 2 pipes for every 100 pipes supplied at site for all works. The parameters to be checked are (i) internal diameter of

pipes (ii) thickness of barrels and sockets (iii) length and straightness of barrels (iv) groovings at the spigot ends and within the socket.

#### 2.1.1 Hydraulic Test :

When subjected to the hydraulic test, straight pipes shall withstand an internal hydraulic test pressure of 1.5 kgf/cm<sup>2</sup> on the barrels and fittings shall withstand a test pressure of 0.75 kgf/cm<sup>2</sup> without showing signs of injury or leakage. The pressure shall be applied on pipes and fittings at a rate not exceeding 0.75 kgf/cm<sup>2</sup> in 5 seconds and full pressure shall be maintained for atleast 5 seconds. Care shall be taken to ensure that all air is expelled before the test is commenced.

#### 2.1.2 Absorption Test :

The specimen for testing shall be taken from the body of a pipe or fitting and in the case of straight pipe not closer than 15 cm to the ends. Each test piece shall be of the whole thickness of the wall of the pipe or fitting and shall have two glazed surfaces each having an area of not less than 50 cm<sup>2</sup> and not more than 130 cm<sup>2</sup>. The test pieces shall be cleaned by wire brush to dislodge any loose particles which may incur weight loss during boiling. The test piece shall be dried at a temperature of not less than 150°C until no further loss of weight is noted and cooled in a desiccator to room temperature and the specimen weighed to an accuracy of 0.1 g. The test piece may be suitably suspended in cold distilled water by means of thread so that the test piece may not strike against each other or the container and incur loss in weight to boiling point. The water shall be maintained at that temperature for one hour and after it has been allowed to cool to room temperature, the test pieces shall be removed, carefully wiped with a dry cloth and then re-weighed. The percentage increase in weight of each test piece by absorption of water shall not exceed the following values. 5 pipes per 1000 pipes or 3 pipes per 500 pipes may be chosen at random and got tested before accepting the pipe for use in works.

Sl. No.	Thickness of pipe or fitting (mm)	Increase in weight (percentage)
1.	upto 20	6
2.	Over 20 and upto 25	7
3.	Over 25 and upto 32	8
4.	Over 32 and upto 38	9
5.	Over 38	10

#### 2.1.3 Test to Find Resistance to Action of Acids :

This can be done in case of doubtful quality of pipe as prescribed in IS:651-1971

#### 2.1.4 Test for Crushing Strength :

When tested along the full length of the pipe barrel from shoulder to spigot in accordance with Appendix - A of IS:651-1971, the pipe tested shall have a minimum crushing strength of 1600 kgf/m in length. This is a simple test which can be got done at the site. Five samples for every 1000 or 3 per 500 pipes supplied can be done before accepting the pipe for use in works.

#### 2.2 Marking :

Every pipe and fittings shall have legibly impressed upon it before firing the name or trade-mark

of the manufacturer. In addition the grade of the pipe, namely, Grade AA shall be stencilled or stamped on the pipe as indicated below. Each pipe and fitting may also be marked with the ISI certification mark.

### **3. Earth Work Excavation of Pipe Trenches :**

#### **3.1 Alignment And Grade :**

The sewers are to be laid to the alignment and gradients shown on the drawings but subject to such modifications as shall be ordered by the Engineer-in-Charge from time to time to meet the requirements of the works. No deviations from the lines, depths of cutting or gradients of the storm water drains/sewers shown on the plans and sections shall be permitted except by the expressed direction in writing of the Engineer-in-Charge.

#### **3.2 Setting out and Excavation :**

Before the excavation for the trench is commenced, sightrails shall be erected every 30M apart or at such distances fixed by the Engineer-in-Charge and at all changes of direction or gradient and at all manholes. The sightrails, (as far as practicable), shall be at a uniform height above the proposed/invert of the pipes, and central line being marked on the horizontal rail by black and white painting (Ref. Fig 8.1). The depth of excavation and level of the pipe invert shall be checked by means of boning rods of appropriate length.

#### **3.3 Width of Trenches :**

The maximum width of trenches to be excavated for pipe laying and in respect of which payment will be allowed for excavation will be as follows :

- a) Trenches upto depth of 90 cms. width of trench = dia of pipe plus 40 cms but minimum width to be 55 cms.
- b) Trenches of depth exceeding 90 cms and upto 2 Mtr. width of trench = diameter of pipe plus 40 cms. but minimum width to be 75 cms.
- c) Trenches exceeding 2 m depth :

Width of trench shall be widened by allowing steps of 50 cms. on either side after every 2 m depth from the bottom, so as to give virtual side slopes of ¼ to 1 where soil is soft, loose or slushy, width of steps are to be suitably increased or the sides shored up as directed by the Engineer-in-Charge.

However, if the actual widths of the trenches excavated are less than the maximum widths permitted, payment shall be restricted to the actuals. Where the trench is dug by the side of an existing structure of building width of trench has to be fixed leaving clear margin to the existing structure and so as not to endanger the structural stability of the existing structure suitable sheet piling, shoring and strutting shall be provided as directed by the Engineer-In-Charge.

#### **3.4 Excavation for Manholes and Inspection Chambers :**

3.4.1 Where a manhole or the foundation thereof, extends beyond the exterior lines of the pipe drains or its foundations the minimum excavation in earth required for the same shall be that contained in a prism with vertical sides and a horizontal section equal to the smallest rectangle which will enclose manhole and its foundation.



3.4.2 The minimum dimensions of the excavation in earth for brick work, junction chambers, storm water overflows, and similar works shall be such as to give a clearance inside the sheeting or timbering of one foot on all sides above the foundation, but in all such cases the excavation shall be large enough to include the foundation for the structures as shown on the drawings.

3.4.3 The Engineer-in-Charge shall have power for giving an order in writing to the contractor to increase the maximum width in respect of which payment will be allowed for excavation in trenches for various classes of storm water drains/sewers, manholes and other works in certain lengths to be specifically laid down by him where on account of bad ground or the unusual conditions, he considers that such increased widths are necessary in the interest of work.

### **3.5 Excavation To Be Taken To Proper Depths Only :**

The trenches shall be excavated to such depth that the storm water drains/sewers shall rest on concrete or firm ground as described in the appropriate clauses relating there to and so that the inverts may be at the levels given on the sections. Care should be taken to see that no extra depth is excavated than what is required by checking the depth with boning rod and site rail as frequently as necessary. If bad ground is met with during excavation of work which might not have been anticipated during estimation stage and not provided for in the schedule of quantities of contract, the Engineer-in-Charge may order the contractor to excavate to a greater depth than that shown on the drawings and to fill up the excavation to the level of the sewer/storm water drain with concrete, broken stone, gravel or other materials. For such extra excavation and concrete, broken stone gravel or other materials the contractor shall be paid extra at the rates laid down for such work in the schedule if the extra work was ordered by the Engineer-in-charge in writing but if the contractor should excavate the trench to a greater depth than is required without specific orders to that effect in writing of the Engineer-in-charge the extra depth shall have to be filled up with cement concrete at the contractor's own cost and charged to the requirements and satisfaction of the Engineer-in-charge.

### **3.6 Transferring Levels to Trench Bottom from SIGHT Rails by using Boning Rod :**

Excavation of trench shall be proceeded to the correct depth less 75 mm by fixing actual depths to be excavated true to the specified gradient. Spot levels shall be fixed at every 3 M spacing in the trench prior to the last 75 mm depth excavation using boning rod and the bottom of the trench trimmed to correct gradient and level.

### **3.7 Excavation of Socket Hollows for Jointing :**

Socket hollows shall be cut in the bottom of the trench at the correct position to receive the sockets on the pipes, and these hollows shall be sufficient depth (about 20 cm) to ensure that the barrels of the pipes rest throughout their entire length on solid ground and the sockets hung from each pipe must be properly housed in, so that the invert is to a true and even gradient. The socket hollows shall be refilled with sand after jointing the pipe. (Ref. fig. 8.2).

### **3.8 Care to be Taken of Existing Pipes, Cables etc :**

While excavating trenches, care shall be taken not to disturb without the consent of the competent authorities any pipe, cable pole, wire etc., and any damage to such pipes etc., or to their jointing, shall be made good by the contractor. The supporting or removing, of such structures either permanently or temporarily, shall be done by the contractor on the orders of the Engineer-in-Charge and any extra on this account will be paid for separately.

### **3.9 Shoring and Timbering :**

During excavation of the trench, the sides of the trench shall be protected by shoring and timbering to prevent any caving in and the contractor shall provide all the materials and securely timber all excavations to the entire satisfaction of the Engineer-in - Charge. This, however, shall not free the contractor from his responsibility for providing adequate protection to prevent any damage to neighbouring property or untoward accidents. The sizes and lengths of timber used for shoring shall be subjected to the approval of the Engineer-in - Charge. Every precaution must be taken against slips and falls of earth, etc., in the excavation and in the event of any such occurrence the contractor shall remove the spoil without extra payment. The contractor shall at all times support effectively the sides of the trenches and other excavations by suitable timbering, piling and sheeting and they shall be close timbered in all loose or sandy strata and below the surface of the subsoil water table without any extra cost. It is intended that all timbering shall be removed as the work proceeds, except timber sheeting against which concrete is placed which shall not be removed unless specially permitted by Engineer-in - Charge. Such sheeting will, however, not be paid for when left in position unless the same was specifically ordered in writing to be left in by the Engineer-in - Charge to protect the sides of the trenches and other excavation as provided for below. The Engineer-in - Charge may require any portion of the timbering, piling or sheeting to be left in the ground in order to protect the sides of the trenches or other excavation by an order in writing to the contractor detailing the quantity of timber to be left in and the place thereof. Such timber will be paid for at the negotiated rate per cubic foot net measurement of timber left in under the said instructions of the Engineer-in - Charge. In soft or water logged ground the contractor shall closely drive the timber sheeting or piling with tongue and grooved or other joints of approved type to such depth below the bed level of the under side of the storm water drains and other work as shall be required by an order in writing of the Engineer-in - Charge and net extra shall be payable to the contractor for such extra work.

### **3.10 Rock Excavation :**

If rock is met with, it will be removed to 15 cm below the level of the pipe and the trench will be refilled with concrete, sand or other suitable material as directed by the Engineer-in-charge to bring it to the required bed level.

### **3.11 Blasting :**

Blasting for excavation in rock shall be permitted only after securing the approval of the Engineer-in - Charge and only when proper precautions are taken for the protection of persons or property. The hours of blasting shall be fixed by the Engineer-in - Charge. The procedure of blasting shall conform to the requirements of local controlling Administrative Authority.

### **3.12 Care of Surface Material for Re-use :**

All surface materials which in the opinion of the Engineer-in - Charge are suitable for re-use in restoring the surface shall be kept separate from the general excavation materials as directed by the Engineer-in - Charge.

### **3.13 Barricades, Guards and Safety Provisions :**

To protect person 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 construction work and until it is safe for traffic to use the roadway. All materials, pipes,

equipment and pipe which may serve as obstructions to traffic shall be enclosed by fences or barricades and shall be protected by proper lights when the visibility is poor. The rules and regulations of the local authorities regarding safety provisions shall be observed.

### **3.14 Maintenance of Traffic and Closing of Streets :**

The work shall be carried in such a manner which will cause the least interruption to traffic and the road or street may be closed in such a manner that it causes the least interruption to the traffic. Where it is necessary for traffic to cross open trenches suitable bridges shall be provided. Suitable signs indicating that a street is closed shall be placed and necessary detour signs for the proper maintenance of traffic shall be provided. The contractor shall not occupy or obstruct by his operation more than one half of the width of any road or street and if insufficient space shall then be left for public and private transit, he shall remove the materials excavated and bring them back again when the trench is required to be refilled. The contractor shall obtain the consent of Engineer-in-Charge in writing before obstructing any vehicular traffic. Foot walks should be provided across the trenches.

### **3.15 Protection of Existing Structures :**

Temporary support, adequate protection and maintenance of all underground and surface structures, drains, sewers and other obstructions encountered in the progress of the work shall be provided under the direction of the Engineer-in-Charge. The structures which may have been disturbed shall be restored upon completion of the work.

Trees, shrubbery, fences, poles and all other property and surface structures shall be protected unless their removal is shown on the drawings or authorised by the Administrative Authority. When it is necessary to cut roots and tree branches, such cutting shall be done under the supervision and direction of the Engineer-in-Charge. The surfaces of all trenches and holes shall be restored and maintained to the satisfaction of the Engineer-in-Charge and of the owners of the roads or other property transversed and the contractor shall not cut or break down any live fence or trees in the line or the proposed work but shall tunnel under them, unless the Engineer-in-Charge shall order to the contrary without any claim for extra cost.

### **4. Handling of SW Pipes and Fittings :**

4.1 While unloading the SW pipes from a truck the pipes shall not be thrown down on hard ground. Pipes shall be unloaded manually and placed gently on the ground. Pipes shall not be dragged on the ground or road surface to avoid damage.

4.2 Under no circumstances the stoneware pipes shall be dropped or dumped into the trench. The pipes have to be transferred from a person standing by the side of the excavated trench to a person standing in the trench and gently placed in the trench bed. In deep trenches pipes shall be lowered into the trench using ropes.

### **5. Laying of SW Pipes :**

#### **5.1 Provision of Minimum Cover :**

The minimum support or protection for glazed stoneware pipes shall be as follows :

When the pipe is laid under road way a minimum cover of 90 cms is necessary. Wherever the cover is less than 90 cms under roadway encasing of pipe with concrete is necessary. Where

pipes are unavoidably exposed above ground surface, the pipes shall be completely encased or surrounded with concrete.

#### **5.2 Provision of Bed Concrete for Soft Soils, Filled up Earth and in Places of High Ground Water Table :**

5.2.1 Where the pipes are in laid on a soft soil or filled up earth with the maximum water table level lying at the invert level of the pipe, the pipe sewer shall be bedded on concrete as shown in **fig. 8.3**.

5.2.2 Where the pipes have to be laid in a soft soil with the maximum water table level rising above the invert level of the pipe but below the top of the barrel, the pipe sewers shall be haunched as shown in **fig. 8.3**.

5.2.3 Where the maximum water table level is likely to rise above the top of the barrel, the pipe sewers shall be completely encased or surrounded with concrete as shown in **fig. 8.3**.

5.2.4 Where the sewers are to be laid adjacent to growing trees, the pipe sewers shall be encased or surrounded with concrete, to avoid damage to pipes likely to be caused by the roots of the tree as shown in **fig. 8.3**.

#### **5.3 Detection of Cracks in Pipes and Fittings :**

The pipe and fittings shall be inspected for defects and be rung with a light hammer preferably while suspended to detect cracks just before laying.

#### **5.4 Cleaning of Pipes and Fittings :**

All lumps, blisters and excess coating materials shall be removed gently from the socket and spigot end of each pipe and the outside of the spigot and the inside of the socket shall be wiped clean and dry before the pipe is laid.

#### **5.5 Placing the Pipes in Trench :**

Every precaution shall be taken to prevent foreign materials from entering the pipes when it is being placed in the line. Normally the socket ends should face the up-stream. When the line runs uphill the socket ends should face the up-grade.

#### **5.6 Laying SW Pipes :**

Pipes shall be laid carefully to the alignment, correct levels and gradients as directed and care shall be taken to prevent any sand, earth or other matter from entering the pipes during laying. The pipes between manholes shall be laid, truly in straight lines without vertical or horizontal undulations.

All invert levels shall be fixed from sight rails fixed at the required true levels with proper boning rods. The pipes shall be laid sockets facing the up gradient, beginning at the lower end, and with the socket resting in the socket holes cut in the concrete bed if specified. Each pipe shall be laid single and no pipe shall be laid until the trench has been excavated to the required depth for a distance of twenty yards in front of the pipe to be laid.

After placing a length of pipe in the trench or on concrete bedding where it is specified, the spigot end shall be centered in the socket and the pipe forced home and aligned to gradient. After ensuring the grade of pipes laid, the joints are caulked with hemp yarn for a reach of pipeline,

boning rod shall be kept on the socket of each SW pipe and correct grading of the pipe line ensured. For this purpose a separate strip of timber piece shall be fixed in the boning rod to suit the socket dia. The pipes shall be secured in place with approved backfill material or concrete tamped under it except at the socket. Pipe and fittings which do not allow sufficient and uniform space in the socket for joints shall be removed and replaced with pipe and fittings of proper dimensions to ensure such uniform space. Precautions shall be taken to prevent dirt from entering the joint space.

#### **5.7 Closing Open Ends of Pipes:**

At times when pipe laying is not in progress, the open ends of pipe shall be closed by a water tight plug or canvas or other means approved by the Engineer-in-Charge.

#### **5.8 Cutting of Pipes:**

The cutting of pipe for inserting, fittings or closure pieces shall be done in a neat and workman like manner without damage to the pipe or cement lining so as to leave a smooth end at right angles to the axis of the pipe.

#### **5.9 Pipe Lines Crossing Railway Lines, Irrigation Channels or Similar Work:**

The work shall be carried out as per the specifications laid down by the concerned department under the supervision of their Engineers.

#### **5.10 Connection to Existing Sewer:**

The connection to an existing sewer shall be done through manholes.

#### **5.11 Connections to Manholes:**

Before connecting a pipe to a manhole, a relieving arch or any other similar protection device should be made in the manhole for the safety of the pipe.

5.12 SW pipes when laid should not be subjected to super imposed load beyond their safe crushing strength (1600 kg/m). Protection may be provided by the following methods.

- a) Bedding, haunching, surround or encasing the pipe as described in para 5.2.
- b) Providing of horizontal wooden struts at suitable intervals near the mid-depth of the trench to distribute a portion of the load to the two side walls of the trench as shown in **fig. 2.1**.

5.13 Socket hollows shall be provided to ensure resting of barrel of pipes on trench bottom (**fig. 8.2**). Laying and jointing of pipes without providing socket hollows and instead raising each socket by brick supports is an incorrect practice and should not be allowed as this may give rise to unfilled gap below the pipe barrel after back filling the trench and the SW pipes will develop shear cracks due to bending action caused by the weight of refilled earth acting on the pipe. Socket pits shall be filled with fine excavated material or river sand and compacted well.

### **6. Jointing of SW Pipes:**

6.1 The stoneware pipe shall be cement jointed using spun yarn or tarred gaskets, cement (conforming to IS: 269-1958 or IS: 455-1962) and sand (conforming to IS: 1542-1960) (Ref **fig. 8.2**). It shall be of natural and crushed stone sand or crushed gravel sand and shall be hard, durable, clean and free from organic matter, alkalis, salts, coal, mica, shale, fine silt and fine dust. Fine river sand shall be used for jointing of sewers.

### 6.2 Caulking of Yarn or Gasket:

In each joint, spun yarn soaked in neat cement slurry or tarred gasket shall be passed round the joint and inserted in it by means of a caulking tool. More skeins of yarn or gasket shall be added if necessary and shall be well caulked. Yarn or gasket so rammed shall not occupy more than one fourth of the depth of socket. The required depth of caulking of spun yarn can be controlled by measuring the depth with a wooden guage having marking groove to show the depth to be maintained for cement mortar packing. Wooden guage shall be prepared with suitable marking for each diameter of SW pipe.

### 6.3 Caulking of Cement Mortar:

Cement mortar (1:1) (one part of cement to one part of sand) shall be slightly moistened and carefully inserted by hand into the remaining space of the joint after caulking of yarn or gasket. The mortar shall then be caulked into the joint with a caulking tool. More cement mortar shall be added until the space of joint has been completely filled with tightly caulked mortar. The joint shall then be finished off neatly outside the socket at an angle of 45° as shown in **fig. 8.2**.

Wooden caulking tool shall be used for forcing the mortar into the sockets. The inside of each pipe shall immediately after making the joint be carefully wiped clean with a mop or scraper sufficiently long to pass two joints from the end of the pipes. All pipes entering manholes shall be set in cement concrete to effect complete water tightness.

### 6.4 Curing of Joints:

All the joints shall be kept moist by means of wet rags or earth to protect them from quick drying which may induce cracks in the mortar due to the action of high sun or wind. The cement mortar joints shall be cured atleast for a period of seven days.

### 6.5 Approximate Quantity of Jointing Materials Required per Joint:

Nominal dia of pipe in mm	Internal depth of socket in mm	Cement in Kgs.	Spun Yarn in Kgs.
100	50	1.0	0.25
150	57	1.5	0.35
200	63	2.0	0.70
250	70	2.5	0.80
300	70	3.25	1.10
350	75	4.50	1.25
400	75	5.50	1.50

## 7. Hydraulic Testing:

### 7.1 Test Pressure:

All pipe lines shall be subjected to a test pressure of at least 2.5 m head of water at the highest point of the section under test.

### **7.2 Allowing Time for Absorption of Water By SW pipes :**

Before commencing the hydraulic test, the pipe lines shall be filled with water and maintained full for 24 hours by adding water, if necessary, under a head of 60 cm of water. The test shall be carried out by suitably plugging the low end of the drain and the ends of connections, if any and filling the system with water.

### **7.3 Testing Method :**

The sewer testing plug is inserted at the upstream and downstream end and also in the various house service tappings and plugged. The testing plug comprises of two flanges, one rubber ring, wing nut etc.

The plug is inserted at the upstream and the lock is obtained by expanding the ring against the pipe wall by tightening the wing nut. To build up necessary compressive force to cause expansion of the rubber ring a roller washer is used.

Water for filling in is let through the funnel connected to the plug provided at the upstream end. To allow the air to escape a small hole is made on the pipe wall at the upstream end and after filling the pipe completely the hole is plugged with a wooden plug wound with hemp.

The down stream end of the sewer and all slants in the sewer line (provided for house service) are plugged with the sewer testing plug and capped.

The funnel is kept at a height of 2.5 m from the invert of the sewer duly filled with water.

The pipe line is considered sound if the water in the funnel does not empty within thirty minutes.

After applying test pressure the pipes and joints shall be thoroughly inspected for leakage of water which will be indicated by fall in water level of the funnel. Subsidence of the test water in funnel may be due to one or more of the following causes :

- a) Absorption of pipes and joints,
- b) Sweating of pipes or joints,
- c) Leakage at joints or from defective pipes and
- d) Trapped air.

Allowance shall be made for (a) by adding water until absorption has ceased and after which the proper test should commence.

Any leakage will be visible and the defective part of the work should be cut out and made good. A slight amount of sweating which is uniform may be overlooked, but excessive sweating from a particular pipe or joint shall be made good.

### **7.4 Rectification of Faulty Joints :**

Any joint found leaking or sweating shall be rectified or embedded into 15 cm layer of cement concrete 30 cm in length and the section retested.

Finally test pressure may be applied for a minimum period of 30 minutes. The pipe line is considered sound if the water level in the funnel does not empty within 30 minutes.

### **8. Back Filling of Trenches :**

Back filling of trenches shall be carried out in accordance with clause 7 under specification for

laying cast iron pipes.

#### **9. Construction of Manholes, Inspection Chambers, Gully Traps and Grease Traps :**

For civil works involved in the construction of manholes etc., relevant specifications under civil works shall be followed.

9.1 Construction of manholes, inspection chambers, gully traps, grease traps shall be carried out for all places where ground water shall not be encountered at shallow depths. In places where high ground water conditions are encountered special precautions have to be adopted to prevent ingress of ground water into the sewer and manhole etc., for this purpose separate type designs are evolved for inspection chamber, manholes, gully traps and grease traps vide **fig. nos. 8.8, 8.11 and 8.12**. These diagrams shall be followed for SHAR and other places where such high ground water conditions exists.

#### **9.2 Manholes to be Water Tight :**

The inside and the outside of all manholes shall be rendered with cement mortar as laid down in the schedule and as shown in the drawing to the required thickness and worked to a polished face with a coat of neat cement and they shall be absolutely water-tight.

#### **9.3 Shaping of Manhole Inverts :**

The channels shall be formed of 1 : 2 : 4 cement concrete as shown in the drawing. There shall be fall of not less than 20 mm in each manhole from inlet to outlet.

#### **9.4 Dewatering of Excavations :**

The contractor shall keep all excavation for manholes and all other work absolutely and continuously clear of all water, down to a level below the bottom of the work to be carried out and shall construct the manholes and other works without allowing any water to rise in the excavation made for said works. He shall moreover continue full pumping operations and shall keep the excavation for each manholes or other work free of water until the manholes or other work is completed and passed. If any defect or defects are found in the said work subsequently, the contractor shall carry out at his own cost all dewatering and pumping operations required to make the defect or defects to the satisfaction of the Engineer-in-Charge.

#### **9.5 Plastering of Inside and Outside Wall Surfaces of Manholes, Inspection Chambers etc.,**

The surface to be plastered shall first be thoroughly cleaned and all joints raked out not less than  $\frac{1}{2}$ " deep to receive key for plaster. The surface shall be thoroughly wetted for atleast 24 hours prior to commencement of work. The mortar shall be of uniform mixture as specified. The thickness of cement and sand plaster shall be 13 mm. The first coat shall be just sufficient to fill up the unevenness in the surface under treatment in case of rubble masonry. It shall not be smoothed and the second coat shall be applied while the first coat is still raw. Cement mortar which falls to the ground during application shall on no account be reused. The floating coat over the plaster shall be done with neat cement as approved by the Engineer-in-Charge.

#### **9.6 Channeling and Benching:**

The channels inside the manholes and chambers shall be formed of cement concrete 1 : 2 : 4 with 20 mm aggregate as shown in the drawings and as specified in the relevant items of the schedule. It shall be to the full width of the drain. The depth of the channels shall be built in the



chambers where branch drains form junctions. All channels shall be given a suitable fall as shown in the drawing.

#### **9.7 Manhole Covers and Frames :**

**Design and manufacture :** The manhole frames and covers shall be of clear size specified opening, CI Double sealed pattern and of weight as specified and as approved by the Engineer-in-Charge. They shall be conforming to IS : 1726-1967 and of weights as specified in **fig. 8.6 to 8.12**.

They shall be of the best foundry grey metal, tough and close grained and the samples of the manhole frame and cover submitted to the Engineer-in-Charge and his approval in writing is to be obtained before the frames and covers are fixed. The frames and covers are to be painted with three coats of anticorrosive black bitumastic paint approved by the Engineer-in-Charge. The frames and covers shall be clean moulded, accurately made and fitted in a workman like manner, the surface being smooth and even.

#### **9.8 Setting of Manhole Frames :**

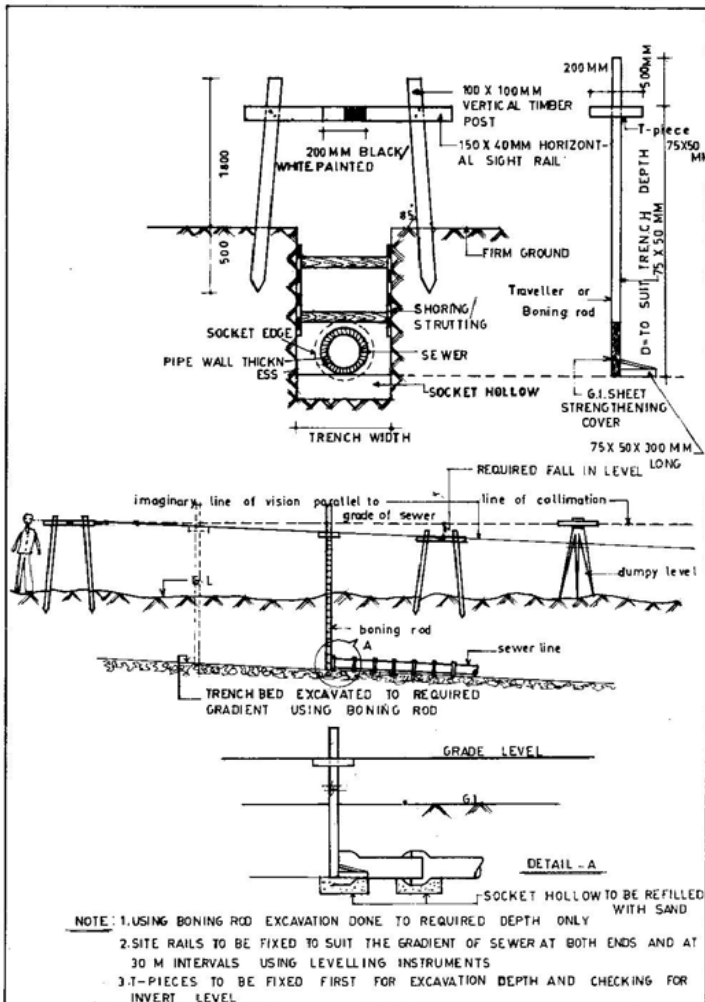
All manhole frames shall be set to correct alignment and levels, embedded in a layers of cement concrete 1 : 2 : 4 to the satisfaction of the Engineer-in-Charge in all respects or as specified.

#### **9.9 Depth of Manholes :**

The depth of manholes shall be measured from the top of cover to the invert level of the manhole.

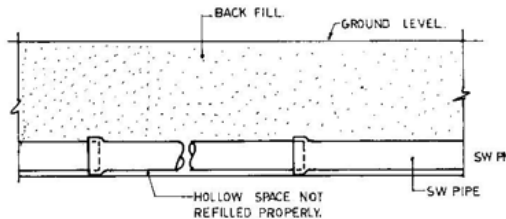
#### **10. Removal, Restoration of Roads Paved Foot Paths etc., and Site Cleaning :**

Removal, restoration of roads and foot paths and site cleaning shall be carried out in accordance with clause 9 of the specifications for laying CI pipes.

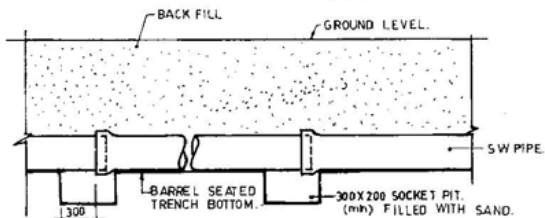


TITLE: SIGHT RAILS FOR SETTING OUT SEWER GRADIENTS.

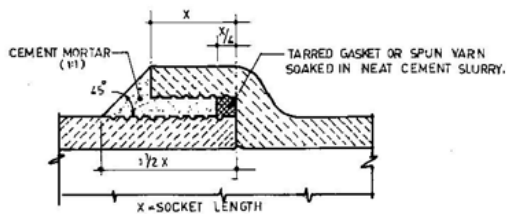
DRAWN <i>g. [signature]</i>	CHECKED <i>[signature] 10/1/85</i>	RECOMM <i>[signature] 12/3/85</i> HEAD PH	APPROVED <i>[signature]</i> CHIEF ENGINEER	SCALE N.T.S DATE JULY 85	FIG. NO. CED: PH. 8-1
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**WRONG METHOD OF LAYING AND  
JOINTING STONEWARE PIPES.**



**CORRECT METHOD OF LAYING AND  
JOINTING OF STONEWARE PIPES.**

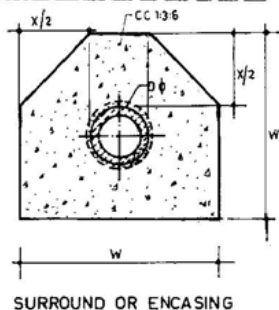
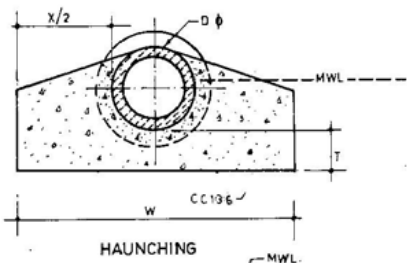
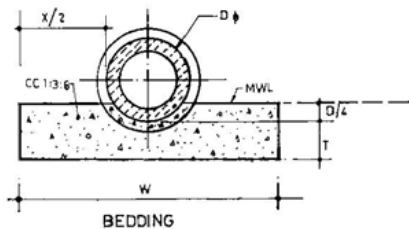


**TYPICAL DETAIL OF CEMENT JOINTS FOR  
GLAZED STONEWARE PIPES.**

TITLE •

**STONE WARE PIPE LAYING AND JOINTING.**

DRAWN • <i>M. S. S. S.</i>	CHECKED • <i>S. S. S.</i> 22/12/84	RECOMMEND • <i>S. S. S.</i> HEAD PH	APPROVED • <i>S. S. S.</i> CHIEF ENGINEER	SCALE • NTS	FIG NO •
				DATE • NOV 1984	<b>CED:PH:82</b>



MWL = MAXIMUM WATER LEVEL.

$W = D + X$ , WHERE 'D' IS THE EXTERNAL DIAMETER OF THE PIPE.

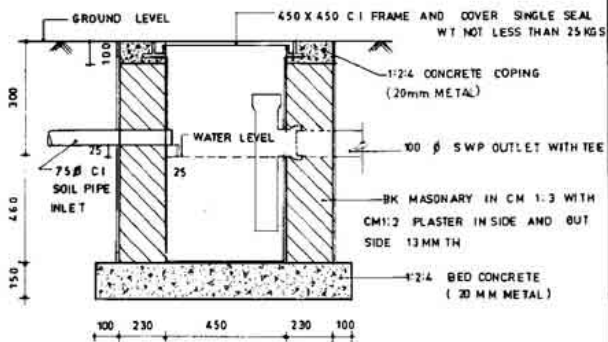
$X = \begin{cases} 30 \text{ cm} - \text{UPTO TRENCH DEPTH OF} \\ 120 \text{ cm} \\ 40 \text{ cm} - \text{TRENCH DEPTH MORE THAN} \\ 120 \text{ cm.} \end{cases}$

$T = 10 \text{ cm}$  FOR PIPES UNDER 150mm NOMINAL DIAMETER; ONE FOURTH OF INTERNAL DIAMETER SUBJECT TO A MINIMUM OF 5cm AND MAXIMUM OF 30cm FOR PIPES OF MORE THAN 150mm DIAMETER.

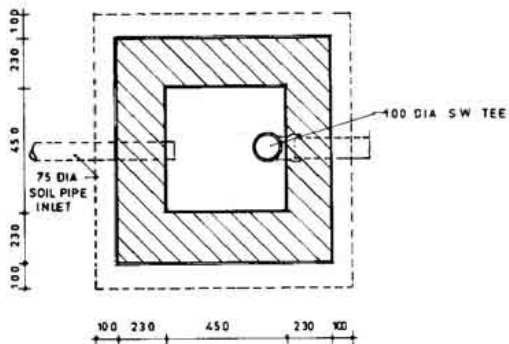
TITLE =

ENCASING DETAIL FOR SEWER LINE.

DRAWN:  
*Manoj K. Sahu*CHECKED:  
*[Signature]*  
27/12/89RECOMMEND:  
*[Signature]*  
15/10/85  
HEAD PHAPPROVED:  
*[Signature]*  
CHIEF ENGINEERSCALE:  
NTS  
DATE:  
NOV. 1986FIG NO.  
CED:PH: 8.3



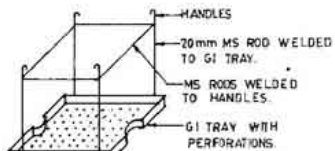
SECTION 1-1



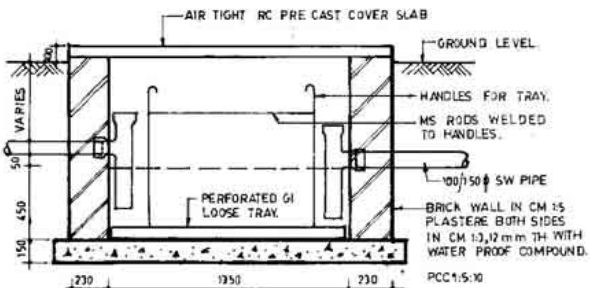
PLAN

TITLE :  
ORDINARY GREASE TRAP

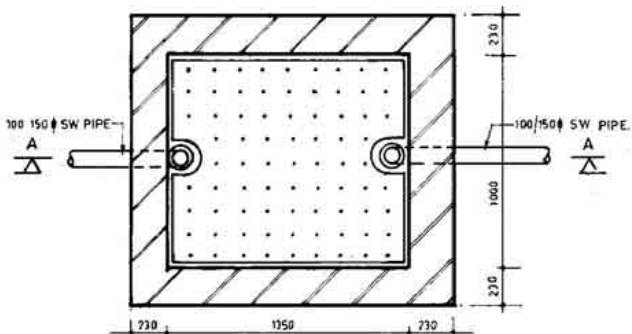
DRAWN G. USHA	CHECKED <i>[Signature]</i> 27/72	RECOMM D <i>[Signature]</i> 16.3.85 HEAD PH	APPROVED <i>[Signature]</i> CHIEF ENGINEER	SCALE : N.T.S DATE -11-84	FIG. NO. CED.PH.84
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DETAIL OF PERFORATED TRAY



SECTION A-A



PLAN

TITLE\*

## DETAILS OF GREASE TRAP WITH TRAY.

DRAWN\*

*M. S. K. S.*  
S. K. S. 19/10/85

CHECKED\*

*P. S.*  
27/12

RECOMMENDED\*

*P. S.*  
16/11/85  
HEAD - PH

APPROVED\*

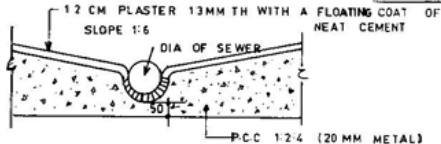
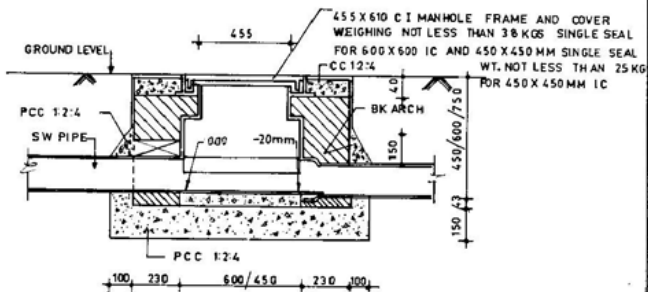
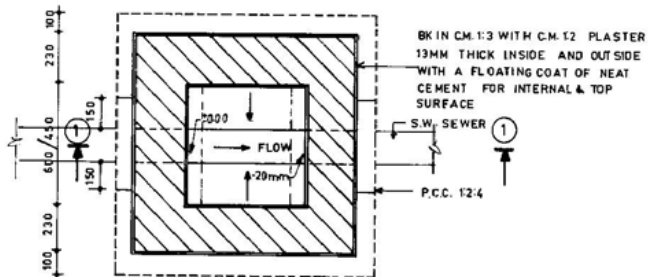
*M. S. K. S.*  
16/11/85  
CHIEF ENGINEER

SCALE\*

DATE\*  
NOV 1986

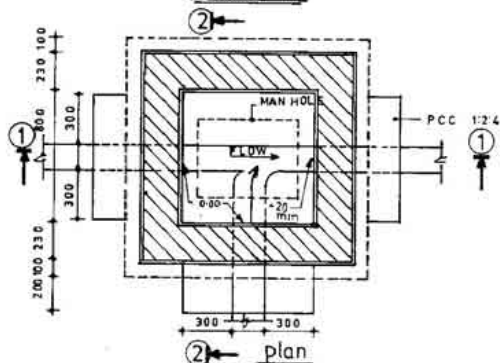
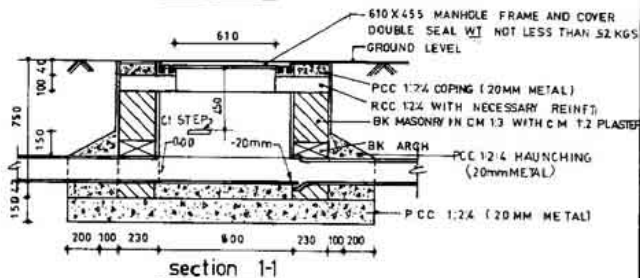
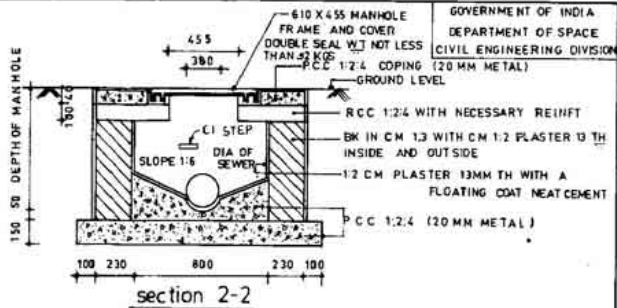
FIG NO\*

CED. PH. 8-5

DETAILS OF BENCHINGSECTION 1-1PLAN

TITLE: INSPECTION CHAMBER 600X 600 MM X 600MM, 750 MM DEPTH  
AND IC 450 X 450 MM X 450 MM DEPTH.

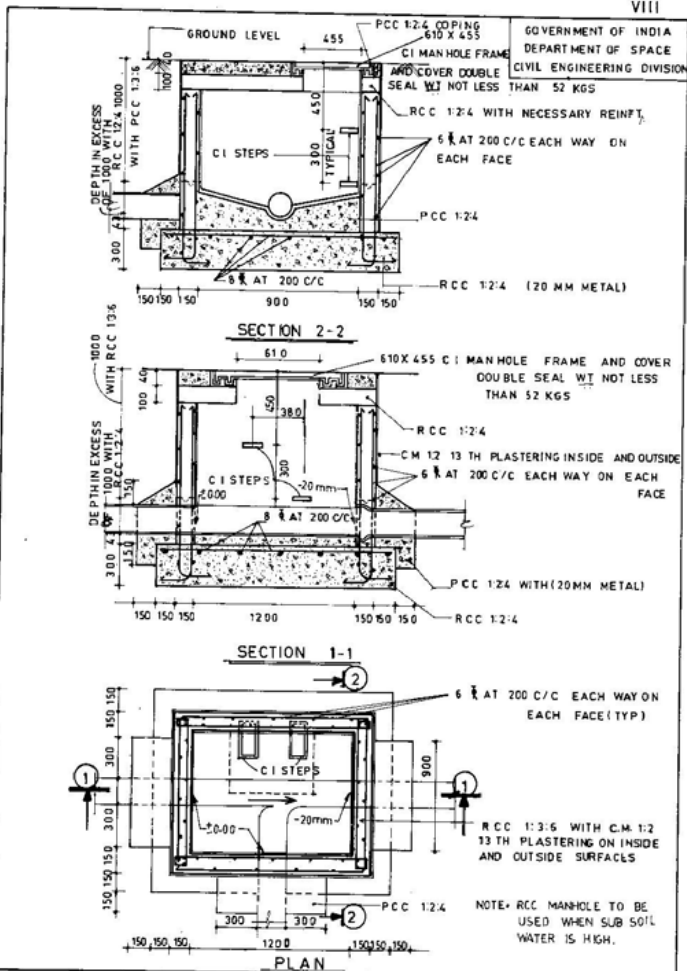
DRAWN	CHECKED	RECOMM.	APPROVED	SCALE	FIG. NO.
G. USHA	<i>P. Srinivas</i> 27/12	<i>Chinnappa</i> 16/3/85	<i>M. Srinivas</i>	1:20 DATE: 20 10 1984	CED:PH:8-6
		HEAD- PH	CHIEF ENGINEER		



TITLE: plan of manhole 800 X 800 mm for initial depth 750  
and upto 1000 mm

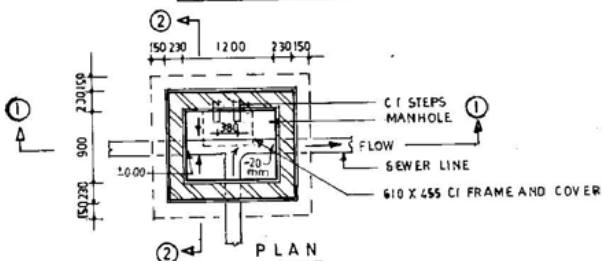
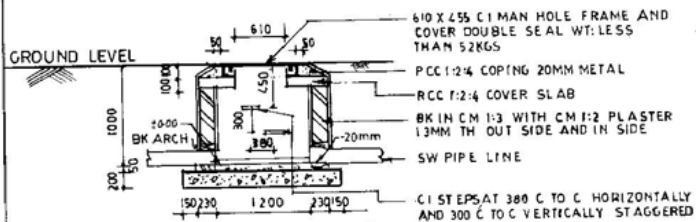
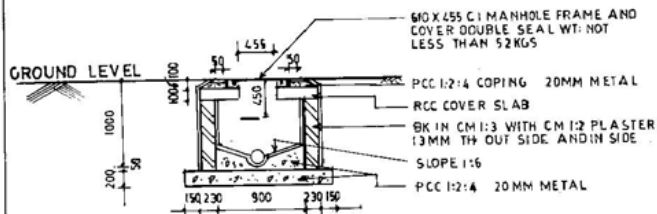
DRAWN	CHECKED	RECOMM'D	APPROVED	SCALE	FIG NO.
G. USHA	<i>P. S. S.</i> 22/12	<i>P. S. S.</i> 16/3/85	<i>[Signature]</i> CHIEF ENGINEER	1:2.5 DATE 25-10-1984	CED. PH 8-7





TITLE: PLAN OF RCC MANHOLE 1200 X 900 INITIAL DEPTH 1000 MM AND UP TO 1500 MM

DRAWN	CHECKED 27/12	RECOMM D HEAD PH 14/3	APPROVED CHIEF ENGINEER	SCALE: M.T.S. DATE: 11-1984	FIG NO. CED.PH. 8-8
G. USHA					



TITLE MANHOLE 1200 X 900 MM FOR INITIAL DEPTH UPTO 1000 MM AND UPTO 1500 MM.

DRAWN  
P-J-C

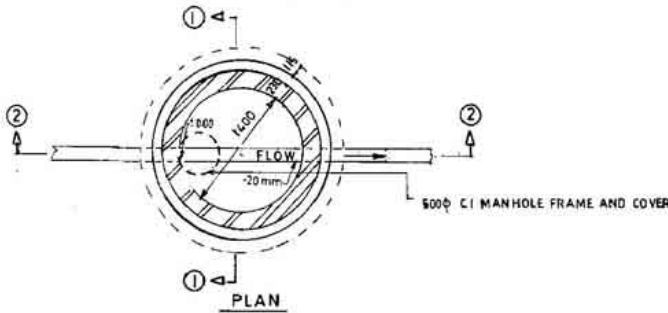
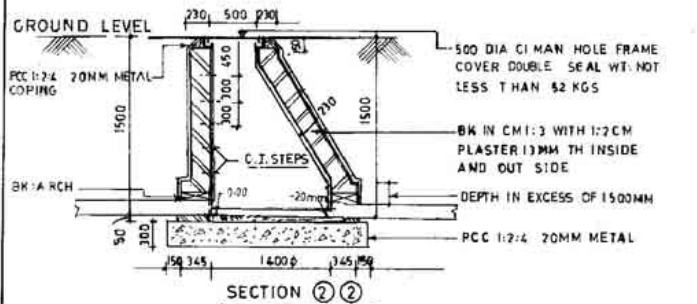
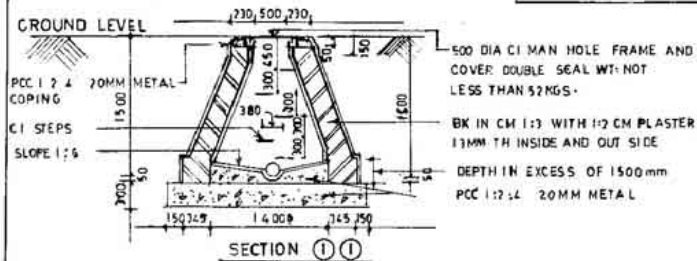
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20/12/84

RECOMMENDED  
HEAD-PH

APPROVED  
C. E.

SCALE 1:50  
DATE DEC 84

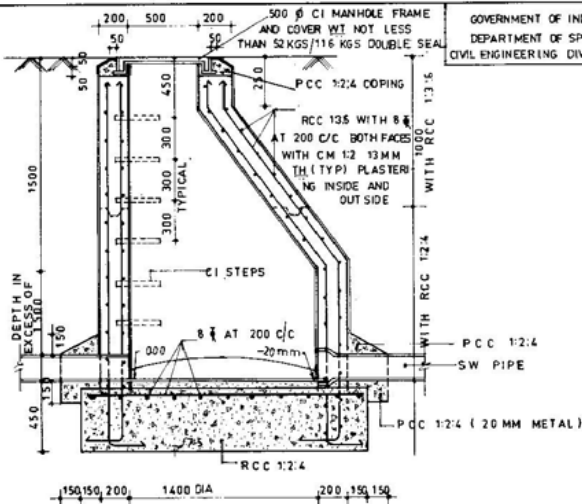
FIG NO:  
CED:PH: 8-9



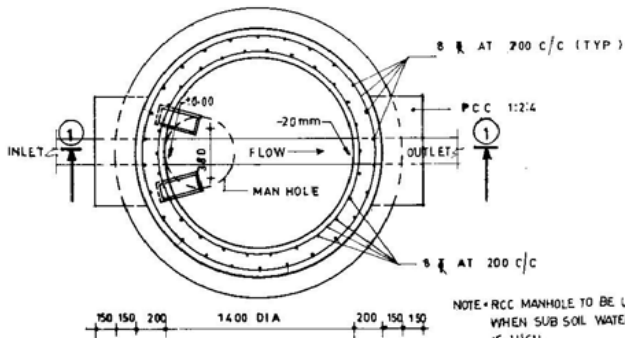
TITLE MANHOLE 1400mm DIA FOR DEPTH MORE THAN 1.5METRE.

DRAWN P. J. C	CHECKED <i>Pm</i> 25/12	RECOMM <i>Ch</i> HEAD PH	APPROVED <i>M.S. Singh</i> C. E	SCALE 1:50 DATE DEC. 64	FIG NO CED:PH: 8-10
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GOVERNMENT OF INDIA  
DEPARTMENT OF SPACE  
CIVIL ENGINEERING DIVISION



SECTION 1-1

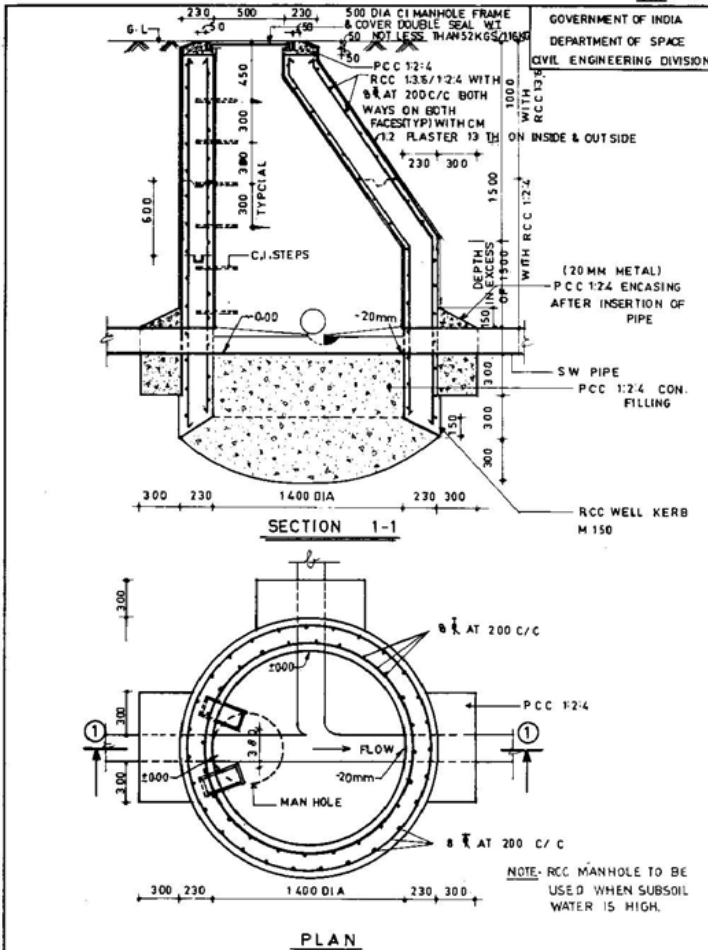


NOTE - RCC MANHOLE TO BE USED WHEN SUB SOIL WATER IS HIGH.

PLAN

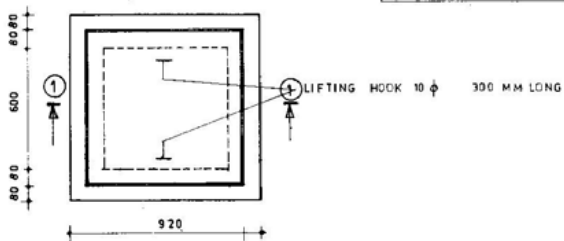
TITLE: RCC MANHOLE 1400 DIA. FOR INITIAL DEPTH 1500 MM AND UP TO 2000 MM

DRAWN	CHECKED	RECOMM D	APPROVED	SCALE:	FIG NO.
G. USHA	<i>G. Usha</i> 22/12	<i>G. Usha</i> 22/12	<i>N. S. S.</i>	N.T.S. DATE	CED: PH: 8-18
		HEAD PH	CHIEF ENGINEER	-11-84	

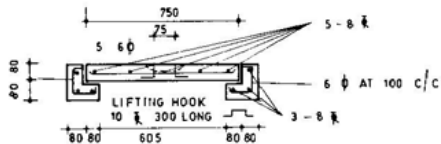


TITLE: RCC MANHOLE 1400 DIA. FOR INITIAL DEPTH 2000 MM AND FOR GREATER DEPTHS

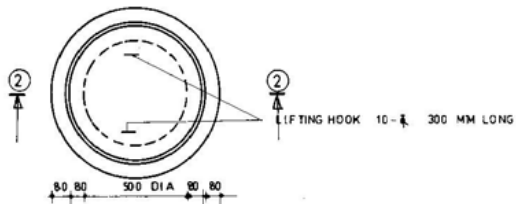
DRAWN G.USAHA	CHECKED <i>[Signature]</i> 27/12	RECOMM D. <i>[Signature]</i> 16/3/25 HEAD PH	APPROVED. <i>[Signature]</i> CHIEF ENGINEER	SCALE: N.T.S. DATE 11-84	FIG. NO. CED: PH: 8-12
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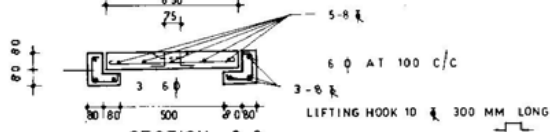
PLAN



SECTION 1-1



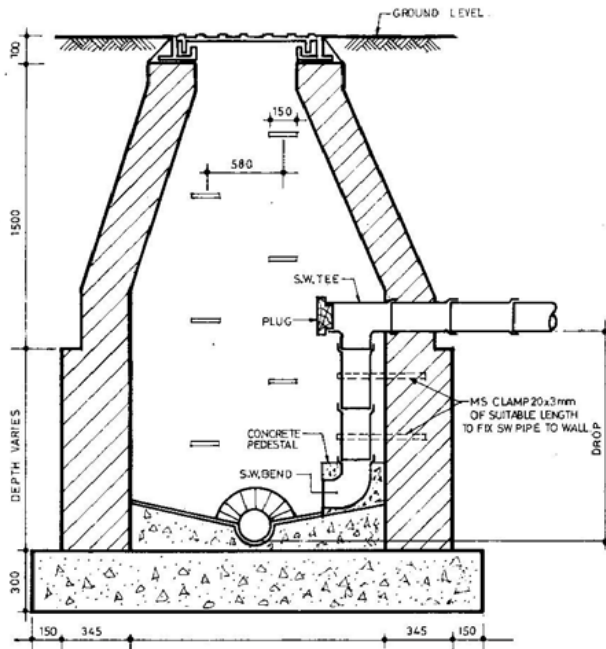
PLAN



SECTION 2-2

TITLE : PRECAST R.C. FRAME AND COVER DETAILS FOR MANHOLES.

DRAWN	CHECKED	RECOMM	APPROVED	SCALE	FIG NO
				N T S	
G. USHA	<i>[Signature]</i> 27/12	<i>[Signature]</i> 14.3.85 HEAD PH	<i>[Signature]</i> CHIEF ENGINEER	DATE 11 84	CED. PH. 8-13



## NOTE:-

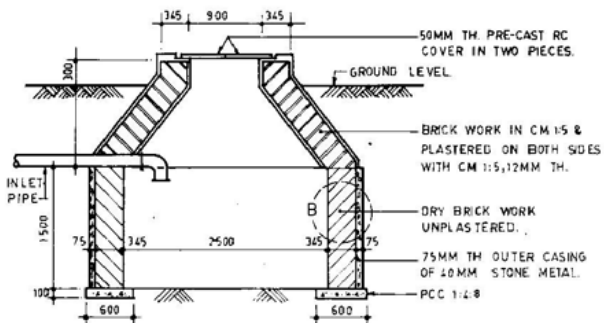
- This detail to be referred only for DROP arrangement.
- DROP arrangement as shown in the figure is to be followed only when drop is more than 60 cm.

TITLE\*

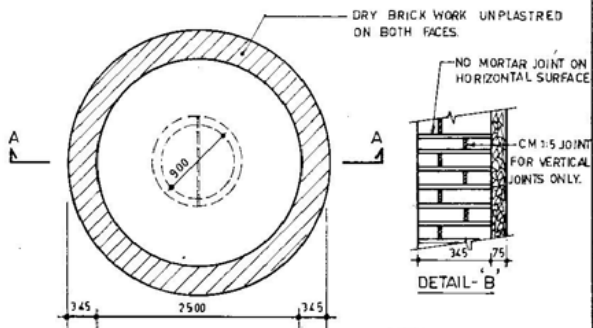
## DROP ARRANGEMENT IN MANHOLE

DRAWN* <i>M. S. Kulkarni</i> <i>B. Kulkarni</i> <i>M. S. Kulkarni</i>	CHECKED* • <i>P. S. Kulkarni</i> • 27/12	RECOMM'D* <i>M. S. Kulkarni</i> 10.10.85 HEAD-PH	APPROVED* <i>M. S. Kulkarni</i> CHIEF ENGINEER	SCALE* DATE* OCT. 1984	FIG NO* CED:PH-814
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DEPARTMENT OF SPACE  
CIVIL ENGINEERING DIVISION



SECTION 'A-A'



PLAN

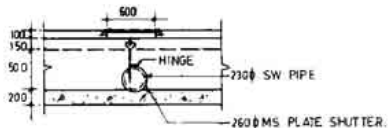
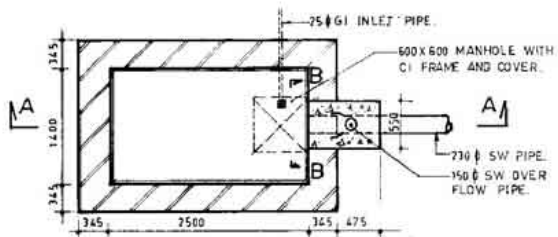
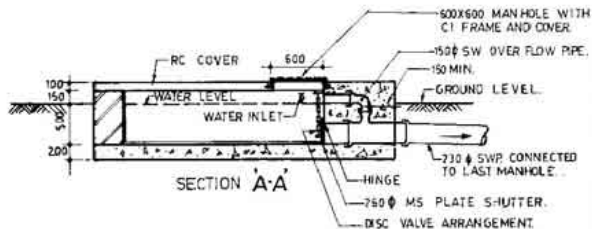
NOTE.  
PERCOLATION AREA-13.77 m<sup>2</sup>

TITLE •

## DETAIL OF SEEPAGE PIT.

DRAWN • <i>Hemant Singh</i> <i>Subhanshu Singh</i>	CHECKED • <i>P. S. Singh</i> 22/12	RECOMM'D • <i>Hemant Singh</i> 20/12/85 HEAD-PH	APPROVED • <i>H. S. Singh</i> CHIEF ENGINEER	SCALE • 1:50 DATE • OCT 1984	FIG NO • FIG:PH:8-15
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TITLE: **DETAIL OF MANUALLY OPERATED FLUSHING TANK FOR SEWERS**  
1750 LITRES CAP. UPTO 300 Ø SEWER LINE

DRAWN • <i>Handwritten Signature</i>	CHECKED • <i>Handwritten Signature</i> • 20/11	RECOMM'D • <i>Handwritten Signature</i> • 1/85 HEAD PH	APPROVED • <i>Handwritten Signature</i> CHIEF ENGINEER	SCALE • NTS DATE • OCT 1984	FIG NO. <b>CE D:PH# 8-16</b>
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SECTION IX  
**SPECIFICATION FOR SUPPLY &  
INSTALLATION OF PUMPSETS.**

## SECTION – IX

### SPECIFICATION FOR SUPPLY AND INSTALLATION OF PUMPSET FOR WATER AND SEWAGE :

#### 1. Characteristics of Water and Sewage :

##### 1.1 Pumps for Water Supply Works :

Pumps shall be of suitable material of construction for pumping clear, cold fresh water having the following characteristics.

- a) Turbidity – 50 mg/l max (sillion scale)
- b) Chlorides – 500 mg/l max
- c) Total Solids – 3000 mg/l max
- d) PH value – 6.5 to 8.5
- e) Specific gravity – 1.004 max
- f) Temperature – 33°C max

##### 1.2 Sewage Pumpsets :

- a) Total Solids – 1000 to 2200 mg/l
- b) Suspended solids – 150 to 500 mg/l
- c) Four hours oxygen consumption – 50 to 120 mg/l
- d) BOD (5 days 20°C) – 150 to 450 mg/l
- e) Alkalinity – 350 to 700 mg/l
- f) Chloride – 120 to 300 mg/l
- g) Free nitrogen – 15 to 45 mg/l
- h) Albuminoid nitrogen – 4 to 40 mg/l
- i) PH value – 6.8 to 7.9

#### 2. Different Types of Pumps :

2.1 The pumpset offered shall be generally horizontal centrifugal pump, single stage or multistage or monobloc pump to satisfy the duty conditions stipulated in the tender schedule. The pumpset shall conform to IS : 1520-1972, IS : 5120-1968 for handling water, IS : 8034 - 1976 for submersible pumpsets and IS : 5600-1970 for pumping sewage.

The pumps shall be selected having their maximum efficiency at average operating conditions. The maximum speed at which a pump shall run is determined by the net positive suction head available at the pump, the quantity of liquid being pumped and the total head.

##### 2.2 Specific pumps Suggested for Different Capacities :

However considering cost and advantage to carryout maintenance on centrifugal pumps following specific types of pumps may be used for different capacity ranges. However, this is only a suggestion and could be modified to suit individual cases.

##### 2.2.1 Water Pumps :

- i) Monobloc pumpsets upto 10 HP capacity

- ii) Coupled centrifugal pumpset above 10 but less than 15 HP
- iii) Coupled pump with split casing from 15 HP and above.

**Suction Head:**

The suction head on centrifugal pumpsets shall be limited to 4.5 mts at mean sea level at water temperature of 30°C to obtain maximum efficiency and to avoid cavitation. Suction lift is to be reduced for higher altitudes, at the rate of 1.5 m for every 1000 m above mean sea level and for higher temperature at the rate of one metre for every 5°C rise above 30°C.

In cases where suction lift exceeds 4.5 mts the centrifugal pump may be installed at a suitable elevation with reference to the liquid level to restrict suction lift to 4.5 mts. Where the suction lift exceeds 6 mts it is preferable to provide submersible pump or turbine pump or jet pump depending on the site condition.

**3. Material of Construction for Centrifugal Pumpsets :**

3.1 Material of construction for different parts of pumpset shall be as per IS:5120. Following alternatives are indicated for guidance for procuring pumps handling clear, cold fresh water.

i) Bronze fitted pump

Casing - cast iron - grade 20 of IS:210-1970.

Impeller, Casing ring, Impeller ring, Shaft Sleeve - Bronze - Grade V of IS:318-1962.

Shaft - Steel.

ii) All cast iron - Grade 20 of IS: 210 - 1970

iii) All Bronze - Grade V of IS: 318 - 1962.

iv) Standard fitted pump

Casing - Cast iron grade 20 of IS 210-1970

Casing ring, impeller ring and shaft sleeve - Bronze Grade V of IS:318-1970

3.2 The material of construction for different classes of construction shall be generally as follows:

<b>Bronze fitted</b>	<b>All cast iron pump</b>	<b>All Bronze</b>	<b>STD fitted</b>
Cast iron	Casing - Cast iron grade 20	Bronze	Cast iron
Bronze	Impellers - Cast iron grade 20	Bronze	Bronze
Bronze	Impellers wearing rings and bush - Cast iron/GM IS: 210 - 1970	Bronze	Bronze
Steel	Shaft - Steel	Steel	Steel
Bronze	Shaft sleeve - mild steel	Bronze	Bronze
Bronze	Sleeve nuts	Bronze	Bronze
CI/GM	Gland-cast iron/GM	CI/GM	CI/GM

3.3 When the quality of water is within characteristics range given in para 1.1 normally standard fitted pump shall be provided. In case of water not complying to the typical characteristics suitable material of construction shall be chosen with reference to page 25 to 27 of IS:5120.

In case of sewage the pump shall be all cast iron unless otherwise specified. In respect of chemical effluent suitable material of construction for pump shall be chosen with reference to page 25 to 27 of IS:5120.

3.4 Material Specification for submersible pump set (generally conforming to IS : 8034 - 1976) will be as indicated below :

a) Pump :

Sl. No.	Relevant Specification
i) Bearing sleeve	: Grade 3, 4 or 5 of IS : 318-1962 'Leaded tin bronze ingots and casting (revised)' or 12 percent chromium steel (grades 94 Cr 13, 12 Cr 13 and 20 Cr 13) conforming to IS : 1570 (part V-1972) 'Schedules for wrought steel : Part V stainless and heat resisting steels (First revision)'
ii) Casting wear ring	: Grade 3, 4 or 5 of IS : 318 - 1962 or grade FG 200 of IS : 210 - 1978 'Grey iron castings (third revision)'.
iii) Discharge Casing	: Grade FG 200 of IS : 210-1978.
iv) Impeller	: Grade 2 of IS : 318-1962 or grade FG 200 of IS : 210-1978 or 12 percent chromium steel (Grade 04 Cr 13, 12 Cr 13 and 20 Cr 13) conforming to IS : 1570 (part V) - 1972.
v) Pump Bowl	: Grade FG 200 of IS : 210-1978.
vi) Pump Shaft	: 12 percent chromium steel (grade 04 Cr 13, 12 Cr 13 and 20 Cr 13) conforming to IS : 1570 (Part V)-1972 or Grades C 40 or C 45 of IS : 1570-1961 'Schedules for wrought steels for general engineering Purposes'.
vii) Suction casing	: Grade FG 200 of IS : 210-1978.

b) General Requirements :

- i) Since the motor and the pump are directly coupled or close coupled, the manufacturer shall indicate the minimum size of the bore hole in which the submersible pump can be erected and suspended freely.

OR

The Clamping details for installation of pumpsets in open well.

- ii) For smooth and efficient working of the submersible pump set, the manufacturer shall recommend the minimum submergence.

c) Submersible Motor :

- i) The submersible motor shall be squirrel cage induction motor.
- ii) The windings shall be wet or dry type.
- iii) The motors shall be suitable for operation in voltages and frequency conforming to IS : 585-1963 voltage and frequency for AC transmission and distribution system (revised).
- iv) The earthing of the motor shall comply with IS : 3043 1966 'Code of practice for earthing'
- v) The thrust bearing shall be of adequate size to withstand the weight of all rotating parts as well as the imposed hydraulic thrust. These shall be lubricated suitably.

- vi) The motor shall be protected by means of cable glands, rubber seals, etc. from ingress of borewell water, sand and other foreign matter.
- vii) The rotor shaft shall be provided with shaft protecting sleeves having a surface finish of 0.75 micron Ra. Max (see IS:3073-1967 Assessment of surface roughness). However, for short length of shaft made of stainless steel, protectings sleeves may not be provided.
- viii) The motor shall be made of corrosion resisting materials or suitably treated materials to resist corrosion under normal conditions.
- ix) The motor shall have a name plate giving the following information :
  - a) Induction motor
  - b) Name of manufacturer
  - c) Manufacturer's number and frame reference
  - d) Type of duty
  - e) Frequency in Hz
  - f) Number of phases
  - g) Rated output in KW
  - h) Rated voltage and winding connections
  - i) Current, approximate, in amperes at rated output and
  - j) Speed in revolution per minute at rated output.

There shall also be an indication to identify a motor with its pump.

- x) The cable used for submersible motors shall conform to IS:694 (Part I)-1964 - Specification for PVC insulated cables with copper conductors.
- 3.5 Material of construction for other parts of pumps shall be as per IS:5120 for pumps handling clean cold fresh water.
- 3.6 Material of construction for handling sewage shall be as per IS:5600-1970.
- i) All cast iron fitted — Grade 20 of IS:210-1962.
  - ii) All stainless steel — schedule I of IS:1570-1961.

#### **4. Gaskets, Seals and Packings: (Centrifugal Pump)**

The gaskets, seals and packings used in special purpose pumps shall be suitably chosen so as to withstand the effect of liquid being pumped.

Liquid pumped clear cold fresh water - Material for seals. Mechanical seal or cotton yarn lubricated seal.

Sewage — Mechanical seal or white metal foil seal crinkled, lubricated asbestos yarn.

#### **5. Accessories for Centrifugal Pump :**

- 5.1 Essential for pumpset used for pumping water:
- a) Oil lubricator with oil level indicator if the pump is oil lubricated.
  - b) Grease cup for grease lubricated bearings.
  - c) Flanged sluice valve on suction side if there is positive suction.
  - d) Flanged sluice valve on delivery side.

- e) Flanged reflux valve (FRV) on delivery with bypass piping and G.M. valve.
- f) Pressure relief valve, Spring loaded valve to be installed outside pumphouse for high head pump.
- g) Pressure guage (for delivery pipe) and vacuum guage (for suction pipe) With brass/copper tubing and vinch cock.
- h) Priming funnel with separate or integral air cock.
- i) Float switches or automatic level operated control switch (Optional)
- j) Base plate.
- k) Foundation bolts and nuts.

5.2 Essential for pumpset used for pumping sewage.

- a) Vacuum pump if there is no positive suction.
- b) Flanged sluice valve on suction side if there is a positive suction.
- c) Flanged reflux valve on delivery side.
- d) Flanged sluice valve on delivery side.
- e) Pressure relief valve. (For high head pumps)
- f) Coupling
- g) Pressure (for delivery pipe) and vacuum guage (for suction pipe) with brass/copper tubing and vinch cock.
- h) Base plate.
- i) Foundation bolts and nuts.
- j) Ball type air relief valve.
- k) An automatic level operated control switch may be provided as an optional accessory.

## **6. Essential Design Features :**

The pumps shall have suitable features properly designed to ensure satisfactory performance. In particular design features, such as the following shall be incorporated.

### **6.1 For Water Pumpsets :**

- a) In case of more than one duty point, the performance range is to be indicated and the prime mover should be of sufficient power to take the entire load in this range. Head restrictions shall be indicated in the name plates to avoid overloading of the prime mover.
- b) For working in parallel pumps should be with stable head capacity characteristics.
- c) Arrangement for cooling of bearings where required.
- d) Balancing water leakage connection should be provided in case of multistage pumps with balancing discs.
- e) Thrust bearing of adequate size.

### **i.2 For Sewage Pumps:**

- i) The size of solids should be atleast upto 80 percent of the outlet width of the impeller.
- ii) Casing and impeller should be so designed as to allow free passage of the specified max size of solid.
- iii) Hand holes should be provided in the casing, one to allow early access to the impeller eye and one as close as possible to the casing throat.
- iv) On account of the abrasive nature of sewage, provision should be made on stuffing boxes to ensure clear water supply or grease lubrication to the glands shall be provided from external sources according to the directions of the manufacturer.

### **7. Information to be furnished by the supplier along with tender for performance with clear cold fresh water.**

- 1) Pump type
- 2) Discharge in litres per second
- 3) Head in metres
- 4) Suction pipe size in mm dia
- 5) Delivery pipe size in mm dia
- 6) Power at shaft in kw
- 7) Speed in revolution per minute
- 8) Required NPS in metres
- 9) Performance curves
- 10) Materials of construction
  - i) Casing - Cast iron Gr.20 IS: 210-1470
  - ii) Casing ring-GM/ - do -
  - iii) Impellers - cast iron
  - iv) Impeller wearing rings and bush cast iron/GM
  - v) Shaft-steel
  - vi) Shaft Sleeves - mild steel
  - vii) Gland - cast iron/GM
  - viii) Sleeve nuts - CI/GM
- 11) Recommendations of manufacturer shall be furnished for:
  - a) Suction pipe size in mm dia
  - b) Delivery pipe size in mm dia
  - c) Weight of the pump in kg
  - d) Any special instructions for installation, operation and maintenance including use of special tools
- 12) Sealing arrangements
- 13) Recommended spares for 2 years service and cost
- 14) Primer mover - all information corresponding to the particulars in the item for satisfactory performance of the pump.



## **8. Pump Set :**

Pump tests are made to determine the following :

- a) The discharge against the specified head when running at the rated speed under specified suction lift or head.
- b) The power absorbed by the pump at the pump shaft (BHP) under the above specified conditions and
- c) Efficiency of the pump under the above specified conditions.

The pump has to be tested at manufacturer's works and a test certificate furnished before supply and tested at site after installation as per procedure in clause 13 of IS :5120 - 1968.

## **9. Pump Installation :**

### **9.1 Installation :**

Certain precautions must be observed in planning a pump installation and during the erection period. Some of these points to be considered are given below.

### **9.2 Piping :**

Both the suction and discharge lines should be independently supported so as no strains will be thrown on the casing ; such strains may cause distortions and rubbing.

9.3 The suction line should be as short and straight as possible. Any elbows should have large radii. For pumps operating with suction lifts no valves other than a foot-valve should be placed in it. Generally, the diameter is made one or two sizes larger than the pump flange size. All these precautions insure the maximum available suction head on the pump. When an oversize line is used an eccentric reducer which is horizontal at top is placed between it and the pump flange as illustrated in **figure No. 9.1, 9.2.**

9.4 It is very important to have the suction line airtight and to avoid high spots at which dissolved gases or air might separate out and destroy the vacuum. After the piping is installed and the pump is running all joints should be inspected with a flame, as air leakage will draw the flame to the opening. The same method can be used to determine leakage through the packing box. The eccentric reducer is used at the suction flange to avoid high spots at which the air might collect. The inlet end of the suction line i.e. submergence should be 1 to 2 m below the minimum water level of the pump (not less than 1m) to prevent air from being drawn into the pipe with the water.

9.5 It is desirable to have as long a length of straight piping between the elbow and suction flange as possible to even out the flow of the water as it enters the pump. The pump should be placed to secure the greatest possible suction head and yet be available for inspection and repair work.

9.6 A check valve and a gate valve are usually placed in the discharge line. The gate valve is used to regulate the flow and the check valve prevents backflow into the pump which might cause it to operate like a turbine and perhaps be damaged on account of overspeed. The check valve is placed between the gate valve and the pump so that it may be inspected or repaired without emptying the discharge line.

### **9.7 Foundation :**

The foundation should be heavy to reduce vibrations and should be rigid enough to avoid any

twisting or misalignment. A space of 2 to 4 cm is allowed between the base plate and top of the foundation which is filled with grouting to secure a uniform load distribution.

When the grouting had dried the base plate should be drawn down evenly to avoid springing it. After this has been done the shaft is finally aligned both radially and axially with the driver by means of shims or wedges so that it turns freely. If the shaft is not properly aligned there will be vibration and excessive wear on the bearings, packing and wearing rings. (Ref. fig. 9.2)

## **10. Pump Operation :**

### **10.1 Trial Operation**

The operation of centrifugal pumps is quite simple and safe. There are relatively few valves and the pump will not be damaged even if the discharge valve is closed for short periods of time.

**10.2 Starting** - The pump must be primed before it will deliver any fluid. Failure to prime the pump may cause the wearing rings rub and seize or the shaft may be scored at the packing boxes. During starting it is wise to have the ventcock in the casing open slightly to remove any dissolved air in the water.

It is best to have the discharge valve closed so that the least load is thrown on the driver when the pump is started. The valve should be opened gradually to avoid throwing a large sudden load on the driver and to prevent a sudden surge in the discharge line. The discharge valve should be fully open when starting mixed flow or propeller pumps because the brake horse power will then be a minimum.

**10.3 Running** : When the unit is running it requires very little attention beyond occasionally checking to see that (a) the journal and thrust bearings are running cool and have a sufficient supply of oil (b) the packing is adjusted to permit a slight leakage to cool and lubricate it and (c) the water is flowing to the water seal if the suction gland to prevent air from leaking in.

**10.4 Shutting Down** : When shutting down, the discharge valve should be in the same position as when starting up by closing the discharge valve gradually so that less power is dropped from the line and any sudden pressure surges in the pipe system are avoided.

**10.5 Inspection and Maintenance** : Manufacturers supply instruction books which give directions for the operation and maintenance of each pump. The following information is for general guidance.

The wearing ring clearances should be checked as they will increase with time and thus cause a decrease in efficiency. The frequency of the inspection will depend upon the liquid handled. If the liquid contains gritty materials or is corrosive, inspection may be made monthly, but if clear water is pumped it may be sufficient to check them annually. A general rule is to replace the rings when the clearance has increased 100 percent above the original.

The packing should be replaced after it becomes hard and tends to score the shaft. When the packing is being replaced, the finish of the shaft sleeves should be examined for smoothness. It is essential that the lantern ring be placed directly under the water inlet when putting in the new packing to ensure a circulation of the water and a satisfactory seal. The packing shall be gradually compressed with the pump running. It should not be compressed too much as local heating of the shaft and consequent misalignment will result. A slight leakage will ensure proper lubrication and cooling.

If the base is not too rigid the shaft alignment should be checked occasionally when the pump is at a temperature corresponding to running conditions. This must be done with the packing removed. At the same time the clearance of the journal bearings should be checked for wear. (For vertical shaft couplings lubricated with oil seal).

The entire pump should be dismantled periodically and examined for excessive wear corrosion.

#### **11. Guarantee of Performance :**

a) The pumps shall be guaranteed by the manufacturer/supplier against defects in material and workmanship under normal use and services, for a period of at least one year from the date of despatch/installation.

#### **b) Guarantee of Performance :**

The supplier shall indicate the working range of the pump and the efficiency of the pump shall be guaranteed at a specified point of rating. If the department so desires, the manufacturer or supplier shall guarantee the non-overload of the prime mover for variations in the head in the working range. In the case of pumps where acceptance tests cannot be conducted on the liquid for which the pump is designed, the manufacturer shall indicate the liquid performance of the pump based on the results of the tests conducted by him on the pump with water as indicated under clause 13 and interpolated as explained under clause 14 of IS:5120. However, in these cases, the manufacturer shall guarantee for the performance of the pump with water for the specified range.

c) **Tolerance :** A tolerance of  $\pm 2.5$  percent shall be permissible on the discharge. However, for small discharges upto 900 litres per minute, a tolerance of  $+ 2.5$  percent shall be permissible on the discharge. However, for small discharges upto 900 litres per minute, a tolerance of  $+ 2.5$  percent or  $+ 24$  litres per minute whichever is higher, is allowed, while the negative tolerance of 2.5 percent is maintained.

The pump efficiency shall be not less than the specified value by more than 2.5 percent. This tolerance may be raised to 5 percent in case the prime mover does not get overloaded.

#### **12. General Requirements of Design Features of Pumps (For Information)**

a) **Performance :** The specified range shall lie on the stable portion of the head characteristic curve. This is applicable in case of parallel operations of pumps only.

b) **Suction and Delivery Ends :** The size of the suction end of a double suction pump should preferably be one size larger than that of the delivery. This is to offset the increased loss in the suction. Typical practices of pipes used are :

85/65 mm, 100/75 mm, 125/100 mm, 150/125 mm, 200/150 mm and 250/200 mm etc.

c) For a high pressure pump, a reflux valve shall be connected on the delivery side and a pressure relief valve installed in the pumping main outside pumphouse. Need for surge control devices verified.

d) **Fluid Passages :** All the liquid passages in the casing and the impeller which are inaccessible to machining shall be finished to smooth surface as far as possible.

e) **Drainage Plugs :** Tapped drain holes with plugs shall be provided for draining the fluid that

may drip from the sealing arrangement. The sealing arrangement shall be sufficiently deep to provide for sufficient quantity of packing to prevent leakage of air.

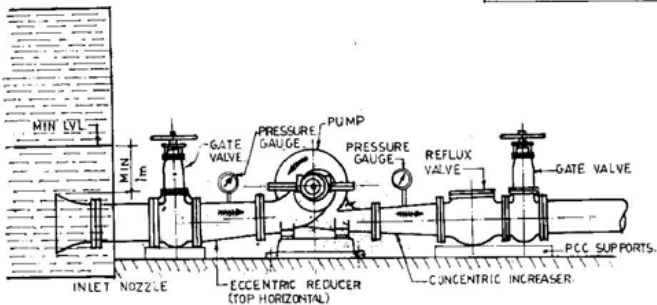
- f) **Lantern Ring** : In case, where a lantern ring is used in a stuffing box, it shall be sandwiched between rows of packings and shall be easily removable.
- g) **Casing** : Casing shall be of robust construction and tested to withstand 1.5 times the shut-off pressure or twice the rated pressure, whichever is higher.
- h) **Impeller** : The impeller shall be properly balanced along with any other unmachined rotating parts on proper balancing equipment so as not to cause any vibration.
- i) **Shaft** : The shaft shall be finished to close tolerances at the impeller coupling, pulley and bearing diameters. The impeller, pulley and shaft sleeves shall be firmly secured to the shaft by keys or nuts or both.
- j) **Shaft Couplings** : Shaft couplings, where provided, shall be properly aligned and firmly secured to the shaft by keys or nuts or both.
- k) The size of the shaft shall be calculated on the basis of the total maximum combined shear stress. This shall not exceed 30 percent of the elastic limit in tension or 18 percent of the ultimate tensile strength.

The next higher standard size of shaft in accordance with the relevant standard shall be chosen.

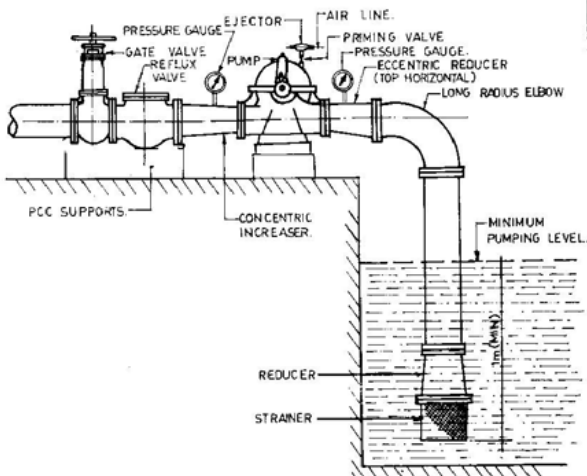
The design of the shaft shall also take into consideration the critical speed of the shaft which shall differ from the actual working speed by at least ten percent on either side.

- l) **Bearings** : The bearings should be designed for a minimum life of 20,000 hours or 40,000 hours as required. The bearing housings shall be designed in such a manner that no liquid being pumped should enter the housing.
- m) The bearings may be ball, roller or sleeve bearings. In the latter case, some sort of thrust bearings are necessary. If sleeve bearings are used, they are to be machined for close running fit. The bearings shall be so designed as to take up the necessary radial load as well as the net hydraulic axial thrust. Bearings shall be lubricated properly.
- n) Where there is a possibility of fluid entering the bearings, the pump shall be provided with suitable preventive arrangements, for example, deflectors.
- o) **Stuffing Boxes** : The stuffing boxes shall be extra deep and provided with a cooling water jacket if so required. In addition, provision for tapping off the leakage liquid shall also be made. The packing materials employed shall be suitable for withstanding the special conditions such as temperature, corrosion due to the fluid being handled etc. Wherever possible, suitable mechanical seals may be used.
- p) **Base Plates** : The base plate which accommodates the pump or the pump and the prime mover, when provided, shall be rigid and stable so that alignment is not affected under normal working conditions.
- q) **Prime Mover** : The prime mover shall be of such a capacity as to provide, under working site conditions, a power which is more than the maximum power required by the pump at any point in the specified range. Should a specific margin be required by the customer in the power of the prime mover, he should so advise the manufacturer for obtaining the proper recommendations.

- r) **Name Plate:** Every pump shall have a name plate indicating :
- a) name and address of the pump manufacturer ;
  - b) type, size and serial number of the pump ; and
  - c) speed, total head, capacity and corresponding pump input for the duty point.
- s) For corrosive liquids the material of the name plate shall be suitable to withstand the corrosive atmosphere.



PUMP INSTALLATION WITH POSITIVE SUCTION HEAD.

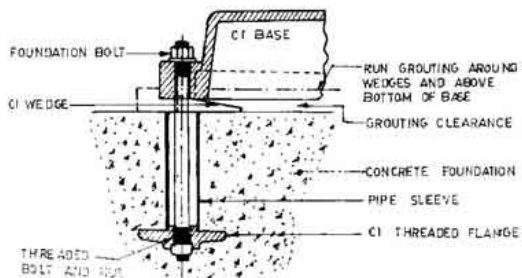


PUMP INSTALLATION WITH SUCTION LIFT.

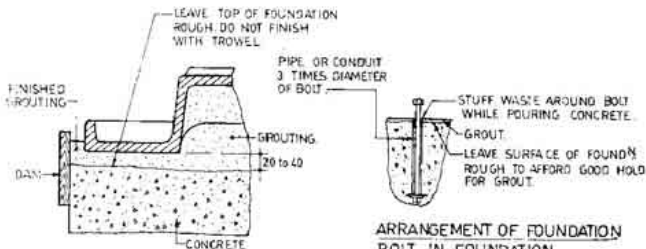
TITLE •

DETAIL SHOWING INSTALLATION OF PUMP.

DRAWN 10/11/85	CHECKED S. Srinivasan 10/11/85	RECOMMENDED S. Srinivasan 10/11/85 HEAD-PH	APPROVED H. D. Srinivasan CHIEF ENGINEER	SCALE NTS DATE DEC 1984	FIG NO. CED:PH: 9-1
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SECTION

ARRANGEMENT OF FOUNDATION  
BOLT IN FOUNDATION.

SCAFFOLDING BUILT AROUND  
FOUNDATION BEFORE POURING  
GROUT UNDER BED PLATE.

TITLE •

FOUNDATION BOLT DETAIL FOR PUMP SET.

DRAWN • <i>Heavilla</i>	CHECKED • <i>Chandra</i>	RECOMM'D • <i>Heavilla</i>	APPROVED • <i>Heavilla</i>	SCALE • NTS	FIG NO •
		HEAD-PH	CHIEF ENGINEER	DATE • DEC 1984	CED:PH:92

SECTION X  
**SPECIFICATIONS FOR SEPTIC TANKS  
SOAK PITS AND DISPERSION TRENCHES.**



## SECTION – X

### BRIEF SPECIFICATIONS FOR SEPTIC TANKS, SOAK PITS AND DISPERSION TRENCHES

#### SCOPE :

This specification covers the method of construction of septic tanks, dispersion trenches and soak pits. The specification includes 1) Materials, appliances and components. 2) Location of septic tanks. 3) Septic tank construction details. 4) Sub-surface absorption systems. 5) Inspection and testing of septic tanks. 6) Commissioning of septic tanks.

#### 1. Materials, Appliances and Components :

1.1 All materials used in the construction of septic tanks and its appurtenances shall conform to relevant detailed civil works specifications and items not covered in civil works specification should conform to relevant Indian Standards and or CPWD specifications.

1.2 Items of works like earth work, plain cement concrete, brick masonry, stone masonry, reinforced cement concrete, form work, reinforcement etc., shall be done as specified and described in relevant detailed civil works specifications.

1.3 In this specifications septic tanks constructed of masonry, concrete and hume pipe septic tanks are considered which are generally used.

#### 2. Location of Septic Tanks :

2.1 Septic tank shall be located at a place open to sky preferably at 10 m distance from the building and necessarily at a minimum distance of 6 m away from the exterior of the wall of building and not less than 18 m clearance from any service or storage of drinking water at or below ground level. Suitable accessibility to the location of septic tanks shall be provided for cleaning purposes.

The location shown in PH drawings are to be verified at site for its suitability with reference to existing water sources, adjoining buildings, ground level sub-soil strata and ground water level etc., and locations finalised at site and wherever locations are changed the same shall be informed to Chief Engineer and modified PH drawing obtained.

#### 3. Septic Tank - Construction Details :

3.1 **Construction :** Septic tanks constructed may be of brick work, stone masonry, concrete Hume pipe or other suitable materials, as specified in the drawing.

3.2 **Brick Work and Stone Masonry :** Walls built out of brick should not be less than 200 mm thick and should be plastered to a minimum thickness of 20 mm inside and outside with cement mortar not weaker than 1 : 3 with water proof compounds as additive. In case of stone masonry the minimum wall thickness shall be 380 mm.

3.3 **Concrete :** When concrete septic tanks are provided the same may be built out of precast or cast in situ concrete and shall have a mix of proportion not lesser than grade M 200.

#### 3.4 Hume Pipe Septic Tank :

Precast, factory made hume pipe septic tanks wherever proposed shall be of reinforced concrete. These tanks shall have suitable openings for inlet pipe, outlet pipe, access opening and

lid and vent hole and shall be provided with a vent pipe and ventilating cowl protected by mosquito proof wire net.

3.5 The floor sloping should be of cement concrete of grade M150 and should be sloped towards the sludge outlet.

3.6 **Cover:** Every septic tank shall be provided with a water tight cover of adequate strength. Access openings are intended for cleaning without entry of men. Entering of work men inside septic tanks should be prohibited as it will lead to fatal accidents of asphyxiation due to obnoxious gases.

If circular, clear opening shall be 500 mm dia minimum and if rectangular, the opening shall have minimum dimensions 500 X 500 mm.

3.7 **Ventilating Pipe:** Every septic tank shall be provided with ventilating pipe with a minimum diameter 50 mm or as specified in drawings. The top of the pipe shall be provided with a suitable cage of mosquito proof mesh. The height of ventilating shaft shall not be less than 2M if the septic tank is located 15M away from building, if it is located within 15M then the height shall be 2M above the height of building.

#### 3.8 Disposal of Sludge:

The sludge removed from septic tanks shall not be applied on ground as it may give rise to smell. In case of precast Hume septic tank and small tanks wherever desludging chamber is not provided cover shall be removed and kept open to allow the foul gases to escape. The sludge and sewage present in the septic tank may be pumped out to an excavated pit using a sewage pump or bailed out using buckets and rope and may be delivered into an excavated pit and neatly covered with a 50 cms, layer of earth. Sludge may be removed by operating the sluice valve in the sludge withdrawal pipe and collecting the sludge in a bucket. Care shall be taken that no persons enter the septic tank for desludging.

#### 4. Sub Surface Absorption Systems:

A sub soil dispersion system shall preferably be about 25 metres away and necessarily shall not be closer than 18 M from any sources of drinking water and 6 M away from exterior wall of the building. In lime stones and rock formations with crevices any absorption system should not be located. In such locations the effluent shall be treated with trickling filter and chlorinated and disposed.

#### 4.2 Construction of Soil Absorption Systems:

a) **Sock Pit:** Soak pit shall be constructed generally as per details shown in the **fig. No. 10.1** and of required diameter and depth as may be necessary.

Earth work excavation for soak pit shall be done truly vertical and in loose soils. Extra protection shall be taken by providing shoring and strutting to retain section of pit. Alternatively suitable offsets as applicable to excavation of deep trenches may be given. (Refer specification for excavating deep trenches for gravity sewers). The filling up stone metal shall be in stacks of a height of 1 M with necessary wooden planks or plywood supporting sheets between 150 mm stone metal and 75 mm metal and quarry dust. After filling 1 M height the wooden planks or plywood shall be pulled up to further height of 85 cms leaving 15 cms overlap in filled up materials as anchorage and further filling of metal continued upto bottom of bamboo mat. At appropriate

invert level inlet stone ware pipe shall be laid before continuing the filling over the bamboo mat. (Any country wood plank can be used in place of bamboo mat at no extra cost after approval of Engineer-in-Charge). One layer of 1000 gauge or 250 micron LDPE polyethylene film will be laid above bamboo mat before earth filling (filling shall be 150 mm above G.L. and turfing to be provided on top).

**b) Dispersion Trench :**

Dispersion trench shall be constructed as per details shown in **figure No. 10.2**. Open jointed glazed stoneware pipes shall be used for dispersion of effluent. Care shall be taken to place the direction of sockets down stream. The gradient to be given in the open jointed pipe length shall be very minimum i.e. 1 : 300 which is provided only to overcome the frictional loss. Provision of any additional gradient will result in non-utilisation of the dispersion trench on the upper portions and all the effluent will flow down to the tail end of trench which is not desirable.

**4.3 Laying of Filter Media Bamboo Mat, LDPE Film etc.**

The trench shall be cut to the size as shown in the fig. 10.2, with 1 in 300 gradient at trench bottom. The width of trench shall be 1 metre. The depth of trench shall be such that to provide 150 mm depth of 20 mm stone media below the invert level of the stone-ware pipe and 450 mm height of stone media above the crown level of stoneware pipe. The vertical sides and bottom of trench shall be neatly trimmed, 20 mm crushed stone shall be filled up in the trench bottom to a uniform depth of 150 mm. The open jointed stone ware pipes shall be laid to gradient of 1 in 300 along the centre line of the trench providing equal width of stone media on both sides of the stoneware pipe. The balance 450 mm depth shall be filled fully with 20 mm crushed stone on the sides of pipe and then to the full height without damaging the stone ware pipe or shifting the alignment of pipe. The stone metal shall be filled in the pipe by gently placing the stone jelly to prevent damage to SW pipe. Dumping of stone jelly from above the trench should not be resorted to. The open jointed portion of SW pipes shall be first covered with stone jelly and the remaining portions done later. 12 mm crushed stones shall be filled up to a depth of 150 mm. Over this metal a layer of bamboo matting both surfaces coated with bitumen shall be laid horizontally on levelled surface of stone jelly. A layer of LDPE polyethylene film of 250 microns shall be laid over the bamboo mat with suitable overlapping pasted with appropriate synthetic adhesive. The balance depth shall be filled up with excavated earth consolidating moderately and an earthen mound of 150 mm high above ground level as shown in **fig. 10.2** shall be formed to avoid formation of drain by subsidence of earth which will collect rainwater and disturb the functioning of absorption system.

4.4 During excavation the soil condition shall be verified by Engineer-in-Charge and in case of larger septic tanks percolation rate test shall be done at site and length of dispersion trenches decided at site.

4.5 Wherever such sub soil water level is high, septic tank shall be located not far away from the building to minimise depth of dispersion trench below ground level. In worst cases pumping of the septic tank effluent to the dispersion trench laid at an elevated place free from ground water may have to be resorted to.

**5. Inspection and Testing of Septic Tanks :**

**5.1 Inspection :**

The work at all stages shall be carefully inspected to ensure that work is done as per specification

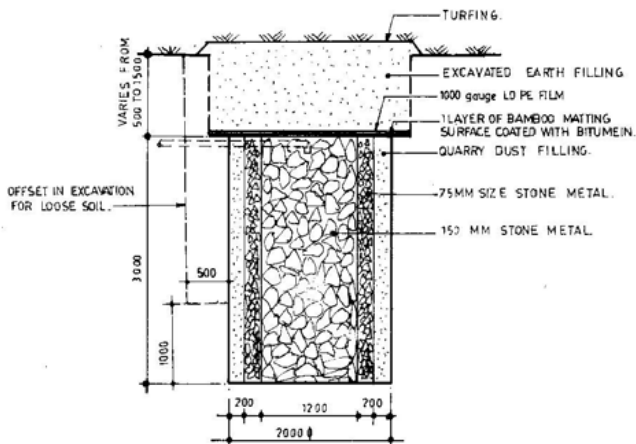
herein specified and also relevant specifications for civil works.

**5.2 Testing:**

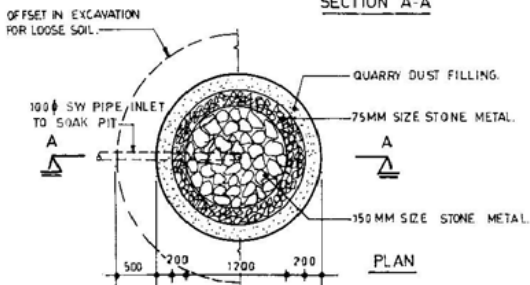
Before commissioning the tank for use it should be tested for water tightness by filling with water and allowing it to stand for 24 hours. It should be topped up, if necessary and allowed to stand for a further period of 24 hours during which time the fall in the level of the water should not be more than 1.5 cms. If the fall is more than 1.5 cms then leakages in septic tanks shall be traced and arrested before commissioning.

**6. Commissioning of Septic Tanks :**

The tank should be filled with water to its outlet level before the sewage is let into the tank. It should, preferably be seeded with small quantities of digested sludge, obtained from septic tanks or sludge digestion tank. In the absence of digested sludge a small quantity of decaying organic matter such as digested cow dung may be introduced.



SECTION A-A



TITLE\*

DETAILS OF SOAK PIT (2m dia, 3m deep)

DRAWN\*

*V. Srinivasan*

CHECKED\*

*[Signature]*

RECOMMND\*

*[Signature]*  
10-1-85  
HEAD - PH

APPROVED\*

*[Signature]*  
CHIEF ENGINEER

SCALE

1: 50

DATE\*

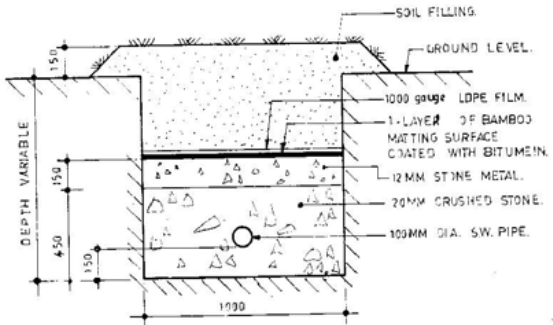
NOV 1984

FIG NO.

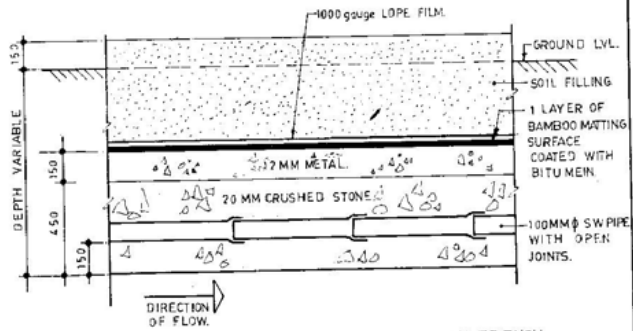
FIG:PH:10-1

X

GOVERNMENT OF INDIA  
DEPARTMENT OF SPACE  
CIVIL ENGINEERING DIVISION



CROSS SECTION OF DISPERSION TRENCH



LONGITUDINAL SECTION OF DISPERSION TRENCH.

TITLE •						DETAILS OF DISPERSION TRENCH	
DRAWN • <i>S. Sankaranarayanan</i>	CHECKED • <i>S. Sankaranarayanan</i>	RECOMM'D • <i>S. Sankaranarayanan</i>	APPROVED • <i>S. Sankaranarayanan</i>	SCALE • 1:20	FIG NO •		FIG:PH-10-2
		HEAD - PH	CHIEF ENGINEER	DATE • NOV 1984			

## ERRATA

Section	Page	Para	Printed as	To be read as
Contents	i	6	Fire clay chinaware kitched sink and drain board	Fire clay kitchen sink and drain board
	iii	1.7	page No.26	Page No.25
	iii	1.7.3.3	page No.27	Page No.26
	iii		Para No.1.8.2 Page No.28	Para No.1.8.1 Page No.27
	iv	1.5	Quantity	Quality
IX	xii		Pumbsets	pumpsets
	xiii	5	Assessories	Accessories.
		11	Gurantee	Guarantee.
I	i	1.5	wherever	wherever
	3	3.1	where-ever	wherever
	4	4.1	hexagonal nipples,pillar cock, stop cock etc.,	hexagonal nipples etc.,
	4	5.1(5)	connecon	connection
		5.1(6)	whereever	wherever
	4	6.2	waste coupling and coupling of	waste coupling of
	5	8.1.2	drain borad	drain board
II	6.	8.4.1	with detachable CP brass	with CP brass washers
	19	3	shll	shall
	19	4	two pieces or screwed	two pieces are screwed
	20	6.4	horizontl	horizontal
III	24	1.2.2	imperfecions	imperfections
	26	1.7.3.3	1.7.3.21(d)	1.7.3.21
	26	1.7.3.12	...not exceeding 30 percent).	...not exceeding 30 percent). The jointing of CI soil pipes shall be done as described in section IV page 36 para 3.1.4.2 and sketch CED/PH/4.1 at page 41
I	27	1.7.3.23	The upper and	The upper end
	29	2.7(c)	diameter of 1200mm	diameter of 1470mm
IV	32	1.4.2.1 Table-1	Bends (plains)	Bends (Plain)
		7	For ears case	For ears cast
	35	1.6.3.8	quantity exceeding 300 mm	quantity exceeding 300 metres

Section	Page	Para	Printed as	To be read as
V	46	2.5	likelihood	likelihood
	46	2.7	compated	compacted.
	47	2.9	shorting	shoring
	48	3.1	thereafter shall be damaged	thereafter if damaged
	55	6.9	$qL = NP D/33$	$qL = \frac{ND\sqrt{P}}{3.3}$
	57	7.8	reinforced	reinforced
VI	70	3(a)	trenched	trenches
	71	3.2(c)	converting	conserving
	73	6(c)	in Table	in Table-3
	74		Table-2	Table-3
	75	10(c)	in Table-3 Table-3	In Table-4 Table-4
VII	79	5.3.3	then using guide ropes.	then lowered gently into the trench using guide ropes.
	80	5.4.3.2	with a small teeth	with small teeth
	82	5.4.6	burried	buried
	82	6.3		Contents in page 84 to be read in continuation of page 82 and contents of page 83 to be read in continuation of page 84.
	87	1.3	Table un-numbered	Table in page 87 to be read as Table-1
VIII	94	5.2	Gigh ground water table	High Ground water table.
	95	5.12(b)	Fig 2.1	Fig. 8.1
	97	7.3	..does not empty with in thirty minutes.	..does not empty with in thirty minutes and make up water added to maintain constant water level in funnel in 30 minutes shall not exceed 0.006 Lts/cm dia/meter length of SW pipe.
	99	16	rods and foothpaths	roads and footpaths
	IX	122	9.3	radie
X	130	4.2(a)	sock pit	soak pit.



# ELECTRICAL ENGINEERING SPECIFICATION

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SECTION I  
**INTERNAL WIRING**

**SECTION – I**  
**SPECIFICATION FOR INTERNAL WIRING**

**1.0 Scope :**

This specification is intended to cover the requirements of supply, installation, testing and commissioning of electrical wiring installations and other accessories required for its satisfactory operation. This also covers the essential requirements for precautions regarding wiring installations for ensuring satisfactory and reliable service. It relates to all wiring installations in non-industrial, industrial and residential buildings. This specification covers different types of wiring such as teak wood batten, surface conduit and concealed conduit wiring, for system voltage not exceeding 650 V.

**2.0 Standards :**

The Electrical wiring installations and other accessories shall comply with latest IS : 732 (part-II)-1983 and National Electrical Code – 1985.

**3.0 Terminology :**

For the purpose of this specification, the following definitions shall apply :

- i) Accessory: Any device, associated with the wiring and electrical appliance of an installation, for example, a switch, a fuse, a plug, a socket out-let, a lamp holder or a ceiling rose.
- ii) Bunched : Cables are said to be 'Bunched' when two or more are contained within a single conduit, or if not enclosed, are not separated from each other.
- iii) Circuit: An arrangement of conductor or conductors for the purpose of conveying electrical energy and forming a system or a branch of a system.
- iv) Cleat: An insulated incombustible support normally used for insulated cable.
- v) Aerial Conductor: Any conductor which is supported by insulators above the ground and is directly exposed to the weather.
- vi) Connector: A mechanical clamp shrouded in insulating material for connecting the conductor of a cable or of a flexible cord to that of another cable or of another flexible cord.
- vii) Connector Box or Joint Box: A box forming a part of wiring installation, provided to contain joints in the conductors of cables of the installation.
- viii) Direct Earthing System: A system of earthing in which the parts of an installation are so earthed as specified but are not connected within the installation to the neutral conductor of the supply system or to earth through the trip coil of an earth leakage circuit breaker.
- ix) Earth: A connection to the general mass of earth by means of an earth electrode. An object is said to be 'earthed' when it is electrically connected to an earth electrode; and a conductor is said to be 'solidly earthed' when it is electrically connected to an earth electrode without a fuse, switch, circuit-breaker, resistance or impedance in the earth connection.

- x) Earth Continuity Conductor: The conductor, including any clamp, connecting to the earthing lead or to other parts of an installation which are required to be earthed. It may be in whole or in part, metal conduit or the metal sheath or armour of the cables, or the special continuity conductor of a cable or the flexible cord incorporating such a conductor.
- xi) Earthing Lead: The final conductor by which the connection to the electrode is made.
- xii) Installation: All the electrical wiring, accessories, fittings, consuming devices, control and protective gear and other apparatus associated with the wiring situated on any premises in which electricity is supplied or is to be supplied through any one service to a consumer or consumers.
- xiii) Live or Alive: Electrically charged so as to have a potential different from that of earth.
- xiv) Multiple Earthed Neutral System: A system of earthing in which the parts of an installation, specified to be earthed or connected to the general mass of earth and in addition, are connected within the installation to the neutral conductor of the supply system.
- xv) Primary Point: Primary point wiring shall include all works necessary to complete the wiring of a switch circuit of any length from the tapping point on the distribution circuit to the following via the switch:
  - a) Ceiling rose or connector (in the case of ceiling/exhaust fan points).
  - b) Ceiling rose (in the case of pendants except stiff pendant points).
  - c) Socket-outlet (in the case of socket-outlet points).
  - d) Lamp holder (in the case of wall brackets, batten lamp holder points, bulk head and similar fittings).
  - e) Call bell/buzzer (in this case the words "via the switch" shall be read as:  
"Via the ceiling rose/socket-outlet or bell push where no ceiling rose/socket-outlet is provided").
- xvi) Secondary Points: The light points which are not having control switches and looped from the primary light point or from the nearest secondary light point in the same lighting circuit are considered as secondary points.
- xvii) Weather Proof: Accessories, lighting fittings, current using appliances and cables are said to be of the Weather proof type, if they are so constructed that when installed in open situation, they will withstand the effects of rain, snow, dust and temperature variations.
- xviii) Service: The conductors and equipments required for delivering energy from the electric supply system to the wiring system of the premises served.

#### **4.0 Construction**

##### **4.1 Control at the point of commencement of supply.**

- 4.1.1 The main switch shall be located near the termination of service line and it shall be easily accessible without the use of any external aid and the main switch shall be installed at a height of 1.8 m from finished floor level. The exact location shall be finalised by the Engineer-in-charge.
- 4.1.2 A circuit breaker or switch fuse unit shall be provided at the point of entry. There shall not

be any break in the neutral wire in the form of fuse or switch unit. The neutral shall also be marked clearly.

#### **4.2 Location of the switches and switch boards.**

4.2.1 Switch boards shall be placed only in dry-locations and in ventilated rooms and they shall not be placed in the vicinity of storage batteries or exposed to chemical fumes.

4.2.2 In a damp situation or where flammable or explosive dust, vapour or gas is likely to be present, the switch board shall be totally enclosed or made flame proof as may be necessitated by the particular circumstances.

4.2.3 Main board location shall be such that it is easily accessible for firemen and other personnel to quickly disconnect the supply in case of emergencies.

4.2.4 Care shall be taken not to erect switch boards above gas stoves or sinks or within 2.5 m of any washing unit in the washing rooms.

4.2.5 Main switch boards shall be installed in rooms or cupboards having provisions for locking arrangement so as to safeguard against operation by unauthorised personnel.

4.2.6 Adequate illumination shall be provided for all working spaces around the switch boards when installed indoors.

4.2.7 In case of switch boards fixed in places likely to be exposed to weather or to abnormal moist atmosphere, the outer casing shall be weather proof and shall be provided with glands or bushings or adopted to receive screwed conduit, according to the manner in which the cables are run.

4.2.8 When the switch boards are recessed in the wall, the front shall be fitted with a hinged panel of teakwood or other suitable material, such as hylum, or with unbreakable glass doors in teak wood frame with locking arrangement, the outer surface of the doors being flush with the walls. Sufficient space shall be provided at the back for connection and at the front between switchgear mountings and the door.

4.2.9 Wall mounted switch boards shall be installed such that the bottom is at a minimum height of 1.20 m above finished floor level wherever applicable, as indicated in the org. CED/ELE/S/1A.

4.2.10 The various live parts, unless they are effectively screened by substantial barriers of non-hygroscopic, non-flammable insulating material, shall be so spaced that an arc cannot maintain between such parts and earth.

4.2.11 No apparatus shall project beyond any edge of the panel. No fuse body shall be mounted within 2.5 cm of any edge of the panel and no hole other than the holes by means of which the panel is fixed shall be drilled closer than 1.3 cm from any edge of the panel.

4.2.12 Equipment which is on the front of a switch board shall be so arranged that inadvertent personnel contact with live parts is unlikely during the manipulation of switches, changing of fuses or similar operation.

4.2.13 In every case in which switches and fuses are fitted on the same pole, these fuses shall be so arranged that the fuses are not live when their respective switches are in 'OFF' position.

4.2.14 No fuses other than fuses in instrument circuit shall be fixed on the back or behind a switch board panel or frame.



4.2.15 The arrangement of the gear shall be such that they shall be readily accessible and their connections to all instruments and apparatus easily traceable.

#### **4.3 Distribution Boards:**

4.3.1 All distribution boards shall be of either MCB or HRC fuse/rewirable fuse as described in the respective schedule.

4.3.2 The distribution boards shall be controlled by a switch fuse, miniature circuit breaker or an isolator as described in the respective schedule. Each outgoing circuit shall be provided either with a MCB or a fuse on the phase. The neutral shall be connected to a common link and be capable of being disconnected individually for testing purposes.

4.3.3 The distribution boards shall be located as indicated in the respective electrical working drawings and as directed by Engineer-in-Charge. The distribution boards shall be fixed on wall or in the niches provided and shall be accessible for either replacement of fuses or maintenance.

4.3.4 The distribution board shall comply with the specifications as given in section IV.

4.3.5 The distribution boards shall be fixed at 1.2 m from FF1 and shall be installed as detailed in the drg. CED/ELE/S/1A.

4.3.6 They shall be weather proof if exposed to weather or damp situations.

4.3.7 The following shall be marked on the distribution boards:

- a) Danger-415 volts.
- b) Accessible only to authorised persons.
- c) Marked 'Lighting' or 'Power' with number of phases and voltage. It shall be provided with circuit list giving details of each circuit which it controls along with circuit rating and fuse size.
- d) The panel from where power is tapped to D.B.

All marking shall be clear and indelible.

4.3.8 The total load of the consuming devices shall be divided evenly between the number of ways of the distribution board.

4.3.9 The consuming devices circuit shall be connected to distribution board in proper sequence, so as to avoid unnecessary crossings of wires.

4.3.10 Cables shall be connected to a terminal only by soldered or crimped lugs.

4.3.11 All bare conductors shall be rigidly fixed in such a manner that a clearance of at least 2.5 cm is maintained between conductors of opposite polarity or phase and between the conductors and any material other than insulating material.

4.3.12 The incoming and outgoing cables shall be neatly bunched.

#### **4.4 Capacity of circuit:**

4.4.1 Circuit shall not have more than a total of ten points of fans, 5A socket outlets and light points and its total load shall not exceed 800 watts. Lights, fans and 5A socket outlets can be wired on a single common circuit. If fan circuit is drawn separately, circuit shall not be used for more than ten points and load shall not exceed more than 800 watts.

4.4.2 When installations require use of group control for switching operation, circuits for socket outlets may be kept separate from fans and lights.

4.4.3 Conductors shall be of aluminium and shall not have a cross section less than 2.5 mm<sup>2</sup> for final sub-circuit for fan and light wiring. The cross sectional areas of conductors for power wiring shall be at least 4.0 mm<sup>2</sup> aluminium. No intermediate joint in the conductor is permitted.

4.4.4 The power circuit shall not have more than two outlets per circuit each of less than 1KW. Whenever the load to be fed by the outlet is more than 1.5 KW, it shall be controlled by a MCB and each outlet shall be connected to separate circuit.

#### 4.5 Passing through walls.

4.5.1 It shall be ensured that wires pass freely through protective pipe or box and that the wire pass through in a straight line without twist or crossing in wire. The conductors shall be carried either in a rigid steel conduit or in a rigid non-metallic conduit of such a size which permits easy drawing in. The end of conduit shall be neatly bushed with porcelain, wood or other approved material.

4.5.2 Where a wall tube passes outside a building so as to be exposed to weather, the outer end shall be bell mouthed and turned downwards and properly bushed on the open end.

#### 4.6 Fixing to walls and ceilings:

4.6.1 Plugs for ordinary walls or ceilings shall be of well-seasoned teakwood, not less than 5 cm long and 2.5 cm square on the inner end and 2 cm square on the outer end. They shall be cemented into walls to within 6.5 mm of the surface, the remainder being finished according to the nature of the surface with plaster.

4.6.2 Where owing to irregular coarsing or other reasons, the plugging on the walls or ceiling with wood plugs presents difficulties, wood batten or metal conduit (as the case may be) shall be attached to the wall or ceiling in a suitable manner. In the case of new buildings, wherever possible, teak wood plugs shall be fixed in the walls before they are plastered.

#### 5.0 Fittings and accessories:

##### 5.1 Fittings:

5.1.1 No inflammable shade shall form a part of a light fitting, unless such shade is well protected against all risks of fire. Celluloid shade light fitting shall not be used under any circumstances. Vitreous enamelled iron shade of suitable size shall be used (nominal size with a tolerance of 5 mm). Plastic shade shall not be generally used in the fittings suitable for incandescent lamps.

5.1.2 When a light fitting is supported by one or more flexible cords, the maximum weight to which the twin flexible cords may be subjected is given in IS : 732 which is reproduced below:

Normal Cross Sectional area of twin flexible cord in mm <sup>2</sup>	Number and diameter in mm of wires	Maximum permissible weight in kg
0.50	16/0.2	1.7
0.75	24/0.2	2.6
1.00	32/0.2	3.5
1.50	48/0.2	5.3
2.50	80/0.2	8.8
4.00	128/0.2	14.0

## 5.2 Accessories :

5.2.1 Switches : All switches shall be placed in the live conductor of the circuit and no single pole switch or fuse shall be inserted in the earth or earthed neutral conductor of the circuit. Single pole switches (other than for multiple control) carrying not more than 15 amperes may be of the piano flush type and the switch shall be "ON" when the knob is down.

5.2.2 Lampholders : Lamp holders for use on brackets and the like shall have not less than 1.3 cm nipple and all those for use with flexible pendant shall be provided with cord grips. All lamp holders shall be provided with shade carriers. Where centre contact Edison screw lamp holders are used, the outer or screw contact shall be connected to the "middle wire" or the neutral or to the earthed conductor of the circuit.

5.2.3 Lamps : All incandescent lamps, unless otherwise specified, shall be hung at a height of not less than 2.5 m above the finished floor level.

5.2.4 Ceiling rose : a) A ceiling rose or any other similar attachment shall not be used on a circuit, the voltage of which normally exceeds 250 volts.

b) Normally only one flexible cord shall be attached to a ceiling rose. Specially designed ceiling roses shall be used for multiple pendants.

c) A ceiling rose shall not embody fuse terminal as an integral part of it.

5.2.5 Socket-outlets : a) A socket-outlet shall not embody fuse terminal as integral part of it. But the fuse may be embodied in plug in which case plug shall be non-reversible and shall be so arranged and connected that the fuse is connected to phase conductor.

b) Every socket-outlet shall be controlled by a switch.

c) The switch controlling the socket shall be on the 'live' side of the line.

d) 5 Amps and 15 Amps socket-outlet shall normally be fixed at any convenient place 60 cm above the floor level or near such level as indicated in drawing CED/ELE/S/2. 15 Amps socket-outlets in the kitchen of the residential buildings shall be fixed at convenient place 23 cm above the working platform. In a room containing a fixed bath or shower, there shall be no socket outlet and there shall be no provision for connecting a portable appliance. Any stationary appliance connected permanently in the bathroom shall be controlled by an isolator switch or circuit breaker, as shown in the drawing CED/ELE/S/1(B).

e) Where socket-outlets are placed at lower level, they shall be enclosed in a suitable wooden or metallic box, as the case may be, to harmonise with the system of wiring adopted.

f) In an earthed system of supply, the socket-outlet and the plug shall be of the three pin type, the third terminal shall be connected to earth.

g) Conductors connecting electrical appliance with socket-outlet shall be of flexible twincord with an earthing cord which shall be secured by connecting between the earth terminal of plug and the metallic body of the electrical appliance.

h) For providing power supply to window air-conditioners, 3 pin 20 A single phase metal clad socket with 20 A SPMCB control shall be provided as indicated in the drawing CED/ELE/S/1(C).

## 5.3 Attachment of fittings and accessories :

5.3.1 In teakwood batten wiring, accessories like switches, socket-outlets, call bell pushes etc.

shall be flush mounted inside a substantial box or block of teak wood or approved hard wood double board construction twice varnished both inside and outside including back side after all fixing holes are made in them and attached to the wall. Blocks shall not be less than 40 mm deep. The cover for the box or block shall be of 3 mm thick Hylum sheet as approved by the Engineer-in-charge.

5.3.2 In teak wood batten wiring groups of accessories and regulators shall be mounted on well seasoned and properly secured teak wood or approved hard wood boards of suitable size to accommodate the number of fittings. The board shall be well varnished with pure shellac on all sides, both inside and outside, irrespective of being painted to match the surroundings. The board shall be divided into two sections, one for the switches which shall be flush mounted and the other for regulators fixed on the board with suitable flat washers and round head iron screws (or any other type of screw as required). The cover for the section, accommodating switches and socket-outlets shall be of 3 mm thick Hylum sheet, as approved by the Engineer-in-charge. In the case of teak wood batten wiring, switches may be surface mounted on teak wood or approved hard wood boxes. But in this case, the rate shall be suitably reduced.

5.3.3 In case of conduit wiring, all accessories like switches, socket-outlets, call bell pushes and regulators shall be fixed in flush pattern inside metal boxes. Accessories like ceiling roses, brackets, battens, stiff pendants etc. shall be fixed on metal outlet boxes.

5.3.4 Aluminium alloy or cadmium plated iron screws shall be used to fix the accessories to their bases.

The board shall normally be mounted with their bottom 1.2 m from finished floor level as indicated in the drawing CED/ELE/S/1A.

## **6.0 Wiring systems:**

### **6.1 Surface conduit wiring system.**

6.1.1 Conduits shall be of M.S. Seamless or E.R.W as situation demands and shall not be less than 19 mm dia and shall be of heavy gauge and shall be finished with stove enamelled surface. All conduit accessories shall be of threaded type and under no circumstances pin grip type or clamp type accessories be used. The number of PVC insulated conductors that can be drawn into rigid steel conduit are given in table II of IS:732-part-II-1983.

6.1.2 Bunching of cables: For lighting and power outlet circuits, the wires shall be taken in separate conduits. Insulated conductors of AC supply and DC supply shall be bunched in separate conduits.

6.1.3 In order to minimise condensation or sweating inside the conduit, all outlets of conduit system shall be properly drained, Ventilated, but in such a way as to prevent the entry of insects.

6.1.4 Conduit shall be joined by means of screwed couplers and screwed accessories only. In long distance straight runs of conduit, inspection type couplers at reasonable intervals shall be provided or running threads with couplers and jam-nuts shall be provided. Threads on conduit pipes in all cases shall be between 11 mm to 27 mm long sufficient to accommodate pipes to full threaded portion of couplers or accessories. Cut ends of conduit pipes shall have no sharp edges or any burrs left to avoid damage to the insulation of conductors while pulling them through such conduits.

6.15 Conduit pipes shall be fixed by 20SWG saddles, secured to in approved manner at an interval of 750 mm but on either side of couplers or bends or similar fitting, saddles shall be fixed at a distance of 30 cm from the centre of such fitting. Where conduit pipes are to be laid along the truss/steel joists etc., the conduits shall be secured by means of girder clips and as directed by Engineer-in-charge. Where it is not possible to drill hole in the truss members suitable clamps with bolts and nuts as directed by Engineer-in-charge shall be used.

6.16 All necessary bends in the system including diversion shall be done by bending pipes or by inserting suitable solid or inspection type normal bends, elbows or similar fittings or fixing MS inspection boxes, whichever is more suitable. Conduit fittings shall be avoided on conduit system exposed to weather. Radius of such bends in conduits shall not be less than 7.5 cm.

6.17 The switch or regulator box shall be made of metal on all sides, except on the front. In the case of welded mild steel sheet boxes, the thickness of the sheet shall not be less than 18 gauge for boxes upto a size of 20 x 30 cm and above this size, 16 gauge MS boxes shall be used. Except where otherwise stated 3 mm thick Hylum sheet shall be fixed on the front with brass screws. Clear depth of the box shall not be less than 60 mm and this shall be increased suitably to accommodate mounting of fan regulators in flush pattern. All fittings shall be fitted in flush pattern.

6.18 Inspection type conduit fittings such as inspection boxes, bends, elbows and tees shall be so installed that they remain accessible for such purposes as withdrawal of existing cables or installation of additional cables.

6.19 Different parts of conduit system such as bends, unions, tees, junction boxes etc. shall be adequately protected against rust particularly when such system is exposed to weather. In all cases, no bare threaded portion of conduit pipe shall be allowed unless such bare threaded portion is treated with anti-corrosive and suitable preservatives.

6.110 After installation, all exposed surface of conduit pipes, fittings, switch and regulator boxes etc. shall be painted with two coats of approved enamel paint or aluminium paint as required to match the finish of surrounding wall, trusses etc.

6.111 Before the conductors are drawn in, the laying of conduit for each circuit or section shall be completed. The entire system of conduit after erection shall be tested for mechanical and electrical continuity throughout and permanently connected to earth by means of suitable earthing clamp, efficiently fastened to conduit pipe in a workman like manner for a perfect continuity between each wire and conduit. Conduits shall be adequately protected from mechanical stresses.

## **6.2 Recessed conduit wiring system.**

Recessed conduit wiring system shall comply with all the requirements for surface conduit wiring system as specified in 6.1.1 to 6.1.11 and in addition, conform to the requirements as specified below:

a) Making of chase: The chase in the wall shall neatly be made and shall be of suitable dimensions to permit the conduit to be fixed in the manner desired by the Engineer-in-charge. In the case of buildings under construction, chases shall be provided in the wall, ceiling etc. at the time of their construction and shall be filled up neatly after erection of conduit and brought to the original finish of the wall.

b) Fixing of conduit in chase: The conduit shall be fixed by means of staples or by means of saddles not more than 600 mm apart. Fixing of standard bends or elbows shall be avoided as far as practicable and all curves maintained by bending the conduit pipe itself with a long radius which will permit easy drawing-in of conductors. All threaded joints of rigid steel conduits shall be treated with approved preservative compound to ensure protection against rust.

c) Inspection boxes: To permit periodical inspection and to facilitate replacement of wires, suitable inspection boxes shall be provided at convenient locations. These shall be mounted in flush with the wall. The minimum sizes of inspection boxes shall be 75 x 75 mm. Suitable ventilating holes shall be provided in the inspection box covers.

d) Types of accessories to be used: All outlets, such as switches and sockets, may be either of flush mounting type or of surface mounting type.

i) Surface mounting type: It shall be with any suitable insulating material, if surface mounting type outlet box is specified.

ii) Flush mounting type: In this case, outlets shall be of mild steel boxes with a cover of hylum sheet of 3 mm thickness. The switches and other outlets shall be mounted on such boxes. The metal box shall be efficiently earthed with the earth continuity wire which shall run along the conduit.

e) When crossing through expansion joints in buildings, the conduit sections across the joint may be through flexible conduits of the same size as the rigid conduit.

### **6.3 Conduit wiring system with rigid non metallic conduits:**

6.3.1 PVC conduit of thickness not less than 2 mm and of size minimum 19 mm dia shall be used.

6.3.2 Bunching of cables: Separate conduits shall be used for bunching of conductors of AC supply and DC supply for lighting and small power outlet circuits.

6.3.3 Conduit joints: Conduits shall be joined by means of screwed or plain couplers depending on whether the conduits are screwed or plain. Where there are long runs of straight conduit, inspection type couplers shall be provided at intervals.

6.3.4 On outdoor systems conduit fittings shall be avoided as far as possible.

6.3.5 Outlets: Outlets for fittings, switches etc. shall be boxes of substantial construction in order to minimise condensation or sweating inside the conduit. All outlets of conduit systems shall be properly drained and ventilated, but in such a manner so as to prevent the entry of insects etc. as far as possible.

6.3.6 Bends in conduit: Wherever necessary, bends or diversions may be achieved by bending the conduits or by employing normal bends, inspection bends, inspection boxes, elbows or similar fittings.

6.3.7 In case of plain conduit, heat may be used to soften the conduit for bending and forming joints. Positioning of conduit in close proximity to hot surfaces should be avoided. Caution should be exercised in the use of this conduit in locations where the ambient temperature is 50°C or above. If the normal working temperature exceeds 55°C, rigid PVC conduits shall not be used. Also, it shall not be used when the ambient temperature falls below - 5°C.

6.3.8 Non-metallic conduit systems shall be used only where it is ensured that they are:  
a) Suitable for extremes of ambient temperature to which they are likely to be subjected in service.

b) Resistant to moisture and chemical atmospheres and

c) Resistant to low temperature and sunlight effects.

6.3.9 The material shall be acceptably resistant to moisture and corrosive agents.

6.3.10 Fixing of conduits: The provision of 6.1.5 shall apply except that the spacing between saddles or supports is recommended to be 60 cm for rigid non-metallic conduits.

#### **6.4 Teakwood batten wiring with PVC sheathed and PVC insulated wire.**

6.4.1 The teak wood battens to be used for TW batten wiring should have been well seasoned and should not be less than 10 mm finished thick. The width of the batten shall be such as to suit the total width of the cables laid on the batten. The batten shall be perfectly straight. They shall be well varnished on all the four sides, prior to fixing of the batten on wall/ceiling. They shall be painted with one coat of varnish of approved paint of colour to match with the surroundings. Where attack from termite is prevalent, antitermite treatment shall be given. These battens shall be secured to the walls and ceilings by counter-sunk head wood screws to wood plugs or other plugs at an interval not exceeding 75 cm; the flat head wood screws shall be counter-sunk within wood batten and smoothed down with file.

6.4.2 Link clips: The link clips shall be made out of aluminium alloy. The thickness shall be as given below:

0.32 mm (30SWG) for length 25 mm to 40 mm

0.40 mm (28SWG) for length 50 mm to 80 mm

Link clips shall be so arranged that one single clip shall not hold more than two twin-core PVC sheathed cables upto 2.5 sq. mm, above which a single clip shall hold a single twin-core cable. The clip shall be fixed on varnished wood battens with any rust resisting pins or screws and spaced at intervals of 10 cm in the case of horizontal runs and 15 cm in the case of vertical runs. For the wiring and run of mains exposed to heat and rain, clips specially made for outdoor use from a durable metal resistant to weather and atmospheric corrosion shall be used.

6.4.3 When chances of damage to wiring are there, then, such wiring shall be protected using sheet metal and the base of which is made in-flush with the plaster or brick work as the case may be.

Such protective covering shall in all cases be fitted on all down drops within 1.5 m from the floor or from floor level upto the switch board whichever is less.

6.4.4 Passing through floors: Cables shall be enclosed in any approved type of metallic covering when taken through floors. Care shall also be taken to see that conduits or pipes are neatly bushed with porcelain, wood or any other approved material.

6.4.5 Bends in wiring: Care shall be taken to avoid right angle bends and shall be rounded off at the corners to a radius not less than six times the overall diameter of the cable.

6.4.6 Buried cables: PVC cable shall not be buried directly in plaster, where so specified, they may be taken in teak wood channelling of ample capacity or cement chase or conduit buried in the wall.

6.4.7 Stripping of outer covering: Care shall be taken that the sharp edge of the cutting instrument does not touch the PVC sheathed insulation of conductors, while cutting and stripping of the outer covering of the cables. The protective outer covering of the cables shall be stripped off near connecting terminals, and this protective covering shall be maintained upto close proximity of connecting terminals. Hammering on clips shall be strictly avoided after the cables are laid. Where junction boxes are provided they shall be made moisture-proof with suitable plastic compound.

6.4.8 Cables through walls: The method to be adopted shall be that laid down in 6.4.4. In the latter case there shall be one or more conduits of adequate size to carry the cables. Cables shall enter the conduits straight without bending.

6.4.9 PVC sheathed wiring shall be painted with a synthetic enamel paint of quick drying type to match the finish of walls and ceiling.

## **7.0 Testing :**

The following tests shall be carried out on all types of wiring on completion of the work and before energising the installation.

- i) Insulation resistance test,
- ii) Electrical continuity test,
- iii) Earth continuity test,
- iv) Earth electrode resistance test,
- v) Switch polarity test.

**7.1 Insulation resistance test:** The insulation resistance shall be measured by using 500 V megger between the following points.

7.1.1 Phase and neutral conductor with all fuses in position and all switches in closed condition and main switch in OFF position with lamps and other devices removed.

7.1.2 Between earth and whole system of conductors with all fuses in place, all switches closed and all lamps in position.

7.1.3 Between all conductors connected to one phase of the supply and the conductors connected to neutral with all lamps in position and switches on OFF position.

The insulation resistance in megaohm as obtained by each of the above tests shall not be less than 50 divided by the number of points on the circuit. Where a whole installation is being tested, a lower value than that given by the above formula is acceptable subject to a minimum of one megaohm.

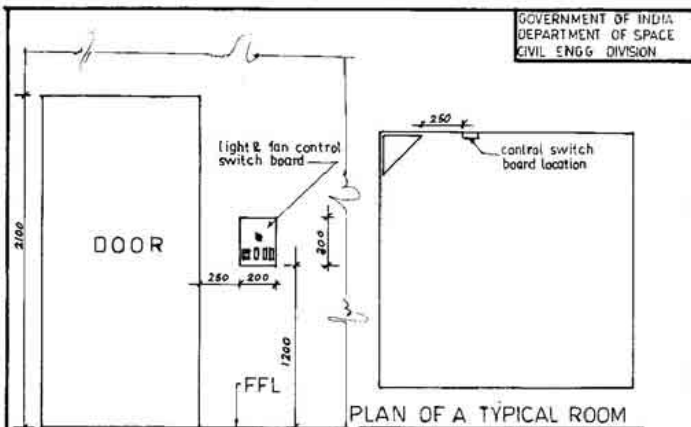
**7.2 Electrical continuity test:** Each and every circuit shall be tested for electrical continuity by using a multimeter.

**7.3. Earth continuity test:** The earth continuity conductor including metal conduit shall be tested for electrical continuity and the resistance of the same along with the earthing lead measured from the connection with the earth electrode to any point in the earth continuity conductor in the complete installation shall not exceed one ohm.

**7.4 Earth electrode resistance test :** The earth electrode resistance shall be tested as specified in section VI.

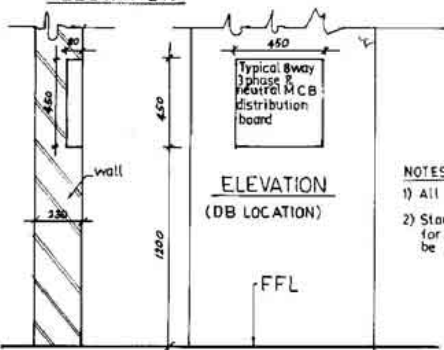


**7.5 Switch polarity test:** Test shall be made to verify that all switches in every circuit have been fitted in the same conductor throughout and such conductor shall be marked for connection to the phase conductor.



ELEVATION

PLAN OF A TYPICAL ROOM



SECTION  
(DB LOCATION)

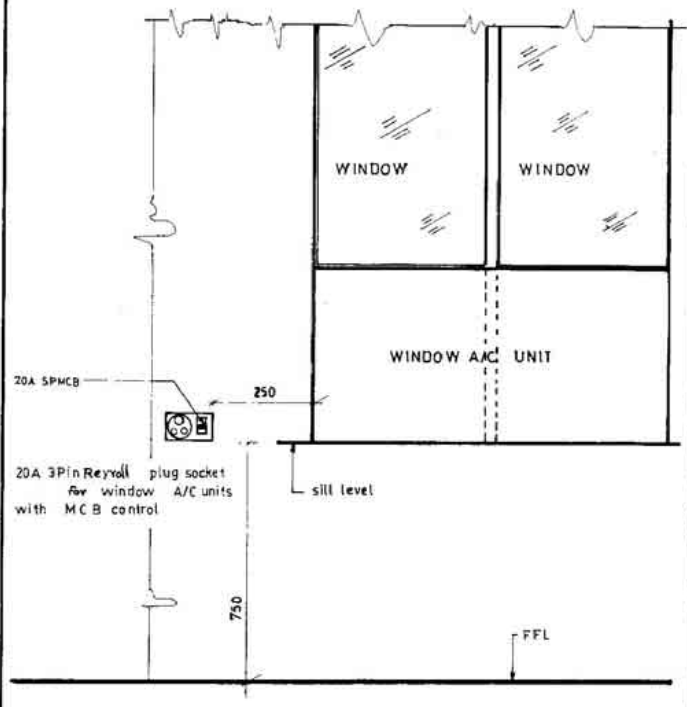
ELEVATION  
(DB LOCATION)

NOTES

- 1) All dimensions in mm
- 2) Standard sizes of M.S boxes for control switch boards shall be fixed in flush with the wall

FIXING ARRANGEMENT OF CONTROL SWITCHES & DISTRIBUTION BOARDS

drawn maheswari engineer SC	checked S D engineer S D	Recommended Head electrical	Approved chief engineer	SCALE N.T.S.	ORG NO.
date 8 February 1986 engineer SC	checked S E engineer S E			DATE June 1986	CED/ELE/S/1A



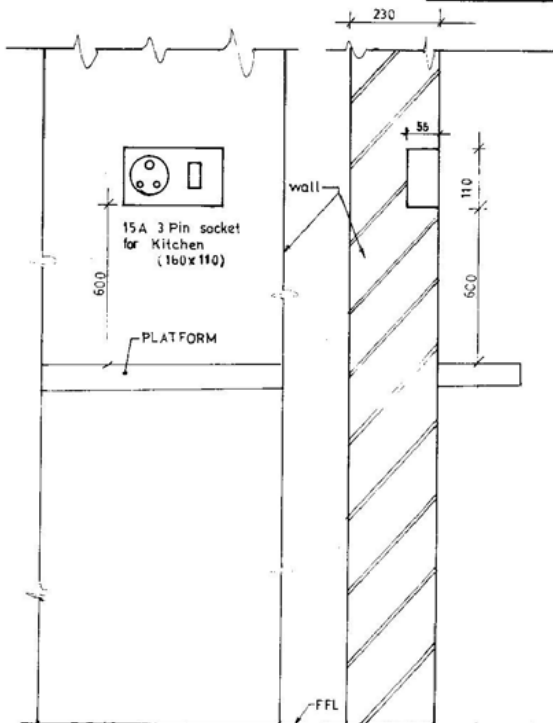
FRONT ELEVATION

NOTE  
All dimensions in mm

**FIXING ARRANGEMENT OF PLUG SOCKETS**  
(WINDOW A/C UNITS)

drawn maheswara	checked engineer SD	recommended Head electrical	Approved chief engineer	SCALE N T S	DRG. No.
designed S. Srinivasan engineer SC	checked engineer SE			DATE June 1986	CED/ELE/S/IC

SECTION II  
**LIGHTING FIXTURES**



FRONT ELEVATION

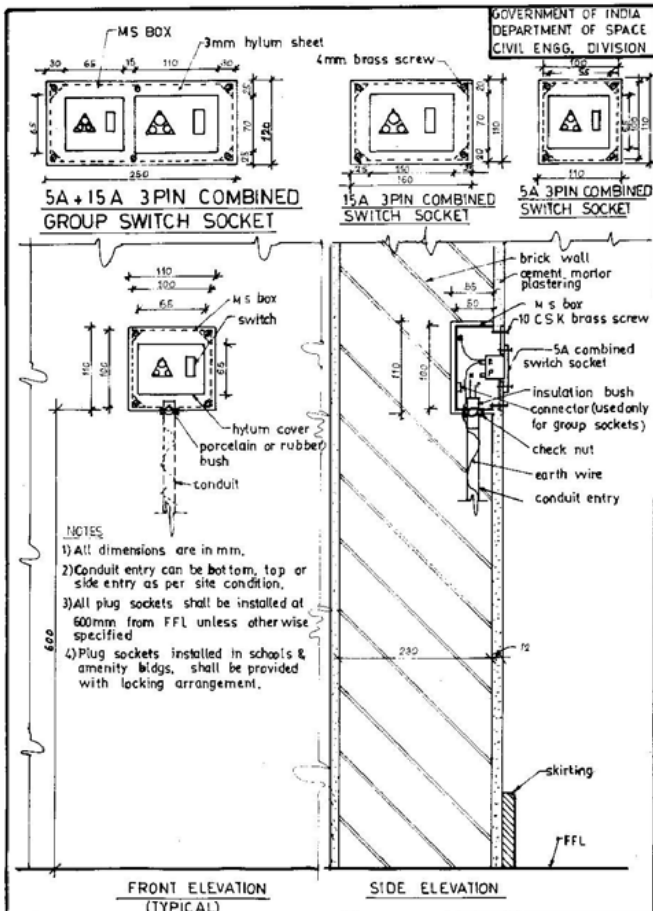
SECTION

NOTES

- 1) All dimensions in mm
- 2) For bath room M S Box for plug sockets shall be fixed at 1300 above FFL

**FIXING ARRANGEMENT OF PLUG SOCKETS**  
(RESIDENTIAL QUARTERS)

drawn <i>[Signature]</i> engineer SW	checked <i>[Signature]</i> engineer SD	recommended <i>[Signature]</i> Head electrical	approved <i>[Signature]</i> chief engineer	SCALE NTS	DRG. No.  CED/ELE/S/1B
drawn <i>[Signature]</i> engineer SC	checked <i>[Signature]</i> engineer SE			DATE June 1986	



**TYPICAL FIXING ARRANGEMENT OF PLUG SOCKETS - CONCEALED WIRING**

Drawn malleswara assistant engineer SC	Checked engineer SD	Recommended Head electrical	Approved chief engineer	SCALE N T S DATE June 1986	DRG. NO. CED/ELE/S/2
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**SECTION – II**  
**SPECIFICATION FOR LIGHTING FIXTURES**

**1.0 Scope :**

This specification is intended to cover the requirements of supply, installation and testing of the lighting fixtures suitable for indoor and outdoor applications of industrial and non-industrial buildings.

**2.0 Standards :**

The lighting fixtures shall comply with the latest relevant Indian Standard Specifications and National Electrical Code.

**3.0 Constructional Requirements :**

**3.1 General :**

3.1.1 All accessories and materials used in the manufacture of lighting fixtures shall comply with the latest relevant Indian Standards and shall be of such quality, type and designs to satisfy the following:

- a) They shall ensure to provide adequate protection in normal use against mechanical and electrical failures.
- b) They shall ensure protection against electro-chemical action and exposure to the risk of injury or electric shock to the personnel.
- c) They shall with-stand the effect of changing weather conditions, water or excessive dampness, corrosive fumes, dust, steam, oil, high temperature or any other deteriorious influences to which they will be exposed under the conditions of their normal use.

**3.2 Lighting fixtures :**

Lighting fixtures shall be so designed and manufactured such that their performance is more reliable, safe, suit the site conditions where the fittings are to be used and efficient in operation. Screwed and other fixed connections between different components shall be made in such a way that they will not work loose by vibration or such other forces as may occur during normal use.

**3.3 Cord Anchorage :**

The stress imposed by the fitting on the current carrying cord or cable which is used as part of suspension system of the lighting fixtures, shall not exceed 15N/mm<sup>2</sup> of conductor cross section. The maximum weight of any fitting which is suspended only by its connecting cable or cord shall be limited to 5 Kg per suspension point unless special cables which include suitable mechanical load carrying wire are used.

Fittings provided with non-detachable flexible cable or cords shall have a cord anchorage so that the conductors are relieved from strain and twisting where they are connected to the terminals. The cord anchorage shall also be such that their outer covering is protected from abrasion. The cord anchorage shall also satisfy the condition that the cord or cables cannot be pushed into the fitting to such an extent, that it is subjected to undue mechanical or thermal stress. Only correct length of cord anchorage shall be used. Knots in the cord anchors shall be avoided.

The cord anchorages shall either be of insulating material or be provided with an insulating lining.

Glands or bushes shall not be used as cord anchorages in portable or adjustable fittings.

It shall be ensured that the fittings used in the work have neat finish and appearance.

### **3.4 Cable End Connectors :**

Where conductors and cables are to be passed through tubes, channels or other passages, they shall have ample size and should be bushed or bell mouthed at the ends/edges which are likely to damage the insulation of the conductor.

The flexible cord shall include an earth conductor, continuously.

### **3.5 Terminal Block and Connectors :**

The terminals and connectors shall be of sound mechanical and electrical design and appropriate to the duty for which they are used.

The terminals for supply cable shall permit the connections of conductor of size upto 2.50 mm .

The screwed terminals shall have metric thread with sufficient mechanical strength and shall not serve to fix any other component.

Terminals shall be such that the conductor of the cable is held firmly and allow a connection to be made with adequate pressure and without damage to the insulator, when the terminal screw is tightened to the conductor and it should not slip out of the terminals. The terminal designs shall be such that it allows a cable to be connected without any special preparation such as soldering of strand, use of cable lugs and formation of eye lid.

Terminals shall be so arranged that when the connection of the cable is correctly made, there is no risk of accidental contact between live parts, between phase and neutral or such parts and accessible metal. Terminals for external connections shall be so located that the conductors can easily be introduced and secured so that a cover if any can be refixed without any risk or damage to the cables. Terminal block shall be firmly fixed to the fixture. The terminals are tested by tightening and loosening 10 times on a largest size conductor with the application of torque as specified and recommended in table - I of IS :1913-1969. With this test the terminals shall not have worked loose and the conductors shall not show damage such as deep incision or shearing.

### **3.6 Internal Wiring of the Lighting Fixtures :**

Conductors of suitable size and type shall be made use of for internal wiring of the lighting fixtures. The conductor insulation shall be capable of withstanding the maximum temperature to which the light fitting is subjected in normal use.

The creepage distance between live parts and non current carrying parts shall not be less than 4 mm over the surface of insulation.

### **3.7 Protection Against Shock :**

It shall be ensured that when the fitting is mounted no person can inadvertently come into contact with any live parts. The enclosure of live parts shall have strength sufficient to ensure that it cannot easily be deformed so as to come into contact with live parts.



### 3.8 Earthing of Fittings :

All non current carrying exposed metal parts which are liable to become live, shall be in good electrical contact with each other and the fitting shall be provided with a common earthing terminal in the vicinity of supply terminal by means of which all the exposed metal parts shall be effectively earthed. As a general rule the earthing terminal shall be independent of any constructional bolt, stud or screw. The current carrying capacity of the earthing terminal shall be adequate and shall be not less than that of earthing conductor to be connected and shall be capable of accommodating of earth continuity conductor of required size and have screw threads not less than M4. The resistance between the metal part of the fitting and the earth terminal of the fitting shall not exceed 0.50 ohm.

### 3.9 Markings :

Each lighting fixtures shall have clear marking for the following information.

- i) Name of the manufacturer or trade mark or both,
- ii) Model or type designation,
- iii) Capacity in watts,
- iv) Rated maximum voltage.

Marking shall be legible and shall be made either on the fitting or a name plate securely fixed there to.

The earthing terminal should be marked by the symbol E or 

### 4.0 Fittings :

#### 4.1 Incandescent Fitting :

4.1.1 Incandescent ceiling mounted decorative type fitting shall have spun aluminium body finished in stove enamelled maroon outside and white inside complete with decorative glass ware, lamp holder suitable for  $1 \times 40/1 \times 60/2 \times 40/2 \times 60W$  GLS lamps. The overall diameter shall not be less than 250 mm in case of circular type fitting. In case of square type fitting the size shall not be less than 200 mm.

4.1.2 The pendant type fixture shall have a suitable canopy, downrod, decorative diffusing glass with a lamp holder suitable for 40/60/100W GLS lamp.

4.1.3 The incandescent bracket type fitting shall have bracket of suitable length not less than 225 mm finished in laqured brass with white enamel, opal glass, lamp holder to take one no. 40/60W GLS lamp.

4.1.4 Decorative adjustable type incandescent fitting-wall bracket shall have provision for easy replacement of bulb and adjust the fitting at any required angle.

4.1.5 Bulkhead fitting shall be of cast iron body stove enamelled silver grey outside, white inside complete with clear front glass fitted with tropicalised gasket and mounted on a hinged front ring with porcelain lamp holder suitable for 60/100W GLS lamp.

4.1.6 The cylindrical part of the fitting is finished either in wrinkled black stove enamel or copper anodizing. A clear acrylic crystal ring is to be attached to the cylinder to lend sparkie and warmth to the interior. The fitting shall be suitable for lamps upto 150W GLS lamps.

4.1.7 Vapour proof well glass fitting shall be with cast iron/cast alloy body finished in anticorrosive 'EPOXY' paint grey outside and white inside complete with clear screw neck well glass, tropicalised gasket, galvanised wire guard, porcelain lamp holder suitable for 100/200W GLS lamp.

#### **4.2 Fluorescent Fittings:**

4.2.1 Channel Mounting/Box type Fitting: This fitting shall have stove enamelled sheet steel box housing complete with copper wound polyester filled ballasts, starter, rotor lamp holders, power factor improvement capacitor, starter-holders, terminal block, knockouts for conduit entry and all other accessories.

4.2.2 Decorative lighting fixtures with polyesterene louvres: These fixtures shall be constructed with stove enamelled sheet steel channel housing complete with all accessories as detailed in item 4.2.1 and with stove enamelled sheet steel side panels with "cats-eye" stove enamelled end plates, polyesterene louvre and all other accessories.

4.2.3 Decorative fitting with Acrylic diffuser: These fixtures shall have construction as detailed in item 4.2.2 but with opal acrylic diffuser.

4.2.4 Decorative recessed type lighting fixture with polyesterene louvres: This fitting shall have construction as detailed in item 4.2.2 but suitable for recessed mounting.

4.2.5 Decorative recessed type lighting fixture with acrylic diffuser.

This fitting shall have construction similar to the one detailed in item 4.2.3 but suitable for recessed mounting.

4.2.6 Industrial type fluorescent fixtures: This fitting shall have stove enamelled sheet steel channel housing complete with lamps, polyester filled ballasts, starters, rotor lamp holders, starter holders, terminal block, knockouts for conduit entry stove enamelled sheet steel reflector and all other accessories.

4.2.7 Industrial fitting with vitreous enamelled reflector: This fitting is similar to item 4.2.6 above but with vitreous enamelled reflector.

4.2.8 Totally enclosed type with clear acrylic/glass cover: This fitting shall have stove enamelled aluminium housing with lamps, polyester filled ballasts, starters, power factor improvement capacitor, gear cover tray, rotor lamp holder, starter holder, terminal block, knock out for conduit entry and totally enclosed acrylic/glass cover and with all other accessories.

4.2.9 Square type fluorescent fitting: This fitting have construction with stove enamelled aluminium housing with all accessories for 4 no. 2' 20W tubes with polyesterene louvre/acrylic diffuser. This fitting shall have suitable construction for either ceiling mounting or recessed mounting.

4.2.10 Corrosion proof fixtures: This shall be a totally enclosed luminaire, designed to withstand arduous atmospheric conditions of high humidity and corrosive vapours. The canopy shall be made up of fibre glass reinforced polyester with ethylene propylene gasket all round the periphery. The acrylic cover shall be fixed to the canopy with stainless steel toggles. The toggles shall be mounted on the FRP canopy. The canopy shall have two brackets to hold the gear tray intact. The reflector cum gear tray of the fitting shall be made out of sheet steel properly pre-treated,

covered with zinc chromate primer and finally finished with stove enamelled white painted on the reflecting surface. The gear tray shall have capacitor, choke, starter etc. The lamp holder and starter holders shall be made of single piece construction made of moulded formaldehyde. The reflector cum gear tray shall be fixed to the canopy by the help of knurl screws on the mounting bracket in the canopy. The luminaire shall conform IP 43 classification. A cover made of highly transparent reeded acrylic shall be fixed to the canopy with the help of SS clip.

4.2.11. The street light fixtures with clear acrylic cover: The street light fixtures shall be fabricated out of heavy gauge aluminium sheet finished in stove enamelled grey and reflector made of CRCA sheet steel finished in glossy white with bowl made out of a clear acrylic sheet with ribbed profile for optimum photometric performance. The fitting shall have foam rubber gasket firmly seated in well designed grooves for effective water cum insect resistance. The fitting shall be suitable for side entry and weather proof. The fitting shall have all accessories as mentioned in item 4.2.1

4.2.12 Wide-spread mirror optic fitting: This fitting shall have a housing of white stove enamelled sheet steel which carries all electrical accessories such as choke, capacitor, starter, rotor holder, starter holder etc. It shall have a specially designed aluminium mirror system to obtain high optical efficiency and to achieve a wide light distribution. The mirror system shall be assembled with the housing by louvre fixing spring clips fixed on the housing. The mirrors shall be hinged by special clamps and spring wire attachments for lamp/ starter replacement and maintenance. To minimise glare white painted aluminium luminaire louvres are to be put across the mirror system. The reflector shall be mechanically and electrochemically brightened and anodised. The fittings shall give the peak intensity of light distribution at an angle not less than 30° from vertical so as to cut down the glare drastically.

4.2.13 Patty type fitting: This fixture shall have a stove enamelled sheet steel channel with all the electrical accessories suitable for the capacity of the fluorescent lamp as explained in item 4.2.1.

4.2.14. All the fluorescent fixture shall be tested for routine test and acceptance test as per IS : 1913-1978. All the accessories shall comply with the relevant Indian Standards with upto date amendments.

### **4.3 Mercury Vapour Lamp Fixtures :**

4.3.1 Decorative lanterns with prismatic glass cover: The fitting shall have stove enamelled steel/aluminium housing complete with lamps, porcelain base lamp-holder, and prismatic glass reflector globe. The fixtures shall be vermin and weather proof. The fitting shall be with 16 SWG sheet steel galvanised reflector and complete with polyester filled ballast, power factor improvement capacitor, terminal block, conduit entry at bottom, internal wiring and all other accessories.

4.3.2 Decorative post top lantern with acrylic diffuser: The fixture shall be single, self contained, die cast aluminium electrical unit incorporating power factor improvement capacitor, non-hygroscopic lamp holder, all prewired upto the terminal block. It shall have opal white one piece/ single/ double conical dome made out of low density polyethylene which is resistant to light and heat. The luminaire shall be weather proof and rain proof. All metal parts shall be highly resistant to corrosion.

4.3.3 Flood light fixtures : The fitting shall consist of an anodised reflector and a lamp holder housing rivetted together on the front side. The fitting reflector shall be closed by a special heat

resistant glass guard. Special tropic proof rubber clamping ring shall be provided to prevent ingress of rain water and also to act as a shock absorber to the glass guard. It shall be possible to rotate the fitting in vertical as well as horizontal planes and it shall be possible to fix it in the desired direction by means of wing bolts. It shall have non-hygroscopic lamp holder suitable for 80/125/250/400/1000 W lamp. It shall have housing with polyesterene filled ballast and capacitor for power factor improvement. The fitting shall be weather proof and rain proof. All metal parts shall be highly resistant to corrosion.

4.3.4 High bay fixtures – Integral type: The high bay fixture shall have reflector made from spun aluminium, anodised and electrochemically brightened internally with a good finish to give a concentrated type of light distribution and designed for use with 80/125/250/400/1000 W HPMV lamp. The integral control gear shall be housed in an aluminium lamp holder housing, finished in black stove enamel to have radial cooling fins. The complete unit shall be totally enclosed with heat resistant gasket to seal the toughened glass into the reflector. The construction shall be such that it will enable to relamp easily. The control gear shall comprise of power factor improvement capacitor, choke etc. The fitting shall have suspension hook at the top of the canopy and cable entry with cable gland at the side of the canopy.

4.3.5 Non-Integral type highbay fitting: Same as item 4.3.4 but without the control gear.

4.3.6 HPMV lamp street light fixtures - semi cut-off lantern type: The fitting shall comprise of sheet aluminium deep drawn canopy, finished in hammertone silver grey to resist corrosion, two internal anodised aluminium reflectors and a heat resistant glass reflector bowl. The control gear compartment shall have a ballast, a condenser and a terminal block, with an earthing screw. The internal wiring for the fitting shall be with heat resistant insulated wire. The fitting shall have a heat resistant synthetic rubber gasket to ensure weather proof quality. The reflector shall be of anodised aluminium located inside the body, one on either side working in conjunction with a heat resistant prismatic bowl reflector. The reflector bowl shall be in a metal ring which is attached to the lantern body by a hinge at one end and two quick release toggle latches at the other end. The fitting shall be suitable for side entry with locking keys. All the metal parts shall be highly resistant to corrosion. The fitting shall be rain proof and weather proof.

4.3.7 HPMV street light fixtures -Integral cut-off lantern type: This fixtures is similar to item 4.3.6 above but with single piece moulded clear acrylic bowl. The optical system shall have provision for cut-off distribution. The reflector shall be made out of 18 SWG aluminium sheet. The inside of the reflector shall be anodised, providing a high reflecting surface. The contour of the inside surface of the reflector shall be designed to make the maximum use of the light from the lamp. Each side of the reflector shall be in the form of long curved reflecting surface.

All fittings shall be tested for Acceptance test and routine test as per the relevant Indian standards.

#### **4.4 Dust Tight and Dust Proof Fittings:**

The body of the fitting shall be constructed from cast iron/ cast aluminium, finished in grey stove enamel and provided with two side entries suitable for PVC armoured cable of 2C × 4 sq.mm. All terminations shall be suitable for flame proof cable glands. The fitting shall have the top of the canopy with suspension hook. The fitting shall be suitable for 200 W GLS lamp/MV lamp, upto 125 W. The canopy shall have smooth and sloping finish to prevent accumulation of

hazardous dust. The construction shall be such that a thermal shock resistant glass is cemented into the cast iron/cast aluminium retaining ring which is treated and screwed into the canopy, thereby completely preventing the entry of dust. The fitting shall have 5A porcelain 2 way connector to provide facilities for looping. The reflector shall be vitreous enamelled and has galvanised and painted protective wire guard. The fitting shall be suitable for indoor or outdoor use where group I, II, or III dust is present and shall have special anti-corrosion finishes. The fitting shall have to be tested and certified by the Central Mining Research Station, Dhanbad and fully complying with IS : 4012-1967 and IS : 4013-1967 with latest amendments. The maximum temperature rise of the fitting shall conform to relevant IS with latest amendments.

#### **4.5 Flame Proof Fixture :**

The flame proof fittings shall withstand the internal explosion of gas or vapour for which it is certified without igniting an explosive atmosphere outside the fitting. It shall conform to IS : 2206 (Part-I)-1962 and IS : 2148-1968 with latest amendments for flame proof well glass and bulk head fixtures and flame proof enclosures respectively.

The fittings shall be tested and certified by Central Mining Research Station, Dhanbad for compliance with the relevant Indian Standard Specifications and approved by the Director General of Mines Safety, Dhanbad.

**4.5.1 Flame proof bulk head fittings :** This fitting shall be constructed in cast iron and finished in stove enamel grey. It shall have a thick toughened glass cemented into the cast iron retaining ring. The terminal chambers shall have separate enclosure fitted with a separate cover plate so that it is left undisturbed during reclamping. It shall have two cable glands with cable sealing and dividing boxes which are affixed by means of 3 bolts to meet statutory requirements. The fitting shall be suitable for Group I areas with GLS lamps upto 150 W and temperature range as specified in relevant IS.

**4.5.2 Flame proof well glass fitting :** The construction shall be similar to the above detailed in 4.5.1 and suitable for 100 W GLS lamp and Group I area.

#### **4.5.3. Flame proof flood lights :**

The fitting shall be constructed in cast iron finished in grey stove enamel, and shall have internal reflector of bright anodised aluminium and mounted in a MS enclosure with a cast iron base and the other features shall be similar to well glass/bulk head fitting as explained above. The fitting shall be suitable for 300 W GLS lamp for temp. range 'Y' and 500 W for 'X' temp. range.

The above flame proof fixtures shall also be suitable for HPMV lamp of capacity to suit the temperature rise as specified in the relevant IS.

#### **4.6 Flame proof enclosure for control gear :**

This shall have cast iron construction, finished in grey stove enamel and shall have the suitable ballast and PF correction capacitors for 80/125/250/400 W MV lamps. It shall have two fixing straps and be provided with two cable entries. It shall conform to the relevant IS with respect to group and temperature range.

#### **5.0 Installation of Lighting Fixtures :**

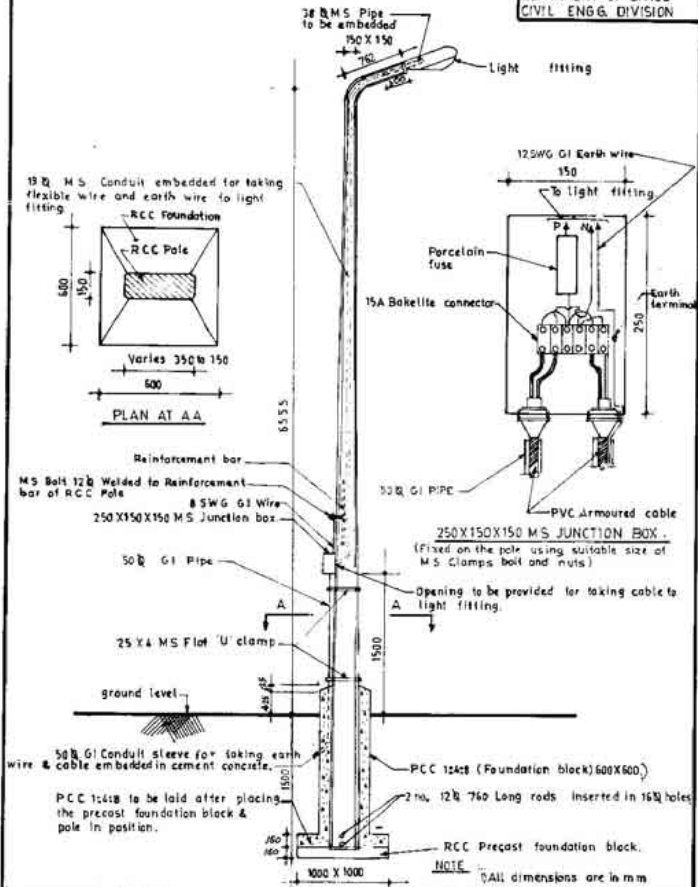
The respective light fixture shall be assembled and installed in position and ready for service and shall conform to the respective detailed drawings, manufacturer's instructions and shall be

to the satisfaction of the Engineer-in-Charge. It shall be ensured that the fixtures are suspended wherever necessary, true to alignment plumb level and capable of resisting all lateral and vertical forces.

All light fittings shall be bonded to earth through proper earth wires.

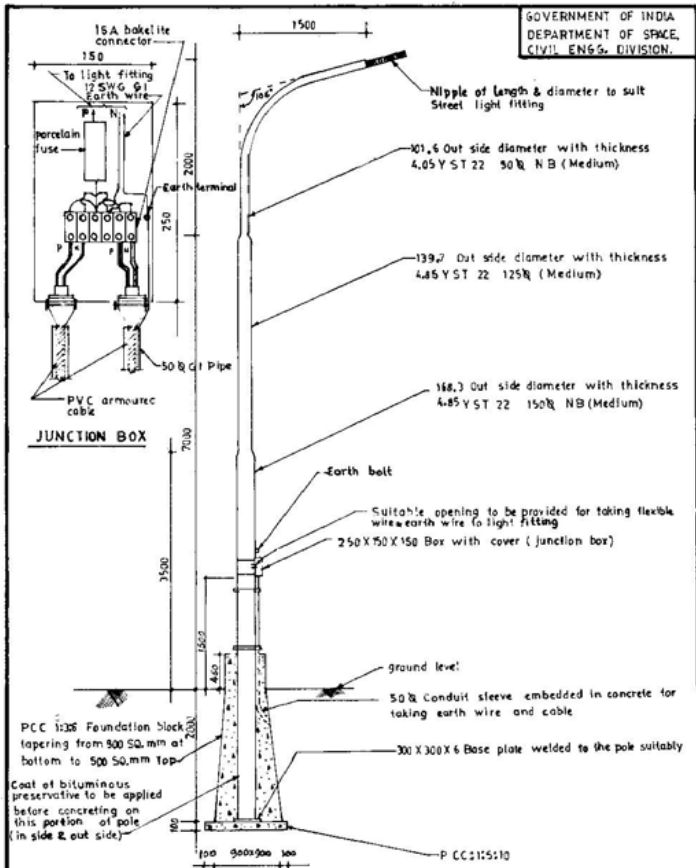
Some of the typical fixing details for different types of light fittings are shown in the following drawings.

- i) CED/ELE/S/11 – Typical detail of street light fixing on RCC pole.
- ii) CED/ELE/S/12 – Typical details of street light fixing on tubular poles.
- iii) CED/ELE/S/13 – Post top lantern pole mounting details.
- iv) CED/ELE/S/14 – Typical flood light pole mounting type fixing details.
- v) CED/ELE/S/20 – Typical light fitting fixing details for wall mounting type (street light fluorescent fittings).
- vi) CED/ELE/S/21 – – do – (for HPMV lamp fittings).
- vii) CED/ELE/S/22 – – do –
- viii) CED/ELE/S/23 – Typical fixing details for High bay fittings.



## TYPICAL DETAILS OF RCC STREET LIGHT POLE

drawn S. B. Maheswara	checked S. D. Engineer	Recommended S. E. Engineer	Approved Chief engineer	SCALE N T S	DRG. No.
DATE June 1986	DATE June 1986	DATE June 1986	DATE June 1986	DATE June 1986	CEC/ELE/S/11



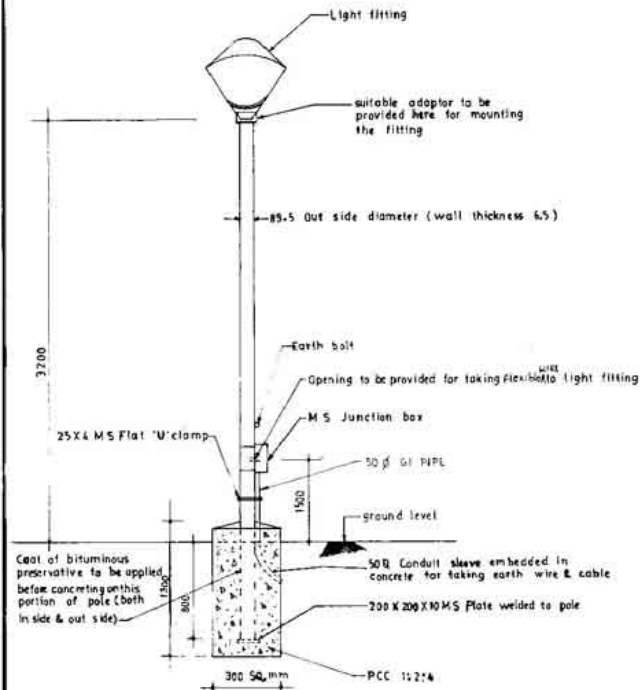
**NOTES**

1) All dimensions are in mm.

**TYPICAL DETAILS FOR TUBULAR STREET LIGHT POLE**

drawn <i>Shri S. B. Maheshwari</i> engineer S B	checked <i>Shri S. D. Maheshwari</i> engineer S D	recommended <i>Shri S. E. Maheshwari</i> Head electrical	approved <i>Shri S. E. Maheshwari</i> chief engineer	SCALE N T S DATE June, 1986	DRG. No. CED/ELE/S/12
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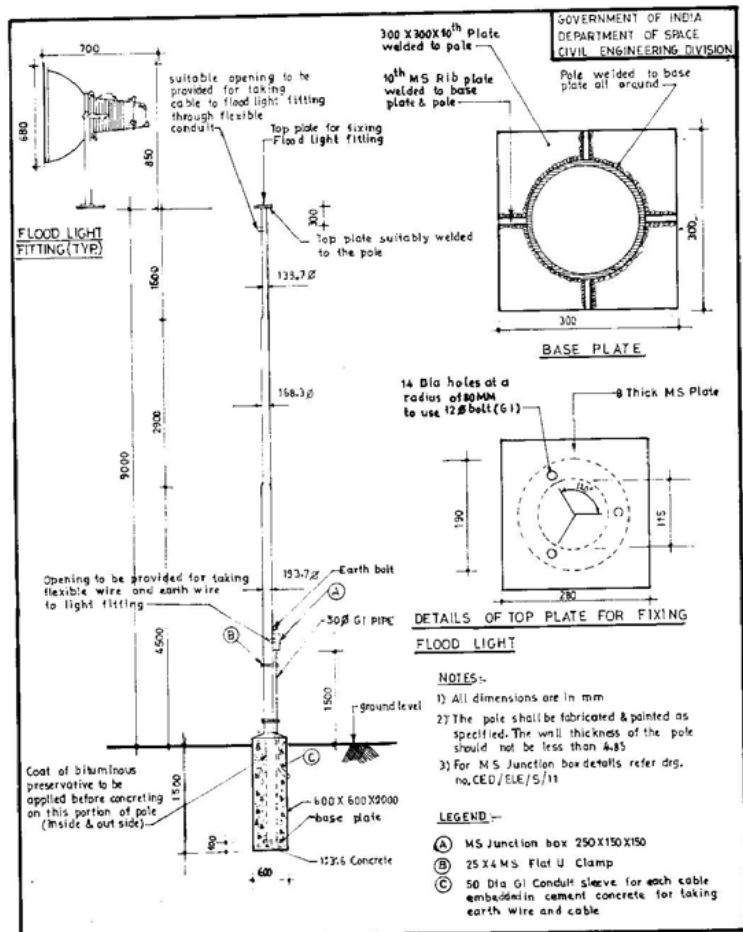


NOTES -1) All dimensions are in mm

2) MS Junction box details refer arg. no. CED/ELE/S/11

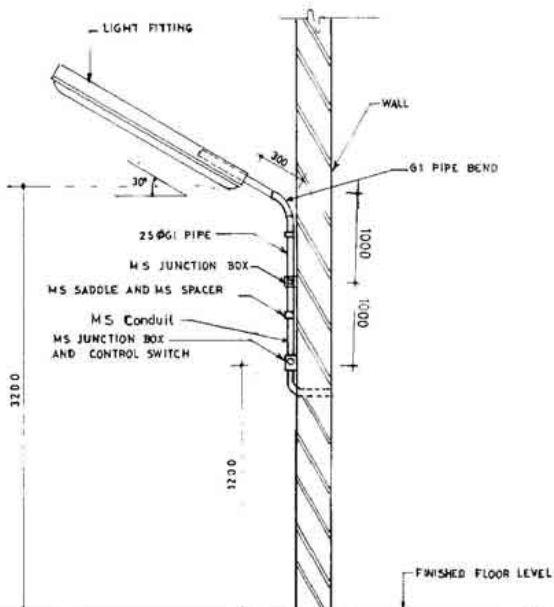
## POST TOP LANTERN POLE MOUNTING

drawn maheshwari	checked engineer S.D.	Recommended Head electrical	Approved Chief engineer	SCALE N T S	DRG. NO. CED/ELE/S/13
designed maheshwari	checked engineer S.C.			DATE JUNE 1986	



## TYPICAL FLOOD LIGHT POLE MOUNTING TYPE

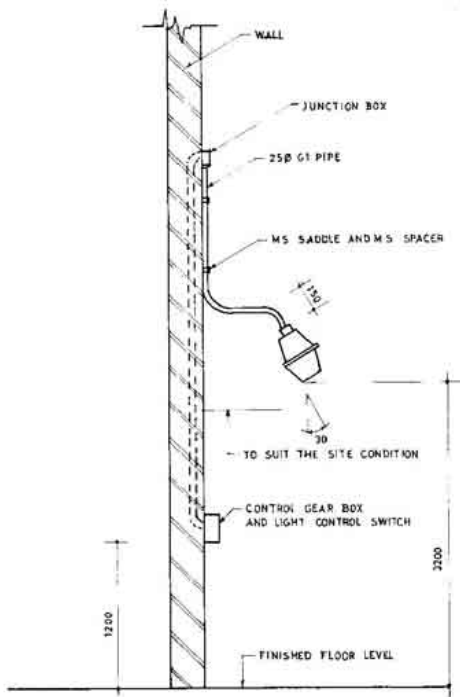
drawn <i>[Signature]</i> maheshwara engineer S B	checked <i>[Signature]</i> engineer S D checked <i>[Signature]</i> engineer S E	recommended <i>[Signature]</i> Head electrical	approved <i>[Signature]</i> Chief engineer	SCALE N T S DATE June 1985	DR6, No. CED/ELE/5/14
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NOTE : All dimensions are in mm

TYPICAL LIGHT FITTING FIXING DETAILS FOR WALL  
MOUNTING TYPE (FLUORESCENT STREET LIGHT FITTING)

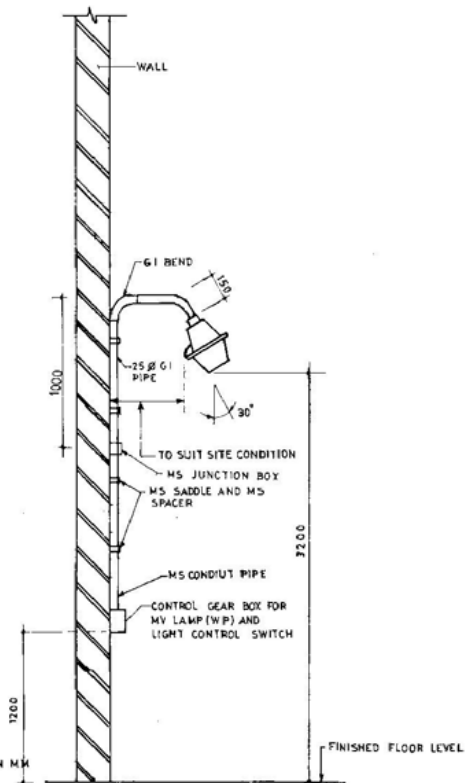
drawn mahasweta	checked engineer SD	recommended Head electrical	Approved chief engineer	SCALE N T S	drg. no.
checked engineer SC	checked engineer SE	Head electrical	chief engineer	DATE JULY 1986	CED/ELE/S/20



NOTES - ALL DIMENSIONS ARE IN MM

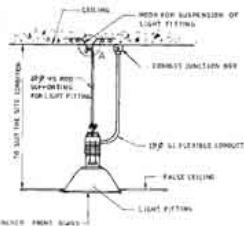
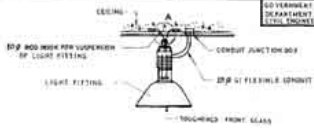
TYPICAL LIGHT FITTING FIXING DETAILS FOR WALL MOUNTING TYPE (MV LAMPS)

Design <i>[Signature]</i> engineer SC	Checker <i>[Signature]</i> engineer SE checked <i>[Signature]</i> engineer SE	Recommended <i>[Signature]</i> Head electrical	Approved <i>[Signature]</i> chief engineer	SCALE N T 5 Date JULY 1986	dra. no. DE/EE/S/21
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TYPICAL LIGHT FITTING FIXING DETAILS FOR WALL MOUNTING TYPE  
(MV LAMPS)

Drawn: mohd. wars	Checked: S B	Recommended: S B	Approved: S B	Scale: NTS	Drw. no.:
Checked: S C	Checked: S B	Head Electrical:	Chief Engineer:	Date: JULY 86	CED/ELE/S/22



DETAIL AT 'X'

- MATERIAL  
1. ALL DIMENSIONS ARE IN MM  
2. ROD SHOULD BE PLATED OVER MAIN REINFORCEMENT OF SLAB WHEN

TYPICAL LIGHT FITTING FIXING DETAILS FOR HIGH BAY FITTING

Drawn S. S. Srinivasan	Checked S. S. Srinivasan	Approved S. S. Srinivasan	Approved S. S. Srinivasan	Date 15/11/2008	Proj. No. ISRO/ISL/S/22
Checked S. S. Srinivasan	Checked S. S. Srinivasan	Checked S. S. Srinivasan	Checked S. S. Srinivasan	Date 15/11/2008	Proj. No. ISRO/ISL/S/22

SECTION III  
**FANS**

**SECTION – III**  
**SPECIFICATION FOR FANS**

**1.0 Scope:**

This specification is intended to cover the requirements of supply, installation and testing of the following type of fans and their associated regulators suitable for use on single phase AC circuits.

- a) Ceiling fan,
- b) Exhaust fan,
- c) Air circulator,
- d) Cabin fan.

**2.0 Standards:**

Fans and regulators shall conform to the latest relevant Indian Standard specifications.

**3.0 Construction:**

**3.1 Standard size of fans:**

- 3.1.1 Ceiling fans: (a) 1200 mm, (b) 1400 mm, (c) 1500 mm.
- 3.1.2 Exhaust fans: (a) 305 mm, (b) 380 mm, (c) 457 mm, (d) 610 mm.
- 3.1.3 Air circulators: (a) 450 mm, (b) 600 mm, (c) 750 mm.
- 3.1.4 Cabin fans: (a) 225 mm, (b) 305 mm, (c) 400 mm, (d) 500 mm.

Sizes of fans specified above are subject to a tolerance of  $\pm 5$  mm.

**3.2 General:**

- 3.2.1 The speed of fans shall be as per relevant IS. The speeds of the above exhaust fans, air circulators and cabin fans shall not exceed 900, 1400 and 900 RPM respectively at the highest value of the rated voltage 230V, AC and rated frequency 50HZ.
- 3.2.2 Fans shall operate on 230V  $\pm 5\%$ ; 50HZ; single phase AC.
- 3.2.3 The motors of the fans shall be of totally enclosed type.
- 3.2.4 Stampings of fan motors shall be made from electrical sheet steel of cold rolled grain oriented type.
- 3.2.5 Fans shall be fitted with three or more well balanced blades made from metal or other suitable material. The blades and blade carriers shall be fixed so that they do not loosen while in operation.
- 3.2.6 Class 'B' insulating materials shall be used in the fans and regulators.
- 3.2.7 The insulation resistance of the fan motor and its regulator shall not be less than 2 megaohm when tested with 500 volts insulation tester.
- 3.2.8 Capacitors shall be easily replaceable and placed at sufficient distance from the windings, so that its maximum working temperature is not exceeded. Capacitors shall be clearly marked with the maximum safe working temperature and the corresponding voltage and capacitance.



3.2.9 Components of a particular model and size of fan, its associated regulator and set of blades shall be inter-changeable.

3.2.10 A device shall be provided in pedestal fans and cabin fan to render the oscillating mechanism inoperative when desired. Means shall be provided to ensure that when properly installed, the fan is not stalled or overturned if the oscillating mechanism is impeded.

### **3.3 Markings :**

Each fan shall be indelibly marked with at least the following information.

3.3.1 Manufacturer's name/trade name.

3.3.2 Rated voltage or voltage range and number of phases.

3.3.3 Input in watts.

3.3.4 Size of fan.

3.3.5 Rated speed in RPM.

3.3.6 Rated frequency.

### **3.4 Regulator :**

All fans except exhaust fans shall be capable of running on all the contacts of regulator at the rated voltages and regulators shall be capable of reducing the speed of the fan by at least 50 percent of the full speed at the rated voltage. Regulator shall have an 'OFF' position preferably next to the lowest speed contact, and shall be provided with not less than five running positions.

Regulator knob shall be either of insulating material or, if of metal, shall be adequately insulated electrically and thermally so that its temperature rise above ambient is limited to 20° C. The mechanism of the regulator shall be so designed as to ensure positive contact at each running position.

### **4.0 Exhaust Fan :**

The exhaust fan shall be of heavy duty type and provided with gravity louvres and shutters. The blades shall be with broad surface for large air delivery and quiet operation.

### **5.0 Air Circulator :**

The air circulator shall be such as to ensure that the fan is stable with an angle of tilt upto 10° in any direction with fan fully extended.

The air circulator shall be of adjustable height type if it is pedestal mounted and shall conform to the relevant IS which is reproduced below :

Size of fan	Minimum (mm)	Maximum (mm)
450 mm	1100	1400
600 mm	1400	1650
750 mm	1500	1950

and conform to the minimum heights specified above for the respective sizes, if it is fixed height type.

The air circulator shall be of oscillation type and the number of oscillations per minute at full speed shall not be less than four.

## **6.0 Installation :**

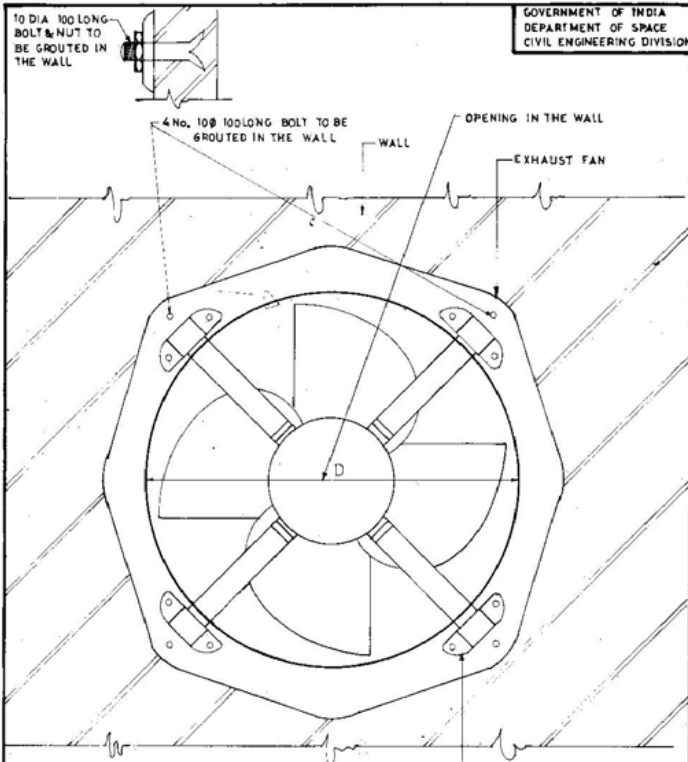
**6.1 Ceiling fan :** The ceiling fan shall be provided with suspension arrangements in concrete slab/roof members. In the case of concrete slab tubular box shall be embedded as indicated in the drawing CED/ELE/S/19. It shall be ensured that the fan hook is within the bottom of the slab and when the fan is installed it gives a neat appearance. While installing the fan care shall be taken to provide with split pin and locking nuts such that the down rod is firmly fixed and the fan does not slip from the down rod. A typical fixing arrangement of a ceiling fan is indicated in the drawing CED/ELE/S/19. The fan and the regulator shall be suitably earthed.

## **6.2 Exhaust Fan :**

For fixing the exhaust fan suitable opening in the wall to suit the dimension of the exhaust fan shall be made and the required no. of bolts shall be grouted. It shall be ensured that the opening is finished neatly to match with the finished surface of the wall. A typical fixing arrangement of an exhaust fan is indicated in the drawing CED/ELE/S/17. One coat of anticorrosive painting shall be applied on the mounting bracket and gravity louvres. The exhaust fan shall be suitably earthed.

## **6.3 Air Circulator and Cabin Fan :**

For fixing air circulators suitable supporting brackets shall be fixed to the wall/column at a height not less than 2.5M for air circulator and 1.75M for cabin fan from the finished floor level and necessary bolts shall be grouted. After the grouting work, the wall/column shall be neatly finished for proper matching of the wall/column. A typical fixing arrangement of an air circulator is indicated in the drawing CED/ELE/S/18. One coat of red oxide primer and two coats of anti-corrosive painting shall be applied on the bracket and other metal parts of fixing accessories.



NOTES -

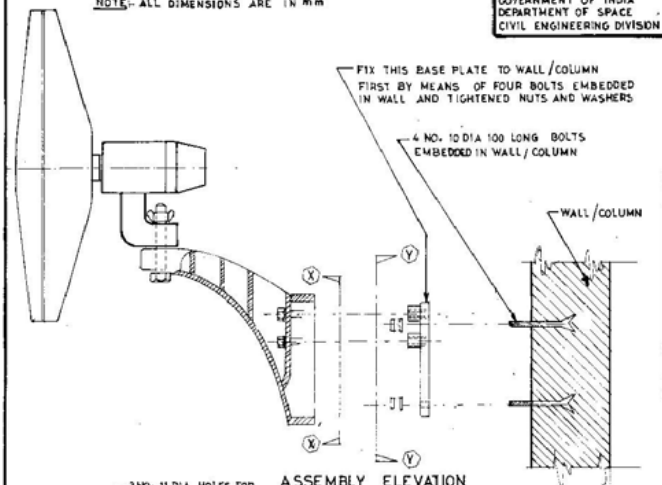
- 1) ALL DIMENSIONS ARE IN MM
- 2) OPENING IN THE WALL (D) IS TO BE PROVIDED DEPENDING UPON SIZE OF EXHAUST FAN

**TYPICAL EXHAUST FAN FIXING DETAILS**

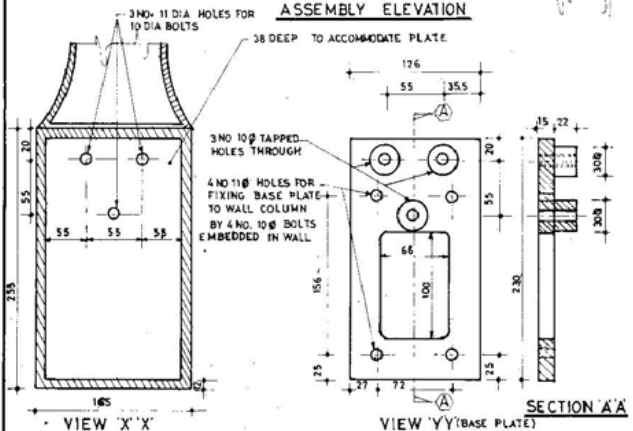
drawn maheshwara	checked engineer S D	Recommended head electrical	Approved chief engineer	SCALE N T S	drg. no.
date 11/11/86 engineer S C	checked engineer S E	11/11/86 head electrical	11/11/86 chief engineer	DATE JULY 1986	CED/ELE/S/17

NOTE- ALL DIMENSIONS ARE IN mm

GOVERNMENT OF INDIA  
DEPARTMENT OF SPACE  
CIVIL ENGINEERING DIVISION

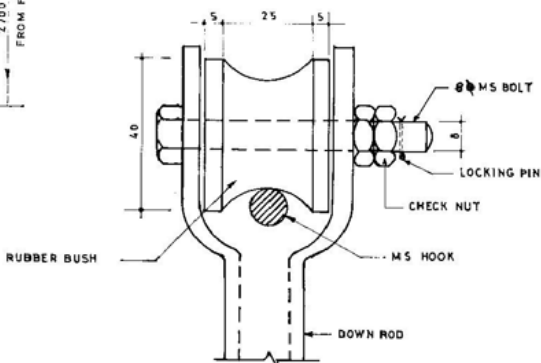
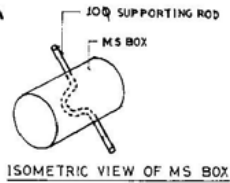
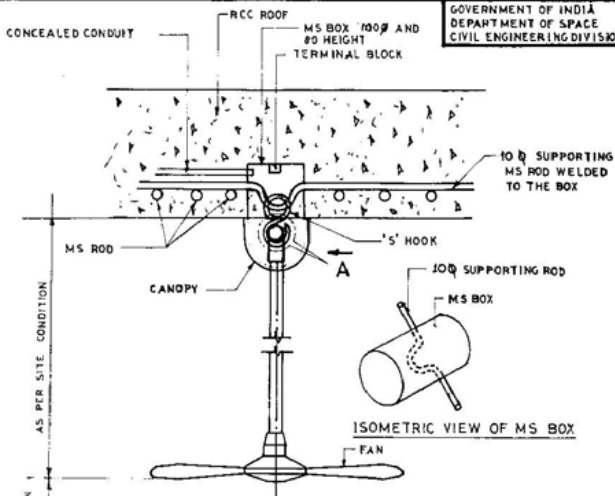


ASSEMBLY ELEVATION



TYPICAL MOUNTING ARRANGEMENT FOR BRACKET  
TYPE AIR CIRCULATOR

drawn maheshwari	checked S. S. Engineer	Recommended S. S. Head electrical	Approved S. S. Chief engineer	SCALE NT S date JULY 1986	drg. no. CED/ELE/S/18
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NOTE: ALL DIMENSIONS ARE IN MM

TYPICAL DETAILS OF FIXING ARRANGEMENT OF CEILING FAN

Drawn <i>SC</i>	Checked Engineer SD <i>SC</i>	Recommended <i>SC</i>	Approved <i>SC</i>	Scale NTS	Drw. no.
Dept. ENGINEER SC	Checked Engineer SE <i>SC</i>	Head Electrical	Chief Engineer	Date JULY 1986	CED/ELE/S/19

SECTION IV  
**POWER CONTROL CENTRES/  
MAIN SWITCH BOARDS**

**SECTION – IV**  
**POWER CONTROL CENTRES/MAIN SWITCH BOARDS**

**1.0 Scope :**

This specification is to cover the requirement of design, supply, installation, testing and commissioning of LT power control centres/main switch boards with all components, fittings and accessories for efficient operation without any trouble.

**2.0 Standards :**

The PCC specified herein, unless otherwise stated shall conform to the relevant and latest revisions of Indian standards and Indian Electricity Rules.

**3.0 Design and Construction :**

**3.1 Design requirements :** The power control centres shall be suitable for operation on 415 volts, 3 phase, 50 HZ system to withstand a short circuit level of 50 KA RMS symmetrical.

The PCC shall be designed for operation in high ambient temperature upto 45° C and high humidity upto 95 % and tropical atmospheric conditions. Means shall be provided to facilitate ease of inspection, cleaning and repairs.

**3.2 Constructional requirements :**

The power control centre shall be of i) metal clad, cubicle, indoor, free standing type.

- ii) made up of the requisite vertical sections, which when coupled together shall form continuous dead front switch board.
- iii) dust and damp protected, the degree of protection shall be better than IP-54 as specified in IS-2147.
- iv) readily extendable on both sides by the addition of vertical sections after removal of the end covers.
- v) single front construction with the circuit breaker feeder and switch fuse feeders suitable for operation from the front of the panel.

The PCC shall have the feeder ratings as per the schematic diagrams enclosed with the schedule and constructed only of materials capable of withstanding the mechanical, electrical and thermal stresses as well as the effects of humidity, which are likely to be encountered in normal service.

**3.3 Vertical Sections :**

Each vertical section shall comprise a front framed structure rolled/folded sheet steel channel section of minimum 2 mm thickness rigidly bolted together. This structure shall house the components contributing the major weight of the equipment, such as circuit breaker, switch fuse units, main horizontal busbars, vertical risers and other front mounted accessories. The structure shall be mounted on a rigid base frame of folded sheet steel of minimum 2.5 mm thickness and 100 mm height. The design shall ensure that the weight of the components is adequately supported without deformation or loss of alignment during transit or during operation.

Suitable cable chamber housing the cable end connections and power/control cable terminations shall be provided. The design shall ensure generous availability of space for ease of installation and maintenance of cabling and adequate safety for working in one vertical section without coming into accidental contact with live parts in the adjacent section.

A cover plate at the top of the vertical section shall be provided with necessary ventilating arrangements. Any aperture for ventilation shall be covered with a perforated sheet having less than 1 mm diameter perforations to prevent entry of vermin.

### **3.4 Sheet Steel Cubicle:**

3.4.1 The sheet steel cubicle shall be designed in fully segregated multitier formation. Each cubicle shall have hinged front access door with easy operating fasteners. All doors and covers shall be heavily gasketed to make the compartment dust tight. Each cubicle shall have a covering at the bottom to make a dust and vermin proof construction. Door hinges shall be of concealed type.

The cubicle shall be of minimum 2 mm thick sheet steel. Sheet steel shrouds and partitions shall be of minimum 1.6 mm thickness. All sheet steel work forming the exterior of switch boards shall be smoothly finished, levelled and free from flaws. The corners shall be rounded.

3.4.2 The apparatus and circuits in the power control centres shall be so arranged as to facilitate their operation and maintenance and at the same time to ensure the necessary degree of safety.

Apparatus forming part of the power control centres shall have the following minimum clearance.

- i) between phases – 25 mm,
- ii) between phases and neutral – 25 mm
- iii) between phases and earth – 25 mm
- iv) between neutral and earth – 19 mm

When, for any reason, the above clearances are not available, suitable insulation shall be provided. Clearance shall be maintained during normal service conditions. Creepage distances shall comply with those specified in relevant standards.

3.4.3 All insulating materials used in the construction of the equipment shall be non-hygroscopic, duly treated to withstand the effect of high humidity, high temperature and tropical ambient service conditions.

3.4.4 Functional units such as circuit breakers and fuse switches shall be arranged in multitier formation, except that not more than two air circuit breakers housed in a single vertical section.

3.4.5 Metallic/insulated barriers shall be provided within vertical sections and between adjacent sections to ensure prevention of accidental contact with:

- i) main busbars and vertical risers during operation, inspection or maintenance of functional units and front mounted accessories.
- ii) cable terminations of one functional unit, when working on those of adjacent unit/units.

3.4.6 All doors/covers providing access to live power equipment/circuits shall be provided



with tool operated fasteners to prevent unauthorised access.

3.4.7 Provisions shall be made for permanently earthing the frames and other metal parts of the switchgear by two independent connections.

### 3.5 Metal treatment and finish :

All steel works used in the construction of the switch boards shall have undergone a suitable rigorous metal treatment process so as to remove oxide scales and rust formation and to facilitate a durable coating of the paint on the metal surfaces and also to prevent the spreading of rust, in the event of the paint film being mechanically damaged.

Two coats of primer followed by a finishing coat of synthetic enamel paint to the shade as specified by the Engineer-in-Charge shall be given. The total thickness of paint shall not be less than 25 micron.

### 3.6 Bus Bars :

3.6.1 The busbars shall be housed in non-segregated sheet steel compartments in the cubicle at convenient locations with provision for access to the buses from the front of the panel. The bus chamber and the breaker cubicle shall have interpanel fire-barriers.

3.6.2 The busbars shall be air insulated and made of high conductivity, high strength aluminium alloy complying with the requirements of IS 5082. The busbar shall be suitably braced with non-hygroscopic supports to provide a through fault withstand capacity of 50 KA RMS symmetrical for one second and a peak short circuit withstand capacity of 150 KA minimum. The neutral as well as the earth bus shall be capable of withstanding the above fault level.

3.6.3 Large clearance and creepage distances shall be provided on the busbar system to minimise the possibility of a fault.

3.6.4 High tensile bolts, nuts and spring washers shall be provided at all busbar joints.

3.6.5 The continuous rating of the busbar shall be 125% of the rated current. Maximum temperature of the bus and the connections shall not exceed 85°C. The busbars shall be of liberal design for the required current rating. However the cross-sectional area of the bus for various ratings shall not be less than as specified below.

Bus bar rating in Amps	Total cross sectional area per phase in mm <sup>2</sup>
100	150
200	300
300	450
400	600
630	1000
800	1100
1000	1300
1250	1500
1600	2000
2000	2500
2400	3000
3000	3500

The main phase busbars shall have continuous current rating throughout the length of each power control centre and the neutral busbars shall have a continuous rating of at least 50% of

the phase busbars.

3.6.6 Connections from the main busbars to functional circuits shall be arranged and supported so as to withstand without any damage or deformation, the thermal and dynamic stresses due to short circuit currents.

All busbars and tapplings shall be provided with colour coded sleeves for phase identification.

All joints/tapping points of the buses shall be suitably shrouded to prevent accidental contact.

#### **4.0 Circuit Breakers :**

##### **4.1 General:**

4.1.1 Circuit breakers shall be of triple pole/four pole, air break, horizontal drawout type, as given in the schedule of work and comply with the requirements of relevant IS with latest amendments and shall have the following:

- i) A short circuit breaking capacity of not less than 50 KA RMS at 415 volts, 50 Hz AC.
- ii) A short circuit making capacity of 105 KA.
- iii) A short time withstand capacity of 150 KA for one second.
- iv) Electrical over load performance at 6 times the rated current, 110% of the rated voltage as recovery voltage at 0.5 power factor.
- v) Dielectric test of 2.5 KV applied for one minute on main circuits.

4.1.2 The circuit breakers shall be fitted with detachable arc chutes on each pole designed to permit rapid dispersion, cooling and extinction of the arc. Interphase barriers shall be provided to prevent flash over between phases.

4.1.3 Arcing contacts shall be of hard wearing material copper tungsten or silver tungsten and shall be easily replaceable. Main contacts shall be of silver plated copper of high pressure butt type and of generous cross section.

##### **4.2 Operating Mechanism :**

The operating mechanism shall be of robust design, with minimum number of linkages to ensure maximum reliability. Manually operated circuit breakers shall be provided with spring operated closing mechanisms which are independent of speed of manual operation. Electrically operated breakers shall have motor wound, spring charged closing mechanisms. Breaker operation shall be independent of the motor which shall be used solely for charging the closing spring.

The operating mechanism shall be such that the breaker is at all times free to open immediately when the trip coil is energised.

Mechanical operation indicators shall be provided to show open and closed positions of the breaker. Electrically operated breakers shall be additionally provided with mechanical indications to show charged and discharged conditions of the charging spring.

Means shall be provided for slow closing and opening of the breaker for maintenance purposes, and for manual charging and closing of electrically operated breakers during emergencies,

##### **4.3 Protection :**

Provisions shall be available for fitting a minimum of five trip devices—three over current, a

shunt trip and an under voltage release or two over current and earth fault release, a shunt trip and one under voltage release. The breakers shall be of the shunt or series trip type as specified in the schedule.

#### **4.4 Housing of Circuit Breaker :**

Circuit breakers shall be individually housed in sheet metal castle provided with hinged doors. The breaker along with its operating mechanism shall be mounted on a robust carriage moving on guide rollers within the castle. Isolating contacts for both power and control circuits shall be of robust design and fully self aligning. The assembly shall be designed to allow smooth and easy movement of the breakers within its castle.

The breaker shall have three distinct positions within the castle as follows :

- i) 'Service' position : with main and auxiliary contacts connected.
- ii) 'Test' position : with power contacts fully disconnected and control circuit contacts connected.
- iii) 'Isolated' position : with both power and control circuit contacts fully disconnected.

It shall be possible to achieve any of the above positions with the castle doors closed. Mechanical position indicators shall be provided for the three positions of the breakers.

#### **4.5 Interlocking :**

4.5.1 The moving portion of the circuit breaker shall be so interlocked that :

- i) it shall not be possible either to isolate it from the connected position, or to plug it in from the isolated position with the breaker closed.
- ii) the circuit breaker can be closed only when it is in one of the three positions or when it is fully out of the castle.
- iii) it shall not be possible to open the hinged door of the castle unless the breaker is drawn to the isolated position.
- iv) inadvertent withdrawal of the circuit breaker too far beyond the supports is prevented by suitable stops.

4.5.2 Provision shall be available for the padlocking of the circuit breaker access flaps in any of the three positions.

4.5.3 Automatically operated safety shutters shall be provided to screen the fixed isolating contacts when the breaker is drawn out from the castle.

4.5.4 The moving portion of the circuit breaker shall be provided with a heavy duty, self aligning earth contact, which shall make before and break after the main isolating contacts during insertion into and withdrawal from the service position of the breaker. Even in the isolated position positive earthing contact should exist.

4.5.5 Auxiliary switches directly operated by the breaker operating mechanism and having 4 'NO' and 4 'NC' contacts, shall be provided on each breaker. The auxiliary switch contacts shall have a minimum rated thermal current of 10 amps.

## **5.0 Switch Fuse Units :**

### **5.1 General:**

The switch fuse units shall be of the load break, heavy duty, cubicle type conforming to the requirements of relevant latest amended IS and of AC 23 duty.

The switch fuse shall be capable of withstanding the thermal and electromagnetic stresses caused by short circuit currents for the time of operation of the associated fuse links.

The switch fuse units shall be double break and have quick make and quick break mechanism, designed to ensure positive operation.

All switch fuse contacts shall be silver plated at the current transfer surfaces.

The unit shall be provided with a front operating handle. The ON and OFF positions of the switch handle shall be clearly marked.

### **5.2 Interlocks and Safety :**

Interlocks shall be provided so as to prevent opening of the unit door when the switch is in the ON position, and also to prevent closing of the switch with the door not properly secured. It should, however, be possible for a competent person to operate the switch with the door open, by releasing the interlock. The handle of the switch shall be suitable for locking the switch in the OFF position by means of a padlock.

The interior arrangement of the switch fuse unit shall be such that all 'live' parts are shrouded.

### **5.3 HRC Fuses :**

The switch fuse units shall be fitted with high rupturing capacity cartridge fuse links with ISI marking for a rupturing capacity of not less than 80 KA at 415 volts. The fuse links shall be mounted in a drawout carriage, thus ensuring positive isolation of contacts during fuse replacement.

### **6.0 Current Transformers :**

Current transformers shall comply with the requirements of relevant latest amended IS. They shall have ratios, outputs and accuracy as specified in the schedule.

### **7.0 Indicating/Integrating Meters :**

All indicating instruments shall be of flush mounted industrial pattern, conforming to the relevant latest amended IS. The instruments shall have non-reflecting bezels, clearly divided and indelibly marked scales, and shall be provided with zero adjusting devices in the front.

Integrating instruments shall be of flush mounted switch board pattern, complying with the requirements of relevant latest IS.

### **8.0 Relays :**

Circuit breakers shall be provided with integrally mounted relays as specified in the schedule. The relay shall have a set of three phase characteristics which shall be adjustable over a wide range, to provide discrimination between a multiplicity of devices. The relay shall be able to provide over current and earth fault protection.

The relays shall be of the drawout type with built-in test facilities. Flag indicators shall be provided in these relays capable of being reset without opening the relay case.

#### **9.0 Control switches/Selector switches:**

Control switches/Selector switches shall be of the heavy duty rotary type, with plates clearly marked to show the operating position. They shall be of the semi-flush mounted-type with only the front plate and operating handle projecting.

Circuit breaker-control switches shall be of the spring return to neutral type.

#### **10.0 Indicating lamps and push buttons:**

Indicating lamps shall be of the filament type of low watt consumption, provided with series resistors where necessary, and with translucent lamp covers. Bulbs and lenses shall be easily replaceable from the front.

Push buttons shall be of the momentary contact, push to actuate type, fitted with self reset contacts and provided with plates marked with its functions.

#### **11.0 Cable terminations:**

Cable entries and terminals shall be provided in the switch board to suit the number, type and size of aluminium conductor power cables and copper conductor control cables as indicated in the schematic diagram.

Provision shall be made for top or bottom entry of cables as required. Generous size of cabling chambers shall be provided, with the position of cable glands and terminals such that cables can be easily and safely terminated.

Barriers or shrouds shall be provided to permit safe working at the terminals of one circuit without accidentally touching that of another live circuit.

Cable risers shall be adequately supported to withstand the effects of rated short circuit currents without damage and without causing secondary faults.

Cable sockets shall be of copper and of the crimping type/soldering type as required.

#### **12.0 Control wiring:**

All control wiring shall be carried out with 1100/650 V grade single core PVC cable conforming to relevant IS having stranded copper conductors of minimum 2.5 sq. mm section.

Wiring shall be neatly bunched, adequately supported and properly routed to allow easy access and maintenance.

Wires shall be identified by numbered ferrules at each end. The ferrules shall be of the ring type and of non-deteriorating material. They shall be firmly located on each wire so as to prevent free movement.

All control circuit fuses shall be mounted in front of the panel and shall be easily accessible.

#### **13.0 Terminal blocks and labels:**

Terminal blocks shall be of 500 volts grade of the stud type. Insulating barriers shall be provided between adjacent terminals.

Terminal blocks shall have a minimum current rating of 10 amps and shall be shrouded. Provisions shall be made for label inscriptions.

Labels shall be of anodised aluminium, with white engraving on black background. They shall be properly secured with fasteners. Danger plate of size and descriptions as recommended in the relevant IS, shall be provided on the PCC.

#### **14.0 Tests :**

- i) The power control centre shall be completely assembled, wired, adjusted and tested for operation under simulated conditions to ensure correctness of wiring and interlocking and proper functioning of all components.
- ii) Each power control centre and components shall be subjected to standard routine tests as per applicable clauses of relevant standards.
- iii) All current carrying parts and wiring of power control centre shall be subjected to power frequency voltage withstand test.

#### **15.0 Drawings :**

After the award of the contract the contractors shall submit three copies of the following drawings for approval of the Department.

- i) Outline dimensional drawing of the PCC showing the general arrangement indicating the following:
  - a) Busbar clearances;
  - b) Power and control cable entry points;
  - c) Configuration of busbars;
  - d) Details of support insulations and spacing;
  - e) Outgoing power cable termination arrangements.
- ii) Single line diagram of power control centre showing protection, metering etc.
- iii) Cubicle wiring diagram.

#### **16.0 Installation and commissioning :**

The power control centre shall be installed over the cable trench/cable pit using suitable size of MS channel including grouting of the channel with necessary bolts and nuts. All cable terminations shall be done as detailed in section VII. Proper earthing of PCC shall be done by using two independent copper/GI strip of sizes as indicated in the schedule. The channel shall be painted with one coat of red oxide primer and two coats of anticorrosive enamel paint of proper shade as directed by the Engineer-in-Charge.

The pre-commissioning tests as indicated in section XII shall be done and the PCC shall be commissioned.

#### **17.0 Technical particulars :**

The tenderer shall fill in this data sheet and submit along with his offer :

1.0.0 Panel details.

1.1.0 Make.

- 1.2.0 Type of enclosure.
- 1.3.0 Sheet metal thickness.
- 1.4.0 Class of protection.
- 2.0.0 Bus bar.
  - 2.1.0 Bus conductor.
    - 2.1.1 Material and grade.
    - 2.1.2 Area of cross section ( $\text{mm}^2$ ).
    - 2.1.3 No. of busbar per phase.
    - 2.1.4 Current density ( $\text{A}/\text{mm}^2$ ).
  - 2.2.0 Minimum clearance of bare bus and connections.
    - 2.2.1 Phase to phase (mm).
    - 2.2.2 Phase to Earth (mm).
  - 2.3.0 Busbars provided with.
    - 2.3.1 Insulating sleeve.
    - 2.3.2 Insulating barriers.
  - 2.4.0 Bus support insulator.
    - 2.4.1 Make.
    - 2.4.2 Material.
    - 2.4.3 Voltage class.
    - 2.4.4 Power frequency withstand voltage for 1 minute, KV.
    - 2.4.5 Minimum total creepage distance (mm).
- 3.0.0 Switch fuse units.
  - 3.1.0 Switches (to be given for each type and rating).
    - 3.1.1 Make.
    - 3.1.2 Standard (IS/BS).
    - 3.1.3 Type.
    - 3.1.4 Rated voltage (V).
    - 3.1.5 Rated normal current (A).
    - 3.1.6 Making capacity.
    - 3.1.7 Breaking capacity.
    - 3.1.8 Short circuit withstand current.
  - 3.2.0 Fuses.
    - 3.2.1 Make.

3.2.2 Type  
3.2.3 Latching capacity  
3.2.4 Fuse standard (V/BS)  
4.00 Current transformer  
4.10 Type  
4.2.0 Make  
4.3.0 Frequency and voltage  
4.4.0 Pole  
4.5.0 Ratio  
4.6.0 Rated VA burden  
4.7.0 Accuracy class  
4.8.0 Class of insulation  
4.9.0 Temperature rise above 45°C ambient  
4.9.0 C.T. Standard (V/BS)  
4.11.0 Mounting  
4.12.0 Dimension and weight  
5.0.0 Relays  
5.1.0 Inverse time over current relay  
5.2.0 IDMT over current with instantaneous trip  
5.3.0 Aux. Relays  
5.3.1 Self reset  
5.3.2 Hand reset  
5.3.3 Standard to which the relays conform  
6.0.0 Selector switch  
6.1.0 Make  
6.2.0 Type  
6.3.0 Contact rating  
6.4.0 24W AC  
7.0.0 Push Buttons  
7.1.0 Make  
7.2.0 Type  
7.3.0 No. of NO and NC contacts  
7.4.0 Contact Rating



- 7.4.1 240V AC.
- 8.0.0 Lamps.
- 8.1.0 Make.
- 8.2.0 Type.
- 8.3.0 Rating.
- 8.4.0 External resistance value.
- 9.0.0 Ammeter and voltmeter selector switches.
- 9.1.0 Make.
- 9.2.0 Type.
- 9.3.0 Contact rating.
- 10.0.0 Switch gear assembly.
- 10.1.0 Breaker provided with service, test and withdrawn positions.
- 10.2.0 Type of indication provided for breaker positions.
- 10.3.0 Cubicle door can be closed with breaker in service or test or withdrawn position?
- 10.4.0 1 minute power frequency withstand voltage, KV rms.
- 10.5.0 Ground bus.
- 10.5.1 Material and size.
- 10.6.0 Control wiring.
- 10.6.1 Size and type.
- 10.6.2 No. and size of strands.
- 10.6.3 Insulation.
- 10.6.4 Voltage class.
- 10.7.0 Control terminal blocks.
- 10.7.1 Make.
- 10.7.2 Voltage grade.
- 10.7.3 Current rating.
- 10.7.4 Type of terminal.
- 10.7.5 Suitable for copper cable sizes mm<sup>2</sup>.
- 10.7.6 % spare terminals furnished.
- 10.8.0 Whether switch fuse units are front or inside mounted.
- 10.9.0 Switch fuse unit for incoming AC supply furnished?

- 10.10.0 Whether key interlock furnished in front mounted?
- 10.11.0 Whether switchgear assembly shall be completely assembled, wired and tested at the factory.
- 10.12.0 Overall dimensions, in mm (L x B x H).
- 10.13.0 Approximate weight, kg.
- 10.14.0 Applicable standards.
- 10.15.0 Shipping dimensions, (L x B x H) in mm.
- 11.0.0 Meters.
  - 11.1.0 Ammeter.
    - 11.1.1 Make.
    - 11.1.2 Type.
    - 11.1.3 Size.
  - 11.2.0 Voltmeter.
    - 11.2.1 Make.
    - 11.2.2 Type.
    - 11.2.3 Size.

SECTION V  
**MOTOR CONTROL CENTRE (MCC)**

**SECTION – V**  
**MOTOR CONTROL CENTRE (MCC)**

**1.0 Scope :**

This specification is to cover the requirements of design, fabrication, supply, installation, testing and commissioning of motor control centre with all components, fittings and accessories for efficient and trouble free operation.

**2.0 Standards :**

The motor control centre specified herein, unless otherwise stated shall conform to the relevant and latest revisions of Indian Standards and Indian Electricity Rules.

**3.0 Construction :**

**3.1 Structures, accessories and requirements :**

3.1.1 The motor control centres shall be metal clad, totally enclosed, rigid, floor mounting, air insulated, cubicle type with fully drawout starter modules for use on 415 volts, 3 phase, 50 cycles per second system to withstand a fault level of 50 KA RMS symmetrical for one second.

3.1.2 The MCC shall be designed for operation in high ambient temp. upto 45° C and high humidity upto 95 % and tropical atmospheric conditions. Means shall be provided to facilitate ease of inspection, cleaning and repair.

3.1.3 The MCC shall be designed for an auxiliary voltage of 230V AC.

3.1.4 The structure of MCC shall be of rigid welded construction with sheet steel of not less than 2 mm thickness. The MCC shall be of self standing, sheet steel cubicle type made up of requisite vertical sections and be of dust and vermin proof construction. The doors, covers, barriers etc. shall be made of minimum 1.6 mm thick sheet steel. All doors shall be of hinged type and provided with gaskets.

3.1.5 The structure shall contain horizontal busbars running throughout the length of the MCC and be readily accessible. Each vertical panel structure shall contain a vertical wire/cable way with provision of suitable cable supports. The cable compartments shall have hinged door.

The construction shall be compartmentalised and the structure shall be of single front.

The sheet steel cubicle shall be designed in fully segregated multitier formation. Each cubicle shall have hinged front access door with easy operating fasteners. All doors and covers shall be having gaskets to make the compartment dust tight. All cubicles shall have covering at the bottom to make dust and vermin proof construction. Door hinges shall be of concealed type.

3.1.6 The structure shall be mounted on a rigid base frame of folded sheet steel of minimum 2.5 mm thickness and 100mm height. This shall be painted black.

3.1.7 The MCC shall be extendable on both sides by addition of vertical sections.

**3.2 Switches and operation :**

3.2.1 Provision shall be made for permanently earthing the frames and other metal parts of the MCC through a copper/GI earth bus running throughout the full length of the MCC panel at the bottom. It shall be possible to earth the MCC at two independent points.

3.2.2 The ratings of different components of individual motor controls shall be as per the list given in the schedule.

All switches, push buttons etc. shall be operable from the front and shall be flush mounted.

The working height shall be limited to a maximum of 1800 mm.

#### 4.0 Metal treatment and finish :

All steel work used in the construction of the switch boards shall have undergone a suitable rigorous metal treatment process so as to remove oxide scale and rust formation and to facilitate durable coating of the paint on the metal surfaces and also to prevent spread of rusting in the event of the paint film being mechanically damaged.

Two coats of primer followed by a finishing coat of synthetic enamel paint to the shade shall be applied as specified by the Engineer-in-Charge. The total thickness of paint shall be not less than 25 microns.

#### 5.0 Busbar :

##### 5.1 Busbar requisites :

5.1.1 The busbar shall be housed in non-segregated sheet steel compartments in the cubicle at convenient locations with provision for access to the buses from the front of the panel. The bus chamber and the breaker cubicle shall have interpanel fire barriers.

The busbar shall be air insulated and made of high conductivity, high strength aluminium complying with the requirements of IS 5082.

5.1.2 The busbars shall be suitably braced with non-hygroscopic supports, to provide a through fault withstand capacity of 50 KA RMS symmetrical for one second and a peak short circuit withstand capacity of 150 KA minimum. The neutral as well as the earth bus shall also be capable of withstanding the above fault level.

5.1.3 Large clearance and creepage distances shall be provided on the busbar system to minimise the possibility of a fault.

5.1.4 High tensile bolts, nuts and spring washers shall be provided at all bus bar joints.

##### 5.2 Busbar ratings :

5.2.1 The continuous rating of the busbar shall be 125% of the rated current. Maximum temperature of the bus and the connections shall not exceed 85 °C. The bus bar shall be of liberal design for the required current rating. However the cross sectional area of the bus for various ratings shall not be less than as specified below :

Busbar ratings in Amps	Total cross-sectional area per phase in Sq. mm
100	150
200	300
300	450
400	600
630	1000
800	1100

1000	1300
1250	1500
1600	2000
2000	2500
2400	3000
3000	3500

5.2.2 All busbars and tappings shall be provided with colour coded sleeves for phase identification.

5.2.3 All joint/tapping points of the buses shall be suitably shrouded to prevent accidental contact.

## 6.0 Unit module :

### 6.1 Module requirements :

6.1.1 Each module shall be suitable for mounting required number of contactors, bi-metal relays, auxiliary contactors, push buttons, isolators, switch fuses, control fuses, mainfuses, indicating lamps, power and control contactors, terminal blocks, etc. to suit non-reversing, reversing and assisted start motor applications, as specified in the schedule.

6.1.2 Each module shall be provided with individual door and the door shall be mounted on the main structure. The doors shall be provided with concealed hinges. The module door shall have a knob with a white dot to indicate position.

6.1.3 Unit doors shall be interlocked mechanically with isolator/fuse switch to prevent unintentional opening of the door while the unit is in energised condition. It should be however possible for a competent examiner to operate the switch with door open by releasing the interlock.

6.1.4 The drawout module shall have the following three distinct positions :

- i) Service position : Both power and control contact engaged.
- ii) Test position : Power contact disengaged, control contact engaged.
- iii) Isolated position : Both power and control contacts in disengaged position.

There shall be positive locations for the drawout module in each of the three positions and provision shall be made for padlocking the module in each of the three position. A positive guiding system shall be provided for accurate alignment of power contacts and control contacts.

6.1.5 The incoming and outgoing power and control contacts shall be of draw out type such that the module shall be inserted or withdrawn without disturbing any cable connection. The contact shall be of self aligning type.

6.1.6 In order to prevent mismatch during replacement, all control and indicating equipments like push buttons, indicating lamps, meters, etc. in a module shall be mounted on a hinged panel which shall be integral with the module. It shall be possible to manually reset the thermal overload relay without opening the door of the module.

6.1.7 Main HRC fuses shall be positioned before the isolator to eliminate any possible hazards during a fault at the isolator terminals. The HRC fuses however shall not be accessible when they are in live condition.

6.1.8 The module shall be connected to the vertical busbars by plug-in contacts.

6.1.9 The various module sizes shall be multiples of a basic dimension so that alteration of module layout at site can be done for quick adoption of the MCC to changing loads.

6.1.10 Each module tray shall be provided with an earth contact and connected to a vertical earth bus. For higher size modules a plug in type earth contact suitable for withstanding the let through energy or HRC fuses shall be provided as per relevant IS, for protection against shock in case of a fault.

## **7.0 Switch fuse and isolators :**

### **7.1 Switch and isolator position and its requirements :**

7.1.1 The incoming to the MCC shall be a switch fuse unit with HRC fuse links or alternatively the MCC panel shall be suitable for coupling with air circuit breakers.

7.1.2 Both isolators and switch fuse units shall comply with the requirements of relevant IS and suitable for AC 23 duty.

7.1.3 Switch fuse units with HRC fuses shall have a withdrawable fuse carriage for quick replacement of HRC fuses. The unit shall be provided with a front operating handle. The 'ON' and 'OFF' position of switch handle shall be clearly marked. The switches shall be capable of withstanding the thermal and mechanical stresses caused by short circuit currents.

## **8.0 Motor starters :**

### **8.1 Contactors :**

8.1.1 Contactors shall be of air break and electromagnetic type rated for uninterrupted duty as defined in relevant IS.

8.1.2 The main contacts shall be of silver or silver alloy.

8.1.3 The insulation for the coils shall be of class 'E'.

8.1.4 Each contactor shall be provided with 2 normally open and 2 normally closed auxiliary contacts.

### **8.2 Thermal overload relays :**

8.2.1 Thermal overload relays shall be of three element positive acting ambient temperature compensated type with adjustable settings.

8.2.2 Thermal overload relays shall be of self/hand reset type as specified in the schedule.

### **8.3 Push buttons :**

8.3.1 All push buttons shall be of heavy duty type, suitable for mounting on sheet steel cubicle door. The push button shall have one 'NO' and one 'NC' contact. The contact shall be rated for 10A. Push buttons shall be of suitable colour according to their functions.

## **9.0 Indicating instruments :**

Ammeters and voltmeters shall be of moving iron, spring controlled and industrial type.

**10.0 Internal wiring :**

Internal wiring for control circuits shall be made with 650V/1100V grade single or multistrand copper conductor of minimum 2.5 mm<sup>2</sup> size PVC insulated wire. Power wiring shall be done with aluminium flexible PVC insulated cable of 650V/1100V grade. The wiring shall be terminated in the respective terminal with suitable crimping type socket.

There shall not be more than two wires connected to a terminal.

Horizontal as well as vertical wire ways shall be provided. At the top, horizontal wireway shall connect the interpanel wiring. Each wire shall be identified at both ends with wire designations in accordance with the approved wiring diagram. Wires shall be neatly bunched and adequately supported so as to prevent sagging and strain on terminals.

**11.0 Terminal blocks :**

Terminal blocks shall be of 500V grade with contacts of ratings not less than 10 Amps. They shall be of the stud type with barriers between adjacent contacts.

The wire terminations to the blocks shall be of screw type suitable for crimping type socket.

Suitable provision shall be made to terminate control/power connections in the respective module.

**12.0 Power cable terminations :**

Gland plates of adequate size shall be provided at the bottom of cable chambers to facilitate cable entry from bottom. Compression type glands shall be provided.

Crimping type sockets shall be provided for terminating cables.

Suitable shrouds shall be provided to prevent accidental contact with live outgoing terminations of other feeders while carrying out maintenance on any one feeder.

**13.0 Name plates :**

Name plates showing feeder designations shall be provided for each module of MCC. Individual panel No. and danger plate shall also be provided.

**14.0 Tests :**

Routine tests shall be conducted on each motor control centre in accordance with relevant IS.

Each MCC shall be completely assembled, wired, adjusted and tested for operation under the simulated conditions to ensure correctness of wiring and proper functioning of all the components.

All current carrying parts and wiring shall be subjected to a high potential test as per the relevant standards.

**15.0 Drawings :**

After the award of the contract the contractor shall submit three copies of the following drawings for approval of the department.

- i) Outline dimensional drawing of the MCC showing the general arrangement indicating the following:



- a) Power and control cable entry points,
  - b) Busbar clearances,
  - c) Details of support insulators and spacing,
  - d) Configuration of busbars,
  - e) Outgoing power cable termination arrangements.
- ii) Single line diagram of MCC showing protection, metering etc.
  - iii) Cubicle wiring diagram.

**16.0 Installation and commissioning:**

Installation and commissioning shall be done as indicated in Section IV.

**17.0 Technical particulars:**

The tenderer shall fill in this data sheet and submit along with his offer:

1.0.0 Panel details

1.1.0 Make

1.2.0 Type of enclosure

1.3.0 Sheet metal thickness

1.4.0 Class of protection

2.0.0 Bus

2.1.0 Bus conductor

2.1.1 Material and grade

2.1.2 Area of cross section ( $\text{mm}^2$ )

2.1.3 No. of busbar per phase

2.1.4 Current density ( $\text{A}/\text{mm}^2$ )

2.2.0 Minimum clearance of bare bus and connections

2.2.1 Phase to phase (mm)

2.2.2 Phase to earth (mm)

2.3.0 Busbars providing with

2.3.1 Insulating sleeve

2.3.2 Insulating barriers

2.4.0 Bus support insulator

2.4.1 Make

2.4.2 Material

2.4.3 Voltage class

2.4.4 Power frequency withstand voltage for 1 minute, KV

- 2. 4.5 Minimum total creepage distance (mm)
- 3. 0.0 Switch fuse units
  - 3. 1.0 Switches (to be given for each type and rating)
    - 3. 1.1 Make
    - 3. 1.2 Standard (IS/BS)
    - 3. 1.3 Type
    - 3. 1.4 Rated voltage (V)
    - 3. 1.5 Rated normal current (A)
    - 3. 1.6 Making capacity
    - 3. 1.7 Breaking capacity
    - 3. 1.8 Short circuit withstand current
  - 3. 2.0 Fuses
    - 3. 2.1 Make
    - 3. 2.2 Type
    - 3. 2.3 Rupturing capacity
    - 3. 2.4 Fuse standard (IS/BS)
- 4. 0.0 Current transformer
  - 4. 1.0 Type
  - 4. 2.0 Make
  - 4. 3.0 Frequency and voltage
  - 4. 4.0 Pole
  - 4. 5.0 Ratio
  - 4. 6.0 Rated VA burden
  - 4. 7.0 Accuracy class
  - 4. 8.0 Class of insulation
  - 4. 9.0 Temperature rise above 45°C ambient.
  - 4.10.0 C. T. Standard (IS/BS)
  - 4.11.0 Mounting
  - 4.12.0 Dimension and weight
- 5. 0.0 Relays
  - 5. 1.0 Inverse time over current relay
  - 5. 2.0 IDMT overcurrent with Instantaneous trip

- 5.3.0 Aux. Relays
  - 5.3.1 Self reset
  - 5.3.2 Hand reset
  - 5.3.3 Standard to which the relays conform
- 6.0.0 Selector switch
  - 6.1.0 Type
  - 6.2.0 Contact rating
  - 6.3.0 240V AC
- 7.0.0 Push Buttons
  - 7.1.0 Make
  - 7.2.0 Type
  - 7.3.0 No. of NO and NC contacts
  - 7.4.0 Contact Rating
    - 7.4.1 240V AC
- 8.0.0 Lamps
  - 8.1.0 Make
  - 8.2.0 Type
  - 8.3.0 Rating
  - 8.4.0 External resistance value
- 9.0.0 Ammeter and voltmeter selector switches
  - 9.1.0 Make
  - 9.2.0 Type
  - 9.3.0 Contact rating
- 10.0.0 Switch gear assembly
  - 10.1.0 Breaker provided with service, test and withdrawn positions
  - 10.2.0 Type of indication provided for breaker positions
  - 10.3.0 Cubicle door can be closed with breaker in service or test or withdrawn position?
  - 10.4.0 1 minute power frequency withstand voltage, KV rms
  - 10.5.0 Ground bus
    - 10.5.1 Material and size
  - 10.6.0 Small wiring
    - 10.6.1 Size and type
    - 10.6.2 No. and size of strands

- 10. 6.3 Insulation
- 10. 6.4 Voltage class
- 10. 7.0 Control terminal blocks
- 10. 7.1 Make
- 10. 7.2 Voltage grade
- 10. 7.3 Current rating
- 10. 7.4 Type of terminal
- 10. 7.5 High Voltage withstand of terminal blocks
- 10. 7.6 Suitable for copper cable sizes mm<sup>2</sup>
- 10. 7.7 % spare terminals furnished
- 10. 8.0 Whether switch fuse units are front or inside mounted
- 10. 9.0 Switch fuse unit for incoming AC supply furnished?
- 10.10.0 Whether they are front or inside mounted
- 10.11.0 Whether key interlock furnished is front mounted?
- 10.12.0 Whether switch gear assembly shall be completely assembled, wired and tested at the factory
- 10.13.0 Overall dimensions, in mm (L x B x H)
- 10.14.0 Approximate weight, kg
- 10.15.0 Applicable standards
- 10.16.0 Shipping dimensions, (L x B x H) in mm
- 11. 0.0 Meters
- 11. 1.0 Ammeter
- 11. 1.1 Make
- 11. 1.2 Type
- 11. 1.3 Size
- 12. 1.0 Voltmeter
- 12. 2.0 Make
- 12. 3.0 Type
- 12. 4.0 Size
- 13. 0.0 Contactors
- 13. 1.0 Make
- 13. 2.0 Type
- 13. 3.0 Rating Amps

- 13. 4.0 De-rating factor, if any for higher ambient 45°C
- 13. 5.0 Duty class
- 13. 5.1 For unidirectional Motor application
- 13. 5.2 For bidirectional Motor application
- 13. 6.0 Utilisation category
- 13. 6.1 For unidirectional motor application
- 13. 6.2 For bidirectional motor application
- 13. 7.0 Contactor conforms to (mention IS/BS number)
- 13. 8.0 Operating coil
- 13. 8.1 Rated voltage
- 13. 8.2 Pick up voltage
- 13. 8.3 Drop out voltage
- 13. 9.0 Power consumption of operating coil during closing/after closing VA/watt
- 13.10.0 Auxiliary contacts
- 13.10.1 Number of NO contacts
- 13.10.2 Number of NC contacts
- 13.10.3 Contact rating of 110V AC
  - (a) Make and continuous Amps
  - (b) Break inductive Amps
- 13.11.0 Starter capable of withstanding let through current of backup protective device? Yes/No
- 14. 0.0 Auxiliary relay/contactors
- 14. 1.0 Furnished as shown in the control schematics Yes/No
- 14. 2.0 Make
- 14. 3.0 Catalogue No.
- 14. 4.0 Type and Rating
- 14. 5.0 Number of NO and NC contacts
- 14. 6.0 Coil voltage with variation
- 14. 7.0 Contact ratings at 110V AC
- 14. 7.1 Make and continuous Amps
- 14. 7.2 Break inductive Amps
- 15. 0.0 Overload relay
- 15. 1.0 Make and type

- |         |  |        |
|---------|--|--------|
| 15. 2.0 | Catalogue number                         |        |
| 15. 3.0 | Furnished with single phasing preventor? | Yes/No |
| 15. 4.0 | Hand reset type?                         | Yes/No |
| 15. 5.0 | Range for each rating                    |        |

SECTION VI  
**EARTHING**

## SECTION – VI

### EARTHING

#### 1.0 Scope :

This specification is intended to cover the requirements of supply, installation, testing and commissioning of

- a) Pipe earthing
- b) Plate earthing
- c) Strip earthing
- d) Coil earthing

required for earthing of buildings, industrial locations, generating stations and substations apart from miscellaneous apparatus.

#### 2.0 Standards :

Earthing installations shall conform to the Indian Electricity Rules-1956, as amended from time to time and IS 3043-1966-“code of practice for earthing”, with latest amendments.

#### 3.0 Terminology :

- i) Earth: A connection to the general mass of earth, by means of an earth electrode. An object is said to be ‘earthed’ when it is electrically connected to an earth electrode, without intentional addition of resistance or impedance in earth connection.
- ii) Earth continuity conductor: The conductor, including any clamp, connecting to the earthing lead or to each other of those parts of an installation, which are required to be earthed. It may be in whole or in part the metal conduit or the metal sheet or armour of the cables, or a special continuity conductor cable or flexible cord incorporating such a conductor.
- iii) Earth electrode: A metal plate, pipe or other conductor or an array of conductors, electrically connected to the general mass of earth.
- iv) Earth fault: Live portion of a system, getting accidentally connected to earth.
- v) Earth terminal (Earthing Terminal): A terminal on a piece of apparatus for the purpose of making a connection to earth.
- vi) Leakage current: A fault current of relatively small value as distinguished due to a short circuit.
- vii) Step potential: The maximum value of the potential difference possible of being shunted by a human body between two accessible points on the ground separated by the distance of one pace which may be assumed to be one metre.
- viii) Touch potential: The maximum value of potential difference between a point on the ground and a point on an object likely to carry fault current such that the points can be touched by a person.



#### 4.0 Types of earth electrodes :

- a) Pipe earth electrodes
- b) Plate earth electrode
- c) Strip conductor earth electrode
- d) Coil earthing

Standard GI pipe earth or GI plate earth electrode shall be used except where it is unavoidable to use copper plate earth electrode due to corrosive soil conditions for direct current systems or for large capacity substations.

Strip or conductor electrode shall be used at places where soil is hard and rocky and in locations where there are limitations to the use of pipe or plate earth electrode.

Where the soil is highly corrosive, the earth electrode shall be of copper and when the soil contains sulphur, copper electrode shall be adequately tinned.

#### 5.0 Earth electrode arrangement :

##### 5.1 Pipe electrode :

5.1.1 Electrode shall be made of GI pipe having a clean surface and not covered with paint, enamel or poorly conducting material. Galvanized pipe shall not be smaller than 38 mm ID. Earthing with pipe electrode shall be done as per the details indicated in drawing No. CED/ELE/S/3.

5.1.2 Electrodes shall be embedded below permanent moisture level.

5.1.3 The length of pipe electrodes shall not be less than 2.5 m. If rock is encountered, pipes shall be driven to a depth of not less than 2.5 m with suitable inclination. Pipe shall be in one piece and deeply driven.

5.1.4 To reduce the depth of burial of an electrode without increasing the resistance, a number of rods or pipes may have to be connected together in parallel. The distance between two electrodes in such a case shall not be less than twice the length of the electrode. The earthing lead shall be connected by means of a through bolt, nuts and washers and cable socket.

##### 5.2 Plate electrode :

For plate electrodes, minimum dimensions of the electrode shall be as under.

5.2.1 GI plate electrode: 600 x 600 x 6 mm thick.

5.2.2 Copper plate electrode: 600 x 600 x 3.15 mm thick.

5.2.3 The electrode shall be buried in ground, with its faces vertical and top not less than 2.5M from the surface of the ground.

5.2.4 Earthing using plate electrode shall be done as per details, indicated in drawing No. CED/ELE/S/4.

5.2.5 Plate electrodes shall have a galvanized iron water pipe, buried vertically and adjacent to the electrode. One end of pipe shall be atleast 5 cm above the surface of the ground and need not be more than 10 cm. The internal diameter of the pipe shall be atleast 19 mm. The length of pipe under the earth's surface shall be such that it shall be able to reach the centre of

the plate. The earthing lead shall be securely bolted to the plate with two bolts, nuts, check nuts and washers.

### 5.3 Strip or conductor electrodes:

5.3.1 Strip electrode shall not be smaller than 25 × 1.6 mm, if of copper and 25 × 4 mm, if of galvanized iron and steel. If round conductors are used as earth electrodes, their cross sectional area shall not be smaller than 3 mm<sup>2</sup>, if of copper and 6 mm<sup>2</sup>, if of galvanized iron and steel.

5.3.2 Conductor shall be buried in trenches not less than 0.5 m deep.

### 5.4 Coil earthing:

Coil earthing shall be done using 8 SWG GI wire. The wire shall be wound into spiral form of 50 mm dia with turns closely made and buried at 1.5 M below ground level. As in the case of pipe electrode, for this earthing also alternate layers of charcoal and salt shall be filled in the earth pit as indicated in the drawing CED/ELE/S/5.

### 6.0 General:

- i) All materials used for connecting the earth lead with electrode shall be of GI in case of GI pipe and GI plate electrodes, and of tinned brass in case of copper plate electrode. The earthing lead shall be securely connected at the other end to the main board.
- ii) The earthing lead from electrode onwards shall be suitably protected against mechanical injury by routing the earth wire/strip through a suitable size of GI pipe.
- iii) All medium voltage equipments shall be earthed by two separate and distinct connections with the earth. In the case of high and extra high voltages, the neutral points shall be earthed by not less than two separate and distinct connections with the earth, each having its own electrode at the generating station or substation.
- iv) All materials, fittings etc. used in earthing shall conform to Indian standard specifications wherever they exist. In the case of materials for which Indian standard specifications do not exist, such materials shall be approved by the Engineer-in-Charge.
- v) The earth electrode shall be kept free from paint, enamel and grease.
- vi) It shall be ensured that similar materials for respective earth electrodes and earth conductors are used.
- vii) Earth electrode shall not be installed in proximity to a metal fence.
- viii) Copper/GI strip shall be connected to the respective earth electrodes, either by brazing or welding respectively. The copper/GI strip shall be jointed only either by brazing or by riveting at the end of over lapping portions. The over lap shall not be less than 50 mm.
- ix) Earthing clamps used for supporting earth strips shall be made of such materials so as to avoid bimetallic action between strip and clamps.
- x) Size of earth wire/strip for various capacities of the panels/SFUs/equipments shall be as indicated in the relevant IS/IE Rules which is reproduced below:

Equipment earthing: Size of earth lead -(Transformers, motors, generators, switch gears etc.)

Rating of 400V 3 phase 50 cycles equipment in KVA upto 5	Size of earthing conductor	
	Bare copper	Galvanised Iron
6 to 15	14 SWG	12 SWG
16 to 50	12 SWG	8 SWG
51 to 75	10 SWG	25 x 3 m
76 to 100	8 SWG	25 x 3 m
101 to 125	6 SWG	25 x 3 m
126 to 150	4 SWG	25 x 6 mm
151 to 200	25 x 3 m	25 x 6 mm
201 and above	25 x 3 m	37.5 x 6 m 50 x 6 m

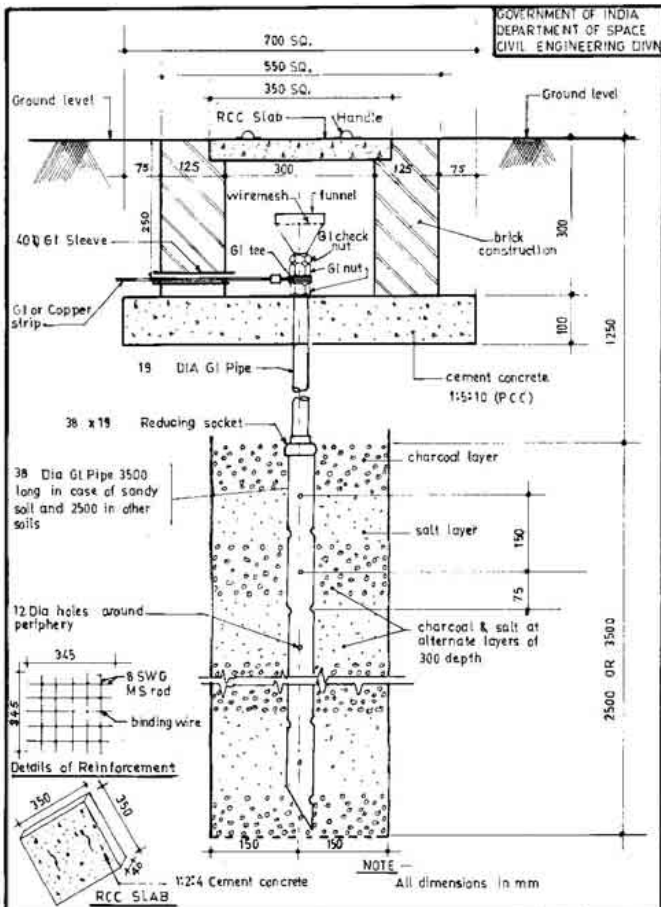
#### Transformer neutral point earthing

Transformer Rating	Copper wire/strip	GI wire/strip
	50 KVA and below	8 SWG
75 KVA	4 SWG	40 x 6 m
100 KVA	4 SWG	40 x 6 m
150 KVA to 300 KVA	25 x 1.5 m	40 x 6 mm
500 KVA	25 x 6 m	50 x 6 m
750 KVA	40 x 6 mm	Above 500 KVA only copper strip shall be used

#### 7.0 Testing:

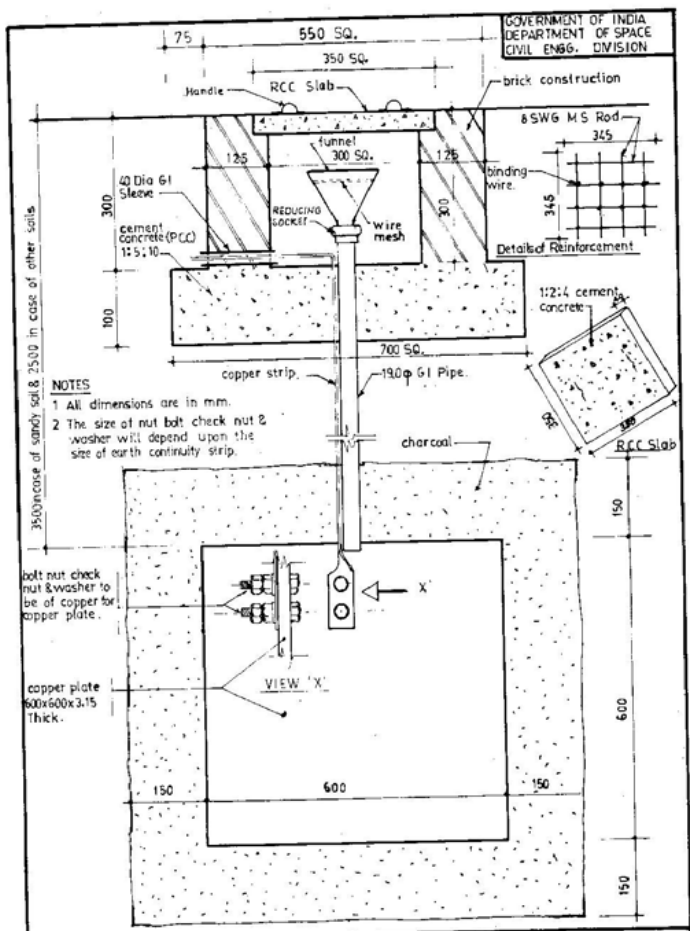
The earth resistance of each electrode shall be measured by using a reliable and calibrated earth megger. The value of the earth resistance shall not exceed the values as given below :

- i) Residential buildings and non-residential buildings 5 ohms.
- ii) Sub-stations and generating stations – 1ohm.
- iii) Lightning protection – 10ohm.
- iv) Special earthing for computer and other electronics Lab – 1ohm.
- v) Hazardous buildings – 1 ohm.



## TYPICAL ARRANGEMENT OF PIPE EARTHING

Drawn M. S. Wani engineer SC	checked S. D. engineer S.F.	Recommended Head electrical	Approved chief engineer	SCALE NTS DATE June 1966	DRG. No. CED/ELE/S/3
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GOVERNMENT OF INDIA  
DEPARTMENT OF SPACE  
CIVIL ENGG. DIVISION

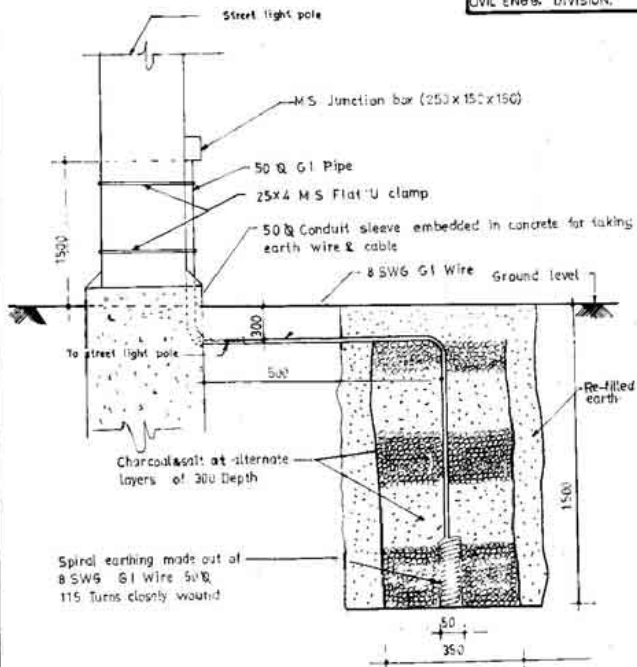
**NOTES**

- 1 All dimensions are in mm.
- 2 The size of nut bolt check nut & washer will depend upon the size of earth continuity strip.

350 increase of sandy soil & 2500 in case of other soils.

**TYPICAL ARRANGEMENT OF PLATE EARTHING**

drawn maheswara	checked engineer: SD	recommended Head electrical	Approved chief engineer	SCALE N T S	DRG. No.
draft engineer: SC	checked engineer: SE			DATE June 1986	CEI/ELE/S/4



**NOTES**

- 1 All dimensions are in mm
- 2 The earthing spiral shall be installed 300mm Behind the street lighting pole

**TYPICAL DETAILS OF SPIRAL EARTHING**

Drawn M. S. Swarna	Checked Engineer S. D.	Recommended Head electrical	Approved Chief engineer	SCALE N.T.S. DATE June 1986	Org. no. CED/ELE/S/5
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SECTION VII  
**LAYING OF CABLES**

**SECTION – VII**  
**SPECIFICATION FOR LAYING OF CABLES**

**1.0 Scope:**

This specification is intended to cover the requirements of installation and energising of PVC/XLPE/PILCDSTA power cables including jointing of cables.

**2.0 Standards:**

The power cable and its fixing accessories shall comply with the latest relevant Indian Standards and National Electrical Code.

**3.0 Laying of Cables:**

**3.1 General:**

3.1.1 Before the commencement of cable laying, it shall be ensured by the Engineer-in-Charge that only ISI marked cables are used. It shall be the responsibility of the contractor to check the soundness and correctness of the size of the cable while taking delivery of the cable from stores. Any defect noticed shall be brought to the notice of the issuing authorities immediately. If any defect is noticed after the cable is laid or during the process of laying, it shall be brought to the notice of the Engineer-in-Charge and upon his satisfaction, that the cable is not damaged due to bad handling, it will be the entire responsibility of the contractor to retrieve the cable already laid and return the defective cable to store and take fresh length of the cable from the store and relay the same.

3.1.2 The material such as bricks, sand, cable route markers, RCC slab of best quality as approved by the Engineer-in-Charge only shall be used for cable laying works.

3.1.3 The contractor shall provide all the necessary labour, tools, plants and other requisites at his own cost for carrying out pumping of water and removing of water from trenches, if any, where required.

3.1.4 Installation shall be carried out in a neat, workman like manner by skilled, experienced and competent workman in accordance with standard practices.

3.1.5 While laying the cable care shall be taken to avoid formation of kinks and also damage to the cable. In the case of cable bends, it shall not have bent radius lesser than 20 times the overall diameter of the cable.

3.1.6 A cable loop of about five meters length and as directed by the Engineer-in-Charge shall be provided at the following locations.

- a) Near the termination points
- b) Near to the straight through joint

3.1.7 The method of cable laying and routing of cables, shall in every case be as directed by the Engineer-in-Charge.

3.1.8 Whenever cable passes through hume pipes/GI pipes embeded across the wall in a building, both the ends of the pipe shall be suitably sealed.

3.1.9 Identification tags indicating the size of the cable and feeder designation shall be securely attached at both ends of the cable. Such tags shall also be attached to the cable at



intervals of 250 Mtrs. The materials of the tag shall be of either 12 SWG GI sheet or plastic. In case of plastic, the details have to be engraved and in case of GI sheet, the details should be punched. Cable route markers shall be provided at the intervals of 200 M with a minimum of one number route marker. The details of the route markers shall be as per the drawing CED/ELE/S/10. At the locations of straight through joints, necessary joint-markers shall be provided.

3.1.10 When cable runs vertically, it shall be clamped on mild steel flats or angle iron fixed on walls and are spaced at such intervals as to prevent buckling of the cables. All steel work shall be painted with a coat of red oxide and thereafter finished with suitable anti-corrosive paints.

### **3.2 Cables laid in ground :**

3.2.1 The cables shall be laid at a minimum depth of 0.75 M when laid in ground. When cable pass through roads, nallahs etc. they must be protected by either hume pipe or GI pipe of suitable dimensions.

3.2.2 Excavations of trenches shall be carried out as indicated in the drawing CED/ELE/S/8 & 9. The width of the trench at the bottom shall be 0.4 M for one cable. In case the total number of cables laid in trenches is more than one, then the width shall be such that the spacing between the cables is maintained as shown in the drawing CED/ELE/S/8 & 9. Before the cable is laid in the trench the bottom of the trench shall be cleared from stones and other sharp materials and filled with sand layers of 75 mm, as shown in the drawing.

3.2.3 While removing the cable from the drum, it shall be ensured that the cable drum is supported on suitable jacks and the drum is rotated to unwind the cable from the drum. The cable should never be pulled while unwinding from the drum. It shall be ensured that the cables are run over the wooden rollers placed in the trench at intervals not exceeding 2 M.

3.2.4 After placing the cables in the trench, the sides and top of the cable shall be covered with bricks/RCC slabs as indicated in the drawing.

After placing brick/RCC slab, the trench shall be filled in layers ensuring that each layer is well rammed by spraying water and consolidated. The extra earth shall be removed from the place of trench and deposited at a place as directed by the Engineer-in-Charge.

### **3.3 Cables laid in built up trench :**

3.3.1 Before the commencement of cable laying the cable trench shall be cleaned properly. Cable shall be laid as explained in item 3.2. Cable shall be properly clamped to the cable supports which are provided in the cable trench. The method of clamping shall suit the size of the cable and the cable supports, as directed by the Engineer-in-Charge.

Care shall be taken while removing and replacing the trench cover slab. It is the responsibility of the contractor to make good any damaged trench covers.

### **3.4 Cable terminations and straight through joints :**

3.4.1 All cable jointing materials such as straight through joint boxes, cable compound, cable lugs, insulation tapes etc. shall be of best quality and as approved by the Engineer-in-Charge.

3.4.2 Cable glands for strip armoured cables shall include a suitable armour clamp for receiving

and securely attaching the armouring of the cable in a manner such that no movement of the armour occurs when the assembly is subjected to tension forces.

The cable gland shall not impose on the armouring, a bending radius not less than the diameter of the cable. The clamping ring shall be solid and of adequate strength.

Provision shall be made for attachment of an external earthing bond between the metallic covering of the cable and the metallic structure of the apparatus to which the cable box is attached.

### **3.5 Sealing boxes :**

3.5.1 A sealing box, irrespective of the class of insulation of the cable for which it is intended, shall be so designed that it may be filled with compound after connecting the cables specially in flame proof/hazardous areas.

3.5.2 All parts and connection for attaching the armouring, wiping or clamping the metallic sheath in a sealing box, shall be easily accessible. This may be achieved by splitting the box or by providing a suitable cover or other such means.

3.5.3 The joints in the box shall prevent leakage of the compound.

3.5.4 Provision shall be made to ensure that the cores of the cable are efficiently sealed to prevent moisture penetrating along the strands or the cable conductors.

3.5.5 The sealing box shall be provided with compound filling orifices with suitable covers or plugs of size that will permit easy pouring of the compound.

In all cases where screwed plugs are used, one or more air vents shall be provided to ensure complete expulsion of air and total filling of the box with compound.

3.5.6 The box shall be of sufficient length to allow for manipulation of the insulated cover without damage to them or to the insulation.

3.5.7 A sealing box intended to be attached directly to the apparatus shall be designed such that the box together with the connected cable may be detached from the apparatus without disturbing the sealing compound.

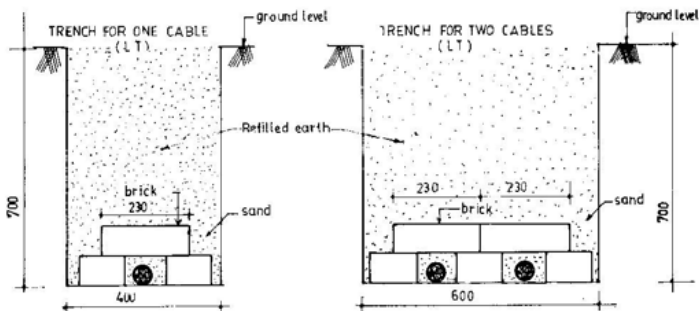
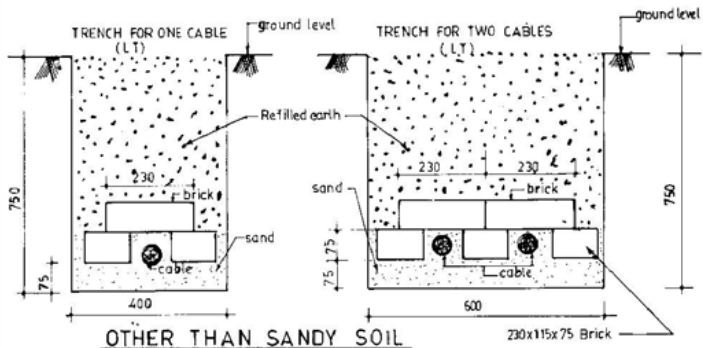
3.5.8 Cable sealing and dividing boxes intended for use in the flame proof areas shall comply additionally with the relevant requirements of IS : 2148-1968.

### **4.0 Testing**

Once cable is laid, following test shall be conducted in the presence of Engineer-in-charge, before energising the cable :

- i) Insulation resistance test (Sectional and Overall).
- ii) Sheathing continuity test.
- iii) Continuity and conductor resistance test.
- iv) Earth test.
- v) High voltage test.

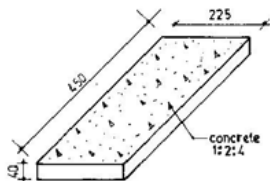
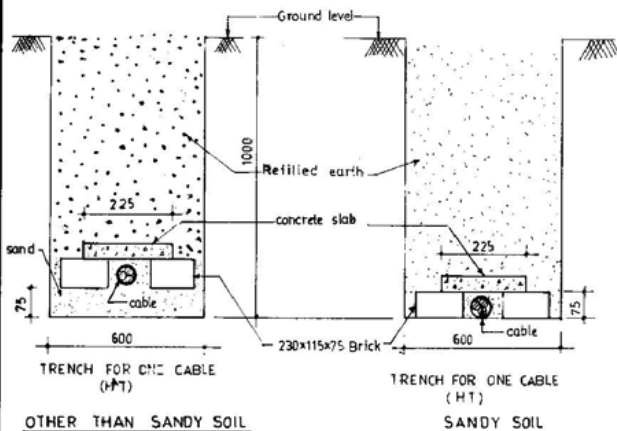
Tests conducted shall be as per Indian Standards and National Electrical Code.



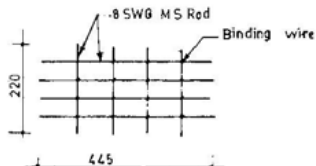
NOTE  
All dimensions in mm

## DETAILS OF LT CABLE LAYING ARRANGEMENT

drawn maheshwara engineer SC	checked engineer S checked engineer SE	Recommended Head electrical	Approved chief engineer	SCALE N.T.S. DATE JUNE 1986	ORG. No. CED/ELE/S/8
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DETAILS OF CONCRETE SLAB



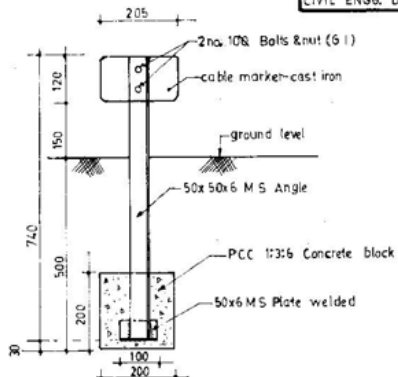
DETAILS OF REINFORCEMENT

NOTE

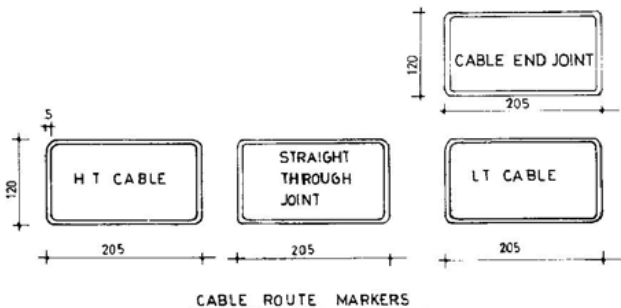
All dimensions in mm

**DETAILS OF HT CABLE LAYING ARRANGEMENT**

drawn maheswara engineer SC	checked S D engineer SE	Recommended Head electrical	Approved chief engineer	SCALE N.T.S.	DRG. No
DATE June 1986					CED/ELE/S/9



TYPICAL ARRANGEMENT OF INSTALLATION OF CABLE MARKER



CABLE ROUTE MARKERS

NOTES

All dimensions in mm.

**DETAILS OF CABLE ROUTE MARKERS**

Drawn maheshwara	Checked engineer S D	Recommended Head electrical	Approved Chief engineer	SCALE N T S	DRG. No. CED/ELE/S/10
Drawn engineer SB	Checked engineer S E			DATE June 1986	

SECTION VIII  
**LEAD ACID STORAGE TYPE BATTERY**

**SECTION – VIII**  
**SPECIFICATION FOR LEAD ACID STORAGE TYPE BATTERY**

**1.0 Scope :**

This specification is intended to cover the requirements of supply, installation, testing and commissioning of DC storage battery, lead acid type with tubular positive plates, complete with all its supporting racks and other accessories required for its satisfactory operation as detailed in the specification at the places specified by the Department.

**2.0 Standards :**

The equipments and materials covered by the specification shall comply with the latest relevant Indian Standards.

**3.0 Design requirements :**

- i) The battery along with the accessories shall be provided with tropical finish to prevent fungus growth. The design shall be such that the battery can be used in highly saline atmosphere.
- ii) The battery shall be suitable for operation in ambient temperature 45° C and humidity upto 95% RH.
- iii) The design and workmanship shall be in accordance with the best engineering practices to ensure satisfactory performance and service life as specified.

**4.0 Technical requirement :**

**4.1 Battery :**

- i) The battery shall consist of the number of cells and AH capacity as specified in the schedule. The AH rating shall be computed at a 10H discharge rate to an end voltage of 1.85V/cell.
- ii) The battery shall be of storage type and cell shall be lead acid type with tubular positive plates.
- iii) Each cell shall be in a suitable leak-proof container with sealed cover. The container shall be made either of hard rubber, glass, plastics or fibre reinforced plastic.
- iv) The separator used shall be either wooden or synthetic and shall permit free flow of electrolyte.
- v) Cell posts shall be sealed against electrolyte creepage. Cell terminal post shall be provided with connector clamps, bolts & nuts. Cell terminal shall be lead alloy, reinforced with copper core inserts of adequate current carrying capacity and complete with acid resistant connecting straps, bolts and nuts.
- vi) The venting device shall be of anti splash type with more than one exit hole and shall allow the gases to escape freely but shall effectively prevent acid particles or spray from coming out.
- vii) Electrolyte level indicator : A suitable electrolyte level indicator indicating lower and upper limit shall be fitted to facilitate checking of electrolyte level in opaque containers.

The material shall be acid proof and shall not deteriorate during service.

- viii) The batteries shall be supplied complete with cell interconnectors made of lead, copper or aluminium suitably coated to withstand corrosion due to sulphuric acid. The connectors shall be of bolted type.
- xi) Bolts and nuts for connecting the cells shall be effectively lead coated to prevent corrosion.

#### **4.2 Electrolyte :**

The electrolyte shall be prepared from the battery grade sulphuric acid conforming to the relevant IS. The standard specific gravity of the electrolyte shall be adjusted to  $1.20 \pm 0.005$  corrected at 27° C. The required quantity of electrolyte shall be supplied by the supplier along with the battery.

#### **4.3 Marking :**

Each cell shall be marked indelibly to indicate the following informations :

- i) Cell No. with battery number
- ii) Type of positive plate
- iii) Cell capacity at 10 Hour rate
- iv) Type of container
- v) Manufacturer's name
- vi) Year of manufacture
- vii) Country of manufacture

#### **4.4 Accessories :**

The following accessories shall be provided for the batteries :

- i) Cell testing voltmeter of range 3-0-3 volts.
- ii) Floating type hydrometer.
- iii) Thermometre with specific gravity correction scale.
- iv) Electrolyte level test tube.
- v) Connector bolt wrench.
- vi) Rubber gloves.
- vii) Acid resistant jugs.
- viii) Glass funnels.
- ix) Rubber aprons.
- x) Acid mixing containers of 50 litres capacity.

#### **4.5 Racks :**

The battery shall be supplied complete with suitable rack protected with acid resistant paint as specified in the schedule. The racks shall be arranged in a proper manner so as to allow easy access to individual cells and adequate space for normal maintenance in battery room.

#### **5.0 General :**

- i) The tenderer shall furnish alongwith the quotation the proposed layout of the battery racks and the size of the battery room required to accommodate the battery.



- ii) The tenderer shall indicate in his offer the charging current and voltage per cell for the proposed method of charging.
- iii) The tenderer shall furnish relation between the specific gravity of the electrolyte used and amount of charge in the battery for both charging and discharging of the battery.
- iv) The batteries shall be shipped uncharged with the electrolyte in separate containers. 10% extra electrolyte shall be supplied.
- v) One complete set of drawing of battery showing the construction, general arrangement, characteristic curves, technical leaflets, operation and maintenance manual shall also be furnished along with the offer.
- vi) The technical particulars enclosed at the end of this specification shall be duly filled in and submitted with offer by the tenderer.

#### 6.0 Tests:

The following tests shall be carried out at the manufacturer's works:

- i) Test for capacity.
- ii) Ampere-hour and watt-hour efficiency tests.
- iii) Test for voltages during discharge.
- iv) Verification of dimensions.
- v) Marking and packing.

#### 7.0 Technical particulars for Battery

- 1. 0.0 Battery
- 1. 1.0 Type
- 1. 2.0 Make
- 1. 3.0 Manufacturer's catalogue No.
- 1. 4.0 Type of positive plate
- 1. 5.0 Voltage rating
- 1. 6.0 Ampere-hour rating
- 1. 7.0 No. of cells required to give rated DC voltage
- 1. 8.0 What is the minimum cell voltage during duty cycle?
- 1. 9.0 Capacity at 27°C at 10 hour discharge rate to 1.85 VDC.
- 1. 9.1 Initial AH
- 1. 9.2 Rated AH
- 1. 9.3 End of life AH
- 1.10.0 Recommended charging rate
- 1.10.1 Float charging voltage/current V/A
- 1.10.2 Trickle charging voltage/current V/A
- 1.10.3 Boost charging in 8 hours
  - a) Start voltage/current V/A
  - b) Finish voltage/current V/A

- |        |  |        |
|--------|--|--------|
| 1.10.4 | Charging time from 0 Volt to 2.75 V  | Hr     |
| 1.10.5 | Time required for boost charging   | Hr     |
| 1.11.0 | Whether explosion vents offered?   |        |
| 1.12.0 | Amount of electrolyte for first filling  |        |
|        | a) per cell  | Litres |
|        | b) per set   | Litres |
| 1.12.1 | First filling with 10% extra furnished   | Yes/No |
| 1.12.2 | Recommended specific gravity of the electrolyte at 27° C                             |        |
|        | a) for first filling   |        |
|        | b) at the end of full charges  |        |
|        | c) at the end of discharge at 10 hours rate  |        |
| 1.13.1 | Catalogue indicating the arrangement of battery showing its constructional features. |        |
| 1.13.2 | Overall dimensions of the battery  |        |
| 1.13.3 | Space required for installation  |        |
| 1.13.4 | Weight of complete battery   |        |
| 1.13.5 | Expected life of battery   |        |
| 1.14.0 | Accessories furnished with the battery?  | Yes/No |

SECTION IX  
**UPS SYSTEM**

## SECTION – IX

### UPS SYSTEM

#### 1.0 Scope:

This specification is intended to cover the requirements of design, supply, testing at manufacturer's works, despatch, installation and commissioning of UPS system at the places specified in the schedule.

#### 2.0 System configuration:

The system comprises of one or more numbers of rated KVA inverter systems connected with the required number of converters, static transfer switches, protective device, metering with annunciating panel and all associated accessories as detailed in the schedule to provide regulated un-interruptible electrical power to important equipments. Continuity of power to the load is maintained with the inverters being supplied by a battery bank of suitable ampere-hour capacity for atleast thirty minutes support. The rectifier and the inverter shall be with solid state devices. In the case of configuration consisting of two or more inverters, normally the inverters run in locked mode so that output of the inverters can be combined through paralleling net work and when any of the inverter develops a fault it can be isolated by inhibiting the trigger signal to the static switch of the respective inverter and the other inverters take up the full load. When all inverters develop fault the load will be transferred to commercial mains through AVR automatically. The system should be capable of meeting the requirement of high inrush current of the critical loads as furnished in the schedule. The inverters shall normally be running in back to back mode when commercial frequency is  $50 \pm 0.5\%$  Hz and in case the frequency exceeds this limit, the inverter should automatically run on its own oscillator such that the output frequency of the system is maintained  $50 \pm 0.5\%$  Hz in all conditions of commercial line frequency. The automatic transfer from the inverter to the by-pass shall be completed within 10 milli seconds even when the inverter is running in out of synchronous mode.

#### 3.0 Detailed specifications for various components of UPS system are given below :

##### 3.1 Inverters:

3.1.1 Type: Static SCR type

3.1.2 Input voltage: 200–300 V DC

3.1.3 Output system rating:

- i) Normal rating: Rated required KVA as specified in the schedule
- ii) Overload: 110% for 10 minutes; 150% for 10 seconds
- iii) Power Factor: 0.8 lag within KW rating
- iv) Efficiency: Better than 90% at full load

3.1.4 Voltage:

- i) Nominal: 415 V
- ii) Accuracy: Balanced load  $\pm 1\%$   
50% unbalanced  $\pm 3\%$

### 3.1.5 Transient performance:

- i) 50% to full load step:  $\pm 8\%$
- ii) Loss of AC input:  $\pm 5\%$
- iii) Return of AC input:  $\pm 5\%$
- iv) Un-interrupted transfer of critical loads from inverter to by-pass or vice versa:  $\pm 8\%$

Response time: Recover to 95% in 50 ms and Nominal voltage in 100 ms.

### 3.1.6 Phases:

- i) Number of phases: Three and neutral
- ii) Displacement
  - a) Balanced load:  $120^\circ \pm 1^\circ$
  - b) 50% unbalanced load:  $120^\circ \pm 3^\circ$

### 3.1.7 Frequency:

- i) Nominal: 50 Hz
- ii) Accuracy:  $\pm 0.5\%$

### 3.1.8 Harmonics:

- i) Total: Not exceeding 5%
- ii) Any single harmonic: 3% maximum.

### 3.1.9 Environment for operating conditions:

- i) Ambient temperature range -  $5^\circ\text{C}$  to  $45^\circ\text{C}$
- ii) Humidity - 95% maximum
- iii) Cooling - Forced air cooling
- iv) Type of voltage control - By closed loop feed back.

### 3.1.10 Protection:

Each inverter shall have built in protection against

- i) Over and under voltage power line surges
- ii) Over voltage and voltage surges introduced at output terminals by parallel sources
- iii) Load switching and circuit breaker operation in the distribution system
- iv) Sudden changes in output load
  - and shall have the following protective devices
  - i) at the output side MCCBs of suitable capacity with magnetic trip release
  - ii) D.C. reverse polarity
  - iii) D.C. under/over voltage trip
  - iv) Fast acting semi-conductor fuses for inverter bridge
  - v) RC network for surge suppression
  - vi) Output phase fail trip
  - vii) Output AC abnormal trip

- viii) HRC fuses for filters, capacitors, auxiliary circuit voltmeter etc.
- ix) Fuse fail trip
- x) Electromagnetic over current relay with IDMTL characteristics
- xi) Battery earth fault relay.

#### 3.1.11 Metering :

The following meters shall be provided and all metering shall be of digital type.

- i) DC Voltmeter – 1 no.
- ii) DC Ammeter – 1 no.
- iii) Three phase AC voltmeter on output side of the inverter with selector switch – 1 no.
- iv) Three phase AC ammeter on output side of the inverter with selector switch – 1 no.
- v) Frequency meter on output side

#### 3.1.12 Indicating lamps :

L.E.D. lamps on the mimic diagram to indicate the state of breakers shall be provided.

3.1.13 Annunciation for the following shall be provided on the inverter panel.

- i) Fuse failure
- ii) Over loading
- iii) Overload shut down
- iv) Emergency shut down
- v) Over temperature
- vi) AC over voltage
- vii) AC under voltage
- viii) Battery on load
- ix) Cooling fan failure
- x) Mains failure
- xi) Control power failure
- xii) Inverter current limit failure
- xiii) Battery circuit breaker open
- xiv) Output harmonic distortion beyond limits
- xv) Output frequency out of limit

3.1.14 Apart from providing annunciation at the inverter panel, annunciation shall also be provided at the places as indicated in the schedule for remote monitoring.

3.1.15 Temperature rise of components above ambient shall not exceed the following limit :

- i) 50°C for wound components

- ii) 70°C maximum for diode case
- iii) 50°C for SCR case

### 3.2 Static switch

- i) Rating – More than 200% of normal current.
- ii) Short time rating –
  - a) 120% continuous
  - b) 150% for 15 minutes
  - c) Short circuit capacity for 1 sec.
- iii) Transfer time – Less than 5 ms when back to back mode and less than 10 ms when out of synchronous mode.

### 3.3 Battery charger/rectifier

- 3.3.1 AC input supply voltage – 415V, 3 phase, 50 Hz nominal.
- 3.3.2 Input voltage variation – +10% to-25% of the nominal input phase voltage.
- 3.3.3 Output voltage – Nominal float voltage to suit the DC input voltage to the inverter.
- 3.3.4 Output ripple – Better than 5% of rated voltage.
- 3.3.5 Output current – Suitable for the inverter and the AH capacity of the battery chosen.
- 3.3.6 Regulation –  $\pm 1\%$  for + 10% to-25% of input voltage and 0-100% load variation.
- 3.3.7 Current limiting – 120% of full load.
- 3.3.8 The battery chargers shall have provision for charging the battery under normal charge, conditioning charge, equalising charge and float charge.
- 3.3.9 Efficiency – Better than 90%.
- 3.3.10 Power factor – Better than 0.8 lag at full load.
- 3.3.11 Cooling – Forced air cooling.
- 3.3.12 Ambient – As indicated above for inverter.
- 3.3.13 Temperature rise – As indicated for inverter.
- 3.3.14 Protection – Each rectifier shall have built in protection against:
  - i) Phase fail protection
  - ii) Semiconductor fuse to protect thyristor bridge
  - iii) HRC fuse for filter circuits
  - iv) Thermal over load relay
  - v) Electromagnetic relay with IDMTL characteristics for over load
  - vi) Under voltage relay
  - vii) Battery earth fault relay
- 3.3.15 Annunciation:

Annunciation for the following shall be provided on the rectifier panel.

- i) Input fuse fail
- ii) Over load
- iii) Phase fail/main fail
- iv) DC over voltage
- v) Thyristor fuse fail
- vi) Filter fuse fail
- vii) DC ground fault
- viii) High temperature of thyristor/diode

#### 3.3.16 Metering :

The following meters shall be provided

- i) AC Voltmeter on input side with selector switch
- ii) AC Ammeter on input side with selector switch

#### 4.0 Inspection, testing and acceptance

- i) The UPS equipment shall be despatched only after the system has been inspected, tested and accepted at the manufacturer's works by the Engineer deputed by the Department. The acceptance test shall include all the tests required to prove the specifications and satisfactory operation of the equipment. The tenderer shall submit the list of tests to be conducted at manufacturer's works.
- ii) The tests shall include burn-in test and temperature rise test in addition to other tests required to prove the specifications and satisfactory operation of the system.
- iii) The list of tests to be conducted shall be decided by mutual agreement between the department and the manufacturers/suppliers. All facilities shall be extended by the manufacturer for conducting the necessary tests.

#### 5.0 Technical Particulars

The bidder shall fill in the following data sheet and submit it along with his offer :

- a) Name of the manufacturer
- b) Place of manufacture
- c) Continuous KVA rating
- d) Efficiency of operation on full load (overall)
  - (i) Inverter efficiency
  - (ii) Rectifier efficiency
- e) Year of manufacture
- f) Mean time between failure (MTBF) in hours
- g) Net weight
- h) Dimensions
- i) Protective device
- j) Design temp. rise for



- i) Wound component
- ii) SCRS
- iii) Diode
- k) Operation manual/Maintenance manual
- l) Type of cooling provided (indicate in detail)
- m) Details of metering
- n) Noise level
- o) Switching transfer time
- p) The bidder shall submit with his offer a list of spare parts with unit rates for three years normal maintenance of the UPS system.

SECTION X  
**DG SETS**

**SECTION – X**  
**SPECIFICATION FOR DG SETS**

**1.0 Scope**

This specification is intended to cover the requirements of supply, installation, testing and commissioning of DG sets.

**2.0 Standards**

Diesel engines should comply with relevant Indian Standard/British standard specification. Self excited and self regulated alternators shall comply with relevant IS/BS.

**3.0 General**

- i) The generator set of capacity as mentioned in the schedule is required to function at places situated at an altitude upto 1000M, ambient temp upto 45°C and relative humidity upto 95%.
- ii) The DG set should be installed in the generator room as shown in the drawings enclosed with the schedule. The switch board including the control panel of the DG set shall be located in the place marked in the drawing enclosed with the schedule.
- iii) The rate quoted by the tenderer shall include all civil works like machine foundation if required, breaking floors, walls etc. and making them good to match with the existing surfaces, pipes and fittings required for fuel line and exhaust.

**4.0 Generator set**

The generator set shall comprise of a diesel engine of adequate capacity directly coupled to an alternator mounted on a common base plate and with floor mounted control panel.

**4.1 Diesel Engine :**

Diesel Engine shall be suitable for generating set application developing suitable BHP at 1500 RPM, powered by multi cylinder. The engine shall be of heavy duty type suitable for cold starting and equipped with a minimum of the following accessories.

- a) Fly wheel to suit flexible couplings with guard
- b) Air cleaner-oil bath type
- c) Corrosion proof radiator with guard
- d) Fan with guard
- e) Water pump-centrifugal type, engine mounted
- f) Fuel pump
- g) Fuel filter
- h) Governor-hydraulic PSG type
- i) Fuel injection equipment
- j) Exhaust silencer
- k) Electric starting equipment comprising of starting motor on 24V DC supply
- l) Lubricant oil cooler
- m) Lubricant oil pump-gear type, engine mounted

- n) Lubricant oil filter
- o) Turbo charger (exhaust gas driven)
- p) Battery charging generator with voltage regulator-24V DC
- q) 24V Battery of suitable AH capacity

4.1.1 Instrument panel shall consist of :

- a) Starting switch with key
- b) Lubricating oil temperature gauge
- c) Lubricating oil pressure gauge
- d) Water temperature gauge
- e) Battery charging ammeter
- f) Circuit breaker
- g) Safety control for low lubricating oil pressure
- h) Safety control for high water temperature
- i) Hour meter (mech.) and RPM indicator

#### 4.2 Base frame :

The engine and alternator shall be perfectly aligned and assembled on a sturdily fabricated adequately machined base frame, made out of high quality MS channels. The base frame should be provided with lifting facilities and pre-drilled foundation holes suitable for installation either on concrete foundation or with anti-vibration mountings.

#### 4.3 Fuel tank :

Fuel tank of 24 hours running capacity on full load with inlet-outlet pipe connections, filling cap, drain plug, level indicator and floor mounting pedestal along with hand operated fuel transfer pump and suitable hose shall be provided.

#### 4.4 Alternator :

Alternator shall be of capacity as mentioned in the schedule, 0.8P.F., 415V  $\pm$  2½%, 3 phase, 4 wire, 50 Hz, 1500 RPM, self regulated and self excited, brushless, AC generator in accordance with relevant IS/BS with screen protected and drip proof enclosure and with damper windings on pole faces. The alternator shall be suitable to supply rectifier, SCR type UPS and computer loads without any distortion in output AC voltage wave form.

4.4.1 Protection : The generator shall be provided with suitable protection against overload and earth fault.

#### 4.5 Control panel :

Control panel shall consist of the following metering :

- a) Frequency meter (Digital type)
- b) Power factor meter
- c) Ammeter of suitable range with selector switch
- d) Voltmeter, 0 to 600V, with selector switch.
- e) Over current and earth fault relays
- f) Neutral isolating link
- g) K.W. hr meter

- h) Maximum demand meter
- i) MCCB or ACB of suitable capacity

## **5.0 Installation of equipments:**

### **5.1 General:**

- i) Plan of the Generator room is shown in the drawing enclosed with the schedule. The tenderer shall furnish the layout of his equipment within a week after the award of the contract for approval of the Engineer-in-Charge.
- ii) The generator set and switchgear panel shall be installed in accordance with latest engineering practice.

### **5.2 Painting:**

Special attention shall be paid to the finish and general appearance of the work. All equipment with factory finished (painted) surfaces require no painting. Contractor shall ensure that no scratches appear on the painted surface while transporting and installing the set.

Pipelines shall be painted in accordance with IS: 2379 : 1963 as amended to date.

The parts of the DG set installation which are not factory painted shall be given three coats of oil paint consisting of one primer coat of red oxide, one under coat and one finishing coat of superior tint.

### **5.3 Earthing:**

All the metal parts of the installation such as the metal bodies of switch gear, generator, control panel etc. shall be connected to earth by means of two distinct and separate earth leads of 25 x 3 mm GI strip. Generator neutral shall be earthed by two separate and distinct earth connections of copper strip of size 32 x 6 mm to two independent earth electrodes as specified and shown in the drawing CED/ELE/S/15. The copper strips shall be laid without kinks and shall have as few joints as possible. The joints shall be mechanically and electrically sound. The plate earthing shall be as per drawing CED/ELE/S/4. The earth resistance in all the cases shall be as low as possible. In any case the earth resistance as measured from any point of the earthing system to the main body of earth shall not exceed 5 ohms.

### **6.0 Acceptance test:**

On completion and before handing over of the work, the following tests shall be carried out by the contractor to the entire satisfaction of the Engineer-in-Charge.

#### **6.1 Phase-I Test:**

- i) Insulation resistance test - Sectional and overall
- ii) Continuity resistance test-sectional and overall
- iii) Earth resistance test
- iv) All instruments and relays shall be tested under normal operating conditions
- v) Visual examination to ensure that the plant equipment and accessories are provided and the finish and general appearance of the work are as per contract specification

- vi) A no load test for a period of 3 hours continuously to see that the engine, alternator and other accessories are functioning normally.

The duration of the test may be increased if necessary and as directed by the authorised representative of the accepting officer.

#### 6.2 Phase-II Test:

On completion of the Phase-I tests to the entire satisfaction of the authorised representative of the accepting officer, a full load test will be carried out for 12 hours continuously and for a period of three days by directly loading or loading artificially.

The overall efficiency of the plant at  $\frac{1}{4}$  load,  $\frac{1}{2}$  load and full load shall be worked out and compared with the figures given by the tenderer in his tender documents. If there is any reduction in the efficiency of the plant, the contractor shall make suitable adjustments, actions etc. to bring up the efficiency to the specified limit.

All necessary arrangements for testing under artificial load conditions, such as cables, electrodes etc. shall be provided by the contractor and the charge for the same is deemed to be included in the rate quoted in the schedule. However the engine should be complete with the first filling of lubricating oil, to be supplied by the contractor.

#### 7.0 Taking over:

If the acceptance test as described above in clause 6.0 does not show satisfactory result, the contractor shall, at his own expense, rectify/replace the defective components or any part thereof as directed by the authorised representative of the accepting officer within one month. The decision of the accepting officer or his authorised representative shall be final and binding in this regard. The installation shall be retested after rectification/replacement of the defective components. The installation shall be finally taken over after the contractor has given satisfactory test as certified by the accepting officer or his authorised representative.

#### 8.0 Technical particulars:

Schedule of particulars about the Diesel oil Engine driven generating sets to be supplied under this contract shall be furnished by the tenderer in the proforma furnished at the end of this section.

#### PROFORMA

#### SCHEDULE OF PARTICULARS AND GUARANTEE ON DIESEL OIL ENGINE DRIVEN GENERATING SETS

Item No	Description	Particulars
	OIL ENGINE	
1.	Maker's Name	
2.	Maker's Type	
3.	No. and arrangements of cylinders	

Item No	Description	Particulars
	a) No. of cylinders	
	b) Arrangement of cylinders	
4.	Method of starting	
5.	Rated Speed (RPM)	
6.	Time required for starting from cold	
7.	Type of Governor	
8.	Guaranteed limits of governing	
	a) Permanent variations	
	i) Full load thrown off	
	ii) Full load put on	
	b) Temporary variations	
	i) Full load thrown off	
	ii) Full load put on	
9.	Total speed variation which can be effected by hand speed regulating gear	
10.	Specification of lubricating oil recommended	
11.	Specification of fuel oil recommended	
12.	Rated output at normal temperature and pressure conditions as defined in BS: 649 latest in the case of Diesel Engine i.e. at 1000M above mean sea level and ambient temperature above 45°C	
13.	Overload for one hour at standard operating conditions	
14.	Guaranteed output at site (continuous running for 12 hours under the worst atmospheric conditions specified in the schedule of requirements)	
15.	Over load for one hour at site	
16.	Guaranteed fuel oil consumption (A) under standard temperature and pressure. (S.T.P)	

Item No	Description	Particulars
	i) at full rated output (litres/metric horse power/hour	
	ii) at $\frac{3}{4}$ rated output	"
	iii) at $\frac{1}{2}$ rated output	"
	(B) at site conditions	
	i) at full rated output	"
	ii) at $\frac{3}{4}$ rated output	"
	iii) at $\frac{1}{2}$ rated output	"
17.	Guaranteed lubricating oil consumption at full rated output	Litres
18.	Mechanical efficiency	%
19.	Thermal efficiency	%
20.	Details of standard accessories offered with the engine	
21.	Safety protections	
	a) Whether over speed trip provided or not	
	b) Whether low lubrication oil trip provided or not	
22.	Direction of rotation when looking from engine towards the driven machine	
23.	Whether the engine is 2 stroke or 4 stroke	
24.	Method of aspiration (eg. natural, turbo, or super charged etc.)	
25.	Method of cooling	
	ALTERNATOR	
26.	Maker's Name	
27.	Maker's type no	
28.	Rated continuous maximum rating in KVA to BS 2613-57	
29.	Rated continuous output in KW at 0.8 PF	
30.	Rated speed (RPM)	



ItemNo	Description	Particulars
31.	Rated voltage	
32.	Number of phases	
33.	Current capacity of starter windings	
34.	Overload capacity	
	a) 10 percent for	Hrs
	b) 50 percent for	Hrs
35.	Temperature rise of the windings measured by thermometer after continuous run at full rated output, rated voltage, frequency and PF and with surrounding air temperature at 45 °C (Amb. temperature)	
36.	a) Efficiency at 0.8 PF at full load b) Efficiency at 0.8 PF at ¾ load c) Efficiency at 0.8 PF at ½ load	
37.	Inherent voltage regulation (increase in voltage from full load to no load with constant speed and excitation)	
38.	Are damper windings fitted on poles?	
39.	Radial clearance between stator and rotor (air gap)	
40.	Peripheral speed of the rotor	
41.	Critical speed of the rotor	
42.	Method of lubrication	
43.	Direction of rotation	
44.	Excitation voltage	
45.	Alternator excitation current at full load on	
	i) Unity PF	
	ii) 0.8 PF	
46.	Whether DG set is suitable for Rectifies/Inverter and computer type loads?	
47.	What is the maximum motor load to which the DG set can be used?	

**SECTION – XI**  
**SPECIFICATION FOR LIGHTNING PROTECTION**

**1.0 Scope:**

This specification is intended to cover the requirements of supply, installation and testing of lightning protection system at places specified by the department.

**2.0 Standards:**

The lightning protection system shall conform to the relevant Indian Standards and National Electrical code.

**3.0 Terminology:**

- i) Air termination (lightning conductor) or Air termination net work: Those parts of lightning protection system that are intended to collect the lightning discharges from the atmosphere.
- ii) Bonds: Electrical connection between the lightning protection system and other metal work, and between various portions of the latter.
- iii) Down conductors: Conductors which connect the air terminations with the earth terminations.
- iv) Earth terminations or earth terminations net work: Those parts of the lightning protection system which are intended to distribute the lightning discharges into the general mass of the earth. All parts below the testing point in a down conductor are included in this term.
- v) Earth electrodes: A metal plate, pipe or other conductor or an array of conductors electrically connected to the general mass of the earth. These include those portions of the earth terminations that make direct electrical contact with the earth.
- vi) Lightning protection system: The whole system of interconnected conductors used to protect a structure from the effects of lightning.
- vii) Side flash: A spark occurring between nearby metallic objects or between such objects and the lightning protection system to earth.
- viii) Testing points: Joints in down conductors or in bonds or in earth conductors connecting earth electrodes, so designed and situated as to enable resistance measurements to be made.

**4.0 Materials to be used:**

Materials to be used in the lightning protection system shall be reliably resistant to corrosion or adequately protected against corrosion. The materials to be used are.

- i) Copper: Solid, or flat copper strips or stranded copper wire of 98 per cent conductivity when annealed, shall be used.
- ii) Galvanised steel: It shall be protected against corrosion by zinc coating.

**5.0 Lightning protection system:**

The lightning protection system comprises of the following major components.

- i) Air terminations
- ii) Down conductors
- iii) Joints and bonds
- iv) Testing points
- v) Earth terminations
- vi) Earth electrodes
- vii) Fasteners

#### **5.1 Air terminations :**

It shall consist of a vertical conductor on a tall structure, a single horizontal conductor for a small building and a system of horizontal and vertical conductors for the protection of bigger buildings.

A vertical air termination shall project atleast 30 cm above the building on which it is fixed.

All horizontal air terminations shall be interconnected such that no part of the roof is more than 9 m away from the nearest horizontal conductor. For a flat roof, horizontal air terminations shall be fixed along the outer perimeter of the roof.

Horizontal air termination shall be fixed along contours of the roof of the buildings in such a way as to join each air termination to the rest and shall themselves form a closed network.

All metallic finials, chimneys, ducts, vent pipes, railings, gutters etc. on or above the main surface of the roof of the structure shall be bonded to the air terminations network. A typical fixing details of vertical air termination on AC sheet roof building and flat roof building are shown in drawing CED/ELE/S/6A & 6B.

All terminals shall be firmly fixed to the building in order to avoid overturning.

#### **5.2 Down conductors:**

5.2.1 Down conductors shall be distributed around the outside walls of the structure and run along the corners and other projections, considering the location of air terminations and earth terminations. Lift shafts shall not be used for fixing down conductors.

5.2.2 The down conductors shall be routed in the most direct path possible between the air termination and the earth termination, avoiding sharp bends, up turns and kinks. Joints shall be avoided in down conductors. Metal pipes shall not be used as protection for the conductors.

5.2.3 In buildings of cantilever construction, down conductors shall be taken straight down to ground by routing through a non-metallic, non-combustible internal duct. Any covered recess not smaller than 75 x 15 mm or any vertical service duct running the full height of the building shall also be used for this purpose, provided it does not contain an unarmoured or non-metal sheathed cable.

The routing of the down conductor shall be such that its accessibility for inspection, testing and maintenance is ensured.

5.2.4 It shall be ensured that the same material is used for both air termination and down

SECTION XI  
**LIGHTNING PROTECTION**

conductor. For example if GI strip is used for air termination, the down conductor shall also be of GI strip.

5.2.5 The shapes and minimum sizes of conductors for use above ground and below ground given in IS: 2309—1969 is reproduced below for ready reference.

Sl.No	Materials and Shape	Minimum size
(i)	Above ground:	
a)	Round copper wire	6 mm diameter
b)	Stranded copper wire	50 mm <sup>2</sup>
c)	Copper strip	20 x 3 mm
d)	Round galvanised iron wire	8 mm diameter
e)	Galvanised iron strip	20 x 3 mm
f)	Round aluminium wire	9 mm diameter
g)	Aluminium strip	25 x 3.15 mm
(ii)	Below ground:	
a)	Round copper wire	8 mm diameter
b)	Copper strip	32 x 6 mm
c)	Round galvanised iron wire	10 mm dia
d)	Galvanised iron strip	32 x 6 mm

5.2.6 During installation of air terminations and down conductors, the following items shall be taken into consideration.

- i) The mechanical forces produced in case of lightning stroke.
- ii) External local heating.
- iii) The Architectural or aesthetic beauty of the building.
- iv) Services entering the structure above and below ground.
- v) Radio and television receiver aerials.
- vi) Flag masts and roof level plant rooms.

### 5.3 Joints and bonds:

5.3.1 Joints: It shall be ensured that the joints are avoided in the lightning protection system as far as possible. In case joints becomes necessary, the number of joints shall be kept as minimum as possible and they shall be mechanically and electrically effective. The joints shall be either bolted, crimped, rivetted or welded. In case of over lapping joints the length of the overlap shall not be less than 20 mm. In the down conductor below ground level, there shall not be any joint.

5.3.2 Bonds: The bond to the lightning protection system shall have a cross sectional area not less than that employed for the main conductors. All bonds shall be suitably protected against corrosion and shall be as short as possible.

#### 5.4 Testing points :

Each down conductor shall be provided with a testing point at a height of 1.5 M from the ground level. It shall be ensured that there is no connection other than the direct connection to the earth electrode is made below a testing point. The details of the test links are shown in the drawing CED/E/E/S/7.

#### 5.5 Earth terminations :

Each down conductor shall have an independent earth termination and have provision for isolation for testing purpose. Water pipe system shall not be bonded to the earth termination system. However if adequate clearance between the two cannot be obtained, they may be effectively bonded and the bonds shall be capable of isolation and testing. The gas pipes, however, shall in no case be bonded to the earth termination system. All earth terminations should be interconnected.

#### 5.6 Earth electrodes :

5.6.1 Earth electrodes shall consist of pipe, strips or plates. Metal sheaths of cables shall not be used as earth electrodes. The earth electrode shall be constructed as per IS : 3043.

5.6.2 When pipes are used they shall be driven into the ground as close as practicable but outside the circumference of the structure.

5.6.3 When strips are used, they shall be buried at a depth not less than 0.5 m deep. The strips shall be laid radially in two or more directions from the point of connection to a down conductor, if this is not possible they shall be laid in one direction. If the space restriction requires the strips to be laid in parallel or in grid formation, the distance between two strips shall not be less than 2 m.

5.6.4 When plate electrodes are used they shall be buried in the ground so that the top edge of the plate is at a depth not less than 2.5 m from the surface of the ground. If two plate electrodes are to be used in parallel, the distance between the two shall not be less than 8 m. For detailed specification of earthing section VI shall be referred.

#### 5.7 Fasteners :

The conductors used for lightning protection shall be securely attached to the building or other object to be protected by fasteners made of galvanised steel. The fasteners shall be substantial in construction not subjected to breakage and protected against corrosion. Guidelines given in page 24 IS 2309 – 1969 shall be referred.

#### 6.0 Testing :

On the completion of the installation of lightning protection system the following tests shall be carried out.

i) Continuity test :

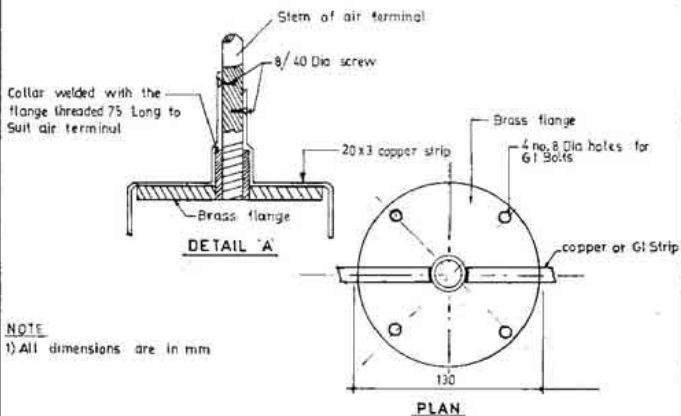
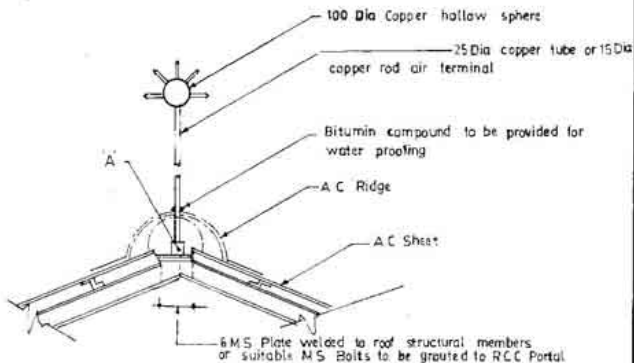
The continuity of all conductors and the efficiency of all bonds and joints shall be checked.

ii) Resistance tests :

The resistance of the lightning protection system complete with air terminations but without the earth connection shall be measured and its value shall not exceed one ohm.

iii) Earth resistance test :

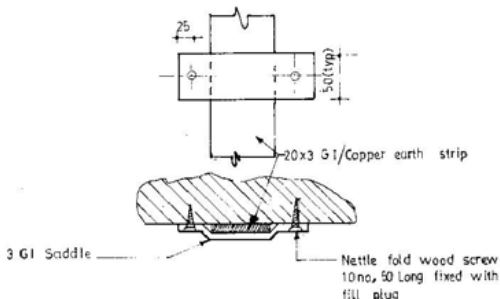
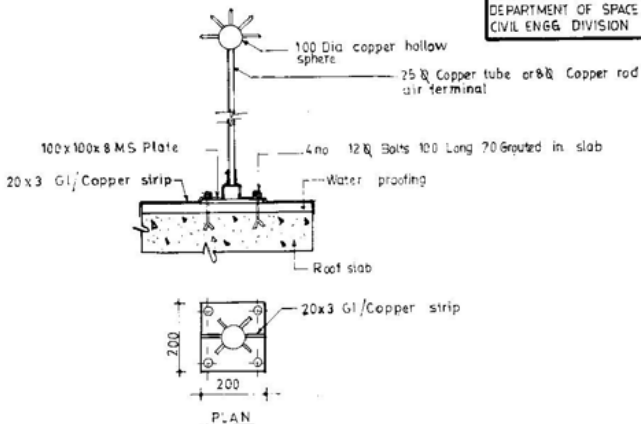
The earth resistance shall be measured and it should not exceed 10 ohm.



NOTE  
1) All dimensions are in mm

### TYPICAL LIGHTNING PROTECTION AIR FINAL FIXING DETAILS

Drawn <i>[Signature]</i> engineer SC	checked <i>[Signature]</i> engineer S O	Recommended <i>[Signature]</i> Head electrical	Approved <i>[Signature]</i> chief engineer	SCALE N T S DATE June 1966	DRG No  CED/ELE/5/6
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NOTE

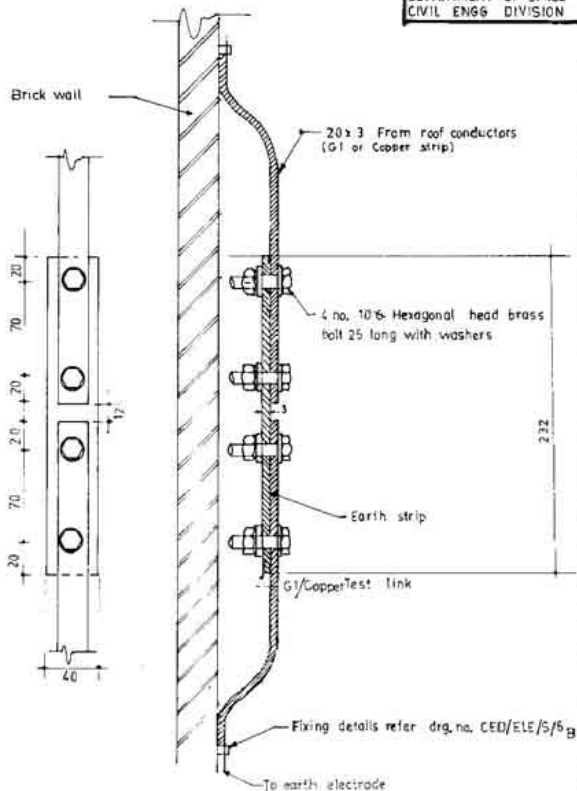
- 1) All dimensions are in mm.
- 2) Refer drg no CED/ELE/S/16A of the GI Copper strips to the vertical air terminal rod

FIXING ARRANGEMENT FOR HORIZONTAL DOWN CONDUCTORS

**TYPICAL LIGHTNING PROTECTION AIR FINIAL FIXING DETAILS**

drawn maheshwari engineer SC	checked with engineer SD checked/ engineer SE	recommended Head electrical	Approved chief engineer	SCALE N T S DATE June 1986	DRG No. CED/ELE/S/6B
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NOTE All dimensions in mm

## TEST LINK FOR LIGHTNING PROTECTION SYSTEM

drawn maheshwara	checked engineer S B	recommended S B	Approved S B	SCALE NTS	DRG. No.
design engineer S C	checked engineer S E	Head electrical	chief engineer	DATE June 1986	CED/ELE/5/7

SECTION XII  
**SUB-STATION**

## SECTION – XII

### SUB-STATION

#### 1.0 Scope:

This specification is intended to cover the requirement of supply, testing at manufacturer's works, installation, testing and commissioning of various sub-station equipments such as HT & LT switch gear, transformer, instrument transformer, battery and battery charger, HT & LT Cables and earthing.

#### 2.0 Standards:

All the sub-station equipments shall comply with the latest relevant Indian Standards, National Electrical Codes and IE Rules.

#### 3.0 HT Switchgear:

##### 3.1 Configuration:

The configuration of the HT switch gear shall be as indicated in the schematic diagram enclosed with schedule. The switch gear shall be of integrated cubicle type, floor mounting, free standing, front operable type and shall be suitable for operation on 11KV, 3 Phase, 50Hz supply. The switch gear shall be designed for a fault level of 350 MVA at 11 KV. The switch gear construction shall be such that it can be readily extendable on either side.

The switch gear shall be suitable for operation at an ambient temperature of + 5 °C to 45 °C, and relative humidity between 30 % to 95 %.

##### 3.2 Constructional features:

The switch gear cubicle shall be fabricated from 2 mm thick MS sheet steel and shall be folded and brazed to provide rigid support for all components. All joints in sheet steel shall be seam welded, all welding slag shall be grounded off, and welding pits smoothed. All panels and covers shall be properly fitted. The board shall be of totally enclosed design and completely dust and vermin proof. Gasket between all covers shall be used to render the joints effectively dust tight. Soft compressible gasket shall be used between all metal joints, doors and covers to prevent ingress of dust. A horizontal wire way with screwed cover shall be provided at the top to take interconnecting control wiring between different vertical sections. Separate and adequate compartments shall be provided for accommodating instruments, indicating lamps selector switches, control fuses etc. These shall be accessible for testing and maintenance without any danger of accidental contact with live parts of circuit breaker or busbar connections.

##### 3.3 Busbars:

The busbar shall be air insulated and made up of high conductivity, high strength aluminium alloy complying with the requirement of IS: 5082.

The busbar shall be housed in a non-segregated compartment in the cubicle at convenient locations.

The main horizontal busbar shall run throughout the entire length of the board and shall be of capacity as indicated in the drawing enclosed with the schedule.

The busbar shall be suitably supported with non-hygroscopic insulators at suitable intervals to withstand the forces arising from short circuits on the system. Large clearances and creepage distances shall be provided in the busbar system to minimise the possibility of a fault. High tensile bolts, nuts and spring washers shall be provided at all busbar joints. The busbars shall be suitably insulated with coloured PVC tape for R, Y, B phases.

#### **3.4 Circuit breaker :**

3.4.1 The circuit breaker shall be suitable for indoor operation and be of triple pole 11KV and current rating as indicated in the schematic drawing. It shall be of minimum oil/bulk oil type as indicated in the schedule with symmetrical breaking capacity of 350MVA at 11KV. The breaker shall be of flush, front operated, metal clad, drawout type and shall be provided with trip free manual closing mechanism, with mechanical ON & OFF indication. The three poles shall have individual arc extinguishing chamber mounted on insulators. The circuit breaker shall be housed in a separate compartment.

3.4.2 The following safety interlocks shall be provided.

- i) The breaker can be plugged in only when the breaker is in 'OFF' condition.
- ii) The breaker can be removed only when the breaker is in 'OFF' condition.
- iii) Automatic shutters shall be provided to prevent access to the busbars when the breaker is removed.

3.4.3 The cradle shall have proper design and construction so as to permit smooth withdrawal and insertion of the breaker. The movements shall be free of jerks, easy to operate and shall be on steel balls/rollers. The cradle shall have the markings for the following four distinct and separate positions of the circuit breaker.

- i) Service
- ii) Isolated
- iii) Test
- iv) Maintenance

3.4.4 There shall be suitable sheet steel barriers between the following:

- i) Instrument panel and potential transformers
- ii) Instrument panel and current transformer
- iii) Busbar chamber and circuit breaker compartments

3.4.5 Terminals : Cable termination shall be provided for the incoming and outgoing feeders suitable for bottom entry. The cable termination boxes shall be with suitable glands for the cable sizes as indicated in the schematic drawing and in the tender schedule.

3.4.6 Protective devices : IDMTL type combined over current and earth fault relay shall be provided as indicated in the schematic drawing. The breaker shall be provided with 24V/110V DC operated shunt trip coil.

#### **3.5 Instrument transformers :**

3.5.1 Current Transformer : The current transformer shall comply with IS : 2705 Part I, II and III

with all latest amendments.

All current transformers supplied shall be of air insulated, moulded or dry type epoxy resin insulated.

The accuracy class of the current transformer used for metering shall be class 1 P and class 5 P for protection as per latest relevant Indian Standards.

The current transformer shall have the required 'VA' capacity to supply connected meters and relays without exceeding the accuracy limits specified above. They shall have a rated secondary current of 5 A.

All the meters supplied shall be suitable for operation from current transformer having a nominal secondary rating of 5 amps.

**3.5.2 Potential Transformers:** The potential transformer shall be of oil immersed and self cooled type suitable for the services indicated complete in all respects conforming to the modern practice of design and manufacture.

The core shall be of high grade, non-aging electrical silicon laminated steel of low hysteresis loss and high permeability to ensure high accuracy at both normal and over-voltages.

**3.5.3 Secondary windings:** All voltage transformers shall be connected in star. The star winding to be used for metering shall be of accuracy class as specified in relevant IS.

The rated burden of this winding shall be as specified in the specification.

**3.5.4 Insulation:** The potential transformers shall withstand satisfactorily dielectric test voltage, corresponding to basic insulation level as specified in relevant Indian Standards specification.

**3.5.5 Tests:** Each potential transformer shall be subjected to routine tests as specified in relevant Indian Standards.

### **3.6 Metering:**

Metering shall be provided as indicated in the schedule and schematic diagram.

- i) Ammeter shall be with suitable CTs and with selector switch
- ii) Voltmeter shall be of 0-15 KV range and with selector switch
- iii) Frequency meter of range 45 - 55 Hz shall be provided
- iv) Trivector meter with maximum load, KVAR and KWH indications shall be provided on the panel as indicated in the drawing and schedule

### **3.7 Wiring:**

Internal wiring of the switch gear shall be with PVC insulated copper conductor wire with good quality plastic beads for identification. The wire shall be neatly laid and bunched.

### **3.8 Earthing:**

The main earth bus shall be of copper strip of 25 mm x 3 mm size. Two independent earth strip of the above indicated size shall be connected to the sub-station earth electrodes and as indicated in the drawing CED/ELE/s/15.

### 3.9 Testing:

The circuit breaker shall be tested for the following routine tests as specified in the relevant latest Indian Standards before despatching and the test certificates shall be furnished in triplicate.

#### 3.9.1 Routine Tests:

- i) Measurement of resistance of the main circuits
- ii) Operation tests
- iii) One minute power frequency voltage dry withstand tests on the circuit breaker
- iv) One minute power frequency voltage dry withstand tests on auxiliary circuits

### 3.10 Painting:

The sheet steel parts of the circuit breaker shall have undergone the process of degreasing, pickling in acid, cold rinsing, passivating and then spray painted with two coats of red-oxide primer followed by stove enamel painting of suitable good shade.

### 3.11 Technical particulars:

The tenderers shall furnish the technical particulars of the circuit breaker as given at the end of the section.

## 4.0 Transformer:

### 4.1 Technical requirements:

The transformer shall conform to the specification as given below:

- i) Capacity: as specified in the schedule
- ii) Voltage ratio: 11KV/433V
- iii) No. of phases: Three phases
- iv) Supply voltage: 11KV, 3 Phase, 50 Hz
- v) Rating: Suitable for continuous rating
- vi) No. load voltage: 11000V on HT side and 433V on LT side
- vii) Connection: Delta on HT side and star on LT side with neutral terminal brought out for solid earthing
- viii) Vector group: DY – 11
- ix) Percentage impedance: Shall not exceed 5%
- x) Tappings: Off load tap changing arrangement on HT side for variation of LT voltage from  $\pm 2.5\%$ ,  $\pm 5\%$  &  $-7.5\%$
- xi) Temperature rise: Not to exceed 40°C by thermometer in oil
- xii) Type: Outdoor/Indoor, as specified in the Schedule.
- xiii) Terminals: Cable end boxes on HT side and cable end boxes on LT side upto 500KVA rating and bus duct arrangement on LT side for capacity more than 500KVA

- xiv) Cooling: Natural oil cooled

#### **4.2 Fitting and accessories :**

- i) Lifting lugs: Necessary lifting lugs shall be provided to lift the transformer without disturbing the connections.
- ii) Swivel type rollers: 4 Nos. Bi-directional rollers shall be fitted on cross channel at the bottom of the transformer so as to facilitate the movement of transformer in both the directions.
- iii) Oil-conservator: Suitable size of oil-conservator shall be provided. The conservator shall have oil level guage with marking for minimum level and oil filling hole with a cap.
- iv) Air release valve: An air release valve shall be provided on the top of the tank cover to facilitate the release of the entrapped air while filling of oil.
- v) Breather: Sufficient capacity of indicating de-hydrating silicagel breather shall be provided.
- vi) Drain-cum-oil filter valve: At the bottom of the transformer drain-cum-oil filter valve shall be provided.
- vii) Earthing terminals: Two separate earthing terminals shall be provided on both the sides of the tank for earthing.
- viii) Off-load tap changing switch: The transformers shall be provided with an externally operated off-load tap changing switch with handle with position indicating plate and locking device.
- ix) Diagram and rating plate: The transformer shall be fitted with a diagram and rating plate indicating the details of the transformer, connection diagram, vector group, tap changing diagram etc.
- x) Dial type thermometer: Dial type thermometer of range 0-100°C shall be provided.
- xi) Explosion vent: The transformer shall be fitted with an explosion vent of suitable size.
- xii) The transformer shall be provided with first filling of oil. The transformer oil shall conform to the latest relevant Indian Standards.
- xiii) Filter valve: Buchholz relay shall be provided for transformer of more than 500KVA rating.
- xiv) Marshalling box: The control cables of thermometer and buchholz relay shall be terminated in a suitable size of marshalling box

#### **4.3 Testing:**

The following tests shall be conducted at the factory before despatching and the test certificates shall be furnished.

- i) Measurement of winding resistance
- ii) Ratio, polarity and phase relationship
- iii) Impedance voltage
- iv) Load losses

- v) No load loss and no load current
- vi) Insulation resistance
- vii) Induced over voltage
- viii) Separate source voltage withstand test
- ix) Temperature rise

#### **4.4 General:**

4.4.1 The technical informations shall be furnished in the proforma given at the end of this section.

4.4.2 The transformer shall be guaranteed for a period of 12 months from the date of commissioning. The contractor shall repair/replace the damaged equipment without any extra cost.

#### **5.0 Automatic voltage regulator:**

##### **5.1 Technical requirements:**

The Automatic Voltage Regulator shall conform to the specifications as given below:

- i) Capacity: As indicated in the schedule
- ii) Type: Outdoor/Indoor type, oil immersed, naturally cooled as indicated in the schedule
- iii) No. of phases: Three phase
- iv) Frequency of operation:  $50 \pm 3\%$  Hz
- v) Fittings: The following standard fittings shall be provided
  - a) Two earthing terminals
  - b) Lifting lugs
  - c) Servomotors/relays, rollers and cable end boxes
  - d) Rating marking plates
  - e) Provision for filling and drainage of oil, oil level indicator
- vi) Input voltage: 300 to 480 volts, 3 phase and neutral, 4 wire
- vii) Output voltage: Voltage shall be stabilised at 415 Volts  $\pm 1\%$  between phases and 240 volts between phase and neutral. The AVR shall be suitable for unbalanced load with the provision of voltage correction on each phase
- viii) Speed of correction: Speed of correction shall not be less than 8 volts/sec and shall be provided on each phase by suitable solid state circuits and servomotors
- ix) AVR shall be in a single unit
- x) Terminal box: The AVR shall have suitable cable terminal box for the termination of PVC insulated cable for both incoming and outgoing sides of sizes as indicated in the schematic drawing
- xi) Winding material: The winding shall be with copper conductor of suitable size to match the capacity of the AVR



- xii) Metering: It shall have 0-500 V AC 3Ø Voltmeter with selector switch on incoming and outgoing sides
- xiii) Protection: Necessary over voltage protection shall be provided, when the voltage exceeds 480 volts and under voltage protection shall be provided when the voltage falls below 300 volts

## **5.2 General:**

- i) No load losses shall be as minimum as possible
- ii) The exterior of the AVR tank and other ferrous fittings shall be thoroughly cleaned, scraped and given a primer coat and two finishing coats of durable oil and weather resisting paint or enamel paint
- iii) All tests shall be carried out in accordance with latest Indian Standards
- iv) Valves and welded joints shall be pressure tested after fabricating the tank, for a minimum period of atleast 12 hours
- v) Tenderer shall submit drawing along with quotation giving details of AVR unit, overall dimensions, internal wiring details etc. Apart from operation/maintenance manual in triplicate, test reports and guarantee certificate shall also be enclosed

## **5.3 Testing :**

The following tests shall be carried out at the manufacturer's works:

- i) Measurement of winding resistance
- ii) Polarity test
- iii) Insulation resistance between phases and between individual phases and earthing
- iv) Load losses and efficiency
- v) Temperature rise
- vi) Speed of correction
- vii) Functional test of solid state control circuits and servomotor
- viii) Dielectric strength of oil, wherever necessary
- ix) Tests on all protective relays such as over voltage, under voltage and overload relay

## **6.0 Battery and battery charger :**

### **6.1 Battery :**

The specification of the battery shall be as detailed in the section viii.

### **6.2 Battery charger :**

The battery charger shall be of static, semi-conductor, full wave silicon rectifier type suitable for operation on 3 phase, 415 V, 50 Hz supply.

The charger shall have suitable capacity for trickle charging, float charging and boost charging of batteries connected to the charger.

The charger with control shall be contained in a totally enclosed dust and vermin proof sheet metal cubicle of self supporting type with adequate ventilation and means for easy access to the interior for the replacement and maintenance of the components.

The charger shall have the following capabilities—

The charger shall have a constant voltage characteristics throughout its ampere rating at the floating value of voltage corresponding to the battery, so as to keep the battery fully charged, but without harmful over-charge.

Normally placed in trickle charge position, it shall supply charge current required for the battery and continuous load current specified.

For boost charging the charger shall be capable of providing the higher voltage (about 2.6V per cell) than the floating voltages as the battery approaches full charge. The charger shall be capable of supplying the quick charging current over and above the continuous load current.

The charger shall be capable of supplying the periodic equalising charge over and above supplying the continuous load current.

The charger shall be suitable for initial charging of the battery.

The charger shall be suitable for the rated capacity of the battery specified.

Capacity of the charger shall be as specified in the specification. If the capacity of the charger as assessed by the tenderer on the basis of duties mentioned above is different from that mentioned above, the tenderer should quote a separate price for such battery charger alongwith the rated capacity.

#### **7.0 LT switchgear and panel:**

The LT switchgear and panel shall conform to the specifications detailed in section iv.

#### **8.0 HT and LT cables :**

HT and LT cables shall be of the sizes as indicated in the schedule and schematic drawing and shall bear the ISI mark. Laying of cable shall conform to the specification detailed in section vii.

#### **9.0 Earthing :**

The pipe and plate earth electrodes shall be installed as detailed in section vi. A drawing indicating typical arrangement of earthing in a sub-station is given in the drawing CED/ELE/S/15.

#### **10.0 Installation, testing and commissioning of sub-station equipments :**

##### **10.1 General:**

The installation of various sub-station equipments shall be carried out in accordance with the working drawings, relevant Indian Standards, code of practice and manufacturer's instruction. The installation shall also be in accordance with IE rules and the regulations of either local electricity authority or central electricity authority which ever is applicable. The installation, testing and commissioning of various sub-station equipments shall also be carried out as per the details briefly described in the subsequent paragraphs.

## **10.2 HT and LT panels:**

10.2.1 Site inspection : The switch boards shall be supplied by the supplier in a properly packed condition. After ascertaining that there is no damage to the packing, all the items shall be inspected after unpacking. It shall be ensured that the switch boards are in accordance with the requirements as described in the schedule and drawings. It shall also be ensured that all the meters, relays, indication lamps etc. are in good condition and have not suffered any damage during transit.

10.2.2 Installation: The switch board shall be assembled together in case the switch board is supplied in section. The switch board shall be installed in position and levelled on the foundation as per the installation drawings furnished by the manufacturer. The busbars of the sections shall be properly connected and checked for tightness after installation. The cable termination shall be carried out in accordance with the relevant standards and the cable end box shall be sealed. The switch board shall be earthed by means of two independent earth strips of sizes as indicated in the working drawing/in the schedule. It shall be ensured that 15 mm thick rubber matting of an approved make is provided in front of the full length of the switch board. The width of the matting shall be 1000 mm and shall withstand 15000V for one minute.

10.2.3 Testing and commissioning: The following tests shall be carried out on the switch boards at site prior to commissioning:

- i) Insulation resistance between phases and individual phase and earth
- ii) Di-electric strength of circuit breaker oil shall be checked in accordance with the relevant IS
- iii) Earth continuity
- iv) Earth resistance
- v) All protective relays and tripping mechanism shall be checked for their proper operation

## **10.3 Transformer:**

10.3.1 Site Inspection: The transformer shall be inspected at site to ascertain that there is no damage to any of the components and accessories of the transformer. Normally inspection manual will be supplied by the manufacturer. The instruction given in the instruction manual shall be followed.

10.3.2 Installation: The transformer shall be installed as per the installation manual provided by the transformer manufacturer. The installation shall also conform to the relevant IS and IE rules. After the completion of the erection of the transformer it shall be ensured that the transformer wheels are suitably locked to prevent accidental movement of transformer. HT & LT cabling/LT bus duct shall be carried out in accordance with the relevant schedule and working drawing. The transformer neutral and body shall be earthed as detailed in the drawing. The breather shall be cleaned and filled with oil and silica gel. In case of pole mounted transformer, the installation shall be carried out as detailed in the schedule and in conformity with the rules and regulations of the inspection authorities. A drawing CED/ELE/S/16 A&B indicating a typical arrangement of pole mounted transformer is given at the end of this specification for guidance.

10.3.3 Testing and commissioning: The following test shall be conducted on the transformer

prior to its commissioning:

- i) Insulation resistance of the winding between phases and between individual phases and earth on both HV and LV sides and also between HV and LV windings
- ii) Winding resistance
- iii) Di-electric strength of transformer oil
- iv) Voltage ratio test at all tap positions
- v) Polarity test
- vi) Operation of Buchholz relay
- vii) Proper functioning of all protective relays

After commissioning of the transformer the LV side voltage shall be measured at different tap positions. The transformer shall be kept on no load for 24 hours, and shall be ascertained that there is no undue temperature rise before loading the transformer.

#### **PROFORMA**

#### **11.0 Technical particulars to be furnished by the tenderer:**

##### **11.1 Circuit breakers:**

1. Number of poles.
2. Indoor/Outdoor.
3. Rated voltage.
4. Rated insulation level.
5. Rated frequency.
6. Rated normal current.
7. Rated line-charging, breaking current.
8. Rated cable charging, breaking current.
9. Rated capacitor breaking current.
10. Rated small inductive breaking current.
11. Rated short circuit breaking current.
12. First-pole-to-clear factor.
13. Rated transient recovery voltage for terminal fault.
14. Rated characteristics for short line faults.
15. Rated short circuit making current.
16. Operating sequence.
17. Duration of short circuit.
18. Out of phase breaking current.

19. Opening time and breaking time.
20. Closing time.
21. Type test certificate.
22. Weight of the circuit breaker.
23. Weight of oil.
24. Number of tanks.
25. Number of breaks in series per pole.
26. Minimum clearance,
  - a) between poles
  - b) to earth and the pole.
27. Operating mechanism of the circuit breaker.
  - a) type of closing mechanism,
  - b) whether the circuit breaker is trip free or fixed trip and whether it is with lockout preventing closing,
  - c) current required at rated supply voltage to close the circuit breaker,
  - d) rated supply voltage of shunt opening release,
  - e) current required at rated supply voltage for shunt opening release,
  - f) number and type of spare auxiliary switches,
  - g) current required at rated supply voltage by other auxiliaries.
28. Overall dimension :

#### 11.2 Transformer :

1. Name of the manufacturer
2. Service
3. Rating
 

Rated KVA .....	Rated KVA
Rated voltage of HV .....	KV
Rated voltage of LV .....	KV
Temperature rise in oil .....	°C
Temperature rise by resistance of windings .....	°C
Rated frequency .....	Hz
4. Number of phases.
5. Connections.
  - High voltage
  - Low voltage
  - Vector group reference
6. Tappings.
 

High voltage	%
--------------	---

7. No load loss at rated voltage and frequency in KW.
8. Load loss at rated current at 75°C in KW.
9. Impedance at rated current and frequency in percentage.
10. Reactance at rated current and frequency in percentage.
11. Efficiency at UPF at
  - (a) full load ..... percentage
  - (b) 75 % of full load ..... percentage
  - (c) 50 % of full load ..... percentage
12. Regulation at full load at
  - (a) unit PF ..... percentage
  - (b) 0.8 PF ..... percentage
13. No load current at rated voltage and frequency ..... percentage
14. Approximate weights
 

Core and windings .....	kg.
Tank and fittings .....	kg.
Oil .....	kg.
Total weight .....	kg.
15. Quantity of oil ..... litres
16. Overall dimension
 

Length .....	mm
Breadth .....	mm
Height .....	mm
17. Terminal arrangement
 

High voltage	
Low voltage	
18. Maximum flux density at rated voltage and frequency ..... CGS Gauge/Cm<sup>2</sup>
19. Load at which maximum efficiency occurs ..... percentage of full load
20. Maximum efficiency ..... percentage
21. Impulse levels with 1/50 Micro Second wave
 

High voltage in KV	
Low voltage in KV	
22. Insulation materials
 

Turn insulation, high voltage side	
Turn insulation, low voltage side	
Insulation, core to low voltage	
Insulation, high voltage to low voltage	
23. Minimum clearance height for lifting core and windings from tank

24. List of fittings
25. Type of winding
  - (a) low voltage side ..... (star/delta)
  - (b) high voltage side ..... (star/delta)

**11.3 Automatic voltage regulator :**

1. Name of the manufacturer and place of manufacture :
2. Rating of AVR and year of manufacture :
3. Type of cooling :
4. No load loss in watts :
5. Voltage correction rate :
6. Winding material :
7. Guarantee period :
8. Percentage of regulation :
9. Insulation level (winding) :
10. Net weight of winding (Kgs) :
11. Net weight of core (Kgs) :
12. Total weight of AVR :
13. Dimensions of AVR :
14. Protection device :
15. Delivery period (in full) :
16. Wide range of temperature without affecting the performance :
17. Whether suitable for balanced/Unbalanced :
18. Range of input voltage variation :
19. Range of output voltage variation :
20. Type of control mechanisms (Mercury switch/Electronic circuitry) :
21. Operating motor capacity :
22. Indoor/Outdoor type :
23. Cable end boxes (if provided, what size) :
24. Spare parts (if provided mention in detail) :
25. Mean time between failure (MTBF) in hours :
26. Whether filled with transformer oil (if filled, total weight of oil) :
27. Instruction manual and maintenance manual :
28. Details of control motor :
29. Test reports :

NOTES -

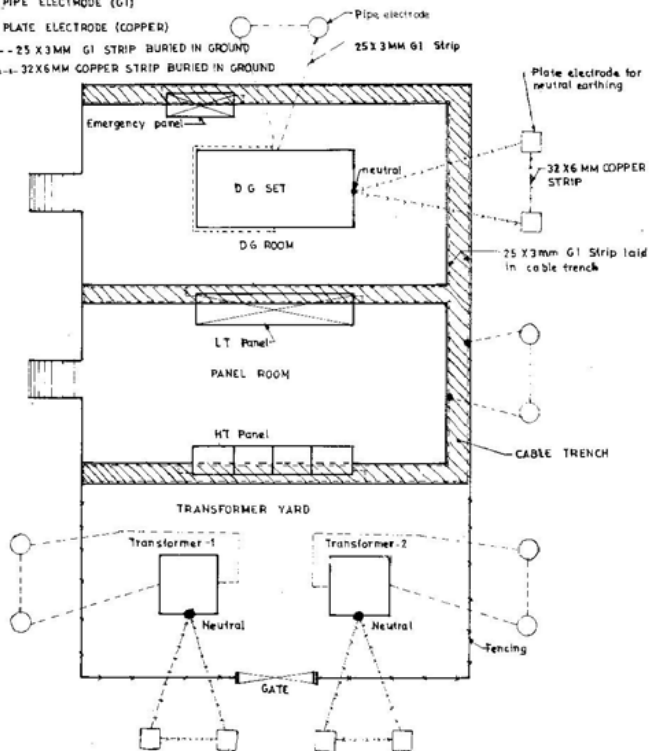
- 1) All dimensions are in mm
- 2) Plate earth for neutral earthing of transformer, D.G Set.
- 3) Pipe earth for the body earthing of D.G Set transformer HT Panel & LT Panel
- 4) The distance between two electrodes shall not be less than 6000

○ PIPE ELECTRODE (GI)

□ PLATE ELECTRODE (COPPER)

--- 25 X 3MM GI STRIP BURIED IN GROUND

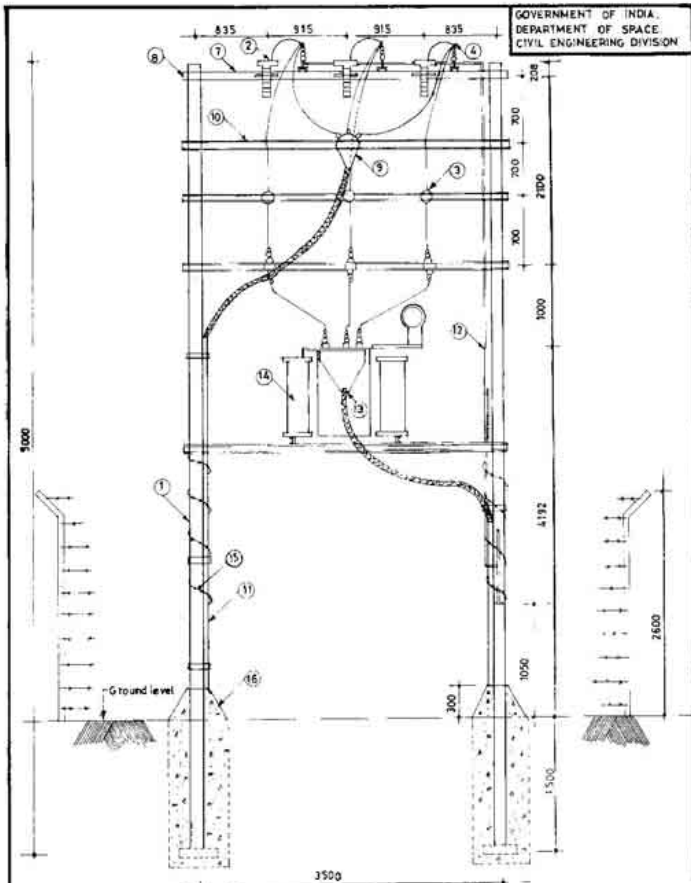
- - - - 32 X 6MM COPPER STRIP BURIED IN GROUND



GENERAL EARTHING ARRANGEMENT FOR S/S WITH DG SET

drawn maheswara	checked engineer SB	recommended head electrical	Approved chief engineer	scale N T S	drg. no.
date engineer S B	checked engineer S E			date JULY 1986	CED/ELE/S/15

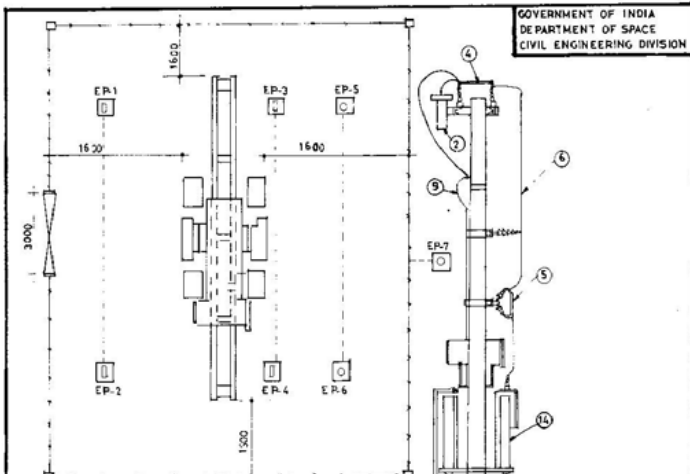




NOTE: FOR DETAILS REFER DRG. NO. CED/ELE/S/16 B

TYPICAL DETAILS OF POLE MOUNTING TRANSFORMER  
WITH DOUBLE POLE STRUCTURE

drawn maheshwari	checked engineer S.C.	Recommended Head electrical	Approved Chief engineer	SCALE N T S	drg. no.
date JFM-86	checked engineer			date JULY 1986	CED/ELE/S/16 A



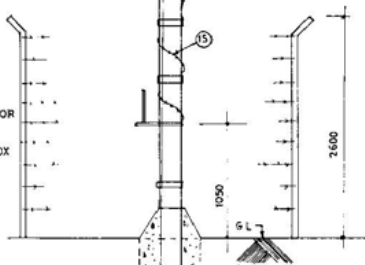
PLAN

LEGEND -

- ① RCC POLE 9000 LONG
- ② LIGHTNING ARRESTOR
- ③ PIN INSULATOR
- ④ 11KV AIR BREAK SWITCH
- ⑤ 11KV DROP OUT FUSE
- ⑥ No 4 SWG COPPER WIRE
- ⑦ M S CHANNEL 100X50X6 FOR A B SWITCH (3780 LONG)
- ⑧ M S CHANNEL 100X50X6 FOR LIGHTNING ARRESTOR (3780 LONG)
- ⑨ 11KV CABLE END BOX
- ⑩ M S CHANNEL 100X50X6 FOR 11KV CABLE END BOX (3780 LONG)
- ⑪ HT CABLE IN GI PIPE
- ⑫ AB SWITCH OPERATING ROD & HANDLE
- ⑬ LT CABLE & CABLE END BOX
- ⑭ TRANSFORMER 15) BARBED WIRE
- ⑮ CEMENT CONCRETE FOUNDATION BLOCK
- ⑯ PLATE EARTH PIT
- ⑰ PIPE EARTH PIT

NOTES -

- 1) All dimensions are in mm do not scale off this drawing.
- 2) EP-1 EP-2 lightning arrester earth pits
- 3) EP-3 EP-4 Neutral earthing
- 4) EP-5 EP-6 Body earthing including double pole structure
- 5) EP-7 Fence earthing
- 6) Size of the pole to be selected to suit the capacity of the transformer.



ELEVATION

TYPICAL DETAILS OF POLE MOUNTING TRANSFORMER  
WITH DOUBLE POLE STRUCTURE

drawn mohd iswar debt engineer SC	checked engineer S D checked engineer S E	Recommended <i>[Signature]</i> Head electrical	Approved <i>[Signature]</i> chief engineer	SCALE N T S date JULY 1986	drg. no. CED/ELE/S/16B
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SECTION XIII  
**AUTOMATIC SMOKE DETECTION  
AND FIRE ALARM SYSTEM**

## SECTION – XIII

### SPECIFICATION FOR AUTOMATIC SMOKE DETECTION AND FIRE ALARM SYSTEM

#### 1.0 Scope:

This specification is intended to cover the requirements of electrical aspects of supply and installation of automatic smoke detection and fire alarm system.

#### 2.0 Standards:

The smoke detection and fire alarm system shall conform to the latest relevant Indian Standards and National Electrical Code.

#### 3.0 Automatic smoke detection system :

Automatic smoke detection and fire alarm system comprises of the following.

- i) Smoke detector
- ii) Control panel

#### 3.1 Smoke detector :

The smoke detector shall be of dual chamber ionization type suitable to operate on 24V DC supply with suitable radio active source to work in normal ambient temperature and humidity conditions with 20 micro Ampere current at normal conditions and 300mA during alarm conditions with terminals and indication lamps.

The unit shall be capable to provide positive, trouble free operation in locations subjected to both external vibration and voltage fluctuation. The unit shall be with solid state circuitry and have special locking screw which locks the detector head to the base securely.

#### 3.2 Control panel:

3.2.1 The control panel shall be suitable for the number of zones as specified in the schedule and comprises of the following:

- i) Visible indication, indicating the zone in which fire has occurred.
- ii) Audible alarm device.
- iii) Power supply with 2 × 12V lead acid battery with transformer, battery charger, with trickle charging facility, so that the control panel operates on AC mains with a back up for operation during mains failure.
- iv) Acknowledge, reset and test devices.

3.2.2 The panel shall also have the provision to indicate the following:

- a) Fire condition
- b) Fault condition
- c) AC pilot indication
- d) AC failure indication
- e) Low battery voltage indication
- f) Blown fuse indication
- g) Open and short circuit.

3.2.3 Indicator mentioned in para 3.2.2 shall include the following:

- a) Two lamps connected in parallel associated with each indication shall be arranged so that failure of either of the lamps is readily apparent, or
- b) One lamp glowing during normal operation for each section and the alarm indicated by extinguishing of the lamp for the section where it originates. Alarm shall not sound in the case of failure of the indicator
- c) The circuits arrangements and the electrical connections shall be such that a call or fault in any circuit does not prevent the receipt of calls on any other circuit
- d) The indicating device associated with the various call points and sections shall be grouped together on the main indicator board. Indicating panel with audible alarm shall be provided at the locations as indicated in the schedule and drawing.
- e) The silencing switches/push buttons in their off position shall give an indication of this fact on the main control panel. Operation of silencing switches shall not prevent sounding of alarm from any other zone simultaneously, or cancel the other indications of the alarm or fault.

3.2.4 Built-in electronic hooter of two tone sound during fire conditions shall be provided

3.2.5 Push button switch for checking of each zone shall be provided.

3.2.6 Push button control for stopping of audible alarm (visual indication to remain) shall be provided.

3.2.7 The control panel shall be of modular design type using electronic printed circuit boards of plug in type to facilitate easy replacement of faulty circuits and electronic components.

### **3.3 Wiring :**

3.3.1 For fire alarm systems, PVC insulated and armoured control cable with 1.5 sq. mm copper conductor shall be used.

3.3.2 The wiring and equipment for the fire alarm system shall be independent of any other equipment or wiring, and shall be spaced atleast minimum of 5 cm from one another. The wiring shall be kept away from lift shafts, stair-cases etc.

### **3.4 Source of supply :**

The source of supply for the alarm system shall be a secondary battery continuously trickle/float charged from AC mains, which facilitates for automatic recharging in 8 hours sufficiently to supply the maximum alarm load at an adequate voltage for atleast 2 hours. The capacity of battery shall be such that it is capable of maintaining the maximum alarm load on the system at an adequate voltage for atleast 1 hour plus the standing load or losses for atleast 48 hours. Suitable overload protective devices shall be provided to prevent discharging of the batteries through the charging equipment.

## LIST OF RELEVANT INDIAN STANDARDS

Sl. No.	Title	IS :
1.	Electrical wiring installations (system voltage not exceeding 650 volts)	732-1963
2.	Conduits for electrical installations : Part I General requirements	9537 (Part I)-1980
3.	Rigid steel conduits for electrical wiring	1653-1972
4.	Rigid non-metallic conduits for electrical installations	2509-1973
5.	Flexible steel conduits for electrical wiring	3480-1966
6.	Rigid steel conduits for electrical wiring, accessories for	3837-1976
7.	Link clips for electrical wiring	2412-1975
8.	Fittings for rigid steel conduits for electrical wiring	2667-1976
9.	Flexible (Pliable) non-metallic conduits for electrical installations	6946-1973
10.	Adapters for flexible steel conduits	4649-1968
11.	Boxes for enclosure of electrical accessories: Part I steel and cast iron boxes Part II Boxes made of insulating material	5133 (Part I)-1969 5133 (Part II)-1969
12.	Polyvinyl chloride sleeving for electrical purposes	1951-1961
13.	Ceiling roses	371-1979
14.	Appliance-connectors and appliance-inlets (non-reversible three pin type) Part I Appliance – connectors Part II Appliance inlets	3010 (Part I)-1965 3010 (Part II)-1965
15.	Switch-socket outlet (non-inter locking type)	4615-1968
16.	Switches for domestic and similar purposes (superseding IS: 1087-1957 and IS: 2120-1963)	3854-1966
17.	Three pin plugs and socket outlets	1293-1967
18.	Inter locking switch socket outlet	4160-1967
19.	Luminaires, general and safety requirements for: Part I Tubular fluorescent lamps	1913 (Part I)-1978
20.	Decorative lighting outfits	5077-1969
21.	Industrial lighting fittings with plastic reflectors	3287-1965
22.	Industrial luminaire with metal reflectors	1777-1978
23.	Industrial lighting, code of practice for	6665-1972
24.	Flood lights	1947-1980

Sl. No.	Title	IS:
25.	Dust-proof electric lighting fittings	4012-1967
26.	Dust-tight electric lighting fittings	4013-1967
27.	Electric lighting fittings for division 2 areas.	8224-1976
28.	Flame proof electric lighting fittings : Part I Well-glass and bulkhead types Part II fittings using glass tubes	2206 (Part I)-1962 2206 (Part II)-1976
29.	Luminaires for street lighting	2149-1970
30.	Water proof electric lighting fittings	3528-1966
31.	Watertight electric lighting fittings	3553-1966
32.	Emergency lighting units	9583-1981
33.	Tubular fluorescent lamps for general lighting services : Part I Requirements and tests	2418 (Part I)-1977
34.	High pressure mercury vapour lamps, methods of tests for	7023-1973
35.	Tungsten filament general service electric lamps	418-1978
36.	Holder for starters for tubular fluorescent lamps	3324-1965
37.	Ballast for high pressure mercury vapour lamps	6616-1972
38.	Ballast for fluorescent lamps : Part I for switch start circuits	1534 (Part I)-1977
39.	Capacitors for use in tubular fluorescent, high pressure mercury and low pressure sodium vapour discharge lamp circuits	1569-1976
40.	Bi-pin lampholders for tubular fluorescent lamps	3323-1980
41.	Bayonet lampholders	1258-1979
42.	Dimensions of caps for tungsten filament general service electric lamps	9206-1979
43.	Fans and regulators, ceiling type, electric	374-1979
44.	Fans and regulators, table type, electric	555-1979
45.	Fans, fixed capacitors for	1709-1960
46.	Fans and regulators, pedestal type, electric	1169-1967
47.	Air circulator type fans and regulators, electric	2997-1964
48.	Electric call bells and buzzers for indoor use	2268-1966
49.	General requirements for switchgear and controlgear for voltages not exceeding 1000 V	4237-1967
50.	Air-break isolators for voltages not exceeding 1000 volts.	2607-1967
51.	Air-break switches, air-break disconnectors, air-break switch disconnectors and fuse combination units for	

Sl.	No.	Title	IS:
		voltages not exceeding 1000 Vac or 1200 Vdc:	
		Part I General requirements	4064 (Part I)-1978
		Part II Specific requirements for the direct switching of individual motors	4064 (Part II)-1978
52.		Carriers and bases used in rewirable type electric fuses up to 650 Volts	2086-1963
53.		Alternating current isolators (disconnectors) and earthing switches	1818-1972
54.		Control switches (switching devices for control and auxiliary circuits including contactor relays) for voltages upto and including 1000 Vac and 1200 Vdc:	
		Part I General requirements and tests	6875 (Part I)-1973
		Part II Pushbuttons and related control switches	6875 (Part II)-1973
		Part III Rotary control switches	6875 (Part III)-1980
55.		Distribution pillars for voltages not exceeding 1000 Volts	7118-1973
56.		Enclosed distribution fuse boards and cutouts for voltages not exceeding 1000 V	2675-1966
57.		HRC cartridge fuse links upto 650V	2208-1962
58.		Degrees of protection provided by enclosures for low-voltage switchgear and controlgear	2147-1962
59.		Miniature air break circuit-breakers for voltages not exceeding 1000 Volts	8828-1978
60.		Rewirable fuses upto 650 V, dimensions for	8724-1978
61.		Switch gear bus-bars, main connections and auxiliary wiring, marking arrangement for	375-1963
62.		Motor starters for voltages not exceeding 1000 V	8544 (Part I to IV)
63.		Application guide for current transformers	4201-1967
64.		Current transformers:	
		Part I General requirements	2705 (Part I)-1981
		Part II Measuring current transformers	2705 (Part II)-1981
		Part III Protective current transformers	2705 (Part III)-1964
		Part IV Protective current transformers for special purpose application	2705 (Part IV)-1981
65.		Code of practice for Earthing	3043-1966
66.		PVC-insulated cables for working voltages upto and including 1100 Volts (Superseding IS :3053 (Part I)-1965)	694-1977



Sl. No.	Title	IS :
67.	PVC-insulated and PVC-sheathed solid aluminium conductored cables of voltage rating not exceeding 1100 Volts.	4288-1967
68.	PVC insulated (heavy duty) electric cables : Part I for working voltages upto and including 1100 Volts Part II for working voltages from 3.3KV up to and including 11 KV	1554 (Part I)-1976 1554 (Part II)-1970
69.	Polyethylene insulated cables for working voltages upto and including 1100 Volts	1596-1977
70.	Paper insulated lead-sheathed cables for electricity supply	692-1973
71.	Paper-insulated power cables (up to and including 33 KV) installation and maintenance of, code of practice for	1255-1967
72.	Paper-insulated lead sheathed cables, straight through joint boxes and lead sleeves for, up to and including 11 KV.	7093-1973
73.	Moulds for cast resin based straight through joints for cables for voltages up to and including 1100 Volts	8438-1977
74.	Moulds suitable for cast resin based terminations for cables for voltages up to and including 1100 volts	9553-1980
75.	Guide for marking of insulated conductors	5578-1970
76.	Soldering and welding type terminal ends for conductors of insulated cables	8394-1977
77.	Soldering ferrules of straight through joints	6554-1972
78.	Cross linked polyethylene insulated PVC sheathed cables : Part I for working voltages upto and including 1100 Volts Part II for working voltages from 3.3 KV up to and including 33 KV.	7098 (Part I)-1977 7098 (Part II)-1973
79.	Rubber and plastics containers for lead-acid storage batteries	2652-1976
80.	Stationary batteries lead-acid type with pasted positive plates	6304-1980
81.	Stationary cells and batteries, lead acid type (with tubular positive plates)	1652-1972
82.	Synthetic seperators for lead-acid batteries	6071-1970
83.	DC sets alternator	4722
84.	Engine	

Sl. No.	Title	IS:
85.	Carbon brushes for electrical machines	3003 (Part I to IV)
86.	Degrees of protection provided by enclosures for rotating electrical machinery	4691-1968
87.	Designation of methods of cooling for rotating electrical machines	6362-1971
88.	Designations for types of construction and mounting arrangement of rotating electrical machines	2253-1974
89.	Protection of buildings and allied structures against lightning	2309-1969
90.	Power transformers: Part I General Part II Temperature rise Part III Insulation level and dielectric tests Part IV Terminal markings, tappings and connections	2026 (Part I)-1977 2026 (Part II)-1977 2026 (Part III)-1977 2026 (Part IV)-1977
91.	Power transformers, fittings and accessories for	3639-1966
92.	Installation and maintenance of transformers, code of practice for	1886-1967
93.	On-load tap changers	8468-1977
94.	On-load tap changers, application guide for	8478-1977
95.	Insulating oil for transformer and switchgear	335-1963
96.	Insulating oil-maintenance of	1866-1961
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**GOVERNMENT OF INDIA  
DEPARTMENT OF SPACE**

# **SPECIFICATIONS FOR AIR CONDITIONING AND VENTILATION WORKS**



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**CIVIL ENGINEERING PROGRAMME OFFICE  
ISRO HQ, BENGALURU**

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**SPECIFICATIONS FOR AIR-CONDITIONING  
AND VENTILATION WORKS**

**SECTION - I  
CHILLER PACKAGES**

## **1. WATER COOLED SCREW CHILLER PACKAGES**

### **1.1 Construction:**

The packaged screw chillers offered shall be of the water cooled type, consisting of hermetic / semi hermetic direct driven screw compressor, with single/multiple compressors as specified in SOQ complete with evaporator, condenser, microprocessor based controls, motor starter etc. Chillers shall be suitable for operation on 3-phase, 50 Hz,  $415 \pm 10\%$  V AC supply and R-134a /407c /410a refrigerant. Chillers shall be completely factory assembled, wired in a single package suitable for indoor duty starting and complete with safety & operating controls. Chillers shall be factory run tested under full load conditions. The coolers of the package chillers shall be selected for a water side fouling factor of  $0.000018 \text{ m}^2 \text{ }^\circ\text{K/W}$ . The condensers shall be selected for water side fouling factor of  $0.000044 \text{ m}^2 \text{ }^\circ\text{K/W}$ . Chiller package shall be designed for maximum corrosion protection with panels of adequate structural strength. The base shall be welded design using spray galvanized channels. The base and frame members shall be painted. Unless otherwise specified, minimum COP, IPLV and  $\text{I kW/ TR}$  of chiller package shall be as indicated in SOQ.

Chillers shall be certified in accordance with applicable standards of AHRI 550/590 (I-P) and AHRI (SI) or equivalent.

OEM name plate with manufacturer's name and location, Type, Model No. & Sl. No. providing complete identification, dimensions of chiller package, operating weight, vibration level, noise level, Refrigerant designation, Voltage, phase & frequency, date of manufacture etc., should be indicated on the machine. The  $\text{I kW/TR}$  vs. % load chart for chillers are to be provided.

The noise level of the chillers shall not exceed around 85 dB(A) at 1m distance from the unit. Brief description of the various components of the chiller is given below.

### **1.2 Compressor:**

The compressor shall be direct driven by a squirrel cage suction gas cooled induction motor, and shall be of hermetic / semi hermetic design. The compressor male and female rotors shall have adequate number of lobes as dictated by design and shall be either Mono or Twin design. The rotor contact elements shall be constructed of material designed for extended service life. The compressor shall be pressure lubricated with required number of bearings to support the rotors and

absorb radial loads. Strainer shall be provided at the suction of the compressor, and the unit shall include oil separator and crankcase heater. Compressor shall be provided with capacity control. The compressor motors shall be high torque, squirrel cage induction type with thermal protection on all three phases and cooled by suction gas.

Each compressor shall have a suction check valve, suction filter and a discharge check valve. Compressor capacity control shall be preferably obtained by a dependable slide valve mechanism, electrically initiated, hydraulically actuated within each compressor housing. Discharge check valves are required for each compressor to allow refrigerant charge to be stored in the condenser for service to compressor or evaporator. Isolation valves shall be provided on all connections to compressor to

(a) allow replacement of one compressor while others are running and also allow refrigerant storage in the evaporator via a service compressor.

(b) allow condenser to be used as a pump down receiver.

### **1.3 Condenser:**

The condensers shall be of bolted construction, cleanable, shell & tube type with copper tubes expanded into tube sheets fins mechanically and externally finned. Number of passes can be as required. Water heads are to be removable type for tube cleaning. Vent and drain plugs are to be provided in each head.

Water cooled Condenser shall be able to handle minimum of 3 US GPM/TR (11.4 LPM/TR) of water from 86°F (30 °C) to 93°F (33.9°C) with a condensing temperature of 97°F (36 °C). The unit shall be able to unload just above 10 to 20 % of cooling (refrigeration) capacity when operating with leaving chilled water and entering condenser water at full load design temperatures. The unit shall be capable of continuous operation at this point, with stable compressor operation, without the use of hot gas bypass. Water quality available at the location to be noted.

The condensers shall have dual pressure relief valves with provision for refrigerant venting.

Test certificates w.r.t Pressure testing of heat exchangers and all other components are to be provided during chillers testing at the manufacturer's works. The heat exchangers shall follow all the standards as applicable. However, internally and externally grooved and high heat transfer enhanced type, copper tubes shall be

used. On receipt of order details such as no. of tubes, diameter of tubes and pressure drop shall be furnished to Department.

#### **1.4 Evaporator:**

Chiller shall be of DX/flooded type. Removable heads shall be supplied for cleaning and servicing of cooler tubes. Vent and drain plugs shall be provided in each head. The flooded – cooler shall have a built-in distributor for feeding refrigerant evenly under the tube bundle to produce uniform boiling action, and baffle plates shall be provided to ensure vapour separation. The cooling shall be fitted with an oil recovery system. Evaporator shall be designed in accordance with ASME pressure vessel codes or equivalent and equipped with spring loaded relief valves.

The shell side of the evaporator is to have a single relief valve with provision for refrigerant venting.

#### **1.5 Refrigerant Circuits:**

Each package chiller shall house single/multiple refrigerant circuits or tandem compressors to obtain part load efficiency as specified in SOQ. Each circuit shall include expansion valve, sight glass, moisture indicator, solenoid valve, filter drier, liquid line shut off valves, charging and gauge connections and discharge line check valve. Thermostatic/Electronic expansion valve/servo controlled modulating type controlled by a pilot float valve to perfectly modulate refrigerant flow to evaporator shall be provided.

Facility foreseen includes compressor/s to be removed for service and also to allow the refrigerant to be pumped down into the condenser. Insulation where ever required to prevent condensation shall also be included.

#### **1.6 Control Panel:**

Microprocessor based unit control centre in a fully enclosed steel cabinet is required. Power and safety/operating controls shall be provided. The control centre shall provide all control and safety functions including start-up and shut down, leaving chilled water temperature control, compressor and expansion valve modulation. In addition, the control centre shall fully protect the compressor motor against overload during start up and operation, phase/power loss, phase unbalance or phase reversal, over/under voltage, etc. Control centre shall facilitate maintenance of chilled water temperature to within  $\pm 0.5$  deg C of set point. The

control panel shall be suitable for remote operation / monitoring of the package chiller system.

Packaged Screw chillers shall be selected for operation in ambient of the places where the chiller is being installed.

The packaged chiller shall be equipped with Proactive Microcomputer Controller to adapt to abnormal operating conditions, tolerant and accommodating of extreme conditions at start up.

In addition, the following features shall be available with the microprocessor based control panel:

- a) The panel shall be user friendly and display message in simple English language with operator pad offering fingertip control for viewing different parameters and changing set points.
- b) The microprocessor panel shall be password protected to make it totally tamper proof.
- c) The panel shall have calendar/clock to program daily start - stop and weekly off. The panel shall log at least 6 fault shut downs which shall be stored in memory along with date and time of occurrence, reason for shut down and important parameters at the time of shut down.
- d) The Microprocessor based control panel shall monitor suction, discharge and oil pressures and compressor current through transducers and display it on the back lit liquid crystal screen for easy viewing during day or night. It shall be password protected to make it totally tamper proof.
- e) The system shall intelligently stage the unit to sustain leaving water temperature precision and stability while minimizing compressor cycling.
- f) The panel shall have adaptive logic which shall ensure that the water chilling unit is kept running during harsh weather conditions when cooling is most wanted.
- g) The panel shall have interface for interconnectivity to a personal computer so that the water chilling unit operation can be monitored from any remote place. The Micro-processor control panel shall support on standard protocols such as BACNET or MODBUS Network.

The panel shall be capable of displaying following:

- Incorrect password message.
- Day, date & time.

- Daily starts and stops time.
- Chiller inlet & outlet temperatures.
- Condenser water inlet and outlet temperature.
- Suction, discharge and oil pressures.
- Each Compressor motor current on all three phases.
- Suction/Discharge pressure cut out setting.
- Anti-freeze temperature cut-out setting.
- Compressor starts & run status and total run time.
- Liquid line solenoid valve status.
- Up to 6 fault shut down conditions.
- Anti-recycle timer status of each compressor.

### **1.7 Electrics:**

The electrical control panel shall be wired to permit fully automatic operation during initial start-up, normal operation, and shutdown conditions. The control system shall contain the following control and safety devices:

#### **1.7.1 Manual Controls:**

- Control circuit stop and start switches
- Compressor enable switch

#### **1.7.2 Safety Controls:**

Solid state compressor motor starter overloads (3 phase), protection for Phase/power loss, phase unbalance or phase reversal, over/under voltage, etc.

- Low oil pressure
- High seal oil temperature
- Low oil level optical sensor
- High condenser pressure
- Low evaporator pressure
- Evaporator water Freeze protection
- Chilled water flow loss

#### **1.7.3 Automatic Controls:**

- Compressor motor increment contactors
- Increment start timer
- Anti-recycle timer
- Oil sump heater interlock relays

#### **1.7.4 Refrigerant Controls:**

- Finite Motorized refrigerant flow control
- Liquid refrigerant level sensor for evaporator
- Compressor load and unload solenoid valves
- Refrigerant wetness sensor at compressor suction

#### **1.7.5 Indication Lights:**

- Power 'ON'
- High motor temperature
- Compressor high oil temperature
- Compressor motor overload
- High/low pressure, low oil and freeze safeties.

The control system shall be provided with an anti-recycle device. The control shall limit compressor starting to a minimum interval between starts. The packaged chiller shall be furnished with unit mounted Circuit Breaker, unit Mounted Contactor and Time Delay wired for reduced inrush starting current system for each compressor. The starters shall be factory mounted and wired, with individual circuit breakers. The unit shall be wired so that the only field electrical connection to the packaged chiller shall be to a single three-phase power terminal. A disconnect switch per compressor and unit fuses/ fuse block are also to be included, along with circuit breakers in motor control centre.

#### **1.8 Other Features:**

- Single point electrical power connection, control power transformers, Under Voltage and Phase Failure Relays.
- Indicator lights for Compressor Overloads, High Motor Temperature, Micro Alarm, Control Power, and Compressor Control Circuit.
- Unit mounted disconnect for each compressor and control circuit with fuses and fuse block for 400 to 575 Volts and 3300/6600/11000 Volts applications as the case may be.

#### **1.9 Operating Benefits, Efficiency and Reliability:**

- The manufacturer shall have adequate experience in manufacture of rotary screw compressors and updated technological advancements.
- The design shall be simple for high reliability with minimum rotating parts.

- To ensure continuous oil flow to each compressor through integral high efficiency oil separation for each compressor.
- To deliver outstanding efficiency and total energy savings through the utilization of economizer cycle and microcomputer-controlled staging producing greater capacity with fewer compressors.
- Maximized performance through computer-matched components.
- High efficiency oil recovery system to guarantee removal of oil carried over with the refrigerant and maintains the heat exchangers at their maximum efficiency at both full and part load.
- Installation Ease.
- Side-by-side evaporator/condenser plus snug arrangement of rotary screw compressors required for an extremely compact work envelope.
- The design shall result in quick payback period due to reduced maintenance and overhaul costs both in down time and in labour expenditures.
- Simplified troubleshooting through microprocessor retention of monitored functions.

All the packaged chillers shall be completely factory assembled, performance witness run tested at manufacturer's works under 25%, 50%, 75% and 100% load conditions prior to shipment with a full operating refrigerant and oil charge, charged and adjusted for ease of installation and minimal field start-up adjustments. The Test bed shall be as per AHRI Standards or equivalent and test shall be conducted, also in accordance with test and evaluation procedures and as per department requirements. The IPLV figure of chillers shall be proved during pre-shipment testing. As per AHRI standards (+) 5% tolerance on power consumption and (-) 5% tolerance on capacity is applicable. Test certificates for individual components shall be furnished. Stringent quality checks such as high quality brazing, pressure testing, triple evacuation and leakage testing shall be ensured. The vendor shall examine the space identified in the plant room and confirm the same for installing the equipment taking into account the maintenance aspects.

$$\text{IPLV FORMULA} = \frac{1}{\frac{0.01}{A} + \frac{0.42}{B} + \frac{0.45}{C} + \frac{0.12}{D}}$$

Where A, B, C and D denotes KW / TR at 100%, 75%, 50% and 25% load points respectively.



### **1.10 VFD Option:**

If VFD drive is opted, the chiller shall be provided with inverter duty compressor motor and remote mounted VFD panel. The VFD shall be constant torque type and able to deliver even 110% torque for 60 seconds during normal operation. Power factor of 0.95 shall be maintained in all conditions by suitable capacitor banks / APFC panels. Unit capacity control shall be done by the combined action of VFD and inlet guide vane to provide optimized performance with stable operation under all operating conditions.

VFD shall have inbuilt protection mode to automatically reduce the frequency and the modulation process adjusted when it detects critical status such as over current or over voltage etc.

VFD shall have inbuilt electronic thermal motor protection against overload. The VFD shall be protected against short circuit on motor terminals. It shall also have protection against main phase loss. VFD shall have built in LCD keypad display and shall show information on motor current, voltage, frequency output, output kW etc.

### **1.11 Safety Codes/Standards:**

- ASME Boiler and Pressure Vessel Code, Section VIII Division 1 "Unfired Pressure Vessels"
- ASME Standard B 31.5 Refrigeration Piping
- ASHRAE Standard 15 Safety Code for Mechanical Refrigeration
- National Electric Code & local Pollution Control Board norms
- AHRI Standard 550/590-2012 "Performance Rating of Water-Chilling and Heat Pump Water-Heating Packages Using the Vapour Compression Cycle"

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## **2. AIR COOLED SCREW CHILLER PACKAGES**

### **2.1 Construction:**

The packaged screw chillers offered shall be of the air cooled type, consisting of Hermetic / semi hermetic direct driven screw compressors, with single/multiple Compressors as specified in SOQ complete with evaporator, condenser, microprocessor based controls, motor starter etc. Chillers shall be suitable for operation on 3-phase, 50 Hz,  $415\pm 10$  % V AC supply and R-134a / 407c/ 410a refrigerant. Chillers shall be completely factory assembled suitable for outdoor installation, wired in a single package complete with safety & operating controls. Chillers shall be factory run tested under full load conditions. The chillers of the package chillers shall be selected for a water side fouling factor of  $0.000018 \text{ m}^2 \text{ K/W}$ . Chiller package unit shall be designed for maximum corrosion protection with all panels being constructed of heavy gauge galvanized steel. The base and frame members shall be painted. Unless otherwise specified, minimum COP, IPLV and  $\text{I kW/ TR}$  of chiller package shall be as indicated in SOQ.

Chillers shall be certified in accordance with applicable standards of AHRI 550/590 (I-P) and AHRI (SI) or equivalent.

OEM name plate with manufacturer's name and location, Type, Model No. & Sl. No. providing complete identification, dimensions of chiller package, operating weight, vibration level, noise level, Refrigerant designation, Voltage, phase & frequency, date of manufacture etc., should be indicated on the machine. The  $\text{I kW/TR}$  vs. % load chart for chillers are to be provided.

The noise level of the chillers shall not exceed around 90 dB(A) at 1m distance from the unit. Brief description of the various components of the chiller is given below.

### **2.2 Compressor:**

The compressor shall be direct driven by a squirrel cage suction gas cooled induction motor, and shall be of hermetic / semi hermetic design. The compressor male and female rotors shall have adequate number of lobes as dictated by design and shall be either Mono or Twin design. The rotor contact elements shall be constructed of material designed for extended service life. The compressor shall be pressure lubricated with required number of bearings to support the rotors and absorb radial loads. Strainer shall be provided at the suction of the compressor, and the unit shall include oil separator and crankcase heater. Compressor shall be

provided with capacity control. The compressor motors shall be high torque, squirrel cage induction type with thermal protection on all three phases and cooled by suction gas. The compressor shall be provided with built-in, high efficiency lubrication system with mesh type oil separator, oil filter etc. The compressors shall be protected by temperature sensor for high discharge temperature and for high winding temperature of motor.

Each compressor shall have a suction check valve, suction filter and a discharge check valve. Compressor capacity control shall be preferably obtained by a dependable slide valve mechanism, electrically initiated, hydraulically actuated within each compressor housing. Discharge check valves are required for each compressor to allow refrigerant charge to be stored in the condenser for service to compressor or evaporator. Isolation valves shall be provided on all connections to compressor to

(a) allow replacement of one compressor while others are running and also allow refrigerant storage in the evaporator via a service compressor

(b) allow condenser to be used as a pump down receiver.

### **2.3 Condenser:**

Condenser coils of seamless copper tubes and shall be of sufficient rows, finning and face area to meet the condensing temperature specified. Integral sub-cooling circuit shall be provided effectively to eliminate possibility of liquid flashing and increase efficiency. Coil shall be constructed of Aluminium fins mechanically bonded to seamless copper tubes which are then cleaned, dehydrated and sealed. It shall be ensured that seasonal low ambient temperature will not hamper the system operation in any way. Condenser tubes and fins shall be given hydrophilic coating/proprietary coating to prevent against corrosion.

Suitable number of low noise condenser fans shall be provided to meet the specified conditions. Condenser fans shall be direct-driven propeller type low noise fans discharging air vertically upwards. The fan shall be driven by totally enclosed fan motors, 3 phase type with minimum class F insulation and permanently lubricated bearings suitable for IP-55 protection. Condenser fans shall be statically and dynamically balanced and the fan openings shall be provided with PVC-coated steel wire guards. The condenser fans shall be designed for outdoor operation in high ambient conditions.

Test certificates w.r.t Pressure testing of heat exchangers and all other components are to be provided during chillers testing at the manufacturer's works. The heat exchangers shall follow relevant standards as applicable. However, internally and externally grooved and high heat transfer enhanced type, copper tubes shall be used. On receipt of order details such as no. of tubes, diameter of tubes and pressure drop shall be furnished to Department.

#### **2.4 Evaporator:**

Evaporator shall be of direct expansion/flooded type, shell and tube type. The chiller shall be circuited so that each compressor is connected to an independent circuit. in case of multiple circuits. High performance chillers with finning may be offered. Evaporator shall be designed in accordance with ASME pressure vessel codes or equivalent and equipped with spring loaded relief valves and low refrigerant pressure drop.

The shell side of the evaporator is to have a single relief valve with provision for refrigerant venting.

The flooded – cooler shall have a built-in distributor for feeding refrigerant evenly under the tube bundle to produce uniform boiling action, and baffle plates shall be provided to ensure vapour separation. The cooling shall be fitted with an oil recovery system.

#### **2.5 Refrigerant Circuits:**

Each package chiller shall have single/multiple refrigerant circuits or tandem compressors to obtain part load efficiency as specified in SOQ. Each circuit shall include expansion valve, sight glass, moisture indicator, solenoid valve, filter drier, liquid line shut off valves, charging and gauge connections and discharge line check valve. Thermostatic/Electronic expansion valve/servo controlled modulating type controlled by a pilot float valve to perfectly modulate refrigerant flow to evaporator shall be provided.

It includes facility for removing compressor/s for service and also to allow the refrigerant to be pumped down into the condenser. Insulation where ever required to prevent condensation shall also be included.

#### **2.6 Control Panel:**

Microprocessor based unit control centre in a fully enclosed steel cabinet is required. Power and safety/operating controls shall be provided. The control centre

shall provide all control and safety functions including start-up and shut down, leaving chilled water temperature control, compressor and expansion valve modulation, condenser fan sequencing, etc. In addition, the control centre shall fully protect the compressor motor against overload during start up and operation, phase/power loss, phase unbalance or phase reversal, over/under voltage, etc. Vendor shall furnish in detail the complete capability of the control centre. Control centre shall facilitate maintenance of chilled water temperature to within  $\pm 0.5$  deg. C of set point. The control panel shall be provided with IP55 protection in weather proof enclosure for outdoor installation. Also control panel will be suitable for interconnectivity to central DDC system.

Packaged Screw chillers shall be selected for operation in ambient of place where the chiller is being installed.

Packaged Screw chillers shall be selected for operation in ambient of the places where the chiller is being installed.

The packaged chiller shall be equipped with Proactive Microcomputer Controller to adapt to abnormal operating conditions, tolerant and accommodating of extreme conditions at start-up.

In addition, the following features shall be available with the microprocessor based control panel.

- a) The panel shall be user friendly and display message in simple English language with operator pad offering fingertip control having 16 keys for viewing different screens and changing set points.
- b) The microprocessor panel shall be password protected to make it totally tamper proof.
- c) The panel shall have calendar/clock to program daily start - stop and weekly off. The panel shall log at least 6 fault shut downs which shall be stored in memory along with date and time of occurrence, reason for shut down and important parameters at the time of shut down.
- d) The Microprocessor based control panel shall monitor suction, discharge and oil pressures and compressor current through transducers and display it on the back lit liquid crystal screen for easy viewing during day or night. It shall be password protected to make it totally tamper proof.
- e) The panel shall have adaptive logic which shall ensure that the water chilling unit is kept running during harsh weather conditions when cooling is most

wanted. Management of compressor steeples capacity and fan modulation shall be feasible.

- f) The panel shall have interface for interconnectivity to a personal computer so that the water chilling unit operation can be maintained from any remote place. The Micro-processor control panel shall support on standard protocols such as BACNET or MODBUS Network.

The panel shall be capable of displaying following:

- Incorrect pass word message.
- Day, date & time.
- Daily starts and stops time.
- Chiller inlet & outlet temperatures.
- Suction, discharge and oil pressures.
- Compressor motor current.
- Suction/Discharge pressure cut out setting.
- Anti-freeze temperature cut-out setting.
- Compressor starts & run status and total run time.
- Liquid line solenoid valve status.
- Up to 6 fault shut down conditions.
- Anti-recycle timer of each compressor
- Ambient temperature.

## **2.7 Electrics:**

Power supply panel for the package chiller shall be part of the chiller package and shall be provided with IP 55 protection in a weather proof enclosure for outdoor installation. This panel shall house the starters for compressor(s), condenser(s), current overloads and factory wiring. The main panel shall be fitted with main switch interlocked door that shuts off power supply while opening.

The electrical control panel shall be wired to permit fully automatic operation during initial start-up, normal operation, and shutdown conditions. The control system shall contain the following control and safety devices:

### **2.7.1 Manual Controls:**

- Control circuit stop and start switches
- Compressor enable switch

### **2.7.2 Safety Controls:**

Solid state compressor motor starter overloads (3 phase), protection for Phase/power loss, phase unbalance or phase reversal, over/under voltage, etc.

- Low oil pressure
- High seal oil temperature
- Low oil level optical sensor
- High condenser pressure
- Low evaporator pressure
- Evaporator water Freeze protection
- Chilled water flow loss

### **2.7.3 Automatic Controls:**

- Compressor motor increment contactors
- Increment start timer
- Anti-recycle timer
- Oil sump heater interlock relays

### **2.7.4 Refrigerant Controls:**

- Finite Motorized refrigerant flow control
- Liquid refrigerant level sensor for evaporator
- Compressor load and unload solenoid valves
- Refrigerant wetness sensor at compressor suction

### **2.7.5 Indication Lights:**

- Power 'ON'
- High motor temperature
- Compressor high oil temperature
- Compressor motor overload
- High/low pressure, low oil and freeze safeties.

The control system shall be provided with an anti-recycle device. The control shall limit compressor starting to a minimum interval between starts.

The packaged chiller shall be furnished with unit mounted Circuit Breaker, unit Mounted Contactor and Time Delay wired for reduced inrush starting current system for each compressor. The starters shall be factory mounted and wired, with individual circuit breakers. The unit shall be wired so that the only field electrical

connection to the packaged chiller shall be to a single three-phase power terminal. A disconnect switch per compressor and unit fuses/ fuse block are also to be included, along with circuit breakers in motor control centre.

## **2.8 Other Features:**

- Single point electrical power connection, control power transformers, Under Voltage and Phase Failure Relays.
- Indicator lights for Compressor Overloads, High Motor Temperature, Micro Alarm, Control Power, and Compressor Control Circuit.
- Unit mounted disconnect for each compressor and control circuit with fuses and fuse block for 400 to 575 Volts and 3300/6600/11000 Volts applications as the case may be.

## **2.9 Operating Benefits, Efficiency and Reliability:**

- The manufacturer shall have adequate experience in manufacture of rotary screw compressors and updated technological advancements.
- The design shall be simple for high reliability with minimum rotating parts.
- To ensure continuous oil flow to each compressor through integral high efficiency oil separation for each compressor.
- To deliver outstanding efficiency and total energy savings through the utilization of economizer cycle and microcomputer-controlled staging producing greater capacity with fewer compressors.
- Maximized performance through computer-matched components.
- High efficiency oil recovery system to guarantee removal of oil carried over with the refrigerant and maintains the heat exchangers at their maximum efficiency at both full and part load.
- Installation Ease -
- Side-by-side evaporator/condenser plus snug arrangement of rotary screw compressors required for an extremely compact work envelope.
- The design shall result in quick payback period due to reduced maintenance and overhaul costs both in down time and in labour expenditures.
- Simplified troubleshooting through microprocessor retention of monitored functions.

All the packaged chillers shall be completely factory assembled, performance witness run tested at manufacturer's works under 25%, 50%, 75% and 100% load conditions prior to shipment with a full operating refrigerant and oil charge,



charged and adjusted for ease of installation and minimal field start-up adjustments. The Test bed shall be as per AHRI Standards or equivalent and test shall be conducted, also in accordance with test and evaluation procedures and as per department requirements. The IPLV figure of chillers shall be proved during pre-shipment testing. As per AHRI standards (+) 5% tolerance on power consumption and (-) 5% tolerance on capacity is applicable. Test certificates for individual components shall be furnished. Stringent quality checks such as high quality brazing, pressure testing, triple evacuation and leakage testing shall be ensured. The vendor shall examine the space identified in the plant room and confirm the same for installing the equipment taking into account the maintenance aspects.

$$\text{IPLV FORMULA} = \frac{1}{\frac{0.01}{A} + \frac{0.42}{B} + \frac{0.45}{C} + \frac{0.12}{D}}$$

Where A, B, C and D denotes KW / TR at 100%, 75%, 50% and 25% load points respectively.

**2.10 VFD Option:**

If VFD drive is opted, the chiller shall be provided with inverter duty compressor motor and remote mounted VFD panel. The VFD shall be constant torque type and able to deliver even 110% torque for 60 seconds during normal operation. Power factor of 0.95 shall be maintained in all conditions by suitable capacitor banks / APFC panels. Unit capacity control shall be done by the combined action of VFD and inlet guide vane to provide optimized performance with stable operation under all operating conditions.

VFD shall have inbuilt protection mode to automatically reduce the frequency and the modulation process adjusted when it detects critical status such as over current or over voltage etc.

VFD shall have inbuilt electronic thermal motor protection against overload. The VFD shall be protected against short circuit on motor terminals. It shall also have protection against main phase loss. VFD shall have built in LCD keypad display and shall show information on motor current, voltage, frequency output, output kW etc.

### **2.11 Safety Codes/Standards:**

- ASME Boiler and Pressure Vessel Code, Section VIII Division 1 "Unfired Pressure Vessels"
- ASME Standard B 31.5 Refrigeration Piping
- ASHRAE Standard 15 Safety Code for Mechanical Refrigeration
- National Electric Code & local Pollution Control Board norms
- AHRI Standard 550/590-2012 "Performance Rating of Water-Chilling and Heat Pump Water-Heating Packages Using the Vapour Compression Cycle"

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### **3.WATER COOLED SCROLL CHILLER PACKAGES**

#### **3.1 Construction:**

The scroll chillers specified in the Schedule shall be water-cooled type consisting of hermetic/semi hermetic scroll compressors. The chiller package shall be factory assembled mainly consisting of multiple scroll Compressor(s), condenser (s), chiller, control panel, piping, lubrication system etc. all assembled into a single Unit and shall be located inside plant room. Chillers shall be suitable for operation on 3-phase, 50 Hz, 415 +/- 10% V AC supply. The unit cabinet shall be constructed of Galvanized steel of suitable thickness. The unit shall be mounted over welded steel base frame structural steel profiles of suitable size made out of MS and duly galvanized for corrosion resistance. Suitable vibration isolators shall be provided for the unit to isolate the Unit from building structure. The evaporators of chiller package shall be selected for water side fouling factor of 0.000018 m<sup>2</sup> °K/W and for water cooled condensers, selection shall be made with fouling factor of 0.000044 m<sup>2</sup> °K/W.

Unless otherwise specified, minimum COP, IPLV and kW/ TR of chiller package shall be as indicated in SOQ. Chillers shall be certified in accordance with applicable standards of AHRI 550/590 (I-P) and AHRI (SI) or equivalent.

OEM name plate with manufacturer's name and location, Type, Model No. & Sl. No. providing complete identification, dimensions of chiller package, operating weight, vibration level, noise level, Refrigerant designation, Voltage, phase & frequency, date of manufacture etc., should be indicated on the machine. The kW/TR vs. % load chart for chillers are to be provided. The noise level of the chillers shall not exceed around 75 dBA at 1m distance from the unit.

#### **3.2 Compressor:**

Compressor shall be scroll type suitable for eco-friendly refrigerants such as R-134a/410a /407c complete with controls, accessories and shall be highly energy efficient & designed for quiet operation. Unit shall be designed for ambient conditions of the place where the chiller is being installed. During the part load operation of the unit, microprocessor ensures that minimum number of compressors shall operate to handle the load thus saving power.

### **3.3 Condenser:**

The condensers shall be of bolted construction, cleanable, shell & tube type with copper tubes expanded into tube sheets fins mechanically and externally finned. Number of passes can be as required. Water heads are to be removable type for tube cleaning. Vent and drain plugs are to be provided in each head.

Water cooled Condenser shall be able to handle minimum of 3 US gpm/TR (11.4 LPM/TR) of water from 86°F (30 °C) to 93°F (33.9°C) with a condensing temperature of 97°F (36 °C). The unit shall be able to unload just above 10 to 20 % of cooling (refrigeration) capacity when operating with leaving chilled water and entering condenser water at full load design temperatures. The unit shall be capable of continuous operation at this point, with stable compressor operation, without the use of hot gas bypass. Water quality available at the location to be noted.

The condensers shall have dual pressure relief valves with provision for refrigerant venting.

Test certificates w.r.t Pressure testing of heat exchangers and all other components are to be provided during chillers testing at the manufacturer's works. The heat exchangers shall follow all the standards as applicable. The condensers shall be of shell & tube type with copper tubes expanded into tube sheets fins mechanically and externally finned. On receipt of order details such as no. of tubes, diameter of tubes and pressure drop shall be furnished to Department.

### **3.4 Evaporator:**

Chiller shall be DX/flooded type. Removable heads shall be supplied for cleaning and servicing of cooler tubes. Vent and drain plugs shall be provided in each head. The flooded – cooler shall have a built-in distributor for feeding refrigerant evenly under the tube bundle to produce uniform boiling action, and baffle plates shall be provided to ensure vapour separation. The cooling shall be fitted with an oil recovery system.

### **3.5 Refrigerant Circuit:**

Refrigerant shall be eco-friendly such as R-134a/410a/407c and Refrigerant piping shall be of Copper with necessary controls such as TEV, pilot operated solenoid valves to interconnect compressor, condenser and evaporator. Liquid cum moisture

indicators, filter drier, shut-off valve shall be provided and also strainer complete with bypass valves.

### **3.6 Control Panel:**

Microprocessor based unit control centre in a fully enclosed steel cabinet is required. All power and safety/operating controls shall be provided in the panel.

The control centre shall provide all control and safety functions including start-up and shut down, leaving chilled water temperature control, compressor and expansion valve modulation. In addition, the control centre shall fully protect the compressor motor against overload during start up and operation, phase/power loss, phase unbalance or phase reversal, over/under voltage, etc. Control centre shall facilitate maintaining of chilled water temperature within  $\pm 0.5$  deg.C of set point. The control panel shall be suitable for remote operation / monitoring of the package chiller system.

Packaged Scroll chillers shall be selected for operation in ambient of the places where the chiller is being installed.

The packaged chiller shall be equipped with Proactive Microcomputer Controller to adapt to abnormal operating conditions, tolerant and accommodating of extreme conditions at start up.

The panel shall have a microprocessor-based controller primarily to perform the following operations.

- a) Auto stop & restart of chiller based on chilled water outlet set temperature.
- b) Auto recycle timer to avoid compressor on/off cycling.
- c) Tripping of Compressor on High Pressure/Low Pressure/Anti-Freeze Temperature /low chilled water & condenser water flow/phase unbalance-phase reversal-overload/under-over voltage
- d) Crank case heater operation
- e) Auto/Manual mode operation
- f) The panel shall be user friendly and display message in simple English language with operator pad offering fingertip control for viewing different parameters and changing set points.
- g) The microprocessor panel shall be password protected to make it totally tamper proof.

- h) The system shall intelligently stage the unit to sustain leaving water temperature precision and stability while minimizing compressor cycling.
- i) The panel shall have adaptive logic which shall ensure that the water chilling unit is kept running during harsh weather conditions when cooling is most wanted.
- j) The panel shall have interface for interconnectivity to a personal computer so that the water chilling unit operation can be monitored from any remote place. The Micro-processor control panel shall support on standard protocols such as BACNET or MODBUS Network.

The following LCD displays shall be made available as minimum in the display panel of the control centre.

- a) Suction pressure
- b) Discharge pressure
- c) Current drawn by the unit
- d) Operating hours
- e) Fault and trip indication
- f) Alarm history for last minimum 6 trips with date, time and cause of failure
- g) Changing/viewing the set point of all parameters
- h) Incorrect password message.
- i) Daily starts and stops time.
- j) Chiller inlet & outlet temperature.
- k) Condenser water inlet and outlet temperature.
- l) Anti-freeze temperature cut-out setting.
- m) Compressor starts & run status and total run time.

### **3.7 Electrics:**

The electrical control panel shall be wired to permit fully automatic operation during initial start-up, normal operation, and shutdown conditions. The control system shall be provided with an anti-recycle device. The control shall limit compressor starting to a minimum interval between starts. The packaged chiller shall be furnished with unit mounted Circuit Breaker, unit Mounted Contactor and Time Delay wired for reduced inrush starting current system for each compressor. The starters shall be factory mounted and wired, with individual circuit breakers. The unit shall be wired so that the only field electrical connection to the packaged chiller shall be to a single three-phase power terminal. A disconnect switch per

compressor and unit fuses/ fuse block are also to be included, along with circuit breakers in motor control centre.

The control system shall contain the following control and safety devices.

#### **3.7.1 Manual Controls:**

- Control circuit stop and start switches
- Compressor enable switch

#### **3.7.2 Safety Controls:**

- Solid state compressor motor starter overloads (3 phase), protection for Phase/power loss, phase unbalance or phase reversal, over/under voltage
- Low oil pressure
- High oil temperature
- High condenser pressure
- Low evaporator pressure
- Evaporator water Freeze protection
- Chilled water flow loss
- Condenser water flow loss

#### **3.7.3 Automatic Controls:**

- Compressor motor increment contactors
- Increment start timer
- Anti-recycle timer
- Oil sump heater interlock relays

#### **3.8 Operating Benefits, Efficiency and Reliability:**

- The manufacturer shall have adequate experience in manufacture of Scroll compressors and updated technological advancements.
- The design shall be simple for high reliability with minimum rotating parts.
- To ensure continuous oil flow to each compressor through integral high efficiency oil separation for each compressor.

- To deliver outstanding efficiency and total energy savings through the utilization of economizer cycle and microcomputer-controlled staging producing greater capacity with fewer compressors.
- Maximized performance through computer-matched components.
- Installation Ease.
- Side-by-side evaporator/condenser plus snug arrangement of Scroll compressors required for an extremely compact work envelope.
- Simplified troubleshooting through microprocessor retention of monitored functions.

### **3.9 Other Features:**

- Software lock to prevent misuse of programming facility
- Provision to store minimum 6 previous faults (minimum) in the memory
- Controllers shall be BMS compatible. Protocol shall be BACNET or MODBUS.

### **3.10 Safety Codes/Standards:**

- ASME Boiler and Pressure Vessel Code, Section VIII Division 1 "Unfired Pressure Vessels"
- ASME Standard B 31.5 Refrigeration Piping
- ASHRAE Standard 15 Safety Code for Mechanical Refrigeration
- National Electric Code & local Pollution Control Board norms
- AHRI Standard 550/590-2012 "Performance Rating of Water-Chilling and Heat Pump Water-Heating Packages Using the Vapour Compression Cycle"

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## **4. AIR COOLED SCROLL CHILLER PACKAGES**

### **4.1 Construction:**

The scroll chillers specified in the Schedule shall be air-cooled type consisting of hermetic/semi hermetic scroll compressors. The chiller package shall be factory assembled mainly consisting of multiple scroll Compressor(s), condenser (s), chiller, control panel, piping, lubrication system etc. all assembled into a single Unit and shall be located outdoor. Chillers shall be suitable for operation on 3-phase, 50 Hz, 415+/-10% V AC supply. The unit cabinet shall be constructed of Galvanized steel of suitable thickness to withstand the harsh outdoor weather conditions. The unit shall be mounted over welded steel base frame structural steel profiles of suitable size made out of MS and duly galvanized as specified above for corrosion resistance. Suitable vibration isolators shall be provided to reduce vibrations and noise. The evaporators of chiller package shall be selected for water side fouling factor of 0.000018 M<sup>2</sup>°K/W.

Unless otherwise specified, minimum COP, IPLV and kW/ TR of chiller package shall be as indicated in SOQ. Chillers shall be certified in accordance with applicable standards of AHRI 550/590 (I-P) and AHRI (SI) or equivalent.

OEM name plate with manufacturer's name and location, Type, Model No. & Sl. No. providing complete identification, dimensions of chiller package, operating weight, vibration level, noise level, Refrigerant designation, Voltage, phase & frequency, date of manufacture etc., should be indicated on the machine. The kW/TR vs. % load chart for chillers are to be provided.

The noise level of the Air cooled chillers shall not exceed 75 dB(A) at 1m distance from the unit. Brief description of the various components of the chiller is given below.

### **4.2 Compressor:**

Compressors shall be scroll type suitable for eco-friendly refrigerants such as R-134a/410a/407c complete with controls, accessories and shall be highly energy efficient & designed for quiet operation. Unit shall be designed for ambient conditions of the place where the chiller is being installed. During the part load operation of the unit, microprocessor ensures that minimum number of compressors shall operate to handle the load thus saving power.

Isolation valves shall be provided on all connections to compressor to

(a) Allow replacement of one compressor while others are running and also allow refrigerant storage in the evaporator via a service compressor

(b) Allow condenser to be used as a pump down receiver.

#### **4.3 Condenser:**

The condenser coils shall be finned for high performance and inner grooved seamless copper tubes to enhance condensation and to reduce power consumption. Copper tubes are mechanically bonded to aluminium fins to maximize heat transfer efficiency. Each coil is pressure tested in the factory at not less than 1.5 times operating pressure. Condenser tubes and fins shall be given hydrophilic coating/proprietary coating to prevent against corrosion

Condenser fans are constructed of die cast aluminium hubs to withstand extreme weather condition with direct driven types. All fans are statically and dynamically balanced to operate at minimum noise and vibration. Fan blades are designed with appropriate pitch angle which results in minimum noise level.

#### **4.4 Evaporator:**

Chiller shall be DX/flooded type. Removable heads shall be supplied for cleaning and servicing of cooler tubes. Vent and drain plugs shall be provided in each head. The flooded – cooler shall have a built-in distributor for feeding refrigerant evenly under the tube bundle to produce uniform boiling action, and baffle plates shall be provided to ensure vapour separation. The cooling shall be fitted with an oil recovery system.

#### **4.5 Refrigerant Circuit:**

Refrigerant shall be eco-friendly such as R-134a /410a /407c and Refrigerant piping shall be of Copper with necessary controls such as TEV, pilot operated solenoid valves to interconnect compressor, condenser and evaporator. Liquid cum moisture indicators, filter drier, shut-off valve shall be provided and also strainer complete with bypass valves.

#### **4.6 Control Panel:**

Microprocessor based unit control centre in a fully enclosed steel cabinet is required. All power and safety/operating controls shall be provided in the panel.

The control centre shall provide all control and safety functions including start-up and shut down, leaving chilled water temperature control, compressor and

expansion valve modulation. In addition, the control centre shall fully protect the compressor motor against overload during start up and operation, phase/power loss, phase unbalance or phase reversal, over/under voltage, etc. Control centre shall facilitate maintaining of chilled water temperature within  $\pm 0.5$  deg.C of set point. The control panel shall be suitable for remote operation / monitoring of the package chiller system.

Packaged Scroll chillers shall be selected for operation in ambient of the places where the chiller is being installed.

The packaged chiller shall be equipped with Proactive Microcomputer Controller to adapt to abnormal operating conditions, tolerant and accommodating of extreme conditions at start up.

The panel shall have a microprocessor-based controller primarily to perform the following operations.

- a) Auto stop & restart of chiller based on chilled water outlet set temperature.
- b) Auto recycle timer to avoid compressor on/off cycling.
- c) Tripping of Compressor on High Pressure/Low Pressure/Anti-Freeze Temperature /low chilled water & condenser water flow/phase unbalance-phase reversal-overload/under-over voltage
- d) Crank case heater operation
- e) Auto/Manual mode operation
- f) The panel shall be user friendly and display message in simple English language with operator pad offering fingertip control for viewing different parameters and changing set points.
- g) The microprocessor panel shall be password protected to make it totally tamper proof.
- h) The system shall intelligently stage the unit to sustain leaving water temperature precision and stability while minimizing compressor cycling.
- i) The panel shall have adaptive logic which shall ensure that the water chilling unit is kept running during harsh weather conditions when cooling is most wanted.
- j) The panel shall have interface for interconnectivity to a personal computer so that the water chilling unit operation can be monitored from any remote place. The Micro-processor control panel shall support on standard protocols such as BACNET or MODBUS Network.

The following LCD displays shall be made available as minimum in the display panel of the control centre.

- a) Suction pressure
- b) Discharge pressure
- c) Current drawn by the unit
- d) Operating hours
- e) Fault and trip indication
- f) Alarm history for last minimum 6 trips with date, time and cause of failure
- g) Changing/viewing the set point of all parameters
- h) Incorrect password message.
- i) Daily starts and stops time.
- j) Chiller inlet & outlet temperature.
- k) Condenser water inlet and outlet temperature.
- l) Anti-freeze temperature cut-out setting.
- m) Compressor starts & run status and total run time.

#### **4.7 Electrics:**

The electrical control panel shall be wired to permit fully automatic operation during initial start-up, normal operation, and shutdown conditions. The control system shall be provided with an anti-recycle device. The control shall limit compressor starting to a minimum interval between starts. The packaged chiller shall be furnished with unit mounted Circuit Breaker, unit Mounted Contactor and Time Delay wired for reduced inrush starting current system for each compressor. The starters shall be factory mounted and wired, with individual circuit breakers. The unit shall be wired so that the only field electrical connection to the packaged chiller shall be to a single three-phase power terminal. A disconnect switch per compressor and unit fuses/ fuse block are also to be included, along with circuit breakers in motor control centre.

The control system shall contain the following control and safety devices.

##### **4.7.1 Manual Controls:**

- Control circuit stop and start switches
- Compressor enable switch

#### **4.7.2 Safety Controls:**

- Solid state compressor motor starter overloads (3 phase), protection for Phase/power loss, phase unbalance or phase reversal, over/under voltage
- Low oil pressure
- High oil temperature
- High condenser pressure
- Low evaporator pressure
- Evaporator water Freeze protection
- Chilled water flow loss
- Condenser water flow loss

#### **4.7.3 Automatic Controls:**

- Compressor motor increment contactors
- Increment start timer
- Anti-recycle timer
- Oil sump heater interlock relays

#### **4.8 Operating Benefits, Efficiency and Reliability:**

- The manufacturer shall have adequate experience in manufacture of Scroll compressors and updated technological advancements.
- The design shall be simple for high reliability with minimum rotating parts.
- To ensure continuous oil flow to each compressor through integral high efficiency oil separation for each compressor.
- To deliver outstanding efficiency and total energy savings through the utilization of economizer cycle and microcomputer-controlled staging producing greater capacity with fewer compressors.
- Maximized performance through computer-matched components.
- Installation Ease.
- Side-by-side evaporator/condenser plus snug arrangement of Scroll compressors required for an extremely compact work envelope.

- Simplified troubleshooting through microprocessor retention of monitored functions.

#### **4.9 Other Features:**

- Software lock to prevent misuse of programming facility
- Provision to store minimum 6 previous faults (minimum) in the memory
- Controllers shall be BMS compatible. Protocol shall be BACNET or MODBUS.

#### **4.10 Safety Codes/Standards:**

- ASME Boiler and Pressure Vessel Code, Section VIII Division 1 "Unfired Pressure Vessels"
- ASME Standard B 31.5 Refrigeration Piping
- ASHRAE Standard 15 Safety Code for Mechanical Refrigeration
- National Electric Code & local Pollution Control Board norms
- AHRI Standard 550/590-2012 "Performance Rating of Water-Chilling and Heat Pump Water-Heating Packages Using the Vapour Compression Cycle"

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## **5. CENTRIFUGAL CHILLER PACKAGES**

### **5.1 Construction:**

Centrifugal chiller shall be of water cooled type consisting of hermetic/ semi hermetic single stage/multi stage centrifugal compressors(s) as specified in the SOQ complete with evaporator, inter connecting refrigerant piping, expansion devices, suitable load controlling mechanisms such as inlet guide vanes and diffusers, control panel, chilled water and condenser water connections. Control panel shall be fully wired connecting and interlocking controller, starter, electrical protection devices etc. Capacity of chiller, chilled water flow rate, condenser water flow rate, power input requirements, voltage etc. will be as specified elsewhere in schedule.

Chillers shall be factory run tested under load conditions. Chiller package shall be designed for maximum corrosion protection with panels of adequate structural strength. The unit shall be mounted over welded steel base frame structural steel profiles of suitable size made out of MS and duly galvanized as specified above for corrosion resistance. Suitable vibration isolators shall be provided to reduce vibrations and noise. The base and frame members shall be painted. Unless otherwise specified, minimum COP, IPLV and IkW/ TR of chiller package shall be as indicated in SOQ.

Chillers shall be certified in accordance with applicable standards of AHRI 550/590 (I-P) 2011 and AHRI 551/591 (SI) 2011 or equivalent.

OEM name plate with manufacturer's name and location, Type, Model No. & Sl. No. providing complete identification, dimensions of chiller package, operating weight, vibration level, noise level, Refrigerant designation, Voltage, phase & frequency, date of manufacture etc., should be indicated on the machine. The IkW/TR vs. % load chart for chillers are to be provided.

The noise level of the chillers shall not exceed 85 dB(A) at 1m distance from the unit. Brief description of the various components of the chiller is given below.

### **5.2 Compressor:**

Centrifuged Compressors should be of semi hermetic/ hermetic type. They shall be of single stage/multistage type as specified in tender schedule. Refrigerant used shall be environmental friendly HFC-134a/positive pressure refrigerant suitable for similar applications.

### **5.3 Impeller:**

The impeller shall be cast from special super high density aluminium alloy having light weight and high anti-corrosive ability. The impeller shall be statically and dynamically balanced and shall be tested at 125% speed at factory for reliability at all loads.

### **5.4 Drive Train:**

Gears shall be used to increase the speed of impeller. Gears shall be of helical type, case hardened and operate in a lubricant moist atmosphere. Gears shall be supported by journal and thrust bearings.

### **5.5 Lubrication System:**

System shall consist of integral oil pump, oil sump, changeable oil filter, oil heater, sight glass etc. Oil pump of high volumetric efficiency shall be used for maintaining required oil pressure and flow throughout the lubrication system to maintain bearing lubrication in compressor, gears and motor. Lubrication system shall be complete with reliable oil recovery system to bring back the oil accumulated in cooler and other locations to oil pump. Oil heater to be provided to maintain oil temperature during shut down period to prevent oil dilution. Necessary heat exchanger shall be used for cooling the oil during operation of the chiller.

An emergency oil reservoir shall be provided exclusively to operate during power failure/pump malfunction and coast down to provide adequate lubricant flow under gravity.

### **5.6 Capacity Control:**

Shall be achieved by using inlet guide vanes which adjust the degree of opening, there by adjusting the volume flow rate. The same shall be able to regulate refrigerant flow through a wide stable operating range.

An adjustable diffuser (if used) on the discharge passage in order to increase the discharge gas velocity for lowering the surge point of the compressor. The unit shall be able to modulate the capacity from 100% to 20%.



### **5.7 Motor:**

Compressor motor shall be squirrel cage induction type. Motor shall have efficient refrigerant cooling system. Motor winding shall have reliable corrosion resistant insulation which shall be compatible with refrigerant and oil. Motor shall be protected by temperature sensors imbedded in stator winding.

### **5.8 Evaporator:**

Evaporator shall be flooded/ DX type with integral finned copper tubes. Chillers shall be horizontal, shell and tube type.

Shell of chiller shall be made out of carbon steel sheet with fusion seam welded seams. Tubes shall be rolled into grooves in steel tube sheets and flanged. Tubes shall be copper seamless, high efficient, internally enhanced and externally finned. Tube diameter and thickness shall be as per OEM. Intermediate tube support shall be in place to provide required tube support in between tube sheets.

Chiller shall be designed for a fouling factor of  $0.000018 \text{ m}^2 \text{ }^\circ\text{K/W}$ . Evaporator shell& tube side shall undergo pneumatic pressure test at 1.5 times the working pressure.

The chiller shall be designed as required in the tender schedule. Vent and drain plugs shall be provided in the water box. Shell side of evaporator shall have pressure relief valve with provision for refrigerant venting. Water connection shall be flanged type /Victaulic groove/marine box type as specified in tender schedule.

The chiller shall be factory insulated with minimum 13 mm thick closed cell insulation.

### **5.9 Condenser:**

Condenser shall be horizontal shell and tube water cooled type, designed, constructed and tested for the refrigerant specified in the tender schedule.

Condenser shell shall be made of carbon steel with electric fusion welded seams. End plates shall be of carbon steel. Intermediate tube supports made out of steel shall be provided to prevent sagging and vibration. Tubes shall be of copper, seamless, high efficient, internally enhanced and externally finned, mechanically expanded into fixed steel tube sheets. Tube diameter and thickness shall be as per

OEM. Water boxes shall be removable for tube cleaning and necessary vent and drain plugs shall be provided. Condensers shall be of single/two/three pass type according to tender schedule. Shell side shall have pressure relief valve with provision for refrigerant venting.

Heat transfer surface of the condenser shall be designed for a fouling factor  $0.000044 \text{ m}^2 \text{ }^\circ\text{K/W}$ . Condenser shell& tube side shall undergo pneumatic pressure test at 1.5 times the working pressure.

Condenser shall have sub cooler located in the bottom of the condenser to increase overall refrigerant effect of chiller and efficiency. Condenser shell volume shall be designed to hold minimum one time of refrigerant charge in the system for full pump down capacity.

Water connection shall be flanged /Victaulic/marine water box type as specified in tender schedule. Refrigeration isolation valves shall be provided to facilitate full pump down capacity in condenser.

#### **5.10 Refrigerant Circuit:**

Refrigerant circuit shall include liquid and discharge line isolation valves, oil filter, replaceable filter/drier on oil line, sight glass on oil line, pressure relief valves on the evaporator and condenser, liquid line angle line valve for refrigerant charging. Economizer shall be provided for two stage chillers.

#### **5.11 Electrical & Control Panel:**

Electrical switch gears, controller, control sensors shall be housed in a NEMA-1 type enclosure panel. Panel casing shall be of galvanized steel with powder coating. Panel shall have two compartments to house power and control devices separately.

Starters shall be anyone of the following as per specification shown in tender schedule.

Low voltage Starters (up to 575 VAC)

- a. Star Delta starter
- b. Solid State starter
- c. Variable Speed Drive

Medium Voltage Starter (3 kV up to 13.8 kV)

- a. Auto Transformer Starter
- b. Solid State Starter
- c. Variable Speed Drive

### **5.12 Control System:**

Chiller shall be provided with proactive advanced microprocessor based controller. Controller shall be equipped with user friendly terminal with colour touch screen display of minimum 10" LED screen. Electronic control system shall constantly monitor various parameters & carry out automatic adjustment of capacity. Operating and safety controls shall be provided. It shall have built in input/output, PC interface, BMS communication port. Parameters shall be stored in a non-volatile memory. There shall be password protection for different levels of operation. All messages shall be displayed in English language and in MKS/SI units. The controller shall be complete with all hardware and software necessary to enable remote monitoring of all data through the BMS with open protocol BACNET/MODBUS etc. The controller shall be complete with an RS485 long distance differential communications port and USB port.

The control system shall contain the controls, displays and safety devices as per standard practice.

- a. Manual/auto control
- b. Refrigerant flow control
- c. Soft indicators on touch screen

The controller shall display operating information, safety and set points and safety protections, as per standard practice. Controller shall be able to retain minimum 6 fault conditions complete with time of failure and all critical sensor readings for aiding technicians for trouble shooting.

### **5.13 Quality Assurance:**

- a) Chiller performance shall be certified by AHRI as per AHRI 550/590 standard latest version.
- b) ASHRAE standard 15 safety code for mechanical refrigeration.
- c) ASME standard for refrigerant piping.

- d) ASME standard for pressure vessels.
- e) Chiller shall be factory run tested and capacity evaluated.
- f) The minimum COP, IPLV and IkW/ TR of chiller package shall be as indicated in SOQ unless otherwise specified.
- g) Chillers shall be certified in accordance with applicable standards of AHRI 550/590 (I-P) and AHRI (SI) or equivalent.

#### **5.14 VFD Option:**

If VFD drive is opted, the chiller shall be provided with inverter duty compressor motor and remote mounted VFD panel. The VFD shall be constant torque type and able to deliver even 110% torque for 60 seconds during normal operation. Power factor of 0.95 shall be maintained in all conditions by suitable capacitor banks / APFC panels. Unit capacity control shall be done by the combined action of VFD and inlet guide vane to provide optimized performance with stable operation under all operating conditions.

VFD shall have inbuilt protection mode to automatically reduce the frequency and the modulation process adjusted when it detects critical status such as over current or over voltage etc.

VFD shall have inbuilt electronic thermal motor protection against overload. The VFD shall be protected against short circuit on motor terminals. It shall also have protection against main phase loss. VFD shall have built in LCD keypad display and shall show information on motor current, voltage, frequency output, output kW etc.

#### **5.15 Centrifugal Compressor with Magnetic Bearings Option:**

Centrifugal chiller with compressor having magnetic bearings shall be oil free type. Compressor shall use HFC refrigerant. The compressor shall incorporate VFD as a standard feature. The compressor shall be compact, highly energy efficient with low noise and vibration levels. The compressor shall have high part load efficiency and infinitely variable capacity control. The chiller shall not have any oil lubrication facility such as pumps, heaters, coolers etc. in lieu of magnetic bearings. Magnetic bearings shall have necessary proximity sensors, digital controllers, pulse width modulation etc. Compressor shall have necessary facility for safety and protection as built in feature.

### **5.16 Safety Codes/Standards:**

- ASME Boiler and Pressure Vessel Code, Section VIII Division 1 "Unfired Pressure Vessels"
- ASME Standard B 31.5 Refrigeration Piping
- ASHRAE Standard 15 Safety Code for Mechanical Refrigeration
- National Electric Code & local Pollution Control Board norms
- AHRI Standard 550/590-2012 "Performance Rating of Water-Chilling and Heat Pump Water-Heating Packages Using the Vapour Compression Cycle"

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**SPECIFICATIONS FOR AIR-CONDITIONING  
AND VENTILATION WORKS**

**SECTION - II  
CENTRIFUGAL PUMPS**

## **1. HORIZONTAL SPLIT CASING PUMPS**

### **1.1 Pump construction:**

Construction of Horizontal split / end suction pumps shall be as per IS or equivalent standards. Tender schedule may be referred with regard to flow rate, head motor speed, efficiency and power requirements.

#### **1.1.1 Casing:**

Pump casing shall be close-grained cast iron of heavy section, split-casing type to enable complete servicing of rotating parts without disconnecting piping or motor connection. Motor to pump connection shall be done with spacer type coupling. Suction passages shall be of volute form promoting smooth entry to impeller and increased efficiency.

#### **1.1.2 Impeller:**

Impeller shall be of bronze or gunmetal, double suction, enclosed type and hydraulically balanced so as not to cause any vibration during operation. Impeller shall be securely keyed to the shaft and 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 for end suction - double shrouded single entry, radial flow hydraulically balanced.

#### **1.1.3 Wearing Rings:**

Wearing rings shall be of renewable type. These shall be held in place by screwing against rotation, press fit and locked with pins, flanged and screwed.

#### **1.1.4 Shaft:**

Shaft shall be made of stainless steel accurately machined, ground and finished. Protected by gun metal sleeves. It shall be finished to close tolerance at the impeller, coupling and bearing diameters. The impellers, pulley and shaft sleeves shall be firmly secured to the shaft by key/nuts.

The shafts size shall be calculated on the maximum combined shear & tensile stresses. This shear stress shall not exceed 30 per cent of the elastic limit in tension or 18 percent of ultimate tensile strength whichever is lower.

### **1.1.5 Shaft Sleeves:**

The pump shall be equipped with mechanical seals. Shaft sleeves shall be of gun metal, provided to protect the shaft. Shaft sleeves shall be securely locked or keyed to the shaft to prevent loosening. Rotating shaft and shaft sleeves shall be machined and assembled for concentric rotation.

### **1.1.6 Bearings:**

- a) The bearings may be ball, roller or sleeves type. Provision shall be made to take axial and radial loads. Oil level indicators shall be provided in oil baths.
- b) Where there is a possibility of liquid entering the bearing, the pump shall be provided with suitable preventive arrangement such as water deflectors.
- c) Bearings shall be easily accessible without disturbing the alignment of the pump.

### **1.1.7 Couplings:**

Pumps shall be furnished complete with flexible spacer type couplings to permit disassembling without disturbing pump driver. Coupling guards, made of expanded metal and bolted to the base plate, shall be furnished for all coupled pumps.

### **1.1.8 Motor:**

Motor shall be of rating suitable for the pump with IE3 or better efficiency. Base shall be cast iron, TEFC designed. Motor shall be suitable for 415 +/- 10% Volts, 3 phase, 50 Hz AC power supply.

### **1.1.9 Base Plates:**

The common base plate for pump and motor shall be in one place and it shall be made of cast iron or welded steel construction. Suitable holes shall be provided for grouting and they shall be so located that the base can be grouted in place without disturbing the pump and motor. All pumps and motors shall be properly aligned, bolted and doweled to the base plates by contractor. Adequate space shall be provided between pump drain connections and base plate for installation of minimum 15mm dia drain piping. Pumps shall be supplied with suitable drain pans or drain rim type base plates with trapped drain connections.

## **1.2 Installation:**

The pump & motor shall be installed on a common mild steel base frame grouted to concrete foundation. The mounting arrangement shall be shown on shop drawings.



**1.2.1 Lubrication:**

Upon installation of the complete system and before testing, the pump shall be lubricated in strict accordance with the manufacturer's instructions.

**1.2.2 Pump alignment:**

All pumps prior to testing shall be aligned with a dial indicator within 0.05mm.

**1.3 Painting:**

All pumps, motors and bases shall be supplied with approved finish. Shop coat of paint that have become marred during shipment or erection shall be cleaned off with mineral spirits, wire brushed and spot primed over the affected areas, then coated with enamel paint to match the adjoining areas.

**1.4 Performance data:**

Pump performance curves and power consumption with operating points clearly indicated shall be submitted, and verified at the time of testing and commissioning of the installation. The pump shall be selected for best efficiency point on the flat portion of the performance curve.

## **2. END SUCTION COUPLED CENTRIFUGAL PUMPS**

### **2.1 Pump construction:**

Construction of end suction coupled centrifugal pumps shall be as per IS or equivalent standards. Pump shall be of back pull out type, end-suction design long coupled to motor. Tender schedule may be referred with regard to flow rate, head motor speed, efficiency and power requirements.

#### **2.1.1 Casing:**

Pump casing shall be cast iron, suitable for 16 bar (232 PSI) working pressure and ductile iron for pressures to 17 bar (250 PSI). The casing shall be hydrostatically tested to 150% maximum working pressure. The casing shall be radially split to allow removal of the rotating element without disturbing the pipe connections. The casing shall be equipped with a drilled and tapped connection. Suction and discharge connections shall be provided with drilled and tapped pressure gauge connections.

#### **2.1.2 Impeller:**

Impeller shall be of bronze hydraulically balanced, fully enclosed type and keyed to shaft, stuffing boxes shall be integral with casing and water sealed. Shaft sleeve shall be of gun metal extending through full length of mechanical seal area.

#### **2.1.3 Mechanical seal:**

Mechanical seal shall be of single spring inside type with carbon face rotating against a silicon carbide O-ring mounted seat. EPDM (Ethylene propylene Diene Monomer) elastomer with stainless steel spring and hardware shall be provided.

#### **2.1.4 Motor:**

Motor shall be of rating suitable for the pump with IE3 or better efficiency. Base shall be cast iron and TEFC designed as integral part of the pump. Motor shall be suitable for 415 +/- 10% Volts, 3 phase, 50 Hz AC power supply.

### **2.2 Installation:**

The pump shall be mounted on mild steel base frame grouted to concrete foundation. The mounting arrangement shall be shown on shop drawings.

**2.3 Painting:**

All pumps, motors and bases shall be supplied with approved finish. Shop coat of paint that have become marred during shipment or erection shall be cleaned off with mineral spirits, wire brushed and spot primed over the affected areas, then coated with enamel paint to match the adjoining areas.

**2.4 Performance data:**

Pump performance curves and power consumption with operating points clearly indicated shall be submitted, and verified at the time of testing and commissioning of the installation. The pump shall be selected for best efficiency point on the flat portion of the performance curve.

### **3. VERTICAL IN LINE SPLIT PUMPS**

#### **3.1 Pump construction:**

Construction of vertical inline split pumps shall be as per IS or equivalent standards. Tender schedule may be referred with regard to flow rate, head motor speed, efficiency and power requirements.

##### **3.1.1 Pump Casing:**

Cast iron for working pressure below 12.00 bar at 65 deg C (PN 16 flange rating). Suction and discharge connections shall be flanged, drilled and tapped for seal flush and gauge connections. Separate drilled and tapped openings for gauge, flush and drain connections shall be provided. Liberal inlet passageways and straightening vanes to provide optimum suction performance and quiet operation. Ribs to be cast integral with volute. Machined surface to accept floor support. Confined casing gasket to meet stringent industrial temperature and pressure applications.

Removal of one casing half and bearing housings shall permit removal of the complete rotating assembly without disturbing piping connections. The casing shall be so designed as to permit horizontal mounting without modifying the casing.

##### **3.1.2 Impeller:**

Impeller shall be made of Bronze and of fully enclosed type. Dynamically balanced to ensure smooth vibration-free operation.

##### **3.1.3 Shaft:**

Provide stainless Steel pump shaft with lower carbon throttle bushing.

##### **3.1.4 Coupling:**

Split type Rigid Spacer type of cast iron precision bored and designed to reduce bearing load. Shaft deflection at mechanical seal limited to 0.05 mm T.I.R. Mechanical seal; couplings shall be split to allow removal from pump and motor shafts, leaving space between the shafts sufficient to replace all mechanical seal components without disturbing the pump or motor. Coupling guard to fully enclose access openings.

### **3.1.5 Mechanical Seals:**

Shall be Stainless Steel inside multi-spring balanced type with carbon rotating face, silicon carbide stationary seat, Viton secondary seal. It shall be accessible and easily replaceable without disturbing the motor. Provide bronze gland plate with Stainless steel hardware. Provide factory installed flush connection to ensure liquid at seal faces and positive venting of seal chamber with manual vent.

All split coupled pumps shall be provided with seal chamber throttle bushing. Seal flush line fittings, if required: Supply in the flush line to the mechanical seal a 50-micron cartridge filter and floating ball type sight flow indicator, to suit the working pressure encountered.

High Efficiency Squirrel Cage induction motor with totally enclosed fan cooled (TEFC) enclosure for Vertical In-Line Operation Heavy cylindrical bracket with 360 deg register on each flange shall provide a rigid union of pump and motor shaft run-out limited to 0.025 mm T.I.R (total Indicator Reading).

### **3.2 Installation:**

Vertical In-Line pumps supplied shall be integral components of the pipework, eliminate need for inertia bases, inertia base springs, flexible pipe connectors, field grouting and alignment. Pipe hangers, sized for the weight of pump, piping and fittings, are the only supports that shall be required. Pipe stools, with vibration isolating pads, may be installed under each pipe leg.

### **3.3 Maintenance:**

Mechanical seal is the critical service item in any pump. Removal of the axially split spacer coupling shall allow all mechanical seal components to be withdrawn for servicing, through the resulting space between pump and motor shafts, without disturbing other pump components or motor connection. Re-installing the rigid coupling shall bring the unit rotating assembly back to factory alignment specifications.

### **3.4 Lubrication:**

Upon installation of the complete system and before testing, the pump shall be lubricated in strict accordance with the manufacturer's instructions.

### **3.5 Pump Alignment:**

All pumps prior to testing shall be aligned with a dial indicator within 0.05mm.

### **3.6 Painting:**

All pumps, motors and bases shall be supplied with approved finish. Shop coat of paint that have become marred during shipment or erection shall be cleaned off with mineral spirits, wire brushed and spot primed over the affected areas, then coated with enamel paint to match the adjoining areas.

### **3.7 Performance Data:**

Pump performance curves and power consumption with operating points clearly indicated shall be submitted, and verified at the time of testing and commissioning of the installation. The pump shall be selected for best efficiency point on the flat portion of the performance curve.

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**SPECIFICATIONS FOR AIR-CONDITIONING  
AND VENTILATION WORKS**

**SECTION - III  
COOLING TOWERS**

## 1. INDUCED DRAFT FRP COOLING TOWERS

Cooling towers shall be of suitable induced draft FRP cooling tower of capacity as indicated in SOQ and complete with direct driven cast aluminium/ Fibre reinforced Plastic (FRP) axial flow fan, totally enclosed weather proof motor of adequate capacity with starter, corrosion proof PVC fill and inlet louvers, drift eliminator, hot water distribution chamber and nozzles, FRP cold water basin etc.

The cooling tower shall be of light weight, modular construction and corrosion resistant. The cooling tower shall be installed as indicated in the tender drawing. Suitable pedestal supports and steel grillage as required for complete installation of the tower shall be included in A/C vendors scope of work & complete as required.

The design of cooling tower shall be suitable for ambient condition of the location where the towers are to be installed. The cooling tower trough shall preferably have water storage capacity for minimum period of four minutes.

All the PVC fills are double folded with an automatic drainage system, producing a minimum pressure drop and a good protection against erosion. They are glued by automatic process. The fills shall withstand a temperature of 65°C. High Efficiency Drift Eliminators manufactured shall ensure a maximum drift loss of 0.2% under standard design conditions. The sub-distribution pipes are made of rigid PVC/ CPVC with a testing-pressure of 4 kg/cm<sup>2</sup>.

The panels and main troughs are of corrosion resistant fibreglass with a longer service life and available in various colour choices. superior quality Isophthalic resin and FRP matting, making the components stronger for withstanding wind pressures, UV sunrays and water treatment chemicals etc.

The Axial Flow Fans are statically balanced and manufactured in strict conformation to latest standards. All motors are of standard make TEFC, with IP 55 protection and guaranteed by the original manufacturers.

The cooling tower shall meet the following minimum specifications:

- Type: Induced Draft Counter flow/ cross flow as indicated in SOQ
- Distribution: Gravity flow (static)/ Main header and branch arm system.
- Fan material & Type: Cast Aluminium / FRP, Axial flow
- Type: Induction Type, Squirrel Cage (IP55), TEAO, IE3 or better efficient.
- Tower structure & Basin: Fibreglass



- Fills: High efficiency PVC fills pack with UV stabilization
- Drift eliminators: PVC
- Fill support: Hot dipped galvanized frame
- Bird screen: Hot dipped galvanized frame
- Distribution supports: Hot dipped galvanized frame
- Hardware: Stainless steel
- Wet bulb approach: 3 deg C
- Evaporation loss: 0.96%
- Drift loss: not exceeding 0.2%
- Total water loss: maximum 1.16% (without bleed off)

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**SPECIFICATIONS FOR AIR-CONDITIONING  
AND VENTILATION WORKS**

**SECTION - IV  
PIPING FOR AC WORKS**

## 1. PRE-INSULATED PIPING

### 1.1 General:

1. The scope of this section comprises the fabrication, supply and laying & welding of pipes, pipe fittings and valves, testing and balancing of all water flow piping required for the complete installation.
2. Pipe sizes shall be as required for the individual fluid flows. Various pipe sizes shall be as indicated in the Drawings and SOQ of the tender document.
3. All pre-insulated chilled water/ brine piping with design temperatures from (-) 5°C to 30 °C. All straight lengths, elbows, tees, reducers, anchors and other accessories shall be designed to prevent the ingress of water or moisture into the insulation and shall be factory fabricated, insulated, and jacketed.
4. All elbows, tees, reducers, anchors and other accessories shall be designed so that field joints are made in straight sections of pipe only.
5. The piping system shall be designed, fabricated and installed in accordance with ASME B 31.1.
6. Installation of the pre-insulated piping shall be in accordance with the pre-insulated pipe manufacturer's instructions.

### 1.2 Carbon Steel Service Pipe:

1. Pipe dia, thickness, IS codes shall be as per the table below.

<b>Pipe Size</b>	<b>Wall Thickness &amp; Manufacturing Standard</b>
150 mm and below	Carbon pipe Heavy duties per IS 1239
200 mm	Min. 6mm,As per IS 3589 2001
300 mm	Min. 6mm,Asper IS 3589 2001
400 mm	Min. 6mm,As per IS 3589 2001
500 mm	Min.6mm,Asper IS 3589 2001
650 mm	Min.6mm,Asper IS 3589 2001
800 mm	Min.8mm,Asper IS 3589 2001

2. Pipe fitting material shall be medium weight ASTM A234, ASTM A105 or ASTM A53 electric resistance welding (ERW) as applicable. Butt-weld fittings shall be

in accordance with ASME B 16.9. Socket weld fittings shall be in accordance with ASME B 16.11.

3. Pipe elbows shall be long radius, 1.5D minimum centreline radius or bent to a 2D centreline radius in accordance with ASME B 31.1.
4. Full and reducing tees shall be forged tees or integrally reinforced forged branch outlet fittings in accordance with MSS SP-97 or weld-o-lets can be used for reducing tees.

### **1.3 Service Pipe Fabrication:**

1. All elbows, tees, reducers, anchors and other accessories shall be designed so field joints are made in straight sections of pipe only.
2. All service pipe welding shall be in accordance with ASME B 31.1
3. All weld procedures and welders shall be qualified in accordance with ASME Section IX.
4. Weld procedures, procedure qualifications and welder qualifications shall be submitted for approval.
5. To ensure proper bonding, the service pipe must be free from rust, oil, grease, dust, moisture and other contaminants.

### **1.4 Insulation:**

The insulation material shall be as specified in tender Schedule.

#### **1.4.1 Polyurethane Foam Insulation (PUF)**

1. The insulation shall completely fill the annular space between service pipe and jacket and shall be bonded to both. Insulation shall be done on a high pressure injection machine. Direction of flow shall be marked on the pipes.
2. The piping shall include valves strainers, measuring instruments etc. as indicated in SOQ. The piping shall be complete with suitable supports wherever required. After the pipes are installed & pressure tested, the joints/fittings shall be insulated as per manufacturer's recommendations and complete as required.
3. The outer jacket shall be 0.6 mm lock seam spiral GI for sizes up to 600 mm dia. for pipes to be installed inside service trenches and same shall be with high density polyethylene (HDPE) for pipes to be buried underground.

4. The insulation shall be rated Class O as per BS 476.
5. The PUF insulation properties shall be in accordance with ASTM C1029, Specifications for spray applied rigid cellular polyurethane Thermal insulation. In general, PUF insulation shall confirm to the following specification:

Property	Value	Test Method
Thermal Conductivity	$\leq 0.023 \text{ W/m } ^\circ\text{C}$	ASTM C518
Compressive Strength	$\geq 300 \text{ kPa}$	ASTM D1621
Closed cell content	$\geq 88\%$	ASTM D6226

6. The minimum thickness of insulation shall be as per the following table:

Pipe Size	Minimum Insulation Thickness
Up to 32 mm	25 mm
40 to 150 mm dia	30 mm
200mm	50mm
300mm	50mm
650mm	75mm

7. The manufacturer must ensure that the foam is bonded to both the service pipe and the jacket.
8. In the case of foam injection manufacturing, the HDPE casings must be internally treated to optimize bonding between polyurethane foam and HDPE jacket.

#### **1.4.2 Poly - Isocyanurate Insulation:**

1. The insulation shall completely fill the annular space between the service pipe and insulation jacket. The fire rated Poly- isocyanurate insulation shall be visually inspected for voids prior to application of the vapour barrier and insulation jacket. Direction of flow shall be marked on the pipes.
2. The fire rated Poly-isocyanurate insulation for pipe sizes 200 mm and larger shall be spray applied directly onto the service pipe.

3. The fire rated Poly-isocyanurate insulation for pipe sizes 150 mm and smaller and for fittings may be injected into the annular space between the service pipe and insulation jacket.
4. The insulation shall be rated Class 0 as per BS 476.
5. The service pipe insulation shall be rigid, closed cell fire rated Poly-isocyanurate insulation with the minimum properties as listed below in Table.

Property	Value	Test Method
Thermal Conductivity	$\leq 0.026 \text{ W/m}^\circ\text{C}$	ASTM C518
Compressive Strength	$\geq 300 \text{ kpa}$	ASTM D1621
Closed Cell Content	$\geq 88\%$	ASTM D6226
Fire Rating	Class 1	BS 476, Part 7

6. The minimum insulation thickness shall be the following:

Pipe Size	Minimum Insulation Thickness
Up to 150 mm	30 mm
200mm	50mm
300mm	50mm
400mm	50mm
500mm	75mm
650mm	75mm
800mm	100mm

### 1.5 Outer jacket requirements:

1. The outer jacket shall be 0.6 mm lock seam spiral GI for sizes up to 600 mm dia for pipes to be installed inside service trenches and same shall be with high density polyethylene (HDPE) for pipes to be buried underground. The outer jacket shall be provided for both straight joints and all fittings also. In case of HDPE jacket, same shall be in accordance with ASTM D3350 minimum cell classification PE 345444C and minimum thickness shall be 3 mm up to 300 mm and minimum 5 mm up to 650 mm/800mm.

2. In case of GI outer jacket, same shall be fastened using stainless straps. Spacing as per supplier's recommendation.
3. Glass reinforced aluminium vapour barrier shall be applied underneath the GI jacket. The vapour barrier shall have a Class 1 fire rating as per BS 476 part 7.
4. The jacket for fittings shall be mitered, riveted or screwed together and shall applied in a way that the vapour barrier is not damaged.
5. Fiberglass reinforced plastic (FRP) jacket may be used for fittings of pipe sizes 900 mm or larger. The FRP jacket for fittings shall be seamless, chop spray applied.

#### **1.6 Installation and quality requirements:**

1. The pre-insulated pipe manufacturer shall have a quality assurance program in place to ensure compliance with this specification.
2. Non-destructive examination of all service pipe welds shall be performed in accordance with ASME B 31.1.
3. The testing listed below shall be performed to ensure the quality of the fire rated Poly-isocyanurate insulation. Test reports shall be provided showing compliance.
  - a. Thermal conductivity
  - b. Compressive strength
  - c. Closed cell content
4. All materials shall be factory inspected and carefully loaded and braced to prevent damage in shipment to the job site. Upon receipt of the materials, it shall be visually inspected and all the related documents to be checked.
5. Proper care and handling techniques shall be adopted to avoid damage.
6. The following instructions are to adhered for handling the piping units:
  - a. Support each piping unit with nylon slings during all phases of handling.
  - b. Do Not use hooks, steel cables or chains for handling any piping units.
  - c. Do Not strike the piping units against hard surfaces at any time.
  - d. Do Not use forklifts for handling piping units.

7. If possible, use a spreader bar to maximize control of the piping units during handling.

### **1.7 Piping Units:**

1. All the piping units are to be stored in a warehouse or heated shelter or on high ground to avoid ingress of water into the pipe ends.
2. When stacking, stack piping units in the same fashion they were received.
3. Wooden shipping braces must be used as runners between layers of pipe.
4. Do Not stack piping units more than three (3) tiers high. Use foam or other padding between layers.
5. If the ends of piping units were shipped with plastic covers and/or plastic pipe end caps, do not remove them when storing the piping units.
6. If any of the protective covers were damaged in shipping or handling, they must be restored by replacing the protective plastic cover where necessary.

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## **2. CHILLED AND CONDENSER WATER PIPING**

### **2.1 Scope:**

The scope of this section comprises the supply and laying of pipes, pipe fittings and valves, testing and balancing of all water piping required for the complete installation as shown in the tender drawings. All piping inclusive of fittings and valves shall follow the applicable Indian Standards. Pipes shall be of ERW/Seamless as indicated in SOQ.

### **2.2 Chilled and Condenser Water Piping**

1. All chilled water and condenser water pipes and fittings shall be of MS (heavy class) conforming to IS 1239 for pipe size up to 150mm dia. For pipe size of 200mm dia and above shall be as per IS 3589 having minimum 6mm thickness unless otherwise specified upto 650 dia and 8mm thickness unless otherwise specified for pipes above 650 dia. All jointing in the pipe system shall generally be by welding, unless mentioned otherwise, or directed at site. All welding shall be done by qualified welders and shall strictly conform to Indian Standards code of procedure for manual metallic welding of Mild steel as per relevant IS or equivalent standards. Condenser & Chilled water line must have quick filling connection arrangement at plant room 40mm size with full way valve & a drain line too of the same size.
2. All pipes and their steel supports shall be thoroughly cleaned and given one primary coat of red oxide paint before being installed. All chilled water piping will rest on PUF blocks 48 kg/cum density neatly moulded or teak wooden block of 65mm thickness with groove to the radius of pipes and seated on MS angles / channel. All welded piping shall be subjected to the approval at site.
3. Fittings shall be malleable casting of pressure rating suitable for the piping system. Fittings used on welded piping shall be of the weldable type.
4. Tee-off connections shall be through equal or reducing tees, otherwise ferrules welded to the main pipe shall be used. Drilling and tapping of the walls of the main pipe shall not be resorted to.
5. Ball valve, Butterfly valves, globe valve, conforming to the following specifications, shall be provided as shown in tender drawings:

Size	Construction	Ends
15 to 40 mm	Gun metal	Screwed
50 mm and above	Body cast iron spindle and valve seat of Bronze or Gun metal or Nitrile rubber. (in case of butterfly valve)	Flanged

6. All valves shall be heavy duty conforming to relevant IS or equivalent standards. Valves shall have non-rising spindles unless specified otherwise and shall be suitable for not less than 16 kg per sq.cm. gauge working pressure.
7. Butterfly valve shall perform the function of isolating valves and shall have cast iron body with black nitrile seat. All Butterfly valves shall be provided with locking devices. Valves 300 mm dia & above shall be gear driven.
8. All AHUs & chillers shall be provided with balancing / control valves with built in pressure drop measuring facility. The water flow shall be measured by online Hydronic Balancing System with data display on monitor screen.
9. Flanges shall be of slip on raised face type. The supply of flanges shall also include supply of bolts and nuts and suitable asbestos/fibre rubber insertion gaskets (minimum 3mm thick).
10. Non-return (check) valves shall be provided as shown on the drawings, conforming to IS 778 and IS 5312 and in accordance with the following specifications.

Size	Construction	Ends
10 to 40 mm	Gun metal	Screwed
50 mm to 150mm	Cast Iron/Gun Metal	Flanged type
200mm to 450 mm	Body casting iron, plate	Flanged carbon steel with 13%chrome overlay

11. The spring and hinge/stop pin shall be SS 304 and bearing fire material. Valves shall be suitable for not less than 16 kg per Sq cm gauge working pressure.
12. Non-return valves shall be swing check valves, normally used in all water services. Lift type valves may be used in horizontal runs. Valves shall be suitable for not less than 16 kg per sq.cm. gauge working pressure.
13. Strainers shall be of 'Y' type or pot strainers as shown on the drawings, with cast bodies designed for the test pressure specified for the butterfly valves. Strainers shall have bronze screen with 3mm perforations. Screen shall be removable and replaceable without disturbing of the main pipes. All strainers shall be provided with isolating valves so that the strainer may be cleaned without draining the system. Strainers shall be provided on the inlet side (at suction) of each pump, and as shown in the tender drawings.
14. Pot strainers shall be fabricated out of MS sheet with bronze/SS 304 basket of sizes as under:

Pipe Size (mm)	Pot Dia (mm)	Pot Ht (mm)	Basket dia (mm)	Basket Ht	Thickness of Basket
50	300	400	200	240	24 Gauge
80	350	450	250	250	
100	450	500	300	280	
125	500	600	330	340	22 Gauge
150	540	700	360	390	
200	610	815	400	470	
250	800	955	550	510	
300	1000	1105	750	580	
350	1190	1300	895	678	20 Gauge
400	1350	1500	1020	785	
450	1518	1700	1060	890	
500	1690	1800	1100	900	

15. Pot strainer shall be fabricated out of MS plate upto 100mm dia pipes shall be fabricated of 6mm thick MS sheet, 125 to 300 mm dia pipes of 8mm thick and higher sizes above of 12mm thick. All strainers shall be sized to provide

minimum resistance through perforated vessel & shall be sized as per given table.

16. Pipe bends shall be prefabricated type up to 150mm dia. Pipe bends fabricated at site shall be provided with segments of bend not exceeding 15° angle. A 90° bend shall thus be provided with 6 Nos. welding joints. Pipes shall be cut with Power saw/Hacksaw only, followed by hand grinding to provide V-groove.
17. All chilled water piping and fitting shall be pressure tested, then insulated as described under the section "Insulation".
18. After all, chilled/condenser water piping has been installed; the system shall be pressure tested as per section 2.5 indicated below. The piping, fittings & supports shall be painted with one coat of red oxide paint & two finish coats of 3 mills each of approved colour of synthetic enamel paint conforming to IS 2379 (Incase the chilled water piping, the paint shall be done after insulation of the pipes). The direction of flow of fluid in the pipes shall be visibly marked with identifying arrows.
19. Auto Air vent & Gun Metal drain valve of suitable size shall be provided in the chilled & condenser water piping at highest point and at lowest points in the risers respectively. Air Vent shall be provided with 15 mm dia pipe connection, drain pipe connection & in built isolation for ease of servicing.

### **2.3 Condensate and Drain Piping**

1. All pipes to be used for cold water (makeup), drain, and condensate drain shall be approved make and fittings as per IS 4736 or galvanized steel class B (medium class) conforming to relevant IS codes.
2. All jointing in the pipe system shall be by screwed fittings using non-hardening lubricant as sealing material and/or by screwed flanges using 3mm 3 ply rubber gaskets. Pipe threads and flanges shall be as per relevant IS or equivalent standards.
3. All pipe supports shall be mild steel, thoroughly cleaned and given on primary coat of red oxide paint before being installed.
4. Fittings shall be galvanized steel 'Medium Class' malleable casting of pressure rating suitable for the piping system. Flanges shall be of approved make. Supply of flanges shall include bolts, washers and gaskets as required.

Sufficient number of flanges and unions shall be provided for future cleaning and servicing of piping. Tee-off connections shall be through equal or reducing tees. All equipment and valve connections or connections to any other mating pipe shall be through unions/screwed flanges up to 50 mm dia and through screwed flanges for larger diameters, or as required for the mating connections.

5. All condensate drain piping shall be insulated as per the section 'Insulation'. Cold water piping within the building may also be insulated.
6. After the piping has been installed, tested and run for at least three days of eight hours each, all piping and pipe supports shall be painted with one coat of red oxide paint & two finish coats of 3 mills (0.0762 mm) each of approved colour of synthetic enamel paint conforming to IS 2379.
7. The direction of flow of fluid in the pipes shall be visibly marked with identifying arrow.

#### **2.4 Piping Installation:**

1. Tender drawings indicate schematically the size and location of pipes. The contractor, on the award of the work, shall prepare detailed working drawings, showing the cross-section, longitudinal sections, details of fittings, locations of isolating and control valves, drain and air auto vent valves, and all pipe supports. The vendor must keep in view the specific openings in buildings and other structures through which pipes are designed to pass.
2. Piping shall be properly supported on, or suspended from, stands, clamps, hangers as specified and as required. The contractor shall adequately design all the brackets, saddles, anchors, clamps and hangers, and be responsible for their structural adequacy.
3. Pipe supports shall be of steel, adjustable for height and primer coated with rust preventive paint and finish coated black. Where pipe and clamps are of dissimilar materials, a gasket shall be provided in between spacing of pipe supports shall not exceed the following:

Pipe Size	ROD Diameter (mm)	Base Support
Up to 125mm	10	clamp support
150 mm to 200 mm	15	ISMC 75

250 mm	20	ISMC 150 *
300 mm	22	ISMC 150 *
350, 400 mm	25	ISMC 150 *
450, 500 mm	32	ISMC 150 *
600 mm	32	ISMC 200 *

\* Floor mounted support shall be preferred.

Pipe Size	Spacing between supports
Up to 40 mm	1.5 meter
50 to 150 mm	2.0 meter
Over 150mm	2.5 meter

4. Vertical risers shall be parallel to walls and column lines and shall be straight and plumb. Risers passing from floor to floor shall be supported at each floor by clamps or collars attached to pipe and with a 15mm thick rubber pad or any resilient material. Where pipes pass through the terrace floor, suitable flashing shall be provided to prevent water leakage. Risers shall have a suitable clean out at the lowest point and air vent at the highest point.
5. Pipe sleeves, 50mm larger diameter than pipes, shall be provided wherever pipes pass through walls and slabs, and annular space filled with fibre glass and finished with retainer rings.
6. Insulated piping shall be supported in such a manner as not to put undue pressure on the insulation. 14-gauge(2mm) metal sheets shall be provided between the insulation and the clamp, saddle or roller, extending at least 150mm on both sides of the clamp, saddles or roller.
7. All pipe work shall be carried out in a workman like manner, causing minimum disturbance to the existing services, buildings, rods and structure. The entire piping work shall be organized, in consultation with other agencies work, so that laying of pipe supports, pipe and pressure testing for each area shall be carried out in one stretch.

8. Cut-outs in the floor slab for installing the various pipes are indicated in the drawings. Contractor shall carefully examine the cut-outs provided and clearly point out where ever the cut- outs shown in the drawings, do not meet with the requirements.
9. The contractor shall make sure that the clamps, brackets, clamps saddles and hangers provided for pipe supports are adequate. Piping layout shall take due care for expansion and contraction in pipes, and include expansion Loop where required.
10. All pipes shall be accurately cut to the required sizes in accordance with IS 554 and burrs removed before laying. Open ends of the piping shall be closed as the pipe is installed to avoid entrance of foreign matter. Where reducers are to be made in horizontal runs, eccentric reducers shall be used for the piping to drain freely. In vertical pipes, concentric reducers shall be used.
11. Flanged inspection pieces 1.5 meters long, with bolted flanges on both ends, shall be provided no more than 30 meters center to center wherever shown in approved drawings for construction to facilitate future cleaning of all welded pipes.
12. All buried pipes shall be laid over 100 mm concrete bed and the pipes have to be insulated as per insulation section of the technical specification.
13. The buried piping has to be sand filled by 300 mm from top of the pipe and then refilling of stone free soil has to take place and the same has to be compacted in order to strengthen the area.
14. The valves for buried piping have to be provided with masonry valve chamber for proper maintenance.
15. Auto/ Manual air vent valves shall be provided at all specified points in the piping system for air venting. All valves shall be of 20mm/15mm pipe size, provided with drain connection & non return valve for ease of maintenance. Discharge from the air valves shall be piped through an equal sized mild steel or galvanized steel pipe to the nearest drain or sump. All pipes shall be pitched towards drain points.
16. Pressure gauges with SS needle valves as specified in tender shall be provided at the suction and discharge of chilled water/condenser water pumps supply and return at air handling units, at chillers and at condensers, as shown on the

drawings and included in schedule of quantities. Care shall be taken to protect pressure gages during pressure testing.

17. Temperature gauge shall be provided at each Air handling units Supply & Return Chilled water line, at chillers, and condensers, as shown in tender drawings and included in schedule of quantities.

## **2.5 Testing & Balancing:**

1. All piping shall be tested to hydrostatic test pressure of at least 1.5 times the maximum operating pressure. Gauge for a period of not less than 24 hours. All leaks and defects in joints revealed during the testing shall be rectified and gotten approved at site.
2. Piping repaired subsequent to the above pressure test shall be re-tested in the same manner.
3. System may be tested in sections and such sections shall be securely capped, then retested for entire system.
4. The contractor shall give sufficient notice to all other agencies at site, of his intention to test a section or sections of piping and all testing shall be witnessed and recorded by Department's representative.
5. The Contractor shall make sure that proper noiseless circulation of fluid is achieved through all coils and other heat exchange equipment in the system concerned. In case of improper circulations, the contractor shall rectify the defective connections. The vendor shall bear all expenses for carrying out the above rectifications, including the tearing up and re-finishing of floors and walls as required.
6. The contractor shall provide all materials, tools, equipment, instruments, services and labour required to perform the test and to remove water resulting from cleaning and after testing.
7. After completion of the installation, all water system shall be adjusted and balanced to deliver the water quantities as specified, quoted or as directed, to individual air handling units and fan coil units cooling coil.
8. Water circuit shall be adjusted by balancing cocks provided for balancing; these shall be permanently marked after balancing is completed so that they can be restored to their correct positions, if disturbed.



9. Complete certified balancing report shall be submitted for evaluation and approval. Upon approval, four copies of the balancing report shall be submitted with complete drawings and documents.
10. Exposed Pipes & insulation surface/cladding shall be provided the approved colour along with name & arrows marked distinctly in service areas.

## **2.6 Chilled Water Pipes Insulations:**

Material for Insulation for chilled water pipes shall be as specified in tender schedule.

### **2.6.1 Insulation Using Nitrile Rubber:**

#### **a) Insulation Material:**

1. Insulation material shall be Closed Cell Elastomeric Nitrile Rubber
2. Thermal conductivity of elastomeric nitrile rubber shall not exceed 0.035 W/ (m.K) at an average temperature of 0°C
3. The insulation shall have fire performance such that it passes Class 1 as per BS 476 Part 7 for surface spread of flame, also pass Fire Propagation requirement as per BS 476 Part 6 to meet the Class 'O' Fire category requirement.
4. It should be self-extinguishing, does not drip and does not spread flames.
5. Moisture Diffusion Resistance Factor or 'μ' value shall be minimum 7,000 for the insulation material without any out covering.

#### **b) Recommended Adhesive:**

1. The adhesive shall be specially formulated for the pipe insulation application and supplied by insulation manufacturer.
2. The adhesive shall be Solvent based rubber insulation adhesive, free from benzene.
3. It should have excellent Bonding to Porous and Non Porous Surfaces.
4. The adhesive shall be quick drying characteristics for tropical conditions and shall have service temperature of -25°C to +90°C.

5. Properties:

Viscosity @ 30°C	:	3500 - 4000 cps
Specific Gravity	:	0.89 - 0.92 g/cc
Density	:	0.085 kg/m <sup>3</sup> + 0.01
Flash Point	:	> 10 °C
Coverage	:	4-5 square meters of bonded material/Litre
Drying Time	:	7 - 8 Minutes
Tack Retention Time	:	25 Minutes

**2.6.2 Bonded Treated Woven Glass Fibre for Outer Covering of Insulation Material**

1. Temperature Range: 0°C to +105°C Overall (irrespective of the base product)  
Colour: Black
2. Treatment: Shall be treated Water Based Acrylic binder to give crisp and non-piling property to the fabric, to help in easy installation, minimize fibre erosion, good aesthetics and resistance to abrasion. Fibre spillage / Thread ravelling should be minimum.

3. Properties:

Density: 200 +/- 20 GSM
Tensile Strength: 275 +/- 25 kg / 50 mm (minimum)
Thickness: 0.18 mm / 7 mill
Type: Solvent based Acrylic Adhesive
Peel Strength: 1000 gm / 25 mm (minimum) - (Adhesive to steel)

4. Thickness:

Inner Pipe Dia.(NB)	Required Thickness	1st Layer thick(mm)	2nd Layer thick(mm)	Class 'O' Nitrile Rubber (Self Sleeve/Pre -Cut sheets)
25	32	32	N/A	Self-Sleeve Class 'O' Nitrile with Company Bonded Cloth in one

				layer
32	32	32	N/A	Self-Sleeve Class 'O' Nitrile with Company Bonded Cloth in one layer
40	32	32	N/A	Self-Sleeve Class 'O' Nitrile with Company Bonded Cloth in one layer
50	38	32	6	1st layer Self-Sleeve tubing & 2nd layer manufacturer bonded Treated Woven Glass fibre covering.
65	38	32	6	1st layer Self-Sleeve tubing & 2nd layer manufacturer bonded Treated Woven Glass fibre covering.
80	38	32	6	1st layer Self-Sleeve tubing & 2nd layer manufacturer bonded Treated Woven Glass fibre covering.
100	38	32	6	1st layer Self-Sleeve tubing & 2nd layer manufacturer bonded Treated Woven Glass fibre covering.
125	44	19	25	1st & 2nd layer manufacturer Pre-Cut (ready to use) Sheet & 3rd layer of readymade manufacturer's supplied Treated Woven Glass fibre covering (as a separate layer).
150	44	19	25	1st & 2nd layer manufacturer Pre-Cut (ready to use) Sheet & 3rd layer of readymade manufacturer's supplied Treated Woven Glass fibre covering (as a

				separate layer).
200	44	19	25	1st & 2nd layer manufacturer Pre-Cut (ready to use) Sheet & 3rd layer of readymade manufacturer's supplied Treated Woven Glass fibre covering (as a separate layer).
250	44	19	25	1st & 2nd layer manufacturer Pre-Cut (ready to use) Sheet & 3rd layer of readymade manufacturer's supplied Treated Woven Glass fibre covering (as a separate layer).
300	50	25	25	1st & 2nd layer manufacturer Pre-Cut (ready to use) Sheet & 3rd layer of readymade manufacturer's supplied Treated Woven Glass fibre covering (as a separate layer).
350	50	25	25	1st & 2nd layer manufacturer Pre-Cut (ready to use) Sheet & 3rd layer of readymade manufacturer's supplied Treated Woven Glass fibre covering (as a separate layer).
400	50	25	25	1st & 2nd layer manufacturer Pre-Cut (ready to use) Sheet & 3rd layer of readymade manufacturer's supplied Treated Woven Glass fibre covering (as a separate layer).
450	50	25	25	1st & 2nd layer manufacturer Pre-Cut (ready to use) Sheet & 3rd layer of readymade manufacturer's supplied Treated

				Woven Glass fibre covering (as a separate layer).
500	50	25	25	1st & 2nd layer manufacturer Pre-Cut (ready to use) Sheet & 3rd layer of readymade manufacturer's supplied Treated Woven Glass fibre covering (as a separate layer).

### 2.6.3 Insulation Using Nitrile Rubber Sheets / Roll:

#### a. Material:

1. Insulation material shall be Closed Cell Elastomeric Nitrile Rubber
2. Thermal conductivity of elastomeric nitrile rubber shall not exceed 0.035 W/(m.K) at an average temperature of 0 °C
3. The insulation shall have fire performance such that it passes Class 1 as per BS 476 Part 7 for surface spread of flame, also pass Fire Propagation requirement as per BS 476 Part 6 to meet the Class 'O' Fire category requirement.
4. It should be self-extinguishing, does not drip and does not spread flames
5. Moisture Diffusion Resistance Factor or 'μ' value shall be minimum 7,000 for the insulation material without any out covering

#### b. Recommended Adhesive:

1. The adhesive shall be specially formulated for the pipe insulation application and supplied by insulation manufacturer.
2. The adhesive shall be Solvent based rubber insulation adhesive, free from benzene.
3. It should have excellent Bonding to Porous and Non Porous Surfaces.
4. The adhesive shall be quick drying characteristics for tropical conditions and shall have service temperature of -25°C to +90°C.

## 5. Properties

Viscosity @ 30°C	:3500 - 4000 cps
Specific Gravity	:0.89 - 0.92 g/cc
Density	:0.085 kg/m <sup>3</sup> + 0.01
Flash Point	:> 10 °C
Coverage	:4-5 square meters of bonded material/Litre
Drying Time	:7 - 8 Minutes
Tack Retention Time	: 25 Minutes

### **c. Bonded Treated Woven Glass Fibre for Outer covering of Insulation Material:**

1. Temperature Range: 0°C to +105°C Overall (irrespective of the base product)  
Colour: Black

2. Treatment: Shall be treated Water Based Acrylic binder to give crisp and non-piling property to the fabric, to help in easy installation, minimize fibre erosion, good aesthetics and resistance to abrasion. Fibre spillage / Thread ravelling should be minimum.

#### 3. Properties:

Density: 200 +/- 20 gsm

Tensile Strength: 275 +/- 25 kg / 50 mm (minimum)

Thickness: 0.18 mm / 7 mill

Type: Solvent based Acrylic Adhesive

Peel Strength: 1000 gm / 25 mm (minimum) - (Adhesive to steel)

#### 4. Thickness of Insulation:

Inner Pipe Dia.(NB)	Required Thickness	1st Layer thick(mm)	2nd Layer thick(mm)	Class 'O' Nitrile Rubber (Self Sleeve/Pre -Cut sheets)
25	32	32	N/A	Self-Sleeve Class 'O' Nitrile with Company Bonded Cloth in one layer and above it 2 layers of FRP lining with Epoxy Resin

32	32	32	N/A	Self-Sleeve Class 'O' Nitrile with Company Bonded Cloth in one layer above it 2 layers of FRP lining with Epoxy Resin
40	32	32	N/A	Self-Sleeve Class 'O' Nitrile with Company Bonded Cloth in one layer above it 2 layers of FRP lining with Epoxy Resin
50	38	32	6	1st layer Self-Sleeve tubing & 2nd layer manufacturer bonded Treated Woven Glass fibre covering. above it 2 layers of FRP lining with Epoxy Resin
65	38	32	6	1st layer Self-Sleeve tubing & 2nd layer manufacturer bonded Treated Woven Glass fibre covering. above it 2 layers of FRP lining with Epoxy Resin
80	38	32	6	1st layer Self-Sleeve tubing & 2nd layer manufacturer bonded Treated Woven Glass fibre covering. above it 2 layers of FRP lining with Epoxy Resin
100	38	32	6	1st layer Self-Sleeve tubing & 2nd layer manufacturer bonded Treated Woven Glass fibre covering. above it 2 layers of FRP lining with Epoxy Resin
125	44	19	25	1st & 2nd layer manufacturer Pre-Cut (ready to use) Sheet & 3rd layer of readymade manufacturer's supplied Treated Woven Glass fibre covering (as a separate layer). above it 2 layers of FRP lining with Epoxy Resin
150	44	19	25	1st & 2nd layer manufacturer Pre-Cut (ready to use) Sheet & 3rd layer of readymade manufacturer's supplied Treated Woven Glass fibre covering (as a separate layer). above it 2 layers of FRP lining with Epoxy Resin
200	44	19	25	1st & 2nd layer manufacturer

				Pre-Cut (ready to use) Sheet & 3rd layer of readymade manufacturer's supplied Treated Woven Glass fibre covering (as a separate layer). above it 2 layers of FRP lining with Epoxy Resin
250	44	19	25	1st & 2nd layer manufacturer Pre-Cut (ready to use) Sheet & 3rd layer of readymade manufacturer's supplied Treated Woven Glass fibre covering (as a separate layer). above it 2 layers of FRP lining with Epoxy Resin
300	50	25	25	1st & 2nd layer manufacturer Pre-Cut (ready to use) Sheet & 3rd layer of readymade manufacturer's supplied Treated Woven Glass fibre covering (as a separate layer). above it 2 layers of FRP lining with Epoxy Resin
350	50	25	25	1st & 2nd layer manufacturer Pre-Cut (ready to use) Sheet & 3rd layer of readymade manufacturer's supplied Treated Woven Glass fibre covering (as a separate layer). above it 2 layers of FRP lining with Epoxy Resin
400	50	25	25	1st & 2nd layer manufacturer Pre-Cut (ready to use) Sheet & 3rd layer of readymade manufacturer's supplied Treated Woven Glass fibre covering (as a separate layer). above it 2 layers of FRP lining with Epoxy Resin
450	50	25	25	1st & 2nd layer manufacturer Pre-Cut (ready to use) Sheet & 3rd layer of readymade manufacturer's supplied Treated Woven Glass fibre covering (as a separate layer). above it 2 layers of FRP lining



				with Epoxy Resin
500	50	25	25	1st & 2nd layer manufacturer Pre-Cut (ready to use) Sheet & 3rd layer of readymade manufacturer's supplied Treated Woven Glass fibre covering (as a separate layer). above it 2 layers of FRP lining with Epoxy Resin

#### 2.6.4 PUF/Rigid Phenolic Foam (Phenotherm):

1. The thickness shall be as follows:

- For pipes 32 mm diameter – minimum 25 mm thick pipe sections.
- For pipes from 40 mm to 125 mm diameter-minimum 30 mm pipe sections.
- For pipes from 150 mm diameter and above - minimum 50 mm pipe.

2. For pipes running inside trenches, cement plastering shall be carried out with minimum 15 mm thick after covering insulation with chicken wire mesh. Cement water based proof paint shall be applied.

3. For pipes running inside plant room and building above false ceiling , Aluminium cladding of minimum 28 SWG thickness shall be fixed over insulation.

4. The adhesive to be used shall be fire retardant and specially formulated for pipe and shall be supplied by insulation manufacturer. It shall have excellent bonding properties and shall be suitable for service temperature of -5 ° C to + 85° C

5. PUF/Rigid phenolic foam shall confirm to the following:

- Thermal conductivity (<0.023 w/m °K)
- Compressive strength
- Closed cell content (<88%)

#### 2.6.5 Insulation with Rockwool Sections:

1. The thickness shall be as follows:

- For pipes 32 mm diameter – minimum 40 mm thick pipe sections.

- For pipes from 40 mm to 125 mm diameter-minimum 50 mm pipe sections.
  - For pipes from 150 mm diameter and above- minimum 75 mm pipe sections.
2. Aluminium cladding of minimum 28 SWG shall be fixed over the insulation
  3. The adhesive to be used shall be fire retardant and specially formulated for pipe and shall be supplied by insulation manufacturer. It shall have excellent bonding properties and shall be suitable for service temperature of -5 ° C to + 85 ° C
  4. Rock wool insulation shall confirm to the following:
    - Thermal conductivity (<0.034 w/m °K)

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**SPECIFICATIONS FOR AIR-CONDITIONING  
AND VENTILATION WORKS**

**SECTION - V  
EXPANSION TANKS**

## **1. OPEN TYPE EXPANSION TANK**

### **1.1 GRP Panel Tank:**

The expansion tank shall be of sectional construction of size indicated as per the specifications specified elsewhere and shall be made by the assembly of modular hot compression moulded GRP panels bearing IS 14399 (Part I) marking.

The panels shall be of minimum 9mm thickness at the flanges and 3mm minimum at the central portion of the shell. Where necessary, flat panels shall be used to accommodate the inlet, outlet overflow and drain connections. The flat panels shall have 11.5 mm thickness at the flanges and minimum 3mm at the flat portion.

All panels shall be insulated with 40 mm thick polyurethane foam with 2mm thick FRP/GRP protective skin on the outer side. The panels should have sufficient strength and rigidity to withstand hydrostatic pressure. The joints between the panels shall be sealed by using gaskets made of closed cell PVC foam to ensure water tightness.

The hardware used for fastening the panels shall be hot dip galvanized high tensile steel. All fasteners, flange support 'C' channels and metal stiffeners and tie rods (used for tanks deeper than 1.5m) shall be hot dipped galvanized and shall be used externally to avoid contact with the water stored.

Inlet & outlet drain and overflow nipples shall be provided either in PVC or MS as per the instruction of the Engineer in charge. However, the material, sizes and specifications of the nozzles shall be pre-determined before the supply of the tank. The expansion tank shall have float valve assembly and manhole with lockable cover.

## **2. CLOSED EXPANSION TANK**

The tank shall be pre charged steel expansion tank with replaceable heavy duty butyl rubber bladder. The Tank shall be Vertical and shall be of suitable size & must be constructed in accordance with section VIII of the ASME Boiler and pressure vessel code & shall be rated for 10 Kg/Cm<sup>2</sup> and with stand a test pressure of 15Kg/Cm<sup>2</sup>. (Test certificate shall be submitted for this test). The tank shall be fitted with lifting rings and a floor mounting skirt for vertical installation. The Tank shall be provided with a pressure relief valve set at a pressure corresponding to the static head in the system. The tank shall have provision for air filling & draining water connections with isolating valves.

The bladder shall be flexible, replaceable and held on both the sides of the tank to avoid failure. The bladder shall be butyl reinforced with Nylon & shall have a minimum life of 5 years.

For tanks bigger than 3000 litres, tank shall have a sight glass & level indicator for detection of bladder failure and shall have pressure gauge fitted along with Midget Poppet Valve to enable reading of air pressure prior to water charging. The tank shall be insulated with material as indicated in SOQ.

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**SPECIFICATIONS FOR AIR-CONDITIONING  
AND VENTILATION WORKS**

**SECTION - VI  
AIR HANDLING UNITS**

## **1. DOUBLE SKIN AIR HANDLING UNITS**

### **1.1 Housing / Casing:**

Air handling unit shall be of draw-through type comprising of filter sections, Return Air/Fresh Air mixing section, cooling coil section, fan section etc. as specified in tender SOQ. The various sections are assembled with self-supporting modular framework constructed of corrosion resistant extruded aluminium profiles joined by moulded high tensile reinforced plastic and shall be assembled to provide a sturdy, strong and self-supporting frame work for the various sections. The entire module is mounted on a continuous beam of heavy galvanized steel channel/sectional aluminium alloy base frame. The frame shall be capable of supporting the components and fittings forming the AHU and withstanding the pressure within the Air system under operating conditions.

The casing of each module shall have double skin construction fabricated from minimum 0.6 mm thick pre-coated GSS for outer skin and minimum 0.6 mm thick plain GSS/0.8 mm thick Aluminium/SS sheet for inner skin with minimum 40 mm/23 mm thick PUF insulation of 40 kg/cum density sandwiched in between as specified in tender SOQ. These panels shall be screwed on to the frame work with soft rubber/neoprene gasket fixed in built-in groove of aluminium frame in between to make joints air tight. Suitable air tight access doors/panels with Nylon or aluminium die cast heavy duty hinges and locks, lights, limit/interlock switch, view glass, belt guard as applicable shall be provided for various sections.

Units installed outside shall be protected with duly sloped weather proof canopy manufactured from aluminium and shall extend on all sides of unit to avoid rain water to fall on side panels.

For clean room AHUs, provision of extruded aluminium face and by pass dampers to be made. Bypass area shall be as indicated in tender SOQ.

AHUs requiring mixing box shall be complete with fresh and return air dampers. Dampers shall be opposed blade type. Blades shall be with aerofoil section made of extruded aluminium alloy frame. Manual dampers shall be provided with a Bakelite knob for locking the damper blades in position. Linkages shall be extended wherever specified for motorized operation. Damper frames shall be sectional to minimize blade wrapping. Air leakage through dampers shall be minimum when in

the closed position and preferably shall not exceed 1.5% of the maximum design air volume flow rate at the maximum design air total pressure.

One-piece drain pan shall be constructed of minimum 1.0 mm stainless steel welded joints with necessary slope to facilitate fast removal of condensate water. Necessary supports will be provided to slide the coil in the drain pan. Outlet shall be provided on both the sides of drain pan. The drain pan shall be sized larger than coil to collect condensate water from coil bends & other control units. The entire assembly shall be mounted on insulated bottom panel.

The casing shall incorporate thermal break profile and all other necessary design features to ensure that condensation does not occur during all seasons

### **1.2 Fan and motor assembly:**

The fan-motor assembly shall be mounted inside the casing, on a separate base frame made up of aluminium profiles and fixed on spring type vibration isolators. Fan wheel and housing shall be fabricated from heavy gauge steel. Fans should be statically and dynamically balanced and shall have sealed type bearings having 100000 hours operating life. Fans shall be DIDW Aerofoil/Backward/Forward curved (as specified in tender SOQ). Fan shaft shall be of solid construction and of EN-8 steel. The entire housing shall be mounted on extruded aluminium channel frame work, with suitable pads for vibration isolation. Fan motors shall be mounted inside the AHU casing on slide rails for easy belt tensioning in case of belt driven motors. Drive to fan shall be provided through belt-drive with bolt and adjustable motor sheave. Belts shall be of the oil-resistant type. Base frame shall be fixed to casing through suitable vibration isolators. Wherever to be used with VFD, the motor should be suitable for the same and temperature should not rise at low speed. Outlet velocity from fans shall not exceed 550 mtr/min.

AHUs shall incorporate standby drive arrangement comprising of additional motor & pulley/belts if specified in tender/SOQ. Motors for AHUs shall be efficiency class IE3 level or better.

Alternately, motors with plug fans are accepted unless otherwise specified in SOQ.

All the finishes of AHUs for clean rooms, including that of fan-motor assembly, shall be compatible for clean room application.

### **1.3 Cooling / Heating coils:**



Chilled/Hot water coils shall be of minimum 12 mm dia tubes and minimum 0.43mm thick or as specified in the tender schedule with sine wave aluminium fins, firmly bonded to copper tubes assembled in zinc coated steel frame, cooling/heating coil shall be integrally finned type with hydrophobic coating. Face and surface areas shall be such as to ensure rated capacity from each unit and such that the air velocity across each coil shall not exceed 153 meters per minute. The end plates shall be made out of 1.2 mm thick (min.) stainless steel. The coil shall be pitched in the unit casing for proper drainage. Each coil shall be factory tested at 21 kg /Sq.cm air pressure while submerged in water for a minimum period of two hours. Tube shall be expanded mechanically by passing of bullet for minimum thermal contact resistance with fins. Cooling coils shall have minimum 433 fins per meter (FPM) and heating coil shall have minimum 315 fins per meter (FPM) or as specified in SOQ. Copper bends shall be brazed by holding the coils vertically to achieve clean finish.

#### **1.4 Filters:**

Filter sections of AHUs comprise, MERV-8 on upstream side, MERV-13, Superfine (Semi HEPA) and HEPA filters on downstream side complete as required and as specified in tender SOQ and meeting the following specifications:

##### **a) MERV-8 Filters:**

MERV-8 pre-filter shall be grade G4/EU4 as per EN-779, flange type with non-woven synthetic media washable type, average arrestance of 85% down to 10 Microns. Media is characterized by relatively low resistance and high dust holding capacity with HDPE mesh both sides, pleated design with pleats support of GI rods and adhesive material made of polyurethane. The filters shall be of size 610 x 610 x 300 mm including flange. Effective filtration area -550x 550 mm. Material of construction-Aluminium. The total no. of filters shall be worked out based on the size and Air quantity to be catered to by the AHU.

##### **b) MERV-13 filters:**

MERV-13 Fine-filters shall be grade F7/EU7 as per EN 779, flange type with non-woven synthetic media washable type, average efficiency of 85 to 90%. The efficiency for 3 microns will be minimum 98%. Media is characterized by relatively low resistance and high dust holding capacity with HDPE mesh both sides, pleated design with pleats support of GI rods and adhesive material made of polyurethane. The filters shall be of size 610mm x 610mm x 300 mm or 610mm x 610mm x 150

mm including flange. Effective filtration area -550x 550 mm. Material of construction-Aluminium. The total no. of filters shall be worked out based on the size and Air quantity to be catered to by the AHU. The filter medium area shall be minimum 8 sq.m. The air quantity and initial pressure drop through the filter shall be as specified in SOQ.

**c) Superfine or Semi HEPA Filters:**

Superfine filters unless otherwise specified with H-11 media confirming to EN 1822 with minimum efficiency of 95% at 0.3 micron, flange type, imported glass fibre media, pleated design with pleats uniformly spaced by aluminium separators. The filters shall be of size 610mm x 610mm x 300mm or 610mm x 610mm x 150 mm including flange. Effective filtration area -550mm x 550 mm. Material of construction-Aluminium. The total no. of filters shall be worked out based on the size and Air quantity to be catered to by the AHU. The filter medium area shall be minimum 12 sq.m. The air quantity and initial pressure drop through the filter shall be as specified in SOQ.

**d) HEPA Filters:**

HEPA filters unless otherwise specified with H-13 media confirming to EN 1822 with minimum efficiency of 99.97% at 0.3 micron, flange type, imported glass fibre media, pleated design with pleats uniformly spaced by aluminium separators. The filters shall be of size 610mm x 610mm x 300mm or 610mm x 610mm x 150 mm including flange. Effective filtration area -550mm x 550 mm. Material of construction-Aluminium. The total no. of filters shall be worked out based on the size and Air quantity to be catered to by the AHU. The filter medium area shall be minimum 20 sq.m. The air quantity and initial pressure drop through the filter shall be as specified in SOQ.

**1.5 Isolators:**

Vibration isolators shall be provided in all floor mounted air handling units. AHUs mounted within the ceiling space shall be hung through vibration isolation suspensions. Suitable vibration isolators shall be provided with minimum of 90% vibration isolation efficiency.

**1.6 Accessories:**

Each air handling unit shall be provided with air vent at highest point in the cooling coil and drain plug at the bottom of coil. In addition, the following

accessories shall be required at air handling units, as described in the schedule of quantities:

- a) Double flexible connection at the outlet of supply air fan. The flexible connection shall be of fire retardant & lint free material.
- b) Vibration Isolators in the form of Ribbed rubber pads between the base frame and the pedestals.

### **1.7 Performance data**

Air handling units shall be selected for the lowest noise level of the equipment. Fan performance rating and power consumption data with operating points clearly indicated shall be submitted with the tender or during execution stage and verified at the time of testing and commissioning of the installation.

### **1.8 Testing:**

Cooling/Heating capacity of various air handling unit models shall be computed from the measurements of air flow and dry and wet bulb temperatures of air entering and leaving the coil and shall be as per the rated capacity. Flow measurements shall be accurately calibrated. Computed results shall conform to the specified capacities and quoted ratings. Power consumption shall be computed from measurements of incoming voltage and input current.

AHUs shall be designed to meet the technical parameters indicated in tender schedule/SOQ.

All AHUs shall confirm to EN 1886 or equivalent standards in respect of following parameters:

Class T2 for Thermal transmittance.

Class TB2 for Thermal bridging factor.

Class L1 for air leakage factor.

Class D1 for casing strength.

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## **2. VENTILATION AIR HANDLING VENTILATION UNITS**

### **2.1 Housing/Casing (Double skin):**

Air handling ventilation unit shall be suitable for ceiling/ floor mounting. The frame work of the AHU shall be of extruded aluminium sections joined by moulded high tensile reinforced plastic and shall be assembled to provide a sturdy, strong and self-supporting frame work for the various sections. Each section shall be complete with its own independent base and mounted on 14 gauge galvanised sheet steel channels and aluminium die-cast legs, with provision for lifting holes.

The casing of each module shall have double skin construction fabricated from 0.6 mm thick GSS for outer skin and 0.6 mm thick GSS/0.8mm Aluminium/SS sheets for inner skin with minimum 40/23 mm thick CFC free PUF insulation of 40±2 kg/cum density sandwiched in between. Zinc deposition on GI sheets shall be minimum 120 gm/sq. m of sheet. These panels shall be screwed on to the frame work with soft rubber gasket fixed in built-in groove of aluminium frame in between to make joints air tight. Frame work for each section shall also be joined together with soft rubber gasket in between to make joints air tight. Suitable air tight access doors/panels with Nylon or aluminium die cast heavy duty hinges and locks shall be provided for various sections. Suitable doors with aluminium die cast hinges and latches shall be provided for access to various panels for maintenance. Access panel shall be provided with safety screen. The entire housing shall be mounted on steel channel frame work.

### **2.2 Housing/ Casing (Single Skin):**

The unit shall be of sectionalized/unitary, single skin construction consisting of fan section, coil section with cooling coil, filter section and an insulated drain pan. Each section shall be constructed of 16-gauge GI/MS sheet steel with spray galvanizing, all welded/bolted construction, adequately reinforced with structural members and provided with access panels with safety screen for maintenance. Base panels shall be constructed of fabricated steel sheets suitably braced. Removable panels in fan sections shall provide access to all internal parts and also when dismantling of unit is required. Fan section panels shall be internally lined with 25 mm thick resin bonded fibreglass as per section "Acoustic Lining". Cover of drip tray should be galvanised sheet steel at least 20/25 micron galvanised.

### **2.3 Fan and Motor Assembly:**

The fan-motor assembly shall be mounted inside the casing, on a separate base frame made up of aluminium profiles and fixed on spring type vibration isolators. Fans should be statically and dynamically balanced and shall have sealed type bearings having 40,000 hours operating life. Fan shaft shall be of solid construction and of EN-8 steel. The entire housing shall be mounted on extruded aluminium channel frame work, with serrated rubber pads for vibration isolation. Fans shall be DIDW backward/forward curved as indicated in tender SOQ. Outlet velocity from fans shall not exceed 550 mtr/min. Fan section shall be provided with an Access door & a limit switch. The access door shall be interlocked with fan motor. Fan motors shall be mounted inside the AHU casing on slide rails for easy belt tensioning and motor efficiency shall be class IE3 level or better. Drive to fan shall be provided through belt-drive with bolt and adjustable motor sheave. Belts shall be of the oil-resistant type. Base frame shall be fixed to casing through suitable vibration isolators. Wherever to be used with VFD the motor should be suitable for the VFDC fan and temperature should not rise at low speed.

### **2.4 Isolator:**

Vibration isolators shall be provided in all floor mounted air handling units. AHUs mounted within the ceiling space shall be hung through vibration isolation suspensions. The vibration isolators shall be of cushy foot mounts/spring type for a minimum of 90% vibration isolation efficiency.

### **2.5 Painting:**

Shop coats of paint that have become marred during shipment or erection shall be cleaned off with mineral spirits, wire brushed and spot primed over the affected areas, then coated with enamel paint to match the finish over the adjoining shop painted surfaces.

### **2.6 Performance Data:**

Ventilation Air units shall be selected for the lowest noise level of the equipment. Fan performance rating and power consumption data with operating points clearly indicated shall be submitted with the tender or during execution stage and verified at the time of testing and commissioning of the installation.

## **2.7 Testing:**

Air Flow measurements shall be accurately measured using calibrated instruments. Computed results shall conform to the specified capacities and quoted ratings. Power consumption shall be computed from measurements of incoming voltage and input current.

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### **3. TUBE AXIAL FANS FOR VENTILATION**

#### **3.1 Axial Fans:**

Axial fans shall be complete with motor, motor mount, direct driven and vibration isolation type, suspension arrangement etc. complete as required. These fans shall be suitable fresh air meant for Car park ventilation/staircase pressurization/Lift/Lift lobby pressurization.

#### **3.2 Casing:**

Casing of axial fans shall be constructed of heavy gauge sheet steel as per DIN EN ISO 1461 or equivalent. Fan casing and motor mount shall be of welded steel construction. Casing should have Spun flanged at both ends for high rigidity as per EUROVENT or equivalent standards suitable for ducted connection. Support brackets for ceiling suspension shall be welded to the casing for connection to hanger bolts. Axial fans shall be suspended using spring loaded hangers to be mounted inside masonry shafts as indicated in the tender drawings/SOQ. Suitable anti vibration mountings shall be provided. Casing shall be hot dip galvanized to protect against corrosion. Length of the casing shall be greater than the length of fan & motor assembly.

#### **3.3 Impeller:**

Casing of axial fans shall be constructed from die cast aluminium. Profiles of impeller blade should be of aerofoil type to have high efficiency and low noise levels. Impeller must be statically and dynamically balanced as per ISO 1940. Fan shall be selected based on best efficiency points with fan pitch angle selected in the middle range out of available whole range of fan pitch angle to allow possible fan speed adjustment on site. All aluminium cast components are X-rayed prior to assembly.

#### **3.4 Fan Motor:**

Fan motor shall be of IE3 or better energy efficiency, squirrel cage, totally enclosed, fan cooled, standard frame, continuous duty, winding type suitable for 415V±10%/3 ph./50 Hz, AC power supply providing with F class insulation with IP55 in accordance with IEC 60034-5 or equivalent for degree of protection and IEC 60085 or equivalent for thermal evaluation. The Fan-motors shall be suitable for variable speed drives.

Fan shall be selected for maximum efficiency or minimum horsepower. Motor shall be specially designed for low noise operation. The motor bearings should be life lubricated and completely maintenance free and can be used at any installation position at indicated maximum temperature of transported air. The life expectancy of the bearing should be at least 40000 hours.

Motor conduit box shall be mounted on exterior of fan casing, and lead wires from the motor to the conduit box shall be protected from the air stream by enclosing in a flexible metal conduit. Fan shall be direct driven to have fewer losses in transmission and shall be mounted on extended motor shaft of carbon steel material.

All fixing / supports to be zinc coated to offer excellent corrosion resistance.

All motor supports are plate type to offer minimal resistance to airflow. These areas are carefully spaced away from the impeller to minimize noise generation.

### **3.5 Vibration Isolation:**

The assembly of fan and motor shall be suspended by vibration isolation suspension of rubber -in -shear type.

### **3.6 Accessories:**

The following accessories shall be provided :( wherever applicable)

- Outlet cone for static pressure regain.
- Bell mouth inlet (if not ducted inlet) with suitable wire guard

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## **4. AXIAL SMOKE SPILL FANS**

### **4.1 Axial Fans:**

Axial fans shall be complete with motor, motor mount, direct driven and vibration isolation type, suspension arrangement etc. complete as required. These fans shall be suitable for handling smoke exhaust which may be up to a temperature of 300 Deg. C and for a period up to 2 Hrs. as per EN 12101-3 or equivalent.

### **4.2 Casing:**

Casing of axial fans shall be constructed of heavy gauge sheet steel as per DIN EN ISO 1461. Fan casing and motor mount shall be of welded steel construction. Casing should have Spun flanged at both ends for high rigidity as per EUROVENT or equivalent standards suitable for ducted connection. Support brackets for ceiling suspension shall be welded to the casing for connection to hanger bolts. Axial fans shall be suspended using spring loaded hangers to be mounted inside masonry shafts as indicated in SOQ/ tender drawings. Suitable anti vibration mountings shall be provided. Casing shall be hot dip galvanized to protect against corrosion. Length of the casing shall be greater than the length of fan & motor assembly.

### **4.3 Impeller:**

Impeller of axial fans shall be constructed from die cast aluminium. Profiles of impeller blade should be of aerofoil type to have high efficiency and low noise levels. Impeller must be statically and dynamically balanced as per ISO 1940. Fan shall be selected based on best efficiency points with fan pitch angle selected in the middle range out of available whole range of fan pitch angle to allow possible fan speed adjustment on site. All aluminium cast components are X-rayed prior to assembly.

### **4.4 Fan Motor:**

Fan motor shall be IE3 or better energy efficiency, squirrel cage, totally enclosed, fan cooled, standard frame, continuous duty, winding type suitable for 415±10% / 3 ph./50Hz, AC power supply providing with H class insulation with IP55 in accordance with IEC 60034-5 or equivalent for degree of protection and IEC 60085 or equivalent for thermal evaluation. The Fan-motors shall be suitable for variable speed drives.

The speed of the fans can be upto 3000 RPM. Fan shall be selected for maximum efficiency or minimum horsepower. Motor shall be specially designed for low noise operation. The motor bearings should be life lubricated and completely maintenance free and can be used at any installation position at indicated maximum temperature of transported air. The life expectancy of the bearing should be at least 40000 hours.

Motor conduit box shall be mounted on exterior of fan casing, and lead wires from the motor to the conduit box shall be protected from the air stream by enclosing in a flexible metal conduit. Fan shall be direct driven to have fewer losses in transmission and shall be mounted on extended motor shaft of carbon steel material.

All fixing / supports to be zinc coated to offer excellent corrosion resistance.

All motor supports are plate type to offer minimal resistance to airflow. These areas are carefully spaced away from the impeller to minimize noise generation.

#### **4.5 Vibration Isolation:**

The assembly of fan and motor shall be suspended by vibration isolation suspension of rubber -in -shear type.

#### **4.6 Accessories:**

The following accessories shall be provided :( wherever applicable)

- Outlet cone for static pressure regain.
- Bell mouth inlet (if not ducted inlet) with suitable wire guard

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## **5. JET FANS**

### **5.1 Composition:**

The fan should be furnished as factory assembled, having characteristic as high performance of ventilation with small air volume. Each unit shall consist of inlet bell mouth with protective screen, silencer both inlet and outlet discharge nozzle, terminal box and mounting arm.

### **5.2 Fan:**

A unique high efficiency Aerofoil section blade shall have smoothed hub and clamp-plate for adjustable pitch angle flexibility. The impellers shall be of precision die-cast to offer thin Aerofoil sections for low generation of noise levels. Every cast aluminium component shall be X-rayed using Real Time Radiography inspection prior to assembly. This feature shall provide evidence of casting quality against product liability legislation if specified.

Aerofoil Fan impellers shall have a unique aerodynamic section blade to optimize the efficiency of performance and minimize the generation of noise. The thin sections shall be obtained by precision die cast manufacturing techniques to have a lighter weight assembly. (Precision die cast aluminum hub and clamp-plate shall be equally spaced, fully adjustable, high pressure die cast Aerofoil section blades)

All rotating aluminium components shall be X-ray examined prior to machining to assure quality and suitable for operation at 300 Deg C for one hour.

### **5.3 Component specifications:**

#### **A. Casings:**

Either a long cased form complete with an externally mounted pre-wired electrical terminal box, or short cased for duct or plate installation. Casings are spun from sheet steel with integral pre-drilled flanges, fully welded seams and hot-dipped galvanized after manufacture for excellent durability.

#### **B. Motors:**

Squirrel cage type, insulated to class H, bearings lubricated with wide temperature grease, keyed shaft and weatherproof to IP55. (Overheat protection shall be provided on most single phase motors).

Speed operation by Delta/Star reconnection shall be available on three phase motor up-to frame size F22. Two speeds can be obtained by reconnecting a single winding via six winding terminals to give two separate pole numbers, Integral pre-wired capacitor on most single phase fans or dual wound of motor which has two separate individual windings of the requisite poles to give the speeds required.

Performance shall be independently approved by AMCA and established in accordance with ISO 5801 installation category D, method of testing air performance and method of noise testing as per relevant IS or equivalent standards.

**C. Discharge nozzle:**

The nozzle shall be made of aluminium round shaped aerodynamically and finished with polishing coat.

**D. Silencer (inlet and outlet):**

Silencer casing is made of 1.0 mm thickness and 710 mm long (min)of cold mill steel. It is baked enamel coated on outside casing. Inside of casing shall be contained 25 mm thickness glass wool and finish with punched stainless steel sheet.

**E. Inlet bell mouth:**

The bell mouth is made of aluminium 3003 and transparent paint coated. It is Shaped to reduce air turbulence in the inlet of the fan.

**F. Protective bird screen:**

The screen shall be circle screen, made of chrome coated.

**G. Terminal box:**

The box shall be equipped with high temperature type indication lamp The wire to the motor shall be enclosed with fiberglass tube for fire protection. It shall be sealed with fire rated sealant and all internal wiring and components tested as per relevant IS or equivalent standards.

**H. Mounting arm:**

Mounting arm shall be permitted adjustment of the air stream, discharge of 180 degrees angle horizontally and 90 degrees of vertically.

**I. Acoustic Data:**

The sound levels quoted shall be based on tests shall be carried out by the manufacturer in-house certified laboratory by AMCA and British Standards by using the spectrum corrections stated on each performance chart, an un-weighted sound power spectrum shall be obtained for the fan.

**J. Non-overloading:**

The fans shall have a non-overloading characteristic; the peak power input occurs within the range of normal operating pressures and is always exceeded by the motor rating.

**K. Testing:**

Performance data has been obtained in accordance with the internationally recognized standard – ISO 5801 installation category D (AMCA approved) for aerodynamic performance and relevant IS or equivalent standards for acoustic performance.

**L. Fixings:**

All fixings are protected with an organically based zinc coating to provide excellent corrosion resistance

**M. Ancillaries for Jetvent fan as required:**

- Mounting Feet
- Impeller and Motor Side Guards
- Two Silencers of length 710 mm (Minimum) with pod.
- Matching Flanges
- Bellmouth Inlets

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**SPECIFICATIONS FOR AIR-CONDITIONING  
AND VENTILATION WORKS**

**SECTION - VII  
PACKAGE UNITS**

## **1. PRECISION PACKAGE UNITS**

### **1.1 General:**

Precision Air-conditioning units (Air-cooled) shall be of high sensible cooling capacity and self-contained unitary packaged Air-conditioners. Units shall feature low running costs, achieved by means of state-of-art design combined with accurate selection of components.

Precision unit shall be of DX/ Dual fluid / Chilled water type as specified in SOQ.

Accessibility for all the equipment of the units shall be provided in order to carry out standard maintenance. All the individual components as well as the packaged unit, as a whole shall be tested as per the relevant standards or as specified in SOQ.

Thermo-acoustic lining for fan section, coil section etc., shall be provided as required and the noise level of indoor & outdoor units shall not exceed 70 dB(A) and 75 dB(A) respectively within 1m of the units.

### **1.2 Cabinet Construction:**

Units shall be constructed with sufficient strength and rigidity to withstand normal manual and mechanical handling transportation and usage. The cabinet housing the components of PACs shall be at least 16-gauge (1.29 mm) steel sheet and shall be suitable for floor mounting. This cabinet shall be preferably of riveted construction for improved rigidity and panel alignment. The cabinet shall be given 2 coats of rust preventive paint.

### **1.3 Compressors:**

The Compressors shall be of latest generation hermetic scroll type characterized by a high COP and shall be suitable for R-410a / R-407c. Compressor shall be mounted on suitable vibration isolation mountings and shall be complete with suction and discharge service valves, hi-low pressure safety controls and built-in over load protection. Pump down control shall be provided with liquid line solenoid valve. The low-pressure switch shall have automatic reset whereas the high-pressure switch shall be equipped with manual reset. The compressor shall be driven by suction gas cooled motor of adequate horse power and shall be complete with starter. The



motor shall be suitable for operation on 415 V $\pm$ 10%, 50 Hz 3, Phase power supply. Crankcase heaters as required for the compressor shall be provided. Motor winding thermostat shall be preferably installed for compressor motors.

#### **1.4 Evaporator Coil:**

Cooling coil shall be of direct expansion type made of seamless copper tubes of not less than 12mm OD and complete with aluminum fins numbering not less than 500  $\pm$ 10 per mtr. The cooling coil shall have a large face area and adequate rows to take care of the high sensible heat of the cooling load. Refrigerant distributor shall be installed for equal feeding of cooling coil circuits. Insulated drain pan made of stainless steel and drain piping shall be provided for proper drain of the condensate. The cooling coil shall be selected as suitable for under floor air distribution and shall be based on the supply air temperature required for such under floor air distribution/ top discharge / side discharge for server rooms to maintain the desired inside conditions throughout.

#### **1.5 Refrigeration Circuits:**

Refrigerant piping shall be of heavy gauge copper with Electronic Expansion valve (EEV) of adequate capacity and complete as required, shut off valves and HP/LP gauges ports to enable fixing of gauges if so desired. EEV shall ensure precise control and energy efficiency of the cooling cycle.

Liquid receiver with safety plug shall be installed inside the unit to act as storage, absorb refrigerant volume variations and enable wider tolerance in charge accuracy. The circuit shall also include Liquid Line Solenoid Valve & Non-return valve in discharge line to take care of long lengths of piping and for safe operation of compressor.

#### **1.6 Evaporator Fans:**

Single inlet Backward curved centrifugal fan with a low moment of inertia shall be provided to handle the static pressure of the system involved and to deliver the required air quantity as specified in tender schedule. The directly coupled Electronically commuted (EC) electric motor offer the opportunity for speed adjustment by means of controller and complete with thermal protection inside the electric motor winding.

The drive motor of adequate horse power considering the static pressure and air quantity shall be offered. Motor starter shall be installed within the unit. The impellers shall be statically and dynamically balanced with lubricated bearings for quiet vibration free operation. The fan motor arrangement shall be mounted on anti-vibration bases to minimize vibration transmission.

### **1.7 Filtration:**

Necessary washable type Air-filters of minimum MERV-8/ EU 4filter media grade for filtering the supply air level shall be included in the unit. Low airflow and clogged filter alarm sensors consisting of two pressure switches for controlling the operating conditions of the fans shall be provided.

### **1.8 Remote Air-Cooled Condenser:**

The condensers shall be of large face area characterized by a single or dual circuit heat exchanger with aluminum finned hydrophilic coated copper tubes complete with integral sub cooling circuit, with suitable low speed axial flow fan and motor, refrigerant pipe connection, metallic frame work etc. all prewired in a single cabinet, duly painted. The unit shall be covered with aluminum weather cowl which shall be suitably designed to prevent west direction solar rays from directly falling on condenser. The condenser shall be suitable for outdoor duty and operation throughout the year. The steel frame of the condenser shall be hot dip galvanized with a coating of thickness of minimum 100 microns.

Fan speed controller should be provided for remote condenser to allow operation of unit under varying ambient conditions.

### **1.9 Humidification and Dehumidification:**

The precision units shall have humidification and dehumidification featuring the following:

1. Electric heating of adequate capacity with aluminum-finned heating elements (with tubular heaters design) complete with safety thermostat to cut off the power supply and trigger the alarm in the event of overheating. The heating system serves the dual purpose of heating the air to reach & maintain set point and also in the dehumidifying phase for reducing the relative humidity.
2. It shall also be possible to achieve dehumidification by altering ADP.

3. Suitable steam type humidifier shall be provided for precise control of humidity.
4. The accessories for humidification and dehumidification shall ensure maintenance of precise humidity conditions, low energy consumption and greater durability of components.

#### **1.10 Microprocessor Control System:**

The units shall be provided with the latest Microprocessor based controller that monitors, displays and operates the AC system for maintaining the inside design conditions of AC areas throughout the year. This modular expandable controller must be compatible with the Computer. Suitable Electronic Sensors shall be provided for feedback of Room temperature and Room humidity to the Controller. Heaters and humidifier shall be actuated through the Controller based on the temperature and humidity inputs. The microprocessor based control system shall allow monitoring and programming of:

- Room temperature and humidity.
- Set point room temperature and humidity.
- System status.
- Status of each single component of the unit.
- Current operating mode (cooling, heating, dehumidifying, humidifying).
- Date, time and identification display.
- Unit working hours.
- Minimum 6 Fault alarms.

In addition, the controller shall provide necessary alarms to indicate temperature high/low, compressor High Pressure /Low Pressure, no air flow, low humidifier water. The Controller must be easy to operate and shall be provided with push buttons for modifying all parameters, if desired. The unit shall have all the necessary interfaces to connect to a remote Building Management System so that the parameters can be monitored/programmed from the remote terminal. The protocol for communication shall be standard ones such as BACNET or MODBUS.

Following alarms shall be displayed on screen of Microprocessor unit:

- Air flow loss
- Compressor low pressure
- Compressor high pressure

- High/low room temperature
- High/low room humidity
- Filter clog alarm

### **1.11 Electric Switchboard:**

The electrical panel shall be housed in a compartment isolated from the air stream and protected by safety locks and made in compliance with the directive 73/23/EEC and other relevant standards. The units shall be designed for 415V $\pm$ 10% -3Ph-50Hz power supply. Motor starters of all the equipment shall be installed within the unit itself. Switchgears for all the electrical apparatus, humidifier shall be provided in the electrical panel and shall be complete with single phase preventers and overload relays. Automatic restart must be provided after a power failure. A manual electrical disconnect switch shall be installed near the unit in accordance with codes for safety consideration. The switchboard shall include 24 V AC low voltage secondary circuit with isolation transformer, plastic insulating screen for protection from live components, general isolator with mechanical interlock, thermomagnetic circuit breakers for protection and control contacts.

All the units must undergo a safety test cycle to check the continuity of the protection circuit, insulation resistance and a voltage (dielectric strength) test.

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## **2. PACKAGE AIR CONDITIONERS**

Air cooled packaged type air conditioners of nominal cooling capacity shall comprise of hermetic scroll compressor, air cooled condenser, evaporator cooling coil with minimum 3 rows of copper coil with aluminium fins, blower and motor, thermostat, starters for motors of compressors, condenser and blower with over load relay and single phase preventer, HDPE filters, return air slots and associated refrigerant piping all (except condenser unit) housed in a sheet metal cabinet and duly painted. The indoor units comprising of compressor and evaporators shall be installed in the packaged unit room.

The condenser unit shall be of large face area with minimum three rows of copper coil with aluminium fins, integral sub cooling circuit, refrigerant receiver, suitable fan and motor, refrigerant pipe connection, metallic frame work etc. prewired in a single cabinet, duly painted, covered with aluminium weather cowl which shall be suitably designed to prevent west direction solar rays from directly falling on condenser and suitable for outdoor duty and operation throughout the year.

The unit shall be designed for ambient conditions of the location where the unit is being installed. The unit shall be designed to operate on  $415 \pm 10\%$  V, 50 Hz, AC supply and conform to IS:8148/76.

Each unit should be capable of delivering air quantities as indicated in SOQ. Unit should include controls like HP/LP cut out, overload relays etc. The noise level of indoor and outdoor units shall not exceed 70 dB(A) within 1 metre of the units.

Refrigerant used shall be R-407c or equivalent eco-friendly refrigerant. Refrigerant piping of copper with suitable Nitrile rubber thermal insulation wherever required shall be provided. Horizontal refrigerant pipes shall be mechanically protected, wherever running on ground. Condensing units shall be connected to the evaporator/compressor package and the refrigerant piping should include necessary service valves for isolation of refrigerant lines. Each package unit shall be fully automatic in operation.

MS parts including structural members of outdoor condenser units shall be hot dip galvanised/ epoxy coating with a coating thickness of 75-100 microns. Hydrophobic coating (blue fin/gold fin) shall be provided to prevent against corrosion.

Each package unit shall be provided with microprocessor based control system and shall be fully automatic in operation. Auto restart after resumption of power supply

in case of power failures shall be an inbuilt feature of package unit. Display of parameters like return air temperature, status of package unit, Fault / Trip indication shall be provided with packaged unit.

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**SPECIFICATIONS FOR AIR-CONDITIONING  
AND VENTILATION WORKS**

**SECTION - VIII  
VRF SYSTEM**



## **1. VARIABLE REFRIGERANT FLOW (VRF) SYSTEM**

### **1.1 General:**

The VRF system operates on the direct expansion principle, where all indoor units of the premises will be connected to a roof / floor mounted air cooled outdoor unit. The refrigerant in a VRF system is varied to meet the exact requirement of the premises to be cooled. The Co-efficient of performance (COP) at full load i.e. at 100 % load of VRF / VRV AC system shall be as specified in SOQ.

The Indoor Split AC units in general shall conform to IS: 1391 – 1992, Part – II. These shall have standard features such as Air cooled Condensers, Refrigerant Compressors, interconnecting refrigerant Piping, Condensate drain connections, thermostat etc., to make the system complete & give trouble free and satisfactory operation. The units shall be suitable for working under industrial environment and suitable for continuous duty.

Each of the modular outdoor units can be equipped with inverter/ digital scroll type compressors for higher reliability, improved life, better backup and duty cycling purpose. The system shall be capable of changing the rotating speed of compressor by inverter controller in case of inverter compressor and through axial compliance in case of digital scroll compressor to follow variations in cooling and heating load.

Outdoor Units shall be suitable for mix match connection of all type of indoor units. Following types of outdoor units shall be connected to the system:

- Ceiling mounted cassette type
- Ceiling mounted ducted type.
- Wall mounted high wall units
- Floor standing type indoor units.

The refrigerant piping between indoor units and outdoor unit shall be possible to extend up to 1000 m with minimum 70 m level difference without any oil traps. Level difference between indoor units to indoor unit shall be 30 Mtr.

Unless otherwise specified, minimum 1 compressor shall be with inverter type for speed variation/ capacity modulation.

The major components of the VRF system shall comprise the following:

1. Compressors
2. Air-cooled Condenser
3. Condenser fan
4. Evaporator
5. Evaporator fan
6. Filter
7. Controls
8. Refrigerant Circuit
9. Electrics

### **1.2 Outdoor Units (ODUs):**

1. The outdoor unit shall be factory assembled, with weather proof casing constructed from heavy gauge mild steel panels and coated with baked enamel finish. The unit should be completely factory wired tested with all necessary controls.
2. It should also be provided with duty cycling for multiple compressor switching starting sequence for better stability and prolonged equipment life.
3. The outdoor unit shall be modular in design and should be allowed for side by side installation.
4. The unit shall be provided with its own microprocessor control panel.
5. The outdoor units shall be coated with anti-corrosion paint & shall be mounted on galbarium steel base plate.
6. The machine must have a sub-cool feature to use coil surface more effectively through proper circuit / bridge so that it prevents the flushing of refrigerant from long piping due to this effect thereby achieving energy savings.
7. The outdoor unit should be fitted with low noise, aero spiral design fan with aero fitting grille for spiral discharge airflow to reduce pressure loss and should be fitted with suitable high efficiency fan motor for better efficiency.
8. The condensing unit shall be designed to operate safely when connected to multiple indoor units.

9. The Unit should allow for backup operation to facilitate uninterrupted cooling. Auto backup required during compressor failure, sensor failure, ODU fan / motor failure.

### **1.3 Compressor:**

1. The compressor shall be highly efficient Rotary / Scroll type and capable of inverter/ digital control. The inverter/ digital compressor shall change the speed/modulate in accordance to the variation in cooling or heating load requirement.
2. The Compressor shall be capable of operating continuously.
3. All parts of compressor shall be sufficiently lubricated. Oil heater shall be provided in the compressor casing.

### **1.4 Heat Exchanger:**

1. The heat exchanger shall be constructed with copper tubes mechanically bonded to aluminium fins to form a cross fin coil. Tubes shall be arranged in staggered design for best air contact giving low by-pass. The aluminium fins shall be covered by anti-corrosion resin film.
2. The unit should be with E-pass heat exchanger to optimize the path of heat exchanger and for better efficiency of condenser.
3. The unit shall be provided with necessary number of direct driven low noise level propeller type fans arranged for vertical discharge. Each fan shall have a safety guard.

### **1.5 Refrigerant Circuit:**

The refrigerant circuit shall include liquid & gas shut-off valves and a solenoid valves at condenser end. The equipment must have in built refrigerant stabilization control for proper refrigerant distribution. All necessary safety devices shall be provided to ensure safe operation of the system.

### **1.6 Safety Devices:**

All necessary safety devices shall be provided to ensure safe operation of the system. Following safety devices shall be part of outdoor unit

- High pressure switch,
- Fuse,

- Fan drive overload protector,
- Fusible plug,
- Over load relay,
- Overload protection for compressor.

### **1.7 Oil Recovery System:**

Unit shall be equipped with an oil recovery system to ensure stable operation with long refrigeration piping lengths. The system must be provided with oil balancing circuit to avoid poor lubrication.

### **1.8 Indoor Units (IDUs) General Specifications:**

The type, capacity and location of indoor units generally shall be as indicated in SOQ.

Each indoor unit shall have Electronic expansion valve which senses the temperature based on variation of the room load and conveys the same for the outdoor modules to respond accordingly.

1. The indoor units shall be floor mounted/ Hi wall / Cassette/ Ductable type as indicated in SOQ.
2. The unit includes pre-filter, fan section and DX-Coil section.
3. The housing of unit shall be light weight powder coated galvanized steel.
4. Unit shall have an external casing for supply and return air.
5. The address of the indoor unit shall be set automatically for individual and group control. For centralized control, it shall be set by a remote controller with an LCD display panel.
6. The fan shall be dual suction, aerodynamically designed turbo, multi blade type, statically & dynamically balanced to ensure low noise and vibration free operation of the system. The fan shall be direct driven type, mounted directly on motor shaft having supported from housing.
7. The cooling coil shall be made out of seamless copper tubes and have continuous aluminium fins. The fins shall be spaced by collars forming an integral part. The tubes shall be staggered in the direction of airflow. The tubes shall be hydraulically / mechanically expanded for minimum thermal contact

resistance with fins. Each coil shall be factory tested at 21 kg/m<sup>2</sup> air pressure under water.

8. Unit shall have cleanable type filter fixed to an integrally moulded Plastic / Aluminium frame. The filter shall be easily serviceable.
9. Each indoor unit shall have computerized PID control for maintaining design room temperature. Each unit shall be provided with microprocessor thermostat for cooling and heating.
10. Each unit shall be with wireless LCD type remote controller. The remote controller shall memorize the latest malfunction code for easy maintenance. The controller shall have self-diagnostic features for easy and quick maintenance and service. The controller shall be able to change fan speed and angle of swing flap individually as per requirement.

#### **1.8.1 Ceiling mounted cassette type unit:**

1. The unit shall be ceiling mounted type. The unit shall include pre-filter, fan section and DX-coil section. The housing of the unit shall be powder coated galvanized sheet steel. The body shall be light in weight and shall be able to suspend from four corners.
2. Unit shall have an external attractive panel for supply and return air. Unit shall have four way supply air grilles on sides and return air grille in center.
3. Each unit shall have high lift drain pump, fresh air intake provision, Low gas detection system and very low operating sound.
4. All the indoor units regardless of their difference in capacity should have **same decorative panel size** for harmonious aesthetic point of view. It should have provision of connecting branch ducts. Unit shall be provided with a condensate drain pump.

#### **1.8.2 Ceiling mounted ductable type unit:**

1. Unit shall be suitable for ceiling mounted type. The unit shall include pre filter, fan section & DX coil section. The housing of unit shall be light weight powder coated galvanized steel. The unit shall have high static fan for ductable arrangement.

### **1.8.3 Ceiling suspended type:**

1. Unit shall be suitable for ceiling suspended arrangement above false ceiling.
2. The unit includes pre filter, fan section & DX coil section. The housing of unit shall be light weight powder coated galvanized steel.

### **1.8.4 High wall mounted units:**

1. The units shall be wall-mounted type. The unit includes pre filter, fan section & DX coil section. The housing of unit shall be light weight powder coated galvanized steel / moulded plastic.
2. Unit shall have an attractive external casing with sophisticated design and compact casing harmonized in any interior décor.

### **1.8.5 Ceiling mounted built-in type:**

1. Unit shall be suitable for Highly flexible for various arrangement with complete line-up of optional kits to satisfy various needs such as design concept, interior decoration and so on. The units include pre filter, fan section & DX coil section. The housing of unit shall be light weight powder coated galvanized steel. Each unit shall have optional high lift drain pump.

## **1.9 Centralized Type Remote Controller:**

A multifunctional compact centralized controller shall be provided with the system. It shall be able to control all the indoor units with the following functions:

1. Starting / stopping of Air-conditioners as a zone or group or individual unit.
2. Temperature setting for each indoor unit or zone.
3. Switching between temperature control modes, switching of fan speed and direction of airflow, enabling / disabling of individual remote controller operation.
4. Monitoring of operation status such as operation mode & temperature setting of individual indoor units, maintenance information and trouble-shooting information.
5. Display of air conditioners operation history.
6. Daily management automation through yearly schedule function with provision for various schedules.

7. The controller shall have wide screen user friendly display and can be wired by a nonpolar 2 wire transmission cable to a distance of 100m away from indoor unit.

#### **1.10 Refrigerant:**

1. Refrigerant should be non HCFC refrigerant and as specified in SOQ.
2. The entire condensing unit & evaporative unit should be factory assembled and tested. The units should come with an initial charge of Refrigerant from the factory. Any additional required refrigerant shall be added at site free of cost & loss of refrigerant due to defect in equipment or workmanship during execution.

#### **1.11 Refrigerant Piping:**

1. All refrigerant piping for the system shall be constructed from soft seamless hard drawn copper pipes with minimum thickness of 18 SWG, with copper fittings and silver soldered joints. The refrigerant piping arrangements shall be in accordance with good practices within the air conditioning industry, and are to include charging connections, suction line insulation and all other items normally forming part of proper refrigerant circuits.
2. All joints in copper piping shall be sweat joints using low temperature brazing and silver solder. Before joining any copper pipe or fitting, its interiors shall be thoroughly cleaned by passing a clean cloth via wire or cable through its entire length. The piping shall be continuously kept clean while constructing the joints.
3. Pressure testing at 1.5 times the working pressure shall be carried out after the installation of refrigerant piping.
4. All refrigerant pipes shall be properly supported and supports shall be fixed to the building structure by means of inserts or anchor fasteners of adequate size and number to support the load imposed there on.

#### **1.12 Drain Piping:**

The Condensate from the Indoor units shall be drained through properly installed drain piping designed to prevent any accumulation of condensate in the drain pan. Drain piping shall be made of rigid PVC pipe of min. 6 kg/cm<sup>2</sup> pressure rating with water tight threaded connections leading from the Indoor unit to a suitable drain

point. Complete drain piping shall be made leak proof and water tight by means of precise installation and the use of leak proof sealant / adhesives.

**1.13 Insulation:**

Insulation of suction and liquid line shall be carried out with pipe section flexible, closed cell elastomeric, Nitrile rubber insulation with density greater than 40.0 kg/m<sup>3</sup> covered with Aluminium foil. The complete refrigerant piping shall be insulated and provided with weather protection. The drain pipe shall also be insulated to avoid condensation.

**1.14 Control and Instrumentation:**

The AC shall be provided with controls / contactors / thermostats suitable for sequential starting / stopping i.e. the compressor shall start in the last and shall shut off first.

All necessary interlocking and alarm circuits shall be arranged so as to eliminate any possible damage to the AC due to malfunctioning of instruments or any probable operational mistakes.

**1.15 Electrics:**

Electrical control box containing contactors for compressor and fan motors with control relay and high - low pressure cut outs shall be provided. The electric wiring between the mains and control box and between indoor /outdoor units and control box shall be carried out as per standard practice.

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**SPECIFICATIONS FOR AIR-CONDITIONING  
AND VENTILATION WORKS**

**SECTION - IX**  
**UNITARY AIR CONDITIONERS**

## 1. DUCTABLE SPLIT UNITS

Ductable split air conditioning unit of suitable capacity comprising one number indoor and one number outdoor unit shall be provided with R 407c / R410a or equivalent eco-friendly refrigerant.

1. Outdoor unit suitable for operation on  $415\pm 10\%$  V, 3 Phase, 50 Hz AC supply and consisting of suitable number of hermetically sealed scroll compressors, propeller type fans, permanent split capacitor type fan motors, and air cooled condensers fabricated out of copper tubes and aluminium fins, all housed in powder coated sheet metal cabinets. Outdoor units shall be suitable for ambient conditions at location where the unit is being installed. The noise level of outdoor unit shall not exceed 70 dB(A) at a distance of 1 m from the unit. Units with twin compressors can be offered.
2. Indoor unit comprising of DIDW forward curved centrifugal fan driven by suitable capacity motor with multispeed control, synthetic media filter and copper tube aluminium finned evaporator coil of minimum 3 rows, all housed in a powder coated sheet metal cabinet. Capacity of air delivered by fan shall be as indicated in SOQ. Fan shall be selected for sufficient static pressure to overcome losses through equipment and duct.
3. The entire unit shall be acoustically insulated suitably. The noise level of the indoor unit shall not exceed 55 dB(A) at a distance of 1 m from the unit.
4. Interconnecting copper refrigerant piping between outdoor and indoor units, including rigid pipe insulation for suction lines, wherever required. Horizontal refrigerant pipes shall be mechanically protected, wherever running on ground.
5. Controls such as suitable number of thermostat along with one number multispeed fan control.
6. Supporting brackets for indoor units.
7. Each unit shall be provided with microprocessor based control system and shall be fully automatic in operation. All motors shall be provided with suitable starters and shall be located conveniently within the outdoor unit. The unit shall be provided with microprocessor based panel housing microprocessor based motor protection device which includes overload relay, single phase preventer, phase reversal protection, short circuit protection, HP/LP cut-outs etc. and shall control the operation of split unit. The panel shall be provided with LED display for room

temperature, set point temperature, current drawn, status indication, fault display and trip indication. Auto sequence starting and auto sequence stopping shall be provided with predetermined time delays. Auto restart upon restoration of power after a power failure shall be an inbuilt feature.

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## **2. CASSETTE SPLIT UNITS**

Supply of Inverter/ fixed speed Cassette split A/C units, each of nominal capacity as indicated in SOQ suitable for operation on single/ three phase AC supply with R410a / 407c or equivalent eco-friendly refrigerant.

1. Each split type AC unit shall comprise of outdoor unit suitable for ambient weather conditions at location where the unit is being installed and cassette type Indoor unit suitable for ceiling mounting.
2. Outdoor (condensing) unit shall be finished with GI / powder coating & should include hermetically sealed suction gas cooled compressors, overload protection, air cooled condenser coil made of copper of sufficient rows deep and of large face area, fitted with a propeller type fan and suitable motor, service valves arrangements, refrigerant filter etc. all housed in sheet metal cabinet.
3. Cassette type Indoor (room) unit should include evaporator coil made of copper of sufficient rows deep with slide out washable nylon wire mesh/HDPE filters with dirt trap, statically and dynamically balanced blower unit mounted on the shaft of the motor and housed in a scroll etc.
4. Selector control unit with push button, selector switch for multispeed fan operation shall be provided for all units. Supply air grilles made out of non-corrosive material with 4-way adjustable air flow direction arrangement.
5. The split units shall have following features:
  - Auto mode operation
  - Sleep mode operation
  - Auto setting with memory backup
  - Time delay feature
  - Auto restart
  - Programmable timer
  - Automatic drainage of condensate water through the drain pump

6. The unit shall include suitable controls like thermostat and complete as required.
7. Low noise level of unit inside the AC areas is required (around 40 dB(A)). Manufacturers shall indicate average noise level in dB(A) at 1 metre from indoor unit.
8. The inside conditions shall be maintained through speed variation in case of Inverter driven compressor.

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### **3. HI WALL SPLIT UNITS**

Hi wall Split Type AC units with fixed/ inverter type as indicated in SOQ of nominal capacity shall be suitable for operation on 230 V±10%, 50 Hz, single phase AC supply with R 32/ R410a or equivalent eco- friendly refrigerant.

1. Each split type A/C unit shall comprise of outdoor unit suitable for ambient weather conditions at location where the unit is being installed and hi wall mounted Indoor unit with sleek outer cabinet. Both units shall be inter connected through refrigerant (copper) tubing and complete with electrical wiring for satisfactory operation and complete as required. The refrigerant piping shall be mechanically protected, wherever running on ground.
2. Outdoor (condensing) unit shall be finished with GI/ powder coating & should include hermetically sealed suction gas cooled compressors, overload protection, air cooled condenser coil made of copper of sufficient rows deep and of large face area, fitted with a propeller type fan and suitable motor, service valves arrangements, refrigerant filter etc. all housed in sheet metal cabinet.
3. Hi-wall mounted Indoor (room) unit should include evaporator coil made of copper of sufficient rows deep with slide out washable nylon wire mesh/HDPE filters with dirt trap, statically and dynamically balanced blower unit mounted on the shaft of the motor and housed in a scroll.
4. Selector control unit with push button, selector switch for multispeed fan operation shall be provided for all units.
5. Supply air grilles made out of non-corrosive material with adjustable air flow direction arrangement with deflection louvers and complete as required. The split units shall have following features:
  - Auto mode operation
  - Sleep mode operation
  - Auto setting with memory backup
  - Time delay feature
  - Auto restart
  - Programmable timer

6. Each unit shall include suitable controls like thermostat and complete as required.
7. The drain pipes from indoor unit will be terminated at agreed drain point. The refrigerant piping shall be provided with no joints in between and suction lines shall be insulated with elastomeric nitrile foam pipe insulation.
8. Low noise level of unit inside the AC areas is required (around 45 dB(A)). Manufacturers shall indicate average noise level in dB(A) at 1 metre from indoor unit. The finish of the cabinet of the indoor unit shall be got approved by the Engineer-in-Charge.
9. Split AC units shall be energy efficient and shall be of Star rating as indicated in SOQ in case of fixed speed units as certified by Bureau of energy efficiency (latest).
10. The specification, testing and capacities of Split AC units shall confirm to IS 1391 (Part I and Part II).

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**SPECIFICATIONS FOR AIR-CONDITIONING  
AND VENTILATION WORKS**

**SECTION - X**  
**CLEAN ROOM ACCESSORIES**



## 1. AIR SHOWERS

The design, installation, testing and commissioning of clean room air shower shall confirm to ISO 14644.

### 1.1 Specifications:

1. Material of construction : SS 304/CRCA powder coated (powder coating not less than 60 microns) as indicated in SOQ, SS shall be minimum 18-gauge thickness (properly strengthened).All other materials used in Air shower should be cleanroom compatible for the class indicated in SOQ.
2. Size Internal (minimum) : Shall be as indicated in SOQ.
3. Type : Self-contained unit to be mounted directly on the existing cleanroom floor.
4. Nozzles : Provision of adequate top and side walls nozzles of SS 304 for proper air flow for efficient particle removal from persons entering into cleanroom, with minimum air velocity of 1220m/min(approximately).
5. Doors : Aluminium anodized door panel (minimum width of 800mm) with clear view glass and proper handles. Smooth opening and closing of doors with Door closer.
6. Filtration
  - Pre-filter : Dust Guard / pre-filter for removal of particles of size 10 micron and bigger. Efficiency of filters shall be minimum 50%
  - Final Filtration : HEPA Filter - rated at 99.99% efficiency at 0.3 micron & larger particles.
7. Blower/motor : Dynamically balanced Fan/blower , noise & vibration free for long life operation.

8. Control system : Programmable Logic Control (PLC)/ Solid state controller for automatic control of Air shower operation and for timing adjustment from 10-180 second.
9. Mode of operation : Air shower is to be used for entry to and exit from cleanroom. The Air shower should operate only while entering to the cleanroom and not during exit from the cleanroom.
10. Lighting : LED lighting for adequate light in the air shower.
11. Other Features :  
1. Activation of Air flow using a micro-switch in the door.  
2. Interlocked doors with magnetic system for entry and exit.  
3. Emergency door release switch at appropriate location.  
4. Door sensors, Thru beam sensors, hooter system indicate emergency, ASLC (Application specific logic controls) with display for all functional illuminated windows, remote mechanism to deactivate all switches.  
5. Door locking provision for air shower shall be provided if indicated in SOQ.
12. Power & Utilities : 3 Phase, 415V±10%.
13. Packing : Clean room worthy packing so as to protect the air shower from dust and other contaminants.

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## **2. TERMINAL FILTERS**

### **2.1 ULPA Filters for ISO Class 3 and Class 4 Clean Rooms:**

1. The ISO Class 3 and Class 4 Clean Room ceiling system shall include ULPA filters mounted in the pressurised filter plenum or hooded type connected to ducts through flexible ducts as indicated on the reflected ceiling plan.
2. The filters will be used as terminal air distribution device. The air supply plenum shall be installed in T-grid in the pressurised plenum which will be connected to supply air ducts.
3. The filters shall be U15 class of ULPA filters as per EN 1822 with an efficiency of 99.9995% down to 0.12 micron.
4. The Air velocity through filter shall be 0.45m/s with Initial Pressure Drop of  $130 \pm 5\%$  Pa or better.
5. The filter media shall be Glass Fibre with hot melt separator.
6. The filter shall have expanded sheet metal face guard. The face guard shall be powder coated in off-white colour.
7. The filter shall be having endless polyurethane D-profile, Liquid pour to solid in extrusion profile seal at the outlet.
8. All the filters shall be individually tested according to EN 1822 and computerized scan test report should accompany each filter.
9. The filters shall be knife edge type which will be installed in the T-grid filled with Gel to provide leak proof joints.
10. Filter media shall be bonded to extruded aluminium cell sides.
11. Supply casing shall be factory mounted to filter cell sides.
12. The bottom face of the ULPA filter facing clean room shall be provided with SS perforation sheet and same shall align with the face of the ceiling grid system.

## **2.2 HEPA Filters for ISO Class 5 Clean Rooms:**

1. The ISO Class 5 Clean Room ceiling system shall include HEPA filters mounted in the pressurised filter plenum or hooded type connected to ducts through flexible ducts as indicated on the reflected ceiling plan.
2. The filters will be used as terminal air distribution device. The air supply plenum shall be installed in T-grid in the pressurised plenum which will be connected to supply air ducts.
3. The filters shall be H14 class of HEPA filters as per EN 1822 with an efficiency of 99.995% down to 0.3 micron. The filter medium area shall be minimum 20 sq.m.
4. The Air velocity through filter shall be 0.45m/s with Initial Pressure Drop of  $130 \pm 5\%$  Pa or better.
5. The filter media shall be Glass Fibre with hot melt separator.
6. The filter shall have expanded sheet metal face guard. The face guard shall be powder coated in off-white colour.
7. The filter shall be having endless polyurethane D-profile, Liquid pour to solid in extrusion profile seal at the outlet.
8. All the filters shall be individually tested according to EN 1822 and computerized scan test report should accompany each filter.
9. The filters shall be gasketed type / knife edge type as indicated in SOQ which will be installed in the T-grid. The filters shall be complete with holding arrangement (clamp and bolt) to provide leak proof joints.
10. Filter media shall be bonded to extruded aluminium cell sides.
11. Supply casing shall be factory mounted to filter cell sides.
12. The face of the extruded aluminium frame shall align with the face of the ceiling grid system. Faceguard with epoxy coated steel shall be provided.

### **2.3 Terminal HEPA Filters for ISO Class 5,6,7 Clean Rooms:**

1. The terminal HEPA filter modules mounted in the modular walkable false ceiling shall be of hooded type connected to ducts through flexible ducts as indicated on the reflected ceiling plan.
2. The filters will be used as terminal air distribution device. Suitable cut-outs shall be provided in the false-ceiling for installing HEPA filter modules. The collar shall be connected to supply air ducts with individual damper through GI collars or flexible ducts.
3. The filters shall be H14 class of HEPA filters as per EN 1822 with an efficiency of 99.995% down to 0.3 micron. The filter medium area shall be minimum 20 sq.m.
4. The Air velocity through filter shall be 0.45m/s with Initial Pressure Drop of  $130 \pm 5\%$  Pa or better.
5. The filter media shall be Glass Fibre with hot melt separator.
6. The filter shall have expanded sheet metal face guard. The face guard shall be powder coated in off-white colour.
7. The filter shall be having endless polyurethane D-profile, Liquid pour to solid in extrusion profile seal at the outlet.
8. All the filters shall be individually tested according to EN 1822 and computerized scan test report should accompany each filter.
9. The filters shall be gasketed type / knife edge type as indicated in SOQ which will be installed in the T-grid. The filters shall be complete with holding arrangement (clamp and bolt) to provide leak proof joints.
10. All filter modules shall be complete with 300mm (12") diameter inlet collars and an integral supply casing fabricated of 1.5mm (0.062") thick aluminium (min.) with the capability of supporting a person standing on the top surface.
11. Filter media shall be bonded to extruded aluminium cell sides.
12. Supply casing shall be factory mounted to filter cell sides.

13. The face of the HEPA filter shall be provided with extruded aluminium frame and same shall align with the face of the ceiling grid system. Faceguard with epoxy coated steel shall be provided.

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### **3. AI MODULAR PANEL SYSTEM FOR CLEAN ROOMS OF ISO CLASS 3, 4 & 5**

#### **3.1 Modular Wall Panels:**

The Clean Room Wall panels shall be smooth, cleanable, non-contaminating, flexible, easily modifiable, modular, Non-progressive, attractive and air tight.

The specifications for the modular panels shall be as follows:

1. Minimum 44 mm thick (nominal) Aluminium Honeycomb core panel, stud less (non-structural) wall system.
2. The vertical joints in the panels are to be secured utilizing anodized, Aluminium batten strips/Vertical post powder coated matching with clean room wall system.
3. All wall panels shall be double skin type having Aluminium skins (0.8mm thick) on outer surfaces with Aluminium Honey Comb Core with antistatic protection having surface resistivity of  $10^6 - 10^9$  mega ohm and having zero out gassing. All wall panels shall have a powder coat and epoxy finish in standard designer white colour.
4. The wall system must easily accommodate pipe, duct and tool penetration and doors while maintaining its air seal and structural integrity.
5. The system must be capable of performing as a free standing wall.
6. The wall system is to be held in place, utilizing a gasketed head track (secured to the suspended ceiling) and gasketed floor track assembly.
7. The height of wall system shall be as indicated in the tender drawings/ SOQ in all the clean rooms of ISO class 3,4 & 5.
8. All the framing members like head track, floor track, batten strips, corner posts, wall ends, vertical post etc. shall be made of extruded Aluminium in designer white finish matching wall panel system.
9. View panels shall be provided in the wall panels as indicated in SOQ / Tender drawings.

### **3.2 Modular Doors:**

1. The Clean Room wall Panels /systems shall include all doors with associated hardware.
2. The Clean Room doors shall be of Aluminium (Al) construction, flush configuration, swing type, double skin, Al frame and powder coated matching with clean room wall system, with concealed door closer, handles, lock sets with option of one or both side access, with view panels. The view panels to be placed at 1200 mm above finished floor level and size of the view panel shall be as per SOQ.
3. Clean Room Wall System/ Doors shall include view panels with 6mm clear tempered glass with lock sets and other required hardware.
4. All the joints between toughened glass and wall panels to be sealed.

### **3.3 Access Floor System:**

1. Clean Room access floor system shall be removable raised access system consisting of an assembly of perforated floor tiles mounted on adjustable pedestals to provide an under floor space to accommodate mechanical service line, electrical conduits and to serve as an air supply and return plenum.
2. The floor system shall be stringer-less, Electro static dissipative (ESD) conductive type and shall include die-cast Aluminium perforated (with dampers as required) tiles, adjustable pedestals with solid SS-304 construction.
3. The floor tile size is 600 x 600 x 50 mm thick.
4. The height of raised floor shall be as specified in SOQ.
5. The floor tiles shall be capable of carrying the following loads:
  - Concentrated load  $\geq 650$  kg with deflection  $\leq 2.0$ mm
  - Uniform load  $\geq 1250$  kg/sq. m with deflection  $\leq 1.0$ mm
  - Rolling load  $\geq 200$  kg/sq. m with deflection  $\leq 0.5$ mm
  - Ultimate load  $\geq 1575$  kg/6.45 sq. cm at centre
6. Floor tiles shall be Al die cast construction with static conductive vinyl, non-combustible chemical and abrasive resistant cover of minimum 2 mm thickness.



- Floor tiles system resistivity shall have a minimum value of  $1.5 \times 10^5$  ohm and a maximum value of  $2 \times 10^7$  ohm between top structure of tile and under structure.
7. Static conductive vinyl coating tile shall be fabricated in one piece.
  8. Floor tiles with dampers shall be to check/correct the uni-directional flow in the Clean Room.
  9. All tiles shall be completely interchangeable and easily removable with a lifting tool.
  10. Pedestals shall confirm to the panel specifications with regard to the load bearing characteristic. Pedestals assemblies shall be capable of supporting a 2250 kg axial load without deformation.
  11. Pedestals shall be made from hard drawn Aluminium tube.
  12. Floor system pedestals and tiles shall be laterally stable in all the directions with panels in place or removed without the use of additional framing or stringers.
  13. Adjustment of pedestals to be provided by threaded rod member and an elevating collar of  $\pm 25$  mm. The pedestals head of Al die cast construction should provide positive interlocking of panels and pedestals to prevent lateral movement.
  14. Pedestal heads to be equipped with a conductive vinyl grounding pad.
  15. Pedestals are to be vertically true, located on centres to conform with size of panel to be equipped with locking device to prevent the loss of finished elevation.
  16. Installation of the floor system shall include the under floor plenum barriers as required, providing earth clamps and bare copper wire to earth all floor pedestals & interconnection and connecting the same to system earth in sub-fab through PVC insulated Copper earth cable of suitable cross section.

### **3.4 Ceiling System:**

Clean Room Ceiling System shall comprise of ceiling grid, ULPA/ HEPA Filters, Flexible Duct work and Lighting.

#### **3.5.1 Ceiling Grid:**

1. The clean Room ceiling system shall provide rigid frame work to install the terminal filters with 100% coverage (ULPA or HEPA) in Clean Rooms. The ceiling grid shall be heavy duty with walk over capability.
2. The ceiling grid shall be 2" (minimum) heavy duty, inverted "T" grid system.

3. The ceiling grid shall be extruded aluminium construction with white powder coated to match the clean room wall system.
4. The grid system shall include “hold-down” devices, to be used for all filter ceiling modules and blank ceiling panels and hardware to be used at all joints and suspension points.
5. The ceiling grid size shall consist of standard sizes i.e. 1200mm x 600mm or 600mm x 600mm as per SOQ to accommodate terminal filters/Blank ceiling panels etc.
6. Ceiling grid shall comprise of individual ceiling lengths interconnected by cruciform sections which allow connections through grid for sprinklers, wiring etc.
7. The ceiling grid should provide a leak proof filter grid system.
8. The T-grid ceiling system shall be designed for Gel seal type (False ceiling grid filled with gel to provide leak proof joints) and shall be able to accommodate ULPA/HEPA KNIFE EDGE TERMINAL filters in the supply air plenum.
9. Tear drop light fixtures shall be mounted on the ceiling grid.
10. Blank ceiling panels, as required, shall be provided in the ceiling grid.
11. All Blank ceiling panels shall be of 6.35mm (1/4") thick aluminium Honey Comb, with Aluminium facing. All edges shall be folded over to cover exposed Honey Comb material. The finish to the blank ceiling panels shall match the Clean Room wall system.
12. The grid system shall be suspended utilizing 8-10 mm threaded rod and turn buckles (for levelling) with locking nuts.
13. The overall ceiling grid shall be levelled within  $\pm 1.5$ mm in 3m and not over  $\pm 2.5$  mm throughout the room.
14. The ceiling grid shall accommodate airtight seals around all penetrations including fire sprinklers, electrical lines etc. The System shall be pre-drilled, permitting assemblies to be easily carried out in the field.

### **3.5.2 Walkable False Ceiling for Pressurised Plenum :**

1. Heavy duty walkable Al Honeycomb Ceiling Blank Panels of nominal dimension 1200 mm x 600mm or 600mm x 600mm as per SOQ using minimum 44 mm thick aluminium honeycomb core laminated with 'designer white' finished with minimum 0.5mm thick Steel skin on both sides, static dissipative finished & complete as required.
2. Walkable false ceiling shall be double skin totally flush type ceiling panels with minimum 0.5 mm thick steel double skin Epoxy/Powder coated on both sides as per SOQ with aluminium honeycomb as core material.
3. Provision shall be provided in the false ceiling grid to fix HEPA filter modules, light fixtures and sprinkler heads, tear drop light fixtures with indexing screws for proper mounting of the tear drop light fixtures in the false ceiling & Surface mounted white light fixtures in the false ceiling.
4. Walkable false ceiling shall be designed for pointed load of 90 kgs with deflection not exceeding 0.5mm.

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## **4. GI POWDER COATED MODULAR WALL PANELS OF ISO CLASS 6, 7 AND 8**

### **4.1. Wall Panels:**

1. The Wall panels shall be of double skin of thickness as specified in BOQ/tender, sandwiched with quality PUF material of density not less than 38 kg/cum as core material.
2. The inner and outer skins shall be of powder coated steel sheet, the thickness of inner skin and outer skin of the panel shall not less than 0.8mm the powder coated steel sheet and shall be hot dip galvanized with zinc coating not be less than 120 gm/sqm on both side of the panels. The panels shall be smooth finished and both side of the panel shall be epoxy polyester powder coated, off white color, the coating thickness shall not less than 50 microns including the primer and finished coat. The panels shall be covered with peel off film to ensure that the material is protected against scratches and indentation during transit and storage.
3. The wall panels shall have a recessed male edge on one side and roll formed female edge on the other side, which creates and interlock, thus ensuring panel finished and snug insulation to insulation fit, The panels shall be manufactured to a minimum width of not less than 1100 mm and of any suitable length as required in a continuous length lamination. All the wall joints shall be filled with suitable length as required in a continuous length lamination. All the wall joints shall be filled with suitable sealant material.
4. Suitable reinforcement shall be provided between the panels from the floor to ceiling wherever the room doors are shown in the drawing. The wall panels shall have return air risers as specified and indicated in tender/BOQ.

### **4.2. False Ceiling Grid System:**

1. False Ceiling grid shall be of Heavy duty walkable type ceiling grid system consisting of inverted T-grid of extrude aluminum anodized surface, wall angle, suspender rod, turnbuckle, nuts, bolts, anchor fasteners etc., as required for fixing the panels, hooded HEPA filter module, light fixtures etc., and cost for the ceiling grid system deemed to be included in the quoted rate for false ceiling the width of main "T" bar shall not be less than 55mm extruded aluminum anodized

surface. Ceiling grid configuration shall be 1200mm length and 600 mm width and shall be suitable for fixing hooded HEPA filter module, light fixtures etc.

2. All the suspended material shall be galvanized finish. The ceiling grid system shall be suitable for walkable type false ceiling.
3. The ceiling grid shall be suitable for accommodating individual Module of Hooded HEPA FILTERS, Supply & return Air Diffusers, light fixture, blank panels etc., and shall be provided with virgin neoprene or PVC gasket.

#### **4.3 False Ceiling Blank Panels:**

1. Ceiling panel shall be double skin type and thickness as indicated in BOQ/tender, sandwiched with self-extinguishing quality PUF of density not less than 38kg / cum .the inner and outer skin shall be of power coated steel sheet, the thickness of inner skin and outer skin of the panel shall not less than 0.8mm the powder coated steel sheet shall be hot dip galvanized with zinc coating not less than 120 gm / sq m both side of the panel shall be smooth finished and both side of the panel shall be off white color, the coating thickness shall not less than 50 microns including the primer and finished coat, the panels shall be covered with peel off film to ensure that the material is protected against scratches and indentation during transit and storage.
2. The Ceiling panels shall have a recessed male edge on one side and roll formed female edge on the other side, which creates and interlock, thus ensuring panel finished and snug insulation to insulation fit, The panels shall be manufactured to a minimum width of not less than 1100 mm and of any suitable length as required in a continuous length lamination. All the wall joints shall be filled with suitable length as required in a continuous length lamination.
3. Necessary services/trap doors shall be provided to the false ceiling for maintenance on the top of the false ceiling.
4. All the joints and corners between ceiling and wall panels, wall panels and wall panels ,wall panel to floor of modular clean room shall be provided with aluminum R 50 coving same panel finish and colour.

#### **4.4 Doors:**

1. GI Powder Coated double skin door with 44 mm leaf thickness made of 0.80 mm GI sheet for door leaf with PUF infill and door frame made out of 1.20mm thick GI powder coated profile.
2. Doors are designed to fit flush into the wall panel system on both sides and are supplied in different dimensions. Shall have frame width of 50 mm and shutter width of 46mm. Doors are including all accessories, std arms door closer.
3. Doors Accessories shall include SS D handle Back to back / SS D Handle one side and one side SS push Plate, Dead Lock with Both side key operation, SS ball bearing Hinges, SS Kick plate 0.8 mm thick upto 300 mm height, Door closer & Door stopper, Concealed type Bottom Drop seal, Concealed type Flush Bolt for Double leaf door, Double glazed view panel of dimensions as specified in BOQ/tender with 5 mm/ 6 mm thick toughened glass.

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## **5. FAN FILTER UNITS WITH MODULAR PARTITION/ CEILING**

1. The fan filter unit (FFU) shall be supplied to provide unidirectional supply air at controlled discharge velocities. The units shall include a high efficiency HEPA or ULPA filter as specified in SOQ.
2. The unit shall provide filtered air tested at an average velocity of 27.4 mtr/min ( $\pm 4.6$ mpm) measured 304 mm from the face of the unit in accordance with IEST-RP-CC022.2 or relevant standards.
3. The FFU sound level shall be less than 55 dB(A) when measured at 762 mm from the filter face at 27.4 mtr/min average face velocity in accordance with IEST-RP-CC022.2 or relevant standards.
4. The unit is to be factory sealed and tested to ensure no air leakage.
5. Plenum material shall be Aluminium/ 304 Stainless steel and shall be walkable up to 108 kgs.
6. Face material shall be expanded metal grille with powder-coated paint finish/ Aluminium/ 304 stainless steel
7. The diffuser plenum shall feature four eyebolts at each plenum corner for securing the unit to structural supports above the ceiling.
8. The 51% free-area perforated distribution plate shall be secured to the face using quarter-turn fasteners with anti-slip, snap-in retainers and stainless steel retainer cables for ease of installation and removal.
9. Inlet shall be standard round or optional rectangular collar for ducted / non-ducted applications.
10. Eye bolts for hanging shall be mounted on the top four corners of the plenum and capable of each supporting 23 kgs.
11. The filter shall be framed in extruded aluminium with an integral cavity filled with a urethane gel to provide a leak-tight seal between the filter frame and the border.
12. Pre-filter shall be 25-30% MERV 4 washable.
13. Final filter shall be High Efficiency Particulate Air (HEPA) filter having 99.997% efficiency on 0.30  $\mu$ m particulate, with an initial pressure drop of 11.43mm wg at 30.5 mtr/min / Ultra-Low Penetration Air (ULPA) filter having 99.9995%

efficiency on 0.12 µm particulate, with an initial pressure drop of 13.46 mm wg at 30.5 mtr/min.

14. Filter shall be room side removable and replaceable or bench top removable and replaceable
15. Bench top replaceable filters shall be supplied with a room-side accessible static pressure port in an extruded aluminium centre divider.
16. All aluminium components shall have B12 White baked-on powder coat finish. The paint film thickness shall be a minimum of 2.0 mils (0.05 mm).
17. All aluminium components shall have mill finish and all stainless steel components shall have 2B mill finish.
18. The centrifugal type fan shall be supplied with rubber mounts to isolate the motor/blower assembly from the diffuser plenum.
19. Fan shall be of metal construction with a direct drive, forward curved / backward curved impeller. Plastic construction shall not be acceptable.
20. The fan motor shall be Permanent Split Capacitor (PSC) / Electrically Commutated Motor (ECM).
21. About 2-meter power cord shall be supplied for use with a 220 V+/-10% power supply.
22. Wall mounted PSC solid-state/ECM standard speed controller to be provided.
23. Motor status LED:
  - The LED indicator light shall be visible from the occupied area to determine the motor operating status without opening the diffuser.
  - The motor LED shall be green to indicate normal motor operation, and that the unit static pressure is above 5.08 mm wg.
  - The motor LED shall turn from green to red when the motor is not in operation, and when the unit static pressure is below 5.08 mm wg.

**Note:** The available power supply shall be 220 V±10%, 50 Hz or 415±10%, 50Hz.

24. The unit shall be modular in design and shall fit into standard “T”-bar ceiling grid of 1200mm x 600mm /600mm x 600mm as indicated in SOQ.



25. The unit shall meet the "Class 100" specifications as per Federal Standard 209, and ISO standard for Laminar flow.
26. The unit vibration levels shall be less than 0.09 mils (0.0023 mm).
27. Special air baffle system shall be inbuilt into the system for proper airflow.
28. Total height of the complete unit (excluding optional accessories) shall be less than 330 mm.
29. The fan plenum housing shall be constructed of 1.6mm aluminium with 64 mm-20 threaded inserts in four corners for suspension.
30. The filter housing shall be constructed with 1.6 mm thick aluminium.
31. Both the fan and filter housing shall have a mill finish (Polyurethane painted exterior-optional) and sealed airtight.
32. The filter face guard will be epoxy coated expanded steel.

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**SPECIFICATIONS FOR AIR-CONDITIONING  
AND VENTILATION WORKS**

**SECTION - XI**  
**DUCTING & ALLIED ACCESSORIES**

## **1. DUCTING**

The ducts shall be fabricated from galvanized steel sheets class VIII/Aluminium/SS/Polyvinyl chloride(PVC) coated steel sheets as specified in tender.

1. Light coating of Zinc conforming to IS: 277 with accompanying Mill Test Certificates. Galvanizing shall be of 120gms/sq.m or otherwise specified in tender (total coating on both sides). In addition, if deemed necessary, samples of raw material, selected at random by owner's site representative shall be subject to approval and tested for thickness and zinc coating at contractor's expense.
2. In case of factory fabricated duct the G.I. raw material should be used in coil-form (instead of sheets) so as to limit the longitudinal joints at the edges only irrespective of cross-section dimensions.
3. Aluminium material shall conform to the latest IS: 737.
4. Stainless steel shall conform to IS: 6911.
5. Polyvinyl chloride coated sheets shall be manufactured by laminating or coating polyvinyl chloride (Vinyl chloride resin) layer of minimum thickness of 0.2 mm on both sides or on one side metal sheet and the base metal shall be GI sheet confirming to IS: 277.

### **1.1 Rectangular Ducting:**

Unless otherwise specified here, the construction, erection, testing and performance of the ducting system shall conform to IS: 655 latest standards/ SMACNA latest standards ("HVAC Duct Construction Standards-Metal and Flexible-Second Edition SMACNA).

#### **1.1.1 Duct Connectors and Accessories:**

All transverse duct connectors (flanges /cleats) and accessories/related hardware are such as support system shall be zinc-coated (galvanized).

#### **1.1.2 Fabrication Standards:**

All ductwork including straight sections, tapers, elbows, branches, show pieces, collars, terminal boxes and other transformation pieces must be factory-fabricated. Equivalency will require fabrication by utilizing the following machines and processes to provide the requisite quality of ducts and speed of supply. Coil lines to

ensure location of longitudinal seams at corners / folded edges only to obtain the required duct rigidity and low leakage characteristics. No longitudinal seams permitted along any face side of the duct. All ducts, transformation pieces and fittings to be made on CNC profile cutters for required accuracy of dimensions, location and dimensions of notches at the folding lines. All edges to be machine treated using lock formers, flanges and roller for fuming up edges. Sealant dispensing equipment for applying built-in sealant in Pittsburgh lock where sealing of longitudinal joints are specified will be used.

### 1.1.3 Selection of Gauge:

Duct Construction shall be chosen based on the internal pressure of the duct. The thickness of short side of rectangular duct shall be same as long side of the duct. The thickness for various shall be as per the following tables:

**Table 1:** Thickness of Sheet for Galvanized Steel Sheet Duct

Classification of Duct by Pressure (1)	Low Pressure Duct (2)	Medium Pressure Duct and High Pressure Duct (3)	Thickness of Sheet, Min mm (4)
Long side of duct	$l \leq 450$	---	0.5
	$450 < l \leq 750$	---	0.6
	$750 < l \leq 1500$	$l \leq 450$	0.8
	$1500 < l \leq 2200$	$450 < l \leq 1200$	1.0
	$2200 < l$	$1200 < l$	1.2

**Table 2:** Thickness of Sheet for Stainless Steel Sheet Duct

Classification of Duct by Pressure (1)	Low Pressure Duct (2)	Medium Pressure Duct and High Pressure Duct (3)	Thickness of Sheet, Min mm (4)
Long side of duct	$l \leq 750$	---	0.5
	$750 < l \leq 1500$	---	0.6
	$1500 < l \leq 2200$	$l \leq 450$	0.8
	$2200 < l$	$450 < l \leq 1200$	1.0
	---	$1200 < l$	1.2

**Table 3:** Thickness of Sheet for Rigid Polyvinyl Chloride Duct

Classification of Duct by Pressure (1)	Low Pressure Duct and Medium Pressure Duct	High Pressure Duct Pa		Thickness of Sheet, Min mm (5)
		$1000 < p \leq 1500$ (3)	$1500 < p \leq 2000$ (4)	
Long side of duct	$p \leq 1000$ (2)	$1000 < p \leq 1500$ (3)	$1500 < p \leq 2000$ (4)	(5)
	$l \leq 500$	$l \leq 500$	---	3
	$5000 < l \leq 1000$	---	$l \leq 500$	4
	$1000 < l \leq 2000$	$500 < l \leq 2000$	$500 < l \leq 2000$	5
	$2000 < l$	$2000 < l$	$2000 < l$	6

**Table 4:** Thickness of Sheet for Aluminium Duct

Classification of Duct by Pressure (1)	Low Pressure Duct (2)	Medium Pressure Duct and High Pressure Duct (3)	Thickness of Sheet, Min mm (4)
Long side of duct	$l \leq 450$	---	0.8
	$450 < l \leq 750$	---	0.8
	$750 < l \leq 1500$	$l \leq 450$	1.0
	$1500 < l \leq 2200$	$450 < l \leq 1200$	1.5
	$2200 < l$	$1200 < l$	1.8

**Table 5:** Thickness of Sheet for Galvanized Steel Sheet Duct and Stainless Sheet Duct

Classification of Duct by Pressure (1)	Low Pressure Duct (2)	Medium Pressure Duct and High Pressure Duct (3)	Thickness of Sheet, Min mm (4)
Internal diameter of duct (d), mm	$d \leq 500$	---	0.5
	$500 < d \leq 630$	---	0.6
	---	$d \leq 450$	0.8
	---	$450 < d \leq 630$	1.0

**Table 6:** Thickness of Sheet for Circular Spiral Galvanized Steel Sheet Duct

Classification of Duct by Pressure (1)	Low Pressure Duct (2)	Medium Pressure Duct and High Pressure Duct (3)	Thickness of Sheet, Min mm (4)
Internal diameter of duct (d), mm	$d \leq 450$	$d \leq 200$	0.5
	$450 < d \leq 710$	$200 < d \leq 560$	0.6
	$710 < d \leq 1000$	$560 < d \leq 1000$	0.8
	$1000 < d$	$800 < d \leq 1000$	1.0
	---	$1\ 000 < d$	1.2

**Table 7:** Thickness of Sheet for Circular Spiral Stainless Sheet duct

Classification of Duct by Pressure (1)	Low Pressure Duct (2)	Medium Pressure Duct and High Pressure Duct (3)	Thickness of Sheet, Min mm (4)
Internal diameter of duct (d), mm	$d \leq 560$	$d \leq 250$	0.5
	$560 < d \leq 800$	$250 < d \leq 560$	0.6
	$800 < d \leq 1000$	$560 < d \leq 800$	0.8
	$1000 < d$	$800 < d \leq 1000$	1.0
	---	$1000 < d$	1.2

**1.1.4 Transverse Connectors:**

All transverse connectors shall be as per IS: 655 / SMACNA latest standards. Unless otherwise specified, in general, OEM 4-bolt slip-on flange system or equivalent of similar 4-bolt systems with built-in sealant if any to avoid any leakage additional sealant to be used. The specific class of transverse connector and duct gauge for a given duct dimensions will be 250 Pa pressure class. Non-toxic, AC - applications grade P.E (poly ethylene) or PVC gasketing is required between all mating flanged joints. Gasket sizes should conform to flange manufacturer's specification.

**1.1.5 Duct Construction:**

1. The fabricated duct dimensions should be as per approved drawings and all connecting sections are dimensionally matched to avoid any gaps.

2. Dimensional Tolerances: All fabricated dimensions will be within 1.0 mm of specified dimension. To obtain required perpendicularity, permissible diagonal tolerances shall be 1.0 mm per meter.
3. Each and every duct pieces should be identified by colour coded sticker which shows specific part numbers, job name, drawing number, duct sizes and gauge.
4. Ducts shall be straight and smooth on the inside Longitudinal seams shall be airtight and at comers only, which shall be either Pittsburgh or Snap Button Punch as per SMACNA practice, to ensure air tightness.
5. Changes in dimensions and shape of ducts shall be gradual (between 1:4 and 1:7). Turning vanes or air splitters shall be installed in all bends and duct collars designed to permit the air to make the turn without appreciable turbulence.

#### **1.1.6 Installation:**

1. During the construction, the contractor shall temporarily close duct openings with sheet metal covers to prevent debris entering ducts and to maintain opening straight and square.
2. Great care shall be taken to ensure that the duct work does not extend outside and beyond height limits as noted on the drawings.
3. All duct work shall be of high quality approved galvanized sheet steel guaranteed not to crack or peel on bending or fabrication of ducts. All joints shall be air tight and shall be made in the direction of air flow.
4. The ducts shall be re-enforced with structured members where necessary as per IS and SMACNA standards, and must be secured in place so as to avoid vibration of the duct on its support.
5. All air turns of 45 degrees or more shall include curved metal blades or vanes arranged so as to permit the air to make the abrupt turns without an appreciable turbulence. Turning vanes shall be securely fastened to prevent noise or vibration.
6. The duct work shall be varied in shape and position to fit actual conditions at building site. All changes shall be subjected to the approval of the Engineer -In-Charge. The contractor shall verify all measurements at site and shall notify the Engineer-In-Charge of any difficulty in carrying out his work before fabrication.



7. Sponge rubber or approved equal gaskets of 6 mm maximum thickness shall be installed between duct flanges as well as between all connections of sheet metal ducts to walls, floor columns, heater casings and filter casings. Sheet metal connections shall be made to walls and floors by means of wooden member anchored to the building structure with anchor bolts and with the sheet screwed to them.
8. Flanges bracings and supports are to be sourced from the duct manufacturer. Accessories such as damper blades and access panels are to be of materials of appropriate thickness and the finish similar to the adjacent ducting, as specified.
9. Joints, seams, sleeves, splitters, branches, take-offs and supports are to be as per duct details as specified, or as decided by Engineer-In-Charge.
10. Joints requiring bolting or riveting may be fixed by Hexagon nuts and bolts, stove bolts or buck bolts, rivets or closed centre top rivets or spot welding. Self-tapping screws must not be used. All jointing material must have a finish such as cadmium plating or Galvanized as appropriate.
11. Fire retarding flexible joints is to be fitted to the suction and delivery of all fans. The material is to be normally double heavy canvass or as directed by Engineer-In-Charge. On all circular spigots the flexible materials are to be screwed or clip band with adjustable screws or toggle fitting. For rectangular ducts the material is to be flanged and bolted with a backing flat or bolted to mating flange with backing flat.
12. The flexible joints are to be not less than 75 mm and not more than 250 mm between faces. The duct work should be carried out in a manner and at such time as not to hinder or delay the work of the other agencies especially the boxing or false ceiling contractors.
13. Duct passing through brick or masonry, wooden frame work shall be provided within the opening. Crossing duct shall have heavy flanges, collars on each side of wooden frame to make the duct leak proof.

The work shall meet with the approval of Department in all its parts and details. All necessary allowances and provisions shall be made by the Contractor for beams, pipes, or other obstructions in the building, whether or not the same are shown on the drawings. Where necessary to avoid beams or other structural work, plumbing or other pipes, and conduits, the ducts shall be transformed, divided or curved to

one side (the required cross sectional area being maintained) all as per the site requirement. If a duct cannot be run as shown on the drawings, the contractor shall install the duct between the required points by any path available in accordance with other services and as per approval of consultant/customer in charge.

All ductwork shall be independently supported from building construction. All horizontal ducts shall be rigidly and securely supported, in an approved manner, with trapeze hangers formed of galvanized steel rods and galvanized steel angle / channel or a pair of brackets, connected by galvanized steel rod under ducts. The spacing between supports should be not greater than 2.0 meter. All vertical ductwork shall be supported by structural members on each floor slab. Duct supports may be through galvanized steel insert plates left in slab at the time of slab casting. Galvanized steel cleat with a hole for passing the hanger rods shall be welded to the plates. Trapeze hanger formed of galvanized steel rods shall be hung through these cleats. Wherever use of metal insert plates is not feasible, duct support shall be through dash/anchor fastener driven into the concrete slab by electrically operated gun. Hanger rods shall then hang through the cleats or fully threaded galvanized rods can be screwed into the anchor fasteners. Ducting over furred ceiling shall be supported from the slab above or from beams after obtaining approval of Consultant /customer in charge. In no case shall any duct be supported from false ceiling hangers or be permitted to rest on false ceiling. All metal work in dead or furred down spaces shall be erected in time to occasion no delay to other contractor's work in the building.

All ducts shall be totally free from vibration under all conditions of operation. Whenever ductwork is connected to fans, air handling units or blower coil units that may cause vibration in the ducts, ducts shall be provided with a flexible connection, located at the unit discharge. Flexible connections shall be constructed of fire retarding flexible heavy canvas sleeve at least 10 cm long securely bonded and bolted on both sides. Sleeve shall be made smooth and the connecting ductwork rigidly held by independent supports on both sides of the flexible connection. The flexible connection shall be suitable for pressure at the point of installation. Duct shall not rest on false ceiling and shall be in level from bottom. Taper pieces shall taper from top.

### 1.1.7 Hangers for Duct:

Duct Size (mm)	Spacing (m)	Size of Slotted / MS angle (mm x mm)	Size of rod dia (mm)
Up to 750	2.4	1.6 mm thick slotted rail	8
751 to 1500	2.4	40 x 3	10
1501 to 2250	2.0	50 x 3	12
2251 to above	2.0	50 x 3	12

1. Ducts above 750 mm wide to be provided with MS angle supports.
2. Additional hangers shall be provided in ducts near smoke/fire damper connections.
3. All ducts shall be fabricated and installed in workman like manner, conforming to IS 655 / SMACNA latest standards.

### 1.1.8 Documentation to Measurements:

1. For each drawing, all supply of ductwork must be accompanied by computer-generated detailed bill of material indicating all relevant duct sizes, dimensions and quantities. In addition, summary sheets are also to be provided showing duct areas by gauge and duct size range as applicable.
2. Measurement sheet covering each fabricated duct piece showing dimensions and external surface area along with summary of external surface area of duct gauge-wise.
3. All duct pieces to have a part number, which should correspond to the serial number, assigned to it in the measurement sheet. The above system will ensure speedy and proper site measurement, verification and approvals.

### 1.1.9 Testing:

After duct installation, a part of duct section (approximately 20% of total ductwork) may be selected at random and tested for leakage. The procedure for leak testing should be followed as per SMACNA- "HVAC Air Duct Leakage Test Manual".

The entire air distribution system shall be balanced to supply the air quantity as required in various areas and the final balance of air quantity through each outlet shall be submitted to the engineer-in-charge for approval. Measured air quantities at fan discharge and at various outlets shall be identical to or less than 5% in

excess of those specified and quoted. Branch duct adjustments shall be permanently marked after air balancing is completed so that these can be restored to their correct position if disturbed at any time.

### **1.2 GI / SS Spiral Ducting:**

Factory fabricated double skin spiral ducting with insulating material of closed cell elastomeric 9mm thick nitrile rubber or equivalent to be stick in between the walls by using SR 505 adhesive or equivalent.

The outer skin shall be of GI/SS spiral round ducting and the inner skin shall be of Stainless steel plain sheet with internal dimension of the duct after insulation as indicated below.

The duct shall be powder coated externally on the outer skin and necessary bends should be made as per the site conditions/ as indicated in the drawings. Duct connection shall be of double wall with internal insulation coupler/ MS or SS flange with supports from side wall.

The external colour for the outer skin of the duct shall be approved by Engineer-in-charge. The cost should include bends, reducers, collars etc., indicated in the tender drawings.

**Note:** The GI/SS outer skin of the spiral duct shall be with zinc coating of minimum 120 GSM.

### **1.3 Insulated Flexible Duct:**

Insulated flexible duct with multiple layers of Al- polyester laminated with spring steel wire helix supported from GI supply duct work to each filter module of ISO class 6, class 7 and class 8 clean rooms. Flexible ducting of 300mmdia shall be suitable for +2500 Pa of air pressure and 30m/s air velocity.

The flexible duct work shall be sealed and secured at each filter module and sheet metal collar utilizing stainless steel flexible duct bands and duct band locks.

### **1.4 PPFRP Ducting for Scrubbing System:**

Polypropylene Fibre Reinforced Plastic (PPFRP) ducts to carry fume laden air connecting Wet scrubber, Exhaust Unit and Chimney. The ducts shall be connected

to the scrubber and blower with necessary accessories. A sampling point shall be provided at the blower outlet duct for periodical testing of fumes. The chimney shall be provided with string wire supports on all three sides at 120 degrees and ducts shall be provided with adequate supports, flanges, bends etc. All ducts shall be fabricated out of 3mm Poly Propylene and 5 mm thick FRP lining and duct fittings shall be fabricated to have minimum pressure drops across the system.

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## **2. MOTORIZED FIRE/ SMOKE DAMPERS**

Motorized Fire Dampers meeting or exceeding the following specification shall be furnished and installed at locations as indicated in the Tender drawings / SOQ. Dampers shall meet the fire resistance rating of 2 hours as per UL 555 and shall be tested and certified by CBRI. Fire Damper frame shall be galvanized steel of 1.6mm thickness, formed into a C channel in 4-piece construction with flanges suitable for duct connection. Damper Blades shall be single skin galvanized steel of 1.6mm thickness and must have 3 accurately roll formed longitudinal grooves for reinforcement and proper closure and operation. The blades shall be arranged in parallel to provide positive shut off. Each Blade shall have axles supported on both sides with sintered bronze self-lubricating bearings turning in an extruded hole in the frame. All Blades shall be interconnected using linkage in the frame section. Jamb seals shall be of stainless steel flexible metal compression type.

Each Damper shall be supplied with a 24V actuator by the manufacturer at the time of fabrication. The actuator shall be selected to meet the torque requirements of the damper according to its size. Each Motorized Fire Damper shall be equipped with a controlled closure temperature sensor to prevent duct and HVAC component damage. Instantaneous damper closure is unacceptable. The Heat detection device should be 165 Deg. F (74 Deg. C). The Heat device should disconnect electric supply to the actuator in the event of Fire Accident. The Fire and Smoke Damper should be able to close upon receiving a signal from the Fire Control Panel or Smoke Detection control panel.

The Control Panel shall include the following features:

- 220 V/24 V step down transformer
- Open/Close indication light
- Power-On Indication light
- Test Button
- Auxiliary Contact Points

### **3. PAN HUMIDIFIERS**

Stainless steel Pan humidifier kit of adequate capacity for seasonal operation comprising immersion heater, float valve assembly, inlet, make up and drain water connections, cabling and earthing etc. and complete as required with controls such as humidistat, geysersstat etc. The pan humidifier shall be compatible for operation through DDC.

Pan Type Humidifiers shall be Floor/ Wall Mounted type as indicated in SOQ & connected to the supply air duct for introduction of steam as when required. The capacity of heaters shall be as indicated in SOQ.

#### **3.1 Construction:**

Main body shall be made of 2 mm thick stainless steel sheet of SS-304, having connections of quick fill, make up, over flow, drain & steam outlet. A sight glass of 75 mm dia x 12 mm thick is provided to check water level. A top cover operable to access inside the Humidifier for servicing shall be provided. Humidifier shall be insulated and cladded with 0.8mm thick aluminium sheet. Suitable switchgear/ panel shall be provided for the Pan Humidifier.

## **4. VARIABLE AIR VOLUME (VAV) SYSTEM**

### **4.1 VAV Station – General:**

All the VAV (Variable Air Volume) Station shall be Pressure Independent type with Direct Digital Controls to regulate and monitor the primary air flow rate between the scheduled minimum and maximum values to achieve the specified comfort level and ventilation rates within acceptable noise criteria.

The VAV Station shall control air to provide desired zone temperature. The controller shall measure the pressure, position of the damper blades and temperature of the air flowing through the damper.

The VAV Station shall have an air measuring station with an ultra-low leak, high performance control damper similar to AMCA Class-I leakage. The complete assembly shall be factory assembled and tested to provide effective set point monitoring and adjustment. The unit shall come standard with a pressure transducer, with the output signal proportional to air quantity (cfm) and factory fitted standalone DDC controller.

### **4.2 Overview of VAV Station:**

In this application, an air measuring control damper shall provide the air supply at a constant temperature while individual zone thermostats vary the flow of air to each space maintaining the desired zone temperature. The specific amount of air volume required to maintain a particular zone temperature set-point is dictated by the size of the space and the internal and external heat loads, shall be spanned by Direct Digital Controls.

### **4.3 Construction :**

The casing shall be single skin made out of extruded Aluminum. Casing leakage rate shall be similar to AMCA class I leakage. All VAV Station shall have rectangular duct connection with 25 mm. flange connections at the intake & outlet of the station.

The VAV Station shall have air-flow straightener of 75mm deep hexagonal pattern at the inlet of the station to provide necessary laminar air flow suitable for measurement, a multi-leaf opposed blade damper with aluminum, aerofoil blade construction, width 100 mm., and exposed gear driven. The damper spindle shall be made of steel (10 mm. diameter), rotating in self-lubricating Nylon bearings.

Each VAV Station, shall be factory fitted with a multipoint, averaging air flow sensor



in the inlet of the terminal. This air flow sensor shall amplify the air pressure signal linearly with an amplification factor of at least 3.0. The air flow sensor shall contain not less than 2x8 sensing points, which shall be arranged as per log-tchebycheff method. The signal shall be averaged and measured from the center of the sensor. And the accuracy shall be within 5% even with irregular duct approach.

#### **4.4 Controls:**

##### **4.4.1 Controller:**

Controller shall be DDC Advanced Application Controller that communicates on direct digital control using point to point analog controls and compatible with existing or future BMS system.

##### **4.4.2 Actuator:**

Actuator shall have a pressure sensor, digital VAV controller and damper actuator all in one, providing a Compact solution with a communications capability for Pressure-independent VAV systems in the comfort zone.

It should also have a connection facility for commissioning Diagnostic socket for operating devices.

##### **4.4.3 Thermostat:**

Thermostat shall have voltage proportional signal i.e.0-10V DC.

**SPECIFICATIONS FOR AIR-CONDITIONING  
AND VENTILATION WORKS**

**SECTION - XII  
DUCT INSULATION**

## **1. THERMAL INSULATION FOR DUCTS**

### **1.1 General:**

Materials for thermal insulation of ducts, adhesives and thickness of insulation shall be as specified in tender schedule.

### **1.2 Nitrile rubber (Closed cell):**

#### **1.2.1 Properties:**

1. Thermal conductivity of elastomeric nitrile rubber shall not exceed 0.033W/(m.K) at an average temperature of 0°C.
2. The insulation shall have fire performance such that it passes Class 1 as per BS 476 Part 7 for surface spread of flame, also pass Fire Propagation requirement as per BS 476 Part 6 to meet the Class 'O' Fire category.
3. Unlike other generic materials it should be self-extinguishing, does not drip fireballs and does not spread flames.
4. Moisture Diffusion Resistance Factor or 'μ' value shall be minimum 10,000 for the insulation material without any out covering or vapour barrier.
5. It shall have Microban, antimicrobial product protection, EPA approved, Antimicrobial Behaviour: No fungal growth tested as per DIN EN ISO 846 Method A Standard for (Fungi), Bacterial Resistance: No bacterial growth and 99.9% reduction tested as per DIN EN ISO 846 Method C for (Bacteria).
6. Temp Range: Min + 7°C to Max 105°C.
7. Material Colour: Green/ Black.
8. Any application for exposed insulation (Open to sky) shall be further treated by Glass Fibre Cloth above that UV resistant paint coat shall be applied.
9. Special Remark: For calculation of technical results/ test certificates – test results should be taken into consideration without Alu. bonding for duct thermal insulation.

#### **1.2.2 Recommended Adhesive:**

1. The adhesive shall be specially formulated for the Duct insulation application and supplied by insulation manufacturer.

2. The adhesive shall be Solvent based/ water based rubber insulation adhesive, free from benzene.
3. It should have Excellent Bonding to Porous and Non Porous Surfaces.
4. The adhesive shall have quick drying characteristics for tropical conditions and shall have service temperature of 5°C to 85°C.
5. Properties of adhesive material shall be as follows:
  - Viscosity @ 30°C : 700 - 1200 cps
  - Specific Gravity : 0.80 - 0.85 g/cc
  - Density : 0.083 kg/m<sup>3</sup>+ 0.01
  - Flash Point : > 10 °C
  - Coverage : 6-8 square meters of bonded material/litre
  - Drying Time : 4 - 5 Minutes
  - Tack Retention Time : 25 Minutes

#### **1.2.3 Application – Unexposed duct:**

1. Duct surfaces shall be cleaned to remove all grease, oil, dirt, etc. prior to carrying out insulation work.
2. Measurement of surface dimensions shall be taken properly to cut closed cell elastomeric rubbers sheets to size with sufficient allowance in dimension.
3. Material shall be fitted under compression and no stretching of material should be allowed.
4. A thin film of adhesive shall be applied on the back of the insulating material sheet and then on to the metal surface.
5. When adhesive is tack dry, insulating material sheet shall be placed in position and pressed firmly to achieve a good bond.
6. All longitudinal and transverse joints shall be sealed as per manufacturer recommendations.
7. The adhesive shall be strictly as recommended by the manufacturer.

#### **1.2.4 Application – exposed duct:**

1. Duct surfaces shall be cleaned to remove all grease, oil, dirt, etc. prior to carrying out insulation work.

2. Measurement of surface dimensions shall be taken properly to cut closed cell elastomeric rubbers sheets to size with sufficient allowance in dimension.
3. Material shall be fitted under compression and no stretching of material should be allowed.
4. A thin film of adhesive shall be applied on the back of the insulating material sheet and then on to the metal surface.
5. When adhesive is tack dry, insulating material sheet shall be placed in position and pressed firmly to achieve a good bond.
6. All longitudinal and transverse joints shall be sealed as per manufacturer recommendations.
7. The adhesive shall be strictly as recommended by the manufacturer.
8. Apply 1st coat of UV resistant paint on the nitrile rubber insulation.
9. Then wrap 7 mm/mill thick fibre glass cloth.
10. Apply 2<sup>nd</sup> coat of UV resistant paint over the fibre glass cloth.

### **1.3 Bonded Treated Woven Glass Fibre:**

1. Temperature Range: 0°C to +105°C Overall (irrespective of the base product)
2. Colour: Black
3. Treatment: Shall be treated Water Based Acrylic binder to give crisp and non-piling property to the fabric, to help in easy installation, minimize fibre erosion, good aesthetics and resistance to abrasion. Fibre spillage / Thread ravelling should be minimum.
4. Density : 200 +/- 20 gsm
5. Tensile Strength : 275 +/- 25 kg / 50 mm (minimum)
6. Thickness : 0.18 mm / 7 mill
7. Type : Solvent based Acrylic Adhesive
8. Peel Strength : 1000 gm / 25 mm (minimum) - (Adhesive to steel)

## **1.4 Physically Cross-Linked Polyolefin Foam:**

### **1.4.1 Inside Building (Unexposed Ducts):**

Electron Beam (physically) cross-linked polyolefin foam insulation with factory laminated aluminium foil facing and self-adhesive backing. The density of the foam shall be 25kg/m<sup>3</sup> and the maximum thermal conductivity K shall be 0.032W/mK at 23 Deg C. The permeability resistance factor 'μ' should be higher than 80000. The minimum fire rating property of the insulation material when tested to BS 476 Part 6 & BS 476 Part 7 should be Class O.

**Installation:** Foam Insulation must be installed in accordance with manufacturer's instruction. All joints should be butted firmly against each other, seal all joints with 75mm wide reinforced aluminium tape. Insulate each duct separately, flanges should be insulated with a 120mm wide strip of insulation material, ensuring joints are sealed with 75mm reinforced aluminium foil tape. All supporting hangers should be lined with the same insulation material to avoid excess compression of insulation. (refer manufacturer's instruction). Ensure no air pockets during the installation of the insulation to the duct. Any minor surface cuts should be covered with aluminium foil tape.

### **1.4.2 Outside Building (Exposed Ducts):**

Electron Beam (physically) cross-linked polyolefin foam insulation with factory laminated heavy duty and ultra-tough multi-layered composite aluminium foil and self-adhesive backing. The density of the foam shall be 25kg/m<sup>3</sup> and the maximum thermal conductivity K should be 0.032W/mK @ 23 Deg C. The permeability resistance factor 'μ' should be higher than 40000(on 25mm basis). The minimum fire rating property of the insulation material when tested to BS 476 Part 6 & BS 476 Part 7 should be Class O. The material should have puncture resistance of more than 400N as per ASTM D4833. The material shall be UV resistance and weathering tested.

**Installation:** Foam Insulation must be installed in accordance with manufacturer's instruction. All joints should be butted firmly against each other, seal all joints with 75mm wide reinforced aluminium tape with UV resistance and weather resistance properties. Insulate each duct separately, flanges should be insulated with a 120mm wide strip of insulation material, ensuring joints are sealed with 75mm reinforced aluminium foil tape. All supporting hangers should be lined with the same insulation material to avoid excess compression of insulation. (refer

manufacturer's instruction). Ensure no air pockets during the installation of the insulation to the duct. Any minor surface cuts should be covered with aluminium foil tape.

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## 2. ACOUSTIC INSULATION FOR DUCTS

### 2.1 General:

Materials for acoustic insulation of ducts, adhesives and thickness of insulation shall be as specified in tender schedule.

Open Cell Nitrile Rubber Material with Microban for Antifungal and Antimicrobial Properties:

### 2.2 Acoustic Material Properties:

1. Acoustic Material should be open cell nitrile rubber.
2. Its material shall be fibre free.
3. The density of the same shall be within 140-180 kg/m<sup>3</sup>.
4. It shall have Microban, antimicrobial product protection, Antimicrobial Behaviour: No fungal growth tested as per DIN EN ISO 846 Method A Standard for (Fungi), Bacterial Resistance: No bacterial growth and 99.9% reduction tested as per DIN EN ISO 846 Method C for (Bacteria).
5. The material shall have a thermal conductivity not exceeding 0.047 W/m.K @ 20 Deg. C.
6. The material shall withstand maximum surface temperature of +850 C and minimum surface temperature of -20 Deg.C. The material shall conform to Class 1 rating for surface spread of Flame in accordance to BS 476 Part 7 & UL 94.
7. The insulation shall pass Air Erosion Resistance Test in accordance to ASTM C1071-16 from an independent accredited testing agency.
8. Thickness of the material shall be as specified for the individual application.
9. The insulation shall be installed as per manufacturer's recommendation.
10. Approved by the EPA for use in Duct Work.
11. The Random Incidence Sound Absorption Coefficient (RISAC); tested as per ISO 354, shall be minimum as per enclosed Table below.



Freq. Hz	125	250	500	1000	2000	4000
10 mm	0	0.05	0.15	0.4	0.85	1
15 mm	0	0.1	0.3	0.75	1	0.9
20 mm	0.05	0.15	0.4	0.9	1	0.95
25 mm	0.05	0.25	0.85	1	0.9	0.95
30 mm	0.1	0.35	0.95	1	0.95	1
40 mm	0.15	0.5	1	0.9	0.95	0.95
50 mm	0.25	0.75	1	1	1	1

### **2.3 Application:**

The inside surface for the ducts shall be covered with adhesive recommended by the manufacturer. Cut Foamed sheets into required sizes apply adhesive on the foam and stick it to the duct surface.

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**SPECIFICATIONS FOR AIR-CONDITIONING  
AND VENTILATION WORKS**

**SECTION - XIII**  
**VARIABLE FREQUENCY DRIVES**

## 1. VARIABLE FREQUENCY DRIVES

### 1.1 Scope:

This section describes the type of variable frequency drive (VFD) to be supplied for the fan and pump speed control.

### 1.2 General:

1. The VFDs shall be supported by the manufacturer who shall provide full technical support, spares holding and trouble shooting capability from his own facility. A training course shall be provided by the manufacturer to the operating and maintenance engineers.
2. The supplier shall provide complete technical details of the product with the offer including catalogues, operating manual, dimensional drawings, weights etc.
3. VFDs shall conform to the recognized international standards like IEC and manufactured according to ISO 9001 and shall be UL listed.
4. Suppliers shall offer a single series of controller over the whole required power range to ensure a common user interface, common circuit requirements and common spare parts.
5. VFDs shall be suitable for operation in a “Stand Alone” mode, complete with all necessary protection to the motor or as a part of the centrally controlled Building Management System (BMS)/ Direct Digital Control (DDC).

### 1.3 Design Requirements:

1. The VFD shall be suitable for operation on a 3 phase,  $415 \pm 10\%$  V, 50 Hz input power supply.
2. The VFD shall be suitable for operation at full load at the following conditions:
  - Input supply voltage variations :  $\pm 10\%$
  - Input supply frequency variations :  $\pm 6\%$
  - Ambient temperature : 0 - 50°C

- Maximum relative humidity : 95% non condensing
  - Vibration : 0.7 g RMS in 3 directions
  - Minimum efficiency at full load : 96%
3. The VFD shall use the advanced digital Vector Control technology for converting fixed voltage and frequency to variable voltage and frequency. It should ensure that full motor power is utilized at the rated speed.
  4. The VFD shall automatically correct the output voltage during main's variations of  $\pm 10\%$  to prevent loss of torque and speed variations occurring during motor operation.
  5. The VFDs shall have a metallic enclosure with a protection of minimum IP 20 and shall be suitable for installing inside a IP 54 control panel without any de rating. The clearances and air flows required for adequate cooling of the VFDs, while installing inside a control panel shall be stated very clearly.
  6. The output waveform of the VFD shall be suitable to control the quadratic load torques produced by pumps and fans to ensure that maximum total efficiency is obtained from the motor and drive at all loads and speeds.
  7. The V/f ratio of the output of the VFD shall be dynamically variable based on the operating load conditions. It shall not be possible to set a constant V/f ratio to prevent damage to the connected equipment. This is to optimize the energy consumption.
  8. The VFD shall be capable of providing 160% torque for 0.5 sec and even 110% torque for 1 min at starting. This shall truly reflect the operating limits of motor connected to VFD.
  9. The VFD shall work in conjunction with any IEC standard design motor and shall not require the motor to be derated or cause the motor temperature to rise above the normal class 'B' rise expected on normal mains operation. The motor shall not require an external blower even at slow running speed.

10. The VFD shall have protection against electro fluting of motor bearings and damage to motor windings. This protection shall be provided by any one of the following:
  - LC filters fitted to the VFD
  - Soft switching of IGBTs of the VFD
11. The VFD shall incorporate an “Automatic Energy Optimizer” function which continually adjusts the output voltage to a reduced level to give maximum motor efficiency at any given partial load.
12. The VFD shall automatically adjust the output frequency and voltage to maintain a stable motor speed of  $\pm 0.5\%$  at the motor’s rated speed. This accuracy shall be maintained over a speed range of 1% to 100% without the use of a closed feedback loop.
13. The VFD shall allow connection of motors one frame size larger and upto 4 sizes smaller than its nominal rating.
14. The VFD shall comply with Electro Magnetic Compatibility (EMC) document EN 55011/ EN 50270 for Radio Frequency Interference (RFI) control as an integral part of its design by incorporating RFI filters to meet both Class 1A (150 meters) and class 1B (50 meters). The RFI filters shall be supplied by the manufacturer of the VFD itself and should be of their standard design to meet the above criteria.
15. The VFDs shall be immune to interference from other RFI producing equipment and shall comply to AS/NZS 4252.1 – 1994, IEC 61000-4-2, IEC 61000-4-3, IEC 61000-4-4, IEC 61000-4-5, IEC 61000-4-6 and VDE 0160 with latest amendments.
16. The VFD shall contain as a standard, built-in DC reactors with both inductive and capacitive elements to control the mains harmonics. The harmonic current distortion produced by the controllers shall comply with IEC 61000-3-2 and IEC 61000-3-4 respectively according to the current ratings.

17. VFDs that do not include built-in DC reactors for harmonic control shall be supplied with external 3-phase AC reactors on the mains side with a minimum impedance of 3%. These AC reactors shall be of the same make of the VFD and shall be supplied as an integral part of the VFD by the manufacturer itself.
18. The VFDs shall be capable of allowing for a minimum of 1 start/min. on mains operation. Start/stop operation using electronic / automatic operation shall be unlimited.
19. The VFDs shall be suitably protected to allow for switching to take place on the output via a contactor or isolator without damage to the inverter transistors or the switching device.
20. The controller shall include features which limit the rate of the output voltage rise over time ( $dV/dt$ ), and prevent peak voltages from occurring. The maximum peak voltage encountered by the motor shall be 950 V with a rise time of 0.1  $\mu$ sec. Those VFDs having a higher  $dV/dt$  than specified shall be supplied with integral LC filters by the manufacturer itself.
21. The switching frequency of the VFD shall be adjustable to reduce the acoustic noise generated from the motor. While adjusting the switching frequency no de rating shall be applicable to the VFD. The VFD acoustic noise shall not exceed 65 dB(A) at full load and 60 dB(A) at 50% load.
22. The VFD shall be capable of allowing up to 150 meters of armored cabling between the VFD and the motor. If the offered VFD cannot allow this cable length, the supplier shall state the maximum cable length allowed, the motor coil reactance value required to increase the cable length up to 150 meters, the additional voltage drop and motor de rating.
23. The VFD shall incorporate automatic motor tuning function to adapt itself to the actual motor parameters. The tuning shall be based on measurements of the motor's inductance and resistance.
24. The VFD shall be capable of automatically reconnecting to a spinning fan, forward or reverse running without tripping following mains interruption or transfer from bypass running.

25. The VFD shall have DC injection braking to ensure that a pre-rotating high inertia load motor, even in the reverse direction, can be switched onto, braked to zero and then accelerated to the preset speed in the correct direction.
26. The VFD shall be provided with at least 4 by-pass frequencies with adjustable band width in order to eliminate resonance in duct work and pipe lines occurring within the motor's operating frequency range.
27. The VFD shall incorporate an in-built programmable PID controller to enable closed loop control of the process. It shall respect the minimum and maximum limits and shall include an anti wind-up function. The PID controller shall be able to operate in the normal or inverse modes. Remote monitoring of the feedback signal via a 0/4 - 20mA signal from the VFD is required.
28. The PID controller shall be able to accept up to 2 sensor feedbacks. It shall be able to calculate the Minimum, Maximum, Sum, Difference and Average of the 2 signals. In addition, it shall have a 2 zone Minimum or Maximum selection where the zones have independent set points.
29. To allow a pressure transmitter to be used as a flow measuring device the VFD shall be able to perform a square root conversion on the feedback signal.
30. The VFD should include an interlock function which allows control and interlocking of other mechanical equipment such as dampers.
31. To prevent condensation, build up in the stator the VFD shall incorporate a pre-heat function. When the motor is stopped it shall receive a low DC voltage from the controller.
32. In case of a power failure, the VFD shall be capable of automatically restarting after a programmable time delay.

#### **1.4 Control and Monitoring Functions:**

1. Full galvanic isolation between power and control components shall be incorporated to ensure compliance with VDE 0160 PELV (Protective Extra Low Voltage) to prevent damage to BMS interface and ensure operator safety. Short circuiting of the control terminals shall not damage the control card.



2. At least 6 digital inputs shall be provided with freely programmable functions and shall have a scan time less than 3ms. For maximum noise immunity on the digital inputs the sink current shall be minimum 10 mA at 24 V for each input.
3. Two analog inputs accepting voltage (max 10V) and current (max 20mA) inputs shall be provided in the VFD. These inputs shall be freely programmable and scalable.
4. Two programmable relays shall be provided for remote monitoring of the VFD. The programmable options shall include as a minimum ready, run, and alarm. The run relay function shall initiate a run signal only when the frequency output from the VFD is greater than 0.5 Hz.
5. Two programmable analogue outputs of 0/4-20 mA shall be provided for monitoring. The programmable options shall include as a minimum speed, current and torque.
6. The VFD shall be capable of accepting input from a thermistor.
7. The VFD shall be able to accept a pulse train, the frequency of which gives an analogue reference of feedback.
8. The VFD shall have an internal power supply to provide a sensor supply for the digital inputs and any loop powered analogue sensors. This internal power supply shall have a minimum capacity of 100 mA at 24V DC.
9. The VFD shall be able to generate a pulse train output, the frequency of which is proportional to the signal being transmitted.
10. The VFD shall have local control panel with multi-line selectable alpha-numeric display which shall display the following minimum information:
 

• Output Frequency in Hz	• Input Frequency in Hz
• Feedback signal in units	• Power in kW
• Current in A	• Energy in kWh
• Output Voltage in V	• Input voltage in V

- Run time in hours
11. Those VFDs with LED display as standard are not acceptable and shall be supplied with additional Alphanumeric displays. The local control panel shall be used for setting parameters and tuning the VFD.
  12. The VFD shall display the following minimum faults in clear English text and not by codes:
    - Mains phase loss
    - Over voltage
    - Under voltage
    - Inverter Overload
    - Motor Thermal Overload
    - Over current
    - Earth fault
    - Switch mode power supply fault
    - Output short circuit
    - RS485 communications timeout
    - Heat sink over temperature
    - Motor phase missing
    - Inverter fault
  13. The VFD shall provide for Hand /Off /Auto switch to allow for local control by hand or remote Auto control by the BMS. This function shall be selectable via the Local Control Panel or via digital I/O.
  14. The VFD shall log and display “Total kWh consumed” and Total Hours Run” by the motor without additional instrumentation and facility to reset.
  15. The VFD shall be fitted with a RS485 serial port with an open protocol for allowing serial communication with the BMS system.
  16. The following indicating lights shall be provided on the local display panel of the VFD:
    - VFD ‘ON’ light
    - VFD ‘WARNING’ light
    - VFD ‘ALARM’ light

17. A parameter lock shall be available in the VFD local display panel to prevent unauthorized resetting of parameters.

### **1.5 Protection Features:**

1. The VFD shall shut down safely under the following conditions and operate the alarm relay. The display shall indicate the nature of the fault in clear English text.

- Mains phase loss
- Over voltage
- Under voltage
- Inverter Overload
- Motor Thermal Overload
- Over current
- Earth fault
- Switch mode power supply fault
- Output short circuit
- RS485 communications timeout
- Heat sink over temperature
- Motor phase missing
- Inverter fault

2. The VFD shall provide for both automatic and manual reset operation. In automatic mode there shall be a programmable choice of up to 10 reset attempts per fault before the controller shuts down making manual reset necessary to restart the system. The restart time after a trip in automatic mode shall be adjustable. In manual reset mode the reset shall be accomplished from both the keypad on the controller and by remote signal.

3. The VFD shall be equipped with a data log menu that will allow storage of at least 10 latest faults that have occurred. Last fault memory shall be required in the event of power failures.

4. The VFD shall have a sufficiently fast current limit feature to survive a continuous short circuit on the output terminals without damage to any drive components.

5. The VFD shall not require special type input protection devices such as high speed semi-conductor fuses. In case, these are necessary for protection of the VFD, the same should be included in the scope of supply of the VFD supplier.

6. The VFD shall maintain operation as long as possible under fault conditions. For example, the controller should automatically derate itself and reduce the speed to a safe level on high motor temperature or a phase loss to maintain some control of the process rather than shutting down due to a trip.
7. The controller shall include electronic motor thermal overload protection where the trip time is based on the motor's running frequency, actual motor current, operating time and the motors rated current. The device shall automatically modify the trip time to take into account operation at low speed. On trip, the controller shall indicate that the fault is a motor thermal trip.
8. No rear access shall be necessary during normal service function.

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**SPECIFICATIONS FOR AIR-CONDITIONING  
AND VENTILATION WORKS**

**SECTION - XIV  
DIRECT DIGITAL CONTROL**

## **1. DIRECT DIGITAL CONTROL (DDC) SYSTEM**

### **1.1 A/C system details and general particulars:**

The objective in introducing DDC System is primarily from the point of view of Precise control & monitoring of parameters and simultaneously ensure energy savings for the A/C system. As regards the maintenance of positive pressure inside clean rooms, state of the art, variable speed drives have been specified for the centrifugal blowers.

The Air-conditioning System on the High side comprises of water cooled and Air-cooled chiller packages along with associated equipment such as chilled water and condenser water pumps, cooling towers, Air-cooled condenser fans as specified elsewhere. The chillers are connected to large blowers/AHUs for Clean Rooms/normal AC areas through a chilled water circulation system for air-conditioning. The AHUs are spread over in different buildings and floors. DDC designed for energy management, equipment monitoring and control shall be suitable for the building usage. The control strategies shall be developed to ensure that the specified environmental conditions are maintained, whilst giving due regard to minimizing of energy consumption to ensure quick pay back, reliability and traceability of system parameters right from the day one of equipment operations. For effective air-conditioning, it is necessary to precisely control & monitor temperature, pressure, water and air flow rates, voltage, current, etc., as provided for and carryout signature interpretation on routine basis. For this purpose, a DDC system is required. This shall increase the energy savings for the A/C system, due to the possibility of load management more precisely. DDC shall also ensure quick pay back, reliability and traceability of system parameters right from the day one of equipment operations. The DDC system shall have energy management, algorithm to continuously hold the leaving chilled water temperature between 5.0 and 10.0 Deg. C as set during commissioning, based on the no. of AHUs in operation while ensuring temperature, humidity, dew point set points are not compromised. Further refer "Guideline for Chiller Management Software / Logic".

### **1.2 Important points to be considered:**

1. The DDC system shall only carry out the remote monitoring of chiller parameters / events that can be accessed from the chiller's microprocessor panel. No overall plant monitoring and control functions on the chiller, other

than those specified shall be carried out by DDC system. The DDC system specified shall not depend on external hardware / software. In view of this, it is preferred to include sensors for measuring chilled water and condenser water IN / OUT temperatures in the DDC system also, to make it a TRUE STANDALONE type.

2. The DDC system shall have uniformly, matching 16 or 32 bit or later processors at all levels. The system specified is a state of the art, scale able, modular, futuristic, high speed and true peer-to-peer communication type. Historical data storage shall be provided in the individual field controllers also for rugged and non-failure prone type design. This would mean that centralised historical data storage alone, is not permitted to make the DDC system, a TRUE STANDALONE type.
3. The DDC system calls for Open/ Universal Protocol and integration of other external systems like energy management, precision AHU systems, Illumination control/ Lifts management/ Fire alarm/ Access control/ CCTV/ Transport and other PLC based control systems, which may be built around this DDC system at a later date. Hence, 8 Nos. serial ports /serial to Ethernet converters/ Serial to Modbus converters / other interfaces that are necessary for expansions and integration of other systems. However, it is clarified that a minimum of 4 Nos serial ports operated devices shall be interfaced apart from the chillers integration with the DDC system.
4. The vendors are free to use networkable controllers for each equipment or a group of equipment as required in the I/O summary, which will directly get linked to the DDC field bus, communicative with the main PDM (Main PC) for data acquisition.
5. DDC system shall be capable of providing user definable periodical reports / graphs about energy consumption.
6. The DDC system shall include the required no. of user terminals accessible through LAN. Software to be supplied as per order shall be of licensed version only and original user manual / license / media and operation manual shall be provided along with supply. Required number of floating licenses of the software with auto queuing facility, with media and preloaded shall be provided. Node lock license will not be accepted.



7. The DDC system shall also be accessed through INTERNET. For this necessary firewall protection shall be included in the software.

### **1.3 Sub-systems to be monitored:**

Depending on the individual project needs, DDC shall be capable of carrying out Data Acquisition, Monitoring and Control of following subsystems:

Details pertaining to Chiller packages, Condenser water pumps, Chilled water pumps, cooling tower fan motors, Air-cooled fans, of AHU / blower locations, packaged units, Ductable units, VRF systems, Fan coil units and other plant equipment are specified elsewhere and as mentioned in the I/O summary.

The DDC system shall be compatible to protocols of the makes of chillers such as Dunham Bush, Johnson Controls, Mc Quay, Trane and Carrier or other reputed makes. Hence, it is necessary that it has an open or universal protocol. In case of non-compatibility gateways can be utilized. The system design shall utilise the latest technology in “open” network architecture, distributive intelligence and processing. The system offered should be from the latest offerings and should be of freely programmable management and automation stations for the full spectrum of today’s building application services.

A list of I/O summary as per the tender schedule has been enclosed as a guideline where field sensors/ devices are to be installed. All peripheral equipment e.g. sensors, pressure switches, control valves and actuators, shall be of the same manufacture as the direct digital control modules and outstations.

The system offered shall be completely modular in structure and freely expandable at any stage from the smallest system through to large distributed systems. Each level of the system shall operate independently of the next level up.

The system shall fully be consistent with the latest industry standards, Microsoft Windows-10 or latest operating system, allowing the user to make full use of the features provided with these operating systems.

To provide maximum flexibility and to respond to changes in the building use, the system offered shall support the use of BACNET, Profibus and Ethernet TCP/IP communication technologies.

The contractor shall establish the number of equipment to be controlled / monitored by the BMS from the drawing/ schedule/ specifications. This

information shall be furnished to the BMS supplier. All plant and equipment requiring control and / or monitoring functions shall be fitted with all necessary interfacing equipment readable by the BMS network. The contractors shall coordinate and ensure that this equipment shall provide the required signals to the BMS.

#### **1.4 General system architecture:**

The system shall be logically structured into three distinctive levels, which are Management, Communication and Process levels. Each level shall be autonomous from the other. Access protection shall be provided for these levels. Peer to peer communication shall be possible on all system levels and the system design shall be modular in structure to allow straightforward extensions.

##### **1.4.1 Management level:**

The head-end management and operation of the plant shall include process visualization, data analysis, and exchange of data with 3rd parties. At the management level, it shall be possible for communication to flow in all directions, across networks and via direct connections.

Personal computer based operator management stations shall be provided for plant supervision and operation, alarm management, information and database management function. All real-time control functions shall be resident in the DDC controllers to facilitate greater fault tolerance and reliability.

The operator management station should be capable of multi-tasking 32-bit/64 bit programs as applicable by utilising a Microsoft Windows -10 or later operating system.

The management level of the system shall consist of one and shall be capable of handling more management station PCs and the associated software modules.

The management station shall be capable of the following:

- Display of graphical representations of the plant overlaid with live data
- High quality dynamic graphics with true multitasking of all active pages
- Monitor and operate / influence process devices.
- Receiving of alarm messages from the process level and directing them to the appropriate reporting device e.g. printer, mobile, fax, e-mail

- Monitor process devices for communication problems and other device faults.
- Alarm handling – all the alarms shall be displayed in a graphical tree structure in order located alarms quick and easily.
- Adjusting time strategies in the process level.
- Long term storage of logged data from the process devices.
- Multi-level user access control for individual access to sites, applications, functions and objects.
- Display graphically the logged data.
- Custom application programming.
- Use of graphical genies to allow manipulation of data.
- The user interface shall be based on a basic taskbar, which is always visible.
- History logging for alarms, user actions, system events and messages.
- Alarm handling – all the alarms shall be displayed in a graphical tree structure in order located alarms quick and easily.
- Simultaneous connection of at least of 4 sites via serial connections / 50 sites via LAN/WAN connections for a comprehensive overview on geographically distributed projects.
- Trips of equipment/system and cause of all the Trips shall be time tagged for enabling to identify the first cause of trip.

For maximum fault tolerance, the management stations connect to the process level via point-to-point communications. This shall be via RS232, Ethernet/TCP/IP LAN / WAN or via AutoDial links.

#### **1.4.2 Communication level:**

General Purpose controllers shall be used for monitoring / controlling equipment which have to perform based on a customized logic, such as AHUs, Chillers, Chilled water pumps, cooling towers, Lifts, signals from Fire Alarm panels, generators, transformers etc.

At the heart of the DDC system shall be the Microprocessor based modules, which can be individually programmed according to the functional requirements.

The automation level DDC controllers shall monitor and control the main plant in the building. The DDC controller outstations shall be freely programmable and have the ability to perform all the following routines

- a) Process control & interlock functions.
  - Generate alarms/events based on comparing measured values against known parameters.
- b) Time control strategies
- c) Runtime totalisation.
  - Trend logging of specific data-points with transmission of the logged values to the management level.
- d) Energy calculations
- e) Backup of the data/program ( $\geq 5$  years)

The DDC controllers shall be selected from either a modular or compact type of unit to suit the most economic inclusion of all the data points specified. Each control module shall be capable of operating on a stand-alone basis without control from a central computer.

The input/output connection to Modular controllers shall be via individual plug-in modules suitable for the particular peripheral device. The digital modules shall have visual indication of the status of the input/output. Digital input modules shall be capable of accepting control voltages up to 230 V AC and will have integral status indication.

It shall be possible to integrate both types of control module onto the same BACNET communication network. Each controller performance shall be to 0.5% control accuracy with sample rates of less than one second.

Main plant DDC controllers shall be 32 / 64 bits or later freely programmable. Controllers meant for VAV controls cannot be used as DDC controllers.

All DDCs must be UL approved, must have an in-built real time clock and be suitable for PID control.

The products used in constructing the BMS management and automation levels shall conform to BACNET protocol for building automation and control networks.

All controllers shall have attained a BACNET Testing Laboratories (BTL) listing and display BTL logo.

Room units shall utilize a two-wire communication link at each controller for the acquisition of room temperature and local set point. These will also provide an integral temperature/set point digital display. Up to 5 room units shall be able to use the same two-wire communication link.

The system shall have the facility for a Web server to be added to allow full operation of all automation station control modules connected to the Lon Talk BACNET network via a standard thin client/web browser. Functions to include:

- Display of graphical representations of the plant overlaid with live data.
- Data point display and operation of all measured values, set points, plant States, operating states and parameters.
- Alarm monitoring with acknowledgement and visual and audible alarm Indication.
- Alarm and event history.
- Alarm transmission via SMS and e-mail.
- Operation of all time schedules, exception calendar and heating curves.
- Reading of trend data with facility to export data to Microsoft Excel.
- Multi user level access protection.
- Ethernet or Modem connection.

#### **1.4.2.1 DDC Controller Specification:**

The standalone controller i.e. in the event of loss of communication with other DDCs or Control Station, they shall be able to function on their own. For each Air handling unit/ blower system shall be with EPROM chip of required capacity with inbuilt psychometric calculation, providing all required data acquisition, processing capability, RAM, historical database, in a powder coated enclosure, completely prewired, is required. The controller should be complete with display and keypad, 'Rittal' or equivalent panels and relays. The DDC controllers shall be selected from either a modular or compact type of unit to suit the most economic inclusion of all the data points specified.

#### **1.4.2.2 Direct Digital Controllers capabilities:**

1. The Controllers shall have a self-analysis/ diagnostic feature and shall transmit any malfunction messages to the Control Station. For any failed chip the diagnostic tests, printout shall include identification of each and every chip on the board with the chip number/location and whether the chip “Passed” or “Failed” the diagnostic test. This is a desired requirement as it would facilitate trouble-shooting and ensure the shortest possible down time of any failed controller. Controllers without such safety feature shall be provided with custom software diagnostic resident in the EPROM. The tenderer shall confirm in writing that all controllers are provided with this self-diagnostic requirement.
2. Operating system (OS) software for controllers shall be EPROM resident. Controllers shall have resident in its memory and available to the programs, a relevant library of algorithms, intrinsic control operators, arithmetic, logic and relational operators for implementation of control sequences.
3. In the event of failure of communication between the controllers and/or Control Station terminal, alarms, reports and logs shall be stored at the controllers and transmitted to the terminal on restoration of communication.
4. In the event of memory loss of a Controller, or the expiration of backup power, on start-up of the unit the necessary data-base shall be downloaded automatically and without operator instruction. Controllers requiring a manual intervention for the re-boot of software are not desired.
5. Where information is required to be transmitted between controllers for the sharing of data such as outside air temperature, it shall be possible for global points to be allocated such that information may be transmitted either on change of incremental value or at specific time intervals.
6. Each DDC Controller shall have a real time clock with a battery backup for a minimum of 5 years. Upon power restoration all clocks shall be automatically synchronized in the network. Controllers shall be able to perform the following energy management functions as a minimum: -
  - a) Time & Event programs.
  - b) Holiday Scheduling.

- c) Maximum and Distributed power demand.
  - d) Optimum start and stop program.
  - e) Night purge.
  - f) Load reset.
  - g) Zero energy band.
  - h) Duty cycle.
  - i) Enthalpy analysis and control.
  - j) Run Time totalization.
  - k) Sequencing and Optimization.
  - l) Exception scheduling.
7. Detailed description of software features and operating sequence of all available energy management software shall be submitted with the tender for evaluation.
  8. All DDC controllers shall be with proper termination of peripheral devices at the terminal strip and not directly to the controller.
  9. The DDC Controllers shall have Adaptive Control capability whereby the control software measures response time and adjusts control parameters accordingly to provide optimum control. The software shall allow self-tuning of the variable control loops (all or any of P, P+I, P+I+D) of the AHUs and chiller system so as to provide the most efficient and optimised controls at different load conditions.
  10. The energy management programs shall update their parameters based on past experience and current operating conditions.
  11. Run time shall be accumulated based on the status of a digital input point. It shall be possible to total either ON time or OFF time. Run time counts shall be resident in non-volatile memory.

### **1.5 Enclosures for Controllers and Electrical Panels:**

The controllers shall be housed in Lockable vandal proof boxes which shall either be floor mounted or wall mounted, to protect them from tampering by any

unauthorized personnel. All DDC controllers used in plant room spaces and external application shall be housed in IP 54 rating enclosures only. The panel shall be metal enclosed 14 SWG CRCA sheet steel cubicle with gaskets between all adjacent units and beneath all covers to render the joints dust proof. All doors and covers shall be hinged and latched and shall be folded and braced as necessary to provide a rigid support. Joints of any kind in sheet metal shall be seam welded with welding slag grounded off and welding pits wiped smooth with plumber metal. All panels and covers shall be properly fitted and secured with the frame and holes in the panels correctly positioned. Fixing screws shall enter into holes tapped into an adequate thickness of metal or provided with nuts. Self-threading screws shall not be used in the construction of control panels. Knockout holes of approved size and number shall be provided in the panels in conformity with the location of incoming and outgoing conduits/cables. Suitable clamps shall be provided to support the weight of the cables. The dimension of the boxes shall depend on the requirement with the colour decided in consultation with the Engineer-in-charge. The DDC controllers being used should conform to the following specifications as a minimum:

- Based on ANSI/ASHRAE standard 135-2001 (BACNET), ENV13321-1, UL 916 listed and conforming to CE (Euro norms).
- Operation standalone, 78kBits with Built in BACNET interface or ETHERNET / IP.
- Controllers provided by the contractor shall not be of the configurable plug in function cards type.
- Controllers shall have 20% spare capacity (digital / analog input / output) to give flexibility for future expansion.
- Optional connection to operator terminal, management station and via Web browser with Web server device.
- Freely Programmable
- Flash ROM, real time processing and multi-tasking
- 16/32-bit processor system, 1.5 MB program memory
- Supply voltage AC 24V +/-20% 50/60 Hz
- Event driven data transmission.



- Automatic mains recovery.
- PPS2 connection.
- Digital output to be 250V 2A rated changeover contacts.
- Historical data memory storage. The memory available in the controller as working space for storage of the Operating system software and data files shall be decided for the full points, the controller would be having.
- Software application stored in non-volatile memory.
- Controllers requiring nickel-cadmium / lithium battery to support the full operation of the RAM, shall have battery back-up up to 12 hours in the event of a localised mains failure. The battery shall not be required to supply power to actuators, valves, dampers etc. In addition to the above battery reserve a further battery shall be provided to retain the RAM for a minimum of 2 days, after the expiration of the standard battery. A low battery alarm shall be provided with each Controller and with an indication at the Control Station. Even in case the memory is stored on EPROM, the battery backup is required. Battery backup > / 5 Years.

For the generation of the application programs, the following function elements are required as a minimum:

- Reset functions
- Set point jump
- Positioning time
- P-controller (reverse or direct acting)
- P1-controller (reverse or direct acting)
- PI-controller with I-deletion (reverse or direct acting)
- PID controller (reverse or direct acting)
- 2-point controller (reverse or direct acting)
- Proportional additional sequences (reverse or direct acting)
- Data transmitter (digital or analogue)
- Data converter (analogue-digital or digital-analogue)

- Ring Counter
- Timer (switch on or switch off)
- Logic operations:
  - i. logic "AND"
  - ii. logic "OR"
  - iii. logic "EXOR"
  - iv. logic "NOT"
- Comparative operations:
  - i. Maximum values
  - ii. Minimum values
  - iii. Average values
- Enthalpy calculation
- Optimiser
- Mean value calculation
- Hysteresis
- Output steps (digital or analogue)

Digital outputs shall be potential free outputs. Analog outputs shall be true analog outputs (0-10 V DC, 0-20 mA & 4-20 mA). Resistance Signals (either PTC or NTC) (PT 100, PT 1000, PT 3000, Balco 500, NI 1000).

Digital input/output types to be supported shall be, but not limited to the following:

- a) Normally-open contacts.
- b) Normally-closed contacts.
- c) Modulating outputs shall be true proportional outputs and not floating control type.

Above blocks shall be resident in the DDC Controllers and independent of any high level interfaces/controllers. All board terminations shall be made via plug-in

connectors to facilitate trouble-shooting, repair and replacement. Soldering of connections shall not be permitted. Controllers shall preferably be equipped with diagnostic LED indicators with at least indication for Power up Test OK, and Bus Error. All LED's shall be visible without opening the panel door. It shall be possible for the controllers to accept regulated uninterrupted power supply to maintain full operation of the controller functions (control, logging, monitoring and communications) in the event of a localised mains failure. Controllers requiring fan cooling are not acceptable. There shall be the facility for accessing controller data information locally, via a portable plug-in keypad display, which can be common to all controllers and normally removed to prevent unauthorised tampering. Alternatively, each controller shall have a keypad and display integral with its casing for local interrogation and adjustment. In either case, access to the system thus provided shall be restricted by passwords in the same way as at the main operator terminal. In case the Portable operator Terminals (POT) are required to programme the controllers, sockets shall be provided for same. Attachment of POT shall not interrupt or disable normal panel operation or bus connection in any way. It shall be possible to add new controllers to the system without taking any part of the system off-line.

Further, the DDC unit software must have the following additional functions:

Free selection of range and unit (dimension) of all signals (measured values, accumulated values, calculated values, etc.)

Free allocation of access protection in accordance with operating priorities.

Free definition of manual override priorities (software) from operator terminal and/or management station.

Wherever control logic is required for equipment such as AHUs, the DDC controller offered shall have a digital display on the fascia. This display shall be capable of displaying 2 categories of 3 parameters each. In the event of an alarm, the display shall switch over to an 'alarm' indication. In all, the controller shall have the capacity to indicate 8 different alarms. In case more than one alarm is active at the same time, the controller shall display a coded alphabet, to alert that there is more than one alarm in the controller.

#### **1.4.3 Process level:**

A control system is required to ensure the following minimum important functions:

- Monitoring of the conditions of all field controlled spaces
- Data acquisition
- Facility for defined control functions
- Alarm indications

For controlling & monitoring humidity in the blower room / AHUs reheat facility by strip heaters has been proposed. Only limit value based ON/OFF switching in steps to be foreseen.

#### **1.4.3.1 Control function:**

It shall have the following modes of switching commands for the AHUs/ fan coil units/ packaged unit/ Blower systems.

- Auto ON / OFF (Local OFF Possible)
- Manual Mode (Local ON / OFF Possible)
- Schedule Mode (High and low side equipment to come 'ON' automatically as per the automatic time based /event based program).
- Proper sequencing of the equipment shall be ensured so that no equipment runs unless the system demands. Load, time sharing and sequencing of the equipment shall be ensured to reduce the kW per TR of the Air-conditioning system.
- The updating of dynamic data on displays shall be done on regular basis.
- The Keyboard command to field equipment and trip commands shall be executed.
- The response for operator's request from keyboard and display shall be completed in minimum period of time.

Apart from the above control it shall be possible to change set points for:

- Coil Leaving temperature
- R.H
- Temperature
- Positive pressure inside clean room.

The control is to be realized with a latest Microprocessor based controller with inbuilt real-time clock, battery backup for a minimum period of 5 years for with transformer, terminals etc., with I/O's as per enclosed I/O list. The DDC system shall manage each event according to priority, storing of status updates, maintenance issues, critical events in individual files. Suitable display shall also be available. Loss of data shall be avoided in case of PC failure. Hot standby feature including a standby PC, router, all necessary hardware and software to be included. Capacity of UPS supply required for PCs and controllers etc., for DDC system shall be specified. All necessary data cables and accessories shall be included which will be inclusive of accessories, laying and termination charges etc. as required.

Individual terminal unit controllers for autonomous room by room comfort control, based on application specific logic written on the controllers. All the terminal unit controllers shall fulfil following general requirements:

- Lon Mark and BACNET TCP/IP /Modbus.
- AC 230 V power supply or DC power operated with required adaptors.
- Mountable with screws or DIN rail.
- Optional terminal covers for local installation without cabinet.
- Downloadable application software /adjustable parameter set, the type of Use shall be defined by downloadable pre-tested application software.

Common functions like grouping, scheduling, etc., shall be realised within a master controller on automation level.

All terminal unit controllers supplied on the project shall have the facility for local set point adjustment via a room unit.

Application specific controllers shall be used for terminal devices such as Fan Coil Units etc., These controllers shall be with Lon Mark compatible bus communication. Any failure problem in communication bus should not affect the working of the FCU controller. A dedicated stand-alone controller shall be provided for each FCU. A common controller for FCUs serving different areas shall not be acceptable. These controllers shall be looped with a bus cable and connected to the BMS.

In general, they shall comply with the following specifications:

- For 2 or 4 pipe FCUs, with or without changeover
- PID control
- Downloadable application software over the BUS cable.
- LonMark and BACNET compatible bus communication.
- To be integrated to the management station software.
- Control of AC 24 V PWM valve actuators, 3-point AC 24 V valve and damper actuators, or electric heating coils.
- Volt-free relays for fan control.
- Operating Voltage 230 V.
- Internal fuse, thermal, automatic reset.
- Connectable to 1 room unit via local bus, 2/4 wire unscreened twisted pair @ 4.8 kBps or higher.

The application specific controllers shall be capable of working in conjunction with the following type of room controllers. The specific type of room controller to be used in specific applications shall be selected from any one of the following types to meet the description written in the sequence of operation.

1. TYPE 1

- Integrated room temperature sensor

2. TYPE 2

- Integrated room temperature sensor
- Dial for temperature set point

3. TYPE 3

- Integrated room temperature sensor
- Dial for temperature set point
- Rocker switch for off/auto 1 mode (single speed fan)

4. TYPE 4

- Integrated room temperature sensor

- Dial for temperature set point
- Rocker switch for off/auto1 mode and fan speeds (3 speed fan).

#### 5. TYPE 5

- Integrated room temperature sensor
- Dial for temperature set point
- Rocker switch for off/auto1 mode and fan speeds (3 speed fan)
- LCD display of measured temperature

#### 6. TYPE 6

- Integrated room temperature sensor
- Rocker switch for temperature set point (raise/lower)
- Rocker switch for off/auto1 mode and fan speeds
- LCD display of measured temperature
- Communication with controllers via Lon bus.
- Exchangeable rocker switches for lighting and blinds.
- Selection of downloadable software applications for the operation of lighting and blinds.
- Operating mode 'auto' –comfort, 'off' – standby or economy

#### 7. Printing

- It shall be possible to connect printers either directly to the management station or to the file server.

#### 8. Remote Monitoring and Control

It shall be possible, with additional hardware if necessary, to interrogate the system remotely via the following possible methods:

- Telephone connection
- Building IT network

- Web browser technology with password access via IT networks accessing information stored on dedicated embedded web server device installed on automation controller network.
- Alarm reporting to mobile pagers/phones/e-mail etc.,
- Energy usage monitoring and control via Building Management Systems.

## 9. BMS – Records

### **1.5 General:**

The details of the DDC system shall include all the manufacturers Technical Data Sheets and User Manuals. Control valve schedules shall be provided with flow rates, valve pressure drop and system design basis on which the particular valve type shall be selected.

#### DDC Control System Software Strategies

Controller strategies shall be provided, in both hard copy and on CD-ROM, for inclusion in Operating & Maintenance Manuals.

Copies of all the preliminary strategies, in both hard copy and on CD-ROM, shall be supplied to the Engineer-in-charge prior to commencement of control systems commissioning.

Copies of all the 'As Installed' strategies, in both hard copy and on CD-ROM, shall be supplied to the Engineer within three months of hand over of control systems.

### **1.6 BMS Software and Licences:**

The BMS software shall be client/server software with redundancy option.

The BMS software should have license for 10,000 I/O points or more.

Number of clients: 5 or more.

The DDC system shall include the required no. of user terminals accessible through LAN. Software to be supplied as per order shall be of licensed version only and original user manual / license / media and operation manual shall be provided along with supply. Floating licenses of the software with auto queuing facility, with media and preloaded shall be provided. Node lock license will not be accepted. All Licence rights to the control systems, manufacturer's software packages shall be transferred to the client at the time of hand over. User Registration must be made



on behalf of the client, direct to the control system manufacturer by the specialist System House Partner.

Copies of all of the control system manufacturers Monitoring or BMS software shall be provided on CD-ROM, or other mass storage device, together with copies of any graphics and databases that may be required to re-install the system after a fatal computer failure.

### **1.7 Integration of Secondary systems:**

The DDC system shall have the following additional features also. Peer to peer communication between standalone controllers is a must. If any controller fails, the idling controller shall come to its rescue, to make the system available uninterruptedly. The MAC or network-CSMA/CD commonly called the ETHERNET server and the OFC network, when available throughout the location, shall be utilized for data acquisition, transfer, control and monitoring. DDC system shall form a Bus network with this network. The specification of ETHERNET server is normally, Protocol - TCP / IP transportable to any network.

Ethernet switches are available in each block/building/floor/wing with optical fibre cable (OFC). Twisted pair cables shall be used for sensors, differential signals, etc; Shielded twisted pair or shielded multi conductor cabling shall be used for noisy environments.

Additionally, integrations shall also be carried out (if required) at the most appropriate level within a system, depending on the functions and interaction required. The following integrations must be possible.

- Lon Works
- Lon mark
- BACNET /Lon Works
- BACNET/IP & / TCP/IP
- OPC
- Integration of standard proprietary buses: Modbus, M Bus, KNX.

As part of the requirements for an open system device with a Native BACNET, lon mark protocol shall be connected onto a common field bus backbone network directly without any Gateway/Protocol converter device. If interaction is required

between different sub-systems, the integration shall be carried out at either the automation or field level. The integration must not occur at the management level. Link to a third party software package such as a Planned Preventive Maintenance package or an Energy Monitoring package shall be carried out at the management level. When sharing alarm and historical information with Maintenance Management and Energy Management packages, the management system shall provide the information in a standard commercially available format e.g. MS Access and using standard mechanisms e.g. ODBC .Real-time “live” information shall be transferred from the management system to a third party package e.g. MS Excel, either by a standard inter-application mechanism e.g. DDE or OPC or by developing a connection by using a documented API for the management system. Where a physical connection is required between a 3rd party device and the management system, the sub-system supplier shall provide the necessary line drivers and cables, documentation and support to make the connection into the device that will provide the protocol conversion.

### **1.8 Software Modules:**

The management station software shall be modular, object oriented, clearly structured and shall be based on Windows -10 (or later) standard 32 / 64 bit or later technology.

The main software applications shall, as a minimum, include

- Plant Viewer: Graphics based operation of the plant.
- Trend Viewer: Logging and display of measured values.
- Alarm Viewer: Display of alarm messages
- Alarm Router: Automatic routing of alarms.
- Log Viewer : Logging of alarms, system events and user activities.

Alarm Message shall be communicated to the mobiles / fax/ e-mail (for which the necessary software/ hardware shall be included) in case of following: -

- Power supply OFF
- Chiller tripping on controls
- Critical Units OFF

- Abnormality of Temp. & R.H in critical areas
- The report generated by the Software shall be user definable/standard report Supports for cabling and conduits shall be as specified by the department.

The ambient temperature and time functions can be combined to vary the start/stop time of the system from 15 to 75 minutes before the office start/closes depending upon whether ambient is 15 to 30 deg.C at start/stop time.

### **1.8.1 The Task Bar:**

The task bar shall be the 1st and last point of contact for all the interactions between user and system.

In addition to obtaining quick overview of vital system information, users shall be able to click on various icons in the task bar to switch from one program to another in the multi-tasking operating system. In systems, which include remote sites, the task bar shall be used to switch between sites (subject to user's access privileges).

To make the system easier for new users, the system shall support user-specific start-sequences with access to selected programs.

### **1.8.2 Features of The Task Bar:**

- Control of access privileges and security mechanisms for access to program modules and 3rd part software at log-in and log-out.
- User-and-password dependent access to systems and sub-systems.
- Automatic user-specific start sequences.
- Display of alarm and system message status, site connection status, time and date.
- Facility to connect and terminate connection at various sites.
- Simultaneous connection to a maximum of 4 sites.

### **1.8.3 Plant Viewer:**

The plant viewer shall support the following features:

- Hierarchically linked, animated high-resolution bit-map colour graphics (XGA 1024 x 768 pixels).
- Choice of 2D and 3D symbols with animation based on status.

- Direct access to set points, parameters, operating modes, alarms, time-programs, on-line and off-line trend data features.
- Dynamic multi-tasking with all active pages.
- Monitoring and operation of plant at several levels.
- Flexible operation of multiple pages using plant viewer navigation bar combined with standard handling of windows.
- Navigation to all other management station software applications.
- User-definable page size.
- Jump tags for jumps on the same level or between levels.
- ToolTips for all dynamic objects, with the option of 'User', 'Technical' or 'System' information.
- Context-specific information (e.g. data sheets) can be attached to any dynamic object.
- Capable of graphics to be printed in colour or monochrome.
- All 32 / 64-bit graphic file formats supported by Windows can be imported (eg AutoCAD, PCX etc.,).
- Dynamic display of the Psychometric chart, enabling easy simulation of the air - conditioning processes.
- Customer Design of display with the indication of device status, errors and discrepancy etc.
- Dynamic Information shall be updated every second. However, storage of data shall be enabled every hour.
- Inclusion of bar charts and trends as part of mimic diagrams or construct pictures only bar charts and trends.
- Value of variables in alarm to be displayed in Red Colour.
- Change the colour and flash the Variables and equipment symbols to indicate alarm / trip and certain predefined operating conditions.

#### **1.8.4 Alarms Handling & Alarm Viewer:**

As a minimum, the system shall support the following features

- Operation and manipulation of alarms (based on user privileges).
- Alarm message printing.
- Alarms printed independently of the management station (direct connection at automation level).
- Automatic pop-up windows for immediate display and operation of alarms (including pop-ups in 3rd party programs).
- Audible or multi-media alarm indication.
- Continuous overview of all active alarms from site (updated automatically, displayed in order of priority, option of personalized view).
- Graphics based topological view of alarms.
- Chronological alarm view.
- Option of displaying detailed information.
- Direct access to associated plant graphics.
- Comprehensive filter and search criteria (time, date, priority, discipline, alarm status etc.).
- Colour coding based on alarm priority / alarm status (screen and printer).
- Alarms for out of limit values (high, low), change of state, run-time limits exceeded etc.,
- Option of repeating unacknowledged alarms at regular intervals.
- Creation of reports, with facility to print or export alarm data to 3rd party programs for further analysis.
- Facility to save user-defined filter criteria.
- User-specific configuration of the alarm view including on-line configuration.
- Alarms Sequence in line with ISA recommendation.
- If Alarms are grouped, then provide Re-flash facility in line with ISA.

- Adequate storage capacity for alarms.
- Display back log pages on demand.
- Display any software and hardware fault detected by self-diagnostic checks.
- Display summary of different alarms like existing alarms, bad point alarms, lock out alarms etc.,

#### **1.8.5 Alarm Routing:**

In order to monitor alarms round – the – clock, alarm routing is an important feature of the BMS. The BMS shall have the following features:

- Routing of alarms to alarm printer, fax, pager or mobile phone.
- Time schedule for each message recipient.
- Alarm routing based on priority.
- Alarm routing based on discipline (HVAC, Security etc.).
- Alarms routing to person responsible at site.
- Alarm routing based on text.
- Alarm routing to person(s) responsible for specific equipment or systems.
- Option of manual transmission of messages from the management system.

#### **1.8.6 Time Scheduling:**

The time-scheduler shall have the following features:

- 7day time programs.
- Exception programs (local, building-wise or system-wise).
- Direct display of time programs within Plant viewer graphics.
- Simple graphics programming of switch times.
- Graphics based overview of all time programs in the system.
- Graphics based overview of a 7 day programme including all exception programmes.
- Graphics based overview of all plant points affected by a time programme.

- Direct entry of various operating modes (comfort, stand-by, energy hold-off).
- Easy creation, modification and deletion of all time programmes.
- Scroll features for fast access to specific weeks or days.
- Storage and processing independent of management station.
- Automatic synchronization of all time programmes in a system.
- Support of different time zones (remote managed sites).
- Option of synchronization via radio clock.
- Printed reports in various display forms.

### **1.8.7 Trend Viewer:**

The Trend Viewer shall have the following features:

- On-line or off-line real-time data.
- Simultaneous display of up to ten signals per window.
- Absolute or relative time intervals.
- Zoom, scroll and cursor features for faster data analysis.
- Flexible, easy-to-use scaling feature with charts displayed in 2D or 3D.
- Drag-and-drop feature for trend views with automatic scaling and data export.
- Off-line data logging triggered manually, automatically, or on a time or event basis.
- Logging and intermediate storage of off-line trend data operates independently of the management.
- Automatic upload from automation level to local or remote management stations.
- Management station display and archiving of on-line and off-line trend data
- Print-outs of trend data.
- Easy export of data to 3rd party software.
- Facility to export trend data directly to auxiliary programs such as ADP (Advanced Data Processing) or to 3rd party software such as MS-Excel.

- Trend Viewer time base can be used directly as a filter creation in Log Viewer.
- Trending of selected parameters in a group for selected time and at a required (selected) scale.

### **1.8.8 Log Viewer:**

The Log Viewer shall be categorized into the following sections:

- ALARM LOG: contains all incoming alarms in chronological order.
- SYSTEM LOG: shows at a glance if a printer somewhere in the system has run out of paper, or a hard disk is full. Communication events are also recorded here, showing for example when communication was established or terminated.
- USER LOG: lists all the activities carried out by the user at the management station, unauthorized attempts, modification of parameters, set points etc.,
- STATUS LOG: to check the status of all incoming messages.

The Log Viewer shall have the following features:

- Storage of alarms routed to the management station.
- Storage of all system messages (from printer, communications, management station, modem etc.,).
- Storage of all user activities performed at the management station.
- Facility to enter and store user comments on events and activities.
- Facility to display, at a keystroke, detailed information on every entry.
- Extensive filter options to focus and reduce the volume of information displayed.
- Comprehensive search features for fast access to information.
- Facility to display an overview of data for a given day or week.
- Once defined, filter and search criteria can be saved for future re-use.
- Compact archiving of virtually un-limited number of entries (depending on hard-disk capacity).
- Automatic data management and archiving functions.
- Facility to create and print log summaries.



- Export of log entries for further analysis with 3rd party software (eg –MS access).
- User specific configuration of log view can be adapted directly on line.
- Pre and post trip log.
- Operations Engineers action log.
- System/Equipment fault log.

#### **1.8.9 Internet Log Viewer:**

This is an **optional** application, which offers users even greater freedom in the management of a site. A browser such as Microsoft Internet Explorer or Mozilla Firefox, for example, provides the user with access to the log database from any PC with an Internet connection. Just as with standard log viewer, the user can then obtain an overall view of all the plant and events stored or monitored by the system.

The Internet Log Viewer shall be started without any special management station software on the user's PC. Access to the Log Viewer can be password protected.

#### **1.8.10 A Web Control:**

The system shall have the capability to connect to remote sites through a web control module. Individual DDC general purpose communication trunks (described elsewhere) shall have the feature to be connected to this web control module. This should facilitate viewing and controlling the DDC general-purpose controller's trunk via a remote PC / laptop. All parameters as appearing in the Portable Operator Terminal (described elsewhere) shall be available from this remote PC / laptop. The system offered shall have the facility to control / monitor the plant and equipment connected to these communication trunks via password protection.

#### **1.8.11 Integration of 3rd Part Software and Exchange of Data:**

The system shall support the use of standard interfaces and drivers that make it easy to integrate to 3rd party software directly at the management station level, or to make common use of data from the system, e.g. via ODBC (Open Database Connectivity). DDE (Dynamic Data Exchange) shall enable current data to be loaded continuously into a spreadsheet program such as MS Excel, so that constantly updated graphs can be created for further processing.

### **1.8.12 Object Viewer:**

To make operations easier, the software shall have two viewing modes.

- System View: Provides hierarchical view of the system network.
- User Designation View: Gives a hierarchical breakdown of user addresses based on the system database.

In general, the system shall support the following features

- Fast navigation through the system
- Fast location of objects and alarms
- Detailed information of all objects.
- Display of current values from the process level.
- Modification of set points and parameters.
- Users with appropriate access levels can also override outputs manually.
- Two display modes □ system view and user designation view.
- Search features
- Jump features and bookmark features as in various internet browsers.
- Modification of users designation and alarms texts.
- Customization of users addresses with a maximum of 10 hierarchical levels and up to 40 characters.
- “Find” function to locate system objects.

### **1.8.13 Reports:**

Reports shall provide the user with the latest information from the system at specific times or when specific events occur. The following features shall be supported:

- Reports routed on basis of time and / or priority.
- Manual or automatic triggering
- User-definable or standard reports

- Facility to integrate 3rd party report programs into the management station software.

#### **1.8.14 Access Protection:**

The management station shall grant access to the system only to authorized users. The system administrator shall tailor an environment to match the individual requirements of each user. The access protection facility shall define the buildings (sites) and equipment to which a given user has access, the software modules and functions available to that user within the site. The system shall support the following features:

- User name / password
- Individual access privileges covering access to sites, subsystems, program functions down to individual objects in Plant Viewer.
- Up to 1000 users grouped into 100 user groups.
- Automatic log – out (after period of inactivity)
- Encrypted passwords
- Network security provided by Windows.

#### **1.9 Hardware Requirements:**

##### **1.9.1 BMS Main and redundant server specifications:**

Two server grade systems for main and redundant servers with latest windows server or latest windows server as per the specification given below.

Type of computer: Server rack mount

Processor: Intel Xeon (6 cores) 2.2GHz (E5-2420 v2 or equivalent) or higher

RAM : 16GB or higher

Hard disk : Capacity 1 TB or higher

DVD Writer : DVD Writer or Blue-ray drive

Ports : 4 USB ports.

Ethernet ports: 2 ports, each 1 Gbps

Display: 20" LED or bigger colour display

Mouse: Optical scroll mouse

Operating System : Windows Server 2012 R2 Standard 64 bit or latest

Make : DELL / HP

### **1.9.2 Client PC specifications:**

Type of computer : Desktop

Processor : Intel® Core™ i5 (6th generation) or higher

RAM : 8 GB (4 GB X 2 preferable)

Hard disk : Capacity 500 GB or higher

DVD Writer : DVD Writer or Blue-ray drive

Ports : 4 USB ports.

Ethernet ports: 2 ports, each 1 Gbps

Display : 20" LED or bigger colour display

Mouse : Optical scroll mouse

Operating System : Windows 10 Professional 64 bit

Make : DELL / HP

Printer specifications: HP Laser jet pro M 403 dn or latest colour graphic printer.

### **1.9.3 BACNET Routers:**

In addition to exchanging data with the management station and the other Controllers in the same network, a further capability of transferring global data between DDC modules in different groups (i.e. on different buses).

The BMS offered must be capable of being extended with controllers on the BACNET protocol, Modbus, Rs485 and the LON bus.

The BMS must allow for integration of BACNET devices, Modbus devices, RS485 devices on the process level and on the management level via Ethernet TCP/IP.

The BMS must allow integrating future BACNET controllers on the process level and providing inter-process communication with existing controllers.

### **1.9.4 DDC network:**

This network shall allow the DDC modules to communicate with each other and provides the user with access via the operator terminal to all the connected DDC controllers.

The DDC controllers, wherever used, within the same enclosure, should be connected to each other via BACNET IP / LON.

Data must be kept even in the event of power failure. Power failures and peak loads must not cause data loss.

Permanent self-monitoring of the system must be ensured by integrated test and service functions.

Suitable interfaces and appropriate in/outputs must allow the integration of all electrical and mechanical plants.

#### **1.9.5 Central setting of parameters/structuring and programming:**

It must be possible to enter and/or amend all parameters (set points, control algorithms, time, etc.) and the structure diagrams (control and interlock programs) into the lower levels system controllers and DDC units-centrally from the management station and/or the operator terminal from the system controller with a download function. The system manager must be able to read and write all data centrally. It must be possible to set the parameters and structure the application programs by using a graphic and element oriented programming language. A separate PC/Server exclusively identical to that of Operation Engineer for this purpose shall be provided. This shall not be used for operation, under any circumstances.

#### **1.9.6 Portable Operator Terminal (POT):**

Each DDC Controller shall have a dedicated service port to plug in the portable operator's terminal (POT). It shall be possible to read, write and change any parameters on a bus by plugging the POT to any one of the Controllers on the communication trunk. It shall have a visual and audible alarm with mute facility on its fascia. The POT shall have min. three password levels as mentioned elsewhere. Separate cabling for connecting the POT shall not be acceptable. Changing the parameters locally from any Outstation shall be done by POT, which is truly portable, hand held and not via Laptops.

A POT shall allow full operation of all DDC control modules connected to the LonTalk /BACNET network. Functions to include:

- Alarm monitoring with acknowledgement and visual and audible alarm indication.
- Pop up window with detailed message for alarms and events
- Alarm and event history

- Data point display and operation of all measured values, set points, plant states.
- operating states and parameters
- Graphic based display and operation of all time schedules, exception calendar.
- online trending and heating curve.
- User specific configurable overview of main values in plant.
- Multi user level access protection.

The POT shall have a high resolution six line illuminated display for graphics and text, keys for operation and a visual and audible common alarm indication. The textual information displayed must reflect the layout of building and plant with clear text English descriptions of up to 40 characters.

#### **1.10 Documentation:**

In order to have clear system documentation, the following documents have to be provided:

- System diagram
- Wiring diagram
- Lists of parameters

All documents shall be in English. Documents that are multilingual, including English, on the same page is not acceptable. Vendor shall provide TEN (10) identical copies of all documentation necessary to operate, maintain, enhance, or to understand the facilities and functions of the system. This shall include but not limited to at least the following:

- Hardware Installation Manuals containing outline dimensions, equipment specifications, mounting details, power and signal connection details, weights, heat loads and power requirements for all equipment.
- Parts lists with prices for all equipment for major system components, subsystem, power supplies, and printed circuit boards, cards, and modules including bought out items.
- Maintenance Manuals containing:

- Theory of operation
- All necessary schemes, including block schematics of all input /output modules.
- Maintenance instructions for trouble shooting, routine adjustment and preventive maintenance procedures, assembly and disassembly instructions, on and off line testing procedures and all other information required for installation of the system.
- Operating instructions and equipment user manuals for all components, workstations, printers, controllers, data acquisition devices, etc.
- Configuration instructions covering standard configuration tasks of all I/O, control, logic and displays required by this specification.
- Hardware Technical Description Manuals.
- System configuration Diagrams, in block diagrams identifying all the sub-systems with name and (family) model numbers.
- Fill in the blank type programming sheets.
- Program disk.
- Program listing
- As built drawings for
  - Over All general assembly of the Cabinets.
  - Internal Layouts.
  - Internal wiring schemes.
  - I/O listing with card assignments.
  - All field modifications including cables and terminations.
- Hard Copy of all Operator Interface Screens like graphics, overview etc.
- Alarm assignments.
- Serial Data Links listings with encoding information.
- All the Application Engineering documentation in soft copy with proper indexing.

- Hard and software copies of all the configurations (displays) and alarm displays including the various settings for relays and Alarms.

While handing over, all documents must be updated and provided with the date of commissioning.

### **1.11 Services:**

The type and scope of the required services are described below.

The rates for engineering, commissioning and adjustment must contain all services required to ensure optimum operation of the plants.

### **1.12 Engineering / Planning:**

In addition to the required, complete documentation, the service must include:

- Analysis of all functions together with the contractor
- Binding information about conditions of connection of equipment
- Scheduling and co-ordination with the contractor and design engineer

### **1.13 Commissioning/Adjustment:**

Function-oriented commissioning includes the following services, which are to be provided by BMS specialist:

- verification of the external connections of the equipment.
- verification of the data transfer channels of the system.
- loading and testing of all basic and user programs belonging to the equipment.
- optimisation of the control parameters.

### **1.14 Electric & Electronic Related Equipment:**

#### **1.14.1 Ambient Conditions:**

All controls shall be capable of operating in ambient conditions varying between 0-40 deg C and 90% RH non-condensing.

#### **1.14.2 Conduits and Wiring:**

Prior to laying and fixing of conduits (20 or 25 mm dia.), the contractor shall carefully examine the drawings indicating the layout, satisfy himself about the sufficiency of number and sizes of conduits, sizes and location of conduits and



other relevant details. Any discrepancy found in the drawings shall be brought to the notice of Engineer-in-charge. Any modifications suggested by the Contractor shall be got approved by the Engineer-in-charge before the actual laying of conduits is commenced.

#### **1.14.3 Conduits / Trunker:**

Conduits and accessories shall conform to relevant Indian Standards.

PVC conduits of required dia shall be used as called for in the schedule of quantities. Joints between conduits and accessories shall be securely made, with help of adhesive. The conduits shall be delivered to the site of construction in original bundles and each length of conduit shall bear the label of the manufacturer.

#### **1.14.4 Connections:**

All jointing methods shall be subject to the approval of the Engineer-in-charge. Separate conduits shall run for all power wiring. The threads and sockets shall be free from grease and oil. Connections between conduit and controller metal boxes shall be by means of brass hexagon smooth bore bush, fixed inside the box and connected through a coupler to the conduit. The joints in conduits shall be smooth to avoid damage to insulation of conductors while pulling them through the conduits.

#### **1.14.5 Bends in Conduit:**

Where necessary, bends or diversions may be achieved by means of bends and/or circular inspection boxes with adequate and suitable inlet and outlet screwed joints. In case of recessed system each junction box shall be provided with a cover properly secured and flush with a finished wall surface. No bends shall have radius less than 2-1/2 times the outside diameter of the conduit.

#### **1.14.6 Signal Cum Communication Cabling:**

The signal cable shall be of the following specifications:

- a. Wire: Annealed Tinned Copper
- b. Size: 1.5 sq. mm, 7 strands
- c. No. of conductors: Two (One pair)

- d. Shielding: Overall bled foil Aluminium polyester shield.
- e. Jacket: Chrome PVC
- f. Nominal DCR: 17.6 ohm/km for conductor & 57.0 ohm/km for shield
- g. Nominal OD: 8.5 mm
- h. Nominal capacitance: 130 pF/m between conductors at 1 KHz 180 pF/m between one conductor and other conductors connected to shield.
- i. Colour: Black and Red

**1.14.7 Communication Cabling:**

The communication cable shall be of the following specifications:

- a) Wire: Annealed Tinned Copper
- b) Size: Minimum 24 AWG stranded
- c) No. of conductors: One pair (2 conductor)
- d) Shielding: Overall bled foil Aluminium polyester shield.
- e) Jacket: Chrome PVC
- f) Nominal DC Resistance: 78.7 ohm/km for conductor & 55.8 ohm/km for shield
- g) Nominal OD: 5.64 mm
- h) Nominal capacitance: 131 pF/m between conductors at 1 KHz 243 pF/m between one
- i) conductor and other conductors connected to shield.
- j) Colour: Black and Red, Black and White)

**1.15 Ancillary Items:**

When items of equipment are installed in the situations listed below the BMS/ Control Specialist shall include the following ancillary items:

**1.15.1 Weather Protection:**

All devices, which are exposed to the atmosphere, are to be weatherproofed. All controls, peripherals and associated accessories serving Chillers, Roof Mounted Air Handling Units and other equipment which are exposed shall be protected from

Dust, Rain and Solar Radiation. Adequate protection shades etc., shall be provided by the MEP contractor.

#### **1.15.2 Pipe work Immersion:**

Corrosion resisting pockets of a length suitable for the complete active length of the device, screwed 12mm or 18mm British Standard Pipe Thread (BSPT) suitable for the temperature, pressure and medium.

#### **1.15.3 Duct Mounting (Metal or Builders Work):**

Mounting flanges, clamping bushes, couplings, lock nuts, gaskets, brackets, sealing glands and any special fittings necessitated by the device, shall be provided by the contractor.

#### **1.15.4 Samples:**

Samples of all types of room mounted equipment (i.e. detectors, thermostats, etc.) shall be provided by the BMS/Controls Specialist for approval by the Consultant/Engineer.

#### **1.15.5 Accuracy:**

Control and measuring devices shall have the following limits of accuracy:

Temperature : +/- 0.5oC over the range of 0°C to 50°C

Pressure : +/- 1.5% of measured value

Humidity : +/- 2 to 5% RH over the range of 10 to 90% RH

#### **1.16 Averaging Elements:**

Averaging elements shall be used on supply air ducts having a cross-sectional area exceeding 1.6m<sup>2</sup> and shall have a minimum capillary length of 8.2 m.

The capillary element shall be serpentine across the whole duct.

Where the span of the element is less than 1 m then it shall be fixed with purpose-made clips and may be unsupported across the duct.

Where the span of the element is above 1 m then it should be supported on Unistrut or similar rigid support. The element shall be clipped every 200m and the supports and hangers shall be adequate to prevent vibration of the element.

### **1.16.1 Pressure switches for Air Systems:**

Pressure switches for Air Systems shall be diaphragm operated. Switches shall be supplied with air connections permitting their use as static or differential pressure switches.

The switch shall be of differential pressure type complete with connecting tube and metal bends for connections to the duct. The housing shall be IP54 rated. The pressure switches shall be available in minimum of 3 ranges suitable for applications like Airflow proving, dirty filter, etc. The set point shall be concealed type. The contact shall be SPDT type with 250 V AC, 1A rating.

Shall be supplied suitable for wall mounting or mounting on ducts in any plane. It should be mounted in such a way so that the condensation flow out of the sensing tips. Proper adapter shall be provided for the cables.

The set point shall fall within 40%-70% of the scale range.

Shall have differentials adjustable over 10%-30% of the scale range.

### **1.16.2 Air flow Switches:**

The Airflow switches shall be selected for the correct air velocity, duct size and mounting altitude.

Where special atmospheric conditions are detailed in the Motor Control Panel Equipment Schedules, the parts of the switches shall be suitably coated or made to withstand such conditions. Any variations from standard shall be detailed in the Tender.

Shall be suitable for mounting in any plane.

### **1.16.3 Water flow switches:**

Water flow switches shall be selected for the correct water velocity and pipe size and mounting attitude.

### **1.16.4 Room Temperature/Humidity Detectors:**

The temperature sensor shall have sensitivities such that a change at the detector of 0.2 deg C from the stabilised condition is sufficient to start modulating the corrective element.

The temperature sensor shall be with silicon sensor having positive temperature coefficient. The sensor shall be field wired using an unscreened cable to a base plate. The sensor housing shall plug into the base so that the same can be easily removed without disturbing the wiring connections. The protection standard shall be IP30 in accordance with IEC 144, DIN 40050. These should be generally mounted 1.5 m above the floor level. These should not be mounted near the heat sources such as windows, electrical appliances, etc. The final location shall be as per the consulting engineers' approval. The sensor shall be linear over 0°C to 50°C.

Shall operate on extra-low voltage and be suitable for mounting on British Standard conduit boxes.

The humidity sensor shall be in an independent housing or be combined with the room/duct type temperature sensor in the common housing. The sensor should be electronic type with capacitive sensing element. As a minimum it should have a range of 10 to 90% RH.

#### **1.16.5 Immersion/temperature detector and duct mounted temperature/humidity detectors:**

The temperature sensor shall have sensitivities such that changes at the detector, for 0.3 deg C and 0.2 deg C respectively, from the stabilised conditions, are sufficient to start modulating the corrective element.

The humidity sensor shall be in an independent housing or be combined with the room/duct type temperature sensor in the common housing. The sensor should be electronic type with capacitive sensing element. As a minimum should have a range of 10 to 90% RH.

The temperature sensor shall be with silicon sensor having Positive Temperature Coefficient. The sensor shall be field wired using an unscreened cable to a base plate. The sensor housing shall plug into the base so that the same can be easily removed without disturbing the wiring connections. The protection standard shall be IP 43 in accordance with IEC 144, DIN 40050.

The wiring terminals shall be plug-in type for easy installation and maintenance. The sensor shall be mounted in the duct based on the guidelines given by the specialist control supplier. The sensor shall be linear over 0°C to 50°C.

#### **1.16.6 Pressure Detectors (for liquids and gaseous media):**

Pressure detectors shall be suitable for the medium and the working temperatures and pressures. The pressure detector shall be capable of withstanding a hydraulic test pressure of 2 times the working pressure.

Connections shall be suitable for 12mm to 3mm o.d. copper tube.

Ductwork versions shall be supplied with the air connections permitting their use as static or differential pressure detectors.

The set point shall fall within 40%-70% of the sensing range of the detector.

The detector shall have a sensitivity such that a change of 1.5% from the stabilised condition shall cause modulation of the corrective element.

The static pressure sensor shall be rated for IP 65 and the differential pressure sensor shall be as a minimum IP 54.

The principle of operation should be based on a hall-effect transducer. The diaphragm should be copper beryllium type.

The sensor must be pressure compensated for a medium temperature of -10 to 70°C with ambient ranging between 25 to 60°C.

#### **1.16.7 Air Pressure sensor:**

The pressure sensor shall be differential type. The construction shall be spring loaded diaphragm type. The movement of the membrane in relation to the pressure should be converted by an inductive coupling, which would electromagnetically give an output suitable for the controller. The pressure sensor shall be in a housing having IP 54 ratings in accordance with IEC 529. Suitable mounting arrangement shall be available on the sensor. The sensor shall come complete with the PVC tubes, probes, etc.

#### **1.16.8 Actuators:**

Shall be installed in accordance with the manufacturers' recommendations.

Shall have a sufficient torque to open and close valves and dampers against the maximum out of balance pressure across them.

### **A. Control Damper Actuators:**

Control Damper Actuators shall be of the type where the damper spindle passes through the actuator and is secured by a U clamp.

Rotary type damper actuators shall be used on the project. The actuators shall not require any maintenance. The actuators shall have sufficient torque ratings to operate the dampers of various sizes.

These should be available in spring return versions as specified elsewhere in the document. Limit switches, if required/specified shall be provided for.

The actuators shall be suitable for On/Off and modulating operations.

### **B. Actuator Additional features:**

Actuator Additional features are required when detailed in the Motor Control Panel Equipment Schedules or the Performance Section of the Specification.

### **C. Auxiliary Switches:**

For On/off applications, the actuators shall have changeover contacts suitable for 220 V AC, 2 Amp rating.

Auxiliary switch packs containing at least one, if specified two, electrically independent switches one for each end of the motor travel, adjustable for operation over at least half the motor travel.

### **D. Feedback signal:**

0 to 10 V DC or 4-20 mA signals should be available from the modulating damper actuator for parallel operation or as feedback. Please refer the data point schedules / sequence of operation/ drawings to incorporate this feature wherever asked for.

## **1.16.9 Control valves (modulating):**

### **A. General:**

All control Valves with Kv lesser than or equal to 4 shall have RG5 gunmetal / red bronze body. Actuators shall be PWM or 0-10v dc or 4-20 mA modulating motor type or 3 point reversible motor type. PWM actuators shall be used in conjunction with controllers having in-built PID algorithm.

Control Valves with Kv = 6.3 shall have RG5 gunmetal / red bronze body. Actuators shall be 3 point reversible motor type or 0 – 10 V dc or 4-20 mA modulating motor type. Actuators shall have manual override hand-wheel.

Control valves with Kv >6.3 shall have RG5 gunmetal / CI. Actuators shall be magnetic / or 0 – 10 V dc modulating motor type. Actuators shall have manual override hand-wheel.

Valves up to including 40 mm shall be rated for 16 bar Nominal Pressure. Valves for 50 mm and above shall be rated for nominal pressure of 10 bar, provided the operating pressure of the system is not greater than 6 bar. Valves above 100 mm shall be rated for 16 bar Nominal Pressure and actuators shall for these valves be magnetic / electro-hydraulic / motoric working a 0-10v DC or 4-20 mA modulating signal. Actuators for valves 100 mm dia and above shall have spring return feature as well as manual override hand-wheel.

All valves 15mm and above shall have rangeability > 100.

**B. Authority:**

All 3 port modulating valves shall be selected to have an authority between 0.4 and 0.68.

For systems using 2 port modulating valves, the MEP contractor shall furnish the controls' supplier details such as Pressure drop across the index circuit based on which the pump head was calculated, the pump head calculation, the design head of the pump ordered for the project, the available pressure on the system and the nodal pressures on each branch circuit of each AHU / FCU.

Based on these data, the controls' supplier shall submit the working principle for valve selection.

**C. Butterfly valves:**

Butterfly valves shall be manufactured by the Controls Manufacturer or alternative, approved by the Consultant / Engineer.

**1.16.10 Occupancy detector:**

The occupancy detector should be microprocessor based passive infrared detector for control of lighting equipment and VAV boxes in the room. The detector shall operate at 230 V AC and will give a potential free output of minimum rating of 2



amps at 230 V AC for control of lighting and VAV boxes for maximum energy savings and demand dependant controls. It should have an adjustable switch on delay of minimum 0 to 300 sec and an adjustable switch off delay of minimum 0.5 to 30 minutes. The detector should cover a minimum zone of 6 X 12 meters. The detector should be capable of detecting a moving infrared source. It should be optimized to detect the low level of sedentary workers. The detector should have minimum sensitivity of 50cm physical movements. The detector should be minimum IP50 with CE conformance.

#### **1.16.11 BTU meters:**

The flow meter used in the above meter should be based on the ultrasonic principle with no moving parts. The temperature sensors used in the above meter should have a measuring range of 0 to 130 deg C with a resolution of 0.1 deg C. The BTU meter should have a built in minimum 8-digit LCD display for display of parameters, values and faults. The meter should be compatible with the BMS system. The minimum functions to be provided by the BTU meter is as under:

- Calculation and storage of maximum values.
- Storage of billing data
- Measurement of tariff dependent data
- Storage of 13 monthly cumulative energy/volume values in EPROM.
- Detection of faults
- Display of values, parameters and faults
- Selectable scope of display
- Test and service functions.

The BTU meter should have a minimum sampling time for flow every 3 seconds and temperature 24 seconds. Possible displays to be indicated are kWh, MWh, GJ, MJ, kW, m<sup>3</sup>, m<sup>3</sup>/hr, h and deg C. The heat meter should have a minimum accuracy of class 2 with CE conformance.

#### **1.17 DDC Panels:**

The out-station panel housing the DDC controllers shall be located inside the conditioned area. Proper care shall be taken to ensure that there is no induction

problem between the control and power cables. These panels shall be IP54 and supplied by the specialist controls supplier.

The DDC controllers located inside these out-station panels shall provide the required signals to the various equipment's connected to these DDC controllers. The DDC controllers shall be capable of accepting digital input signals in the form of volt-free contacts from Motor control centres. The contractor shall co-ordinate this activity.

All these outstations shall be connected with a communication bus cable and terminated to the BMS central station. The BMS supplier shall supply these bus cables.

It should be possible to connect the Portable hand held terminal to be connected to any of these panels and talk to any other DDC controllers on the same bus.

#### **1.18 Training:**

All training shall be by the BMS contractor and shall utilise specified manuals and as-built Documentation

Operator training shall include total

- Modifying text and graphics
- Sequence of operation review
- Selection of all displays and reports.
- Use of all specified OS functions
- Use of portable operator's terminals
- Trouble shooting of sensors (determining bad sensors)
- Password assignment and modification
- A count of 10 Nos. Engineers/ Technicians/ Operator Engineers need to take Training related to operation, structuring and maintenance of DDC.
- Training required to solve both hardware and software bugs.

The training shall be under taken in two or more phases. One training session shall be conducted at system completion, and the other shall be conducted within forty-

five days of system completion at the convenience of user. The user should get full knowledge of all the above operations including programming and maintenance.

### **1.19 Warranty:**

All component, system software, parts and assemblies supplied by the BMS contractor shall be guaranteed against defects in materials and workmanship for two years from the acceptance date.

Labour to troubleshoot, repair, reprogram, or replace system components shall be provided by the BMS contractor at no charge to the Dept. during the warranty period.

All corrective software modifications made during warranty service periods shall be updated on all user documentation and on user and manufacturer archived software disks.

Guideline for chiller management software/ logic for combination of chillers:

1. The software shall decide on individual or combinations of chiller packages that will require the least kW per TR for the air-conditioning system. The data from chiller manufacturer shall be used for this purpose. The data of chillers, pumps, cooling towers, AHUs, packaged units and fan coil units shall be used to specify on screen the repair/ trouble shooting/ maintenance work to be undertaken by the operator.
2. While switching 'ON' the AC plant, the chiller package which has run least number of hours, has to come 'ON' 1st (In case of multiple compressor chiller package, the compressor which has run least number of hours, has to be come 'ON' 1st). The other chiller packages / compressors have to come 'ON', in an ascending order of running hours, either it is single or multiple compressor type chiller packages.
3. The load sharing between the chillers must be possible. If it is multiple compressor type, if one compressor is having more than 80% load, the chiller package shall call for the next least number of hours run compressor and both these compressors shall together share the load, which is more than 80% for a single compressor. If the total load is more than what two compressors can handle (i.e., 80% load factor on each compressor is in fulfilled condition), then the 3rd compressor of the chiller package should come 'ON' and all the three compressors shall together, share the load. While sharing the load, each

compressor shall be loaded to 80% initially, then depending on the total demand, the equal loading factor on individual compressors shall be decided and brought down in steps.

**Note:** For achieving the above, while DDC system could be foreseen to do the run time equalization for the entire chiller system, in case of multiple compressor chiller package the controls built into the chiller should have the provision for run time equalization amongst the compressors within such a system when the DDC gives the command for the multiple compressor chiller package to come ON. Alternatively, the multiple chiller packages should have access (to accept switching commands for individual compressor and also give feed back to DDC regarding number of compressors working) for switching ON the individual compressors from the DDC.

4. During the lean hours i.e. between 7pm and 7am (12 hours) and during winter season, the chiller package consuming least kW per TR shall be given preference according to the load profile loaded in the software. Due to any reason, if a particular type of chiller package could not be operated, there should be override to put 'ON' any other working chiller package.
5. Individual or Combinations of chiller packages for run time equalizing, load sharing, sequencing and using the available power supply through Local Electricity Board or DG source, throughout the day, month and year shall be automatically decided by the software. Overrides/ user defined mode of operation shall always be available to overcome any circumstance and to enable the discretion of the plant in-charge.
6. The central Chiller system software as well as software residing in DDC shall provide facility for nominating any one of the chiller packages as STANDBY by suitable selection on the chiller screen or through the Portable Operator Terminal (POT), over and above the load sharing, sequencing and run time equalization facilities called for in the above paragraphs.

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**SPECIFICATIONS FOR AIR-CONDITIONING  
AND VENTILATION WORKS**

**SECTION - XV  
COMPRESSED AIR SYSTEM**

## **1. COMPRESSED AIR FACILITY**

### **1.1 Air Compressor:**

Type of Compressor: Single stage Rotary Screw air compressor- air cooled type with highly efficient axis air end  $\eta$ -v profile rotors.

Free Air Delivery and Operating pressure: As specified in tender schedule.

Motor - Squirrel cage motor with class -F insulation along with star-delta starter and suitable protection for operating at 415 V, +/- 10% and 50 Hz +/- 6% & combined variations of +/- 10%, 3 Phase AC supply and provided with power factor improvement capacitors.

Quality of Air: - Dry air, oil free

The Air compressor shall be complete with dry type suction air inlet filter with silencer with provision for maintenance and replacement, un-loader with integrated regulating valve and three-way solenoid valve complete as required for load/unload control system.

Air/oil temperature sensor sense outlet temperature and to shut down compressor shall be included as safety feature.

### **1.2 Air/oil separation system:**

1. Receiver tank incorporating osbic principle mounted on base frame.
2. Oil filling port
3. Oil drain with valve
4. Pressure relief valve
5. Oil sight glass
6. Spin-on air-oil separator element
7. Non-elastic connection from air end to receiver tank for long life.
8. Minimum pressure valve
9. Three stage Air oil separation system
  - First by cyclonic action (Centrifugal)
  - Second by gravitational (Heavier particle separate down)
  - Third by passing through coalescent filter.

### **1.3 Air Inlet System:**

1. Pre-filter shall ensure clean air supplied to the inlet system.
2. Air-filter housing shall have following features:
3. Twin paper element each of 5 microns with efficiency of 99%
4. Plastic baffle
5. Service indicator- indicating filter service need
6. Rubber coupling connecting air filter to the intake valve.

### **1.4 Cooling System:**

1. Air and oil coolers are independent & compact block coolers for:
  - Optimum heat transfer
  - Lower pressure drop
  - Lower weight
2. High efficiency After cooler for low approach temperature.
3. Oil filter mounted on air oil manifold block for filtration of lubricating oil.
4. Thermostatic valve to regulate oil temperature within system.
5. Cooling fan with fan motor for effective cooling.

### **1.5 Lubrication System:**

1. High capacity spin-on filter element with 10-micron rating.
2. Return oil line from separator tank to air end.
3. Rigid pipe connections for durability.

### **1.6 Power and Control Panel:**

This should incorporate the following:

- Suitable star delta starters with contactors, relays, single phase preventer etc. complete as required.
- Emergency stop button

Control panel incorporates Air-logic which offers following functions:

- Load-unload control
- Accurate pressure control
- Programmable start stop
- Dual pressure band setting
- Multi-logic control
- Multi-mode control (local/remote/LAN)
- Intelligent shutdown protection
- Maintenance countdown functions

Keys:

- Start
- Stop
- Cancel
- Validate
- Navigation with 4 keys

Luminous indication:

- Power supply indication
- Automatic function mode
- Error

Compressor warning & shutdown indications:

- Emergency stop
- Element outlet temperature
- Main motor overload
- Phase sequence
- Reverse rotation
- General faults indication



### **1.7 Acoustic Canopy and Drive Arrangement:**

- The enclosure for air-compressor shall be finished with powder coating with service doors with latches for maintenance. The canopy shall be acoustically treated with sound absorbing material for limiting the noise level.
- Canopy is pressurized ensuring no pressure drop at suction filter and avoids entry for dust particles in the element.
- Anti-vibration mounts for support for electric motor and compressor unit and isolate the moving component from rest of the structure thereby reducing sound and vibration transfer.

### **1.8 Air Receiver:**

Horizontal or Vertical Type Air receiver of as capacity indicated in tender schedule suitable for withstanding working pressure of 10 kg/cm<sup>2</sup> with all accessories such as in/out flanged connections, pressure gauge, safety valve, manual drain cock. The Air receiver shall conform to IS:2825 with material as per IS:2062 with welded supporting stand.

### **1.9 Set of filters:**

The set of filters shall be as indicated in the tender schedule as per the project requirement. Based on the requirement, filters shall conform to the following specifications:

1. Grade PF filters shall be high efficiency general purpose protection filters for removal of particles down to 1 micron (1 ppm) coalesced liquid water and oil, providing maximum remaining aerosol content of 0.5 mg/m<sup>3</sup>@ 21 ° C.
2. Grade FF filters shall be high efficiency oil removal filters for removal of particles down to 0.01 micron (0.01 ppm) including water and oil aerosols, providing a maximum of remaining oil aerosol content of 0.01 mg/m<sup>3</sup>@ 21 ° C.
3. Grade CF filters shall be high efficiency oil removal filters for removal of oil vapour and hydrocarbon odour giving maximum remaining oil content of < 0.003 mg/m<sup>3</sup>at 21 ° C.

### **1.10 Stainless Steel Piping:**

Stainless steel piping for compressed air application piping from Ultra filter set point to various user's points as indicated in the drawing. Supply, fabrication, installing and laying of seamless Stainless steel piping suitable for Compressed air application. The pipe line shall withstand the working pressure of 16 kg/cm<sup>2</sup>.

The pipe line shall be provided with required specials such as Flanges, bends, tees, connectors & to be suitable for termination with control valves at the user points inside the lab. The Compressed air line shall be run along the wall / above false ceiling/ below false floor / through trenches with necessary clamps and supports. The Piping shall be connected to the existing Compressed air line and all works shall be executed and as directed by Engineer-in-charge. The lines shall be Stainless steel 304, Sch 40 grade with necessary specials such as Elbow, bends, tees, flanges, isolation valves, clamps etc. lines shall run along the/above false ceiling / below false floor/ through trenches as indicated in the drawing.

The pipe line shall be painted with two coats of blue colour enamel paint over primer coat with arrow indications in black colour complete all & as directed by Engineer-in-charge.

### **1.11 Ultra Filter Set:**

Ultra filter set for compressed air application of required capacity and rated pressure as indicated in SOQ. Filter set shall consist of carbon filter, Pre-filter, fine filter and micro filter with all required connections and complete as required.

End connection shall be of suitable dia SS304 piping with a bypass arrangement. Suitable dia butterfly valves of approved make with a rating of 16bar working pressure shall be supplied and installed in the inlet, outlet and filter bypass circuits. Rates shall be inclusive of cost of specials like SS elbows, SS table E flanges, supports, clamps, synthetic enamel painting over the red oxide primer etc.

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**SPECIFICATIONS FOR AIR-CONDITIONING  
AND VENTILATION WORKS**

**SECTION - XVI**  
**IS CODES AND ASHRAE**  
**STANDARDS**

## IS CODES FOR REFRIGERATION AND AIR CONDITIONING

1. IS 655: 2006 (reaffirmed 2017): air ducts – specification.
2. IS 659: 1964 (reaffirmed 2017): safety code for air conditioning.
3. IS 660: 1963 (reaffirmed 2017): safety code for mechanical refrigeration.
4. IS/ISO 817: 2005 (reaffirmed 2013): refrigerants - designation system.
5. IS 1391: Part 1: 1992 (reaffirmed 2009): room air conditioners - specification - Part 1: unitary air conditioners.
6. IS 1391: Part 2: 1992 (reaffirmed 2013): room air conditioners: Part 2 split air conditioners.
7. IS 1474: 1959 (reaffirmed 2009): commercial refrigerators.
8. IS 1475: Part 1: 2001 (reaffirmed 2017): self-contained drinking water coolers - specification - Part 1: energy consumption and performance.
9. IS 1476: Part 1: 2000 (reaffirmed 2016): performance of household refrigerating appliance - refrigerators with or without low temperature compartment - Part 1: energy consumption and performance.
10. IS 1869: 1961 (reaffirmed 2017): specification for ice cans.
11. IS 2167: 1983 (reaffirmed 2017): specification for bottle coolers.
12. IS 2370: 2014: walk-in cold rooms – specification.
13. IS 2374: 1963 (reaffirmed 2017): specification for ice tanks.
14. IS 3315: 1994 (reaffirmed 2009): evaporative air coolers (desert coolers) – specification.
15. IS 3615: 2007: glossary of terms used in refrigeration and air conditioning.
16. IS 4831: 1968 (reaffirmed 2017): recommendation on units and symbols for refrigeration.
17. IS 5038: 1969 (reaffirmed 2017): specification for ice cube trays for domestic refrigerators.
18. IS 5111: 1993 (reaffirmed 2009): testing of refrigerant compressors.

19. IS 7613: 1975 (reaffirmed 2017): method of testing panel type air filters for air conditioning and ventilation purposes.
20. IS 7872: 1975 (reaffirmed 2017): specification for freezers.
21. IS 7896: 2001 (reaffirmed 2017): data for outside design conditions for air conditioning for Indian cities.
22. IS 8148: 2003 (reaffirmed 2009): packaged air conditioners – specification.
23. IS 9210: 1979 (reaffirmed 2017): specification for display cabinets.
24. IS 10594: 1983 (reaffirmed 2017): specification for thermostatic expansion valves.
25. IS 10617: 2013: hermetic compressors.
26. IS 11327: 2007: requirements for refrigerants condensing units.
27. IS 11328: 1985 (reaffirmed 2017): specification for self-contained automatic ice makers.
28. IS 11329: 1985 (reaffirmed 2017): specification for finned type heat exchanger for room air conditioner.
29. IS 11330: 1985 (reaffirmed 2017): specification for refrigeration oil separator.
30. IS 11338: 1985 (reaffirmed 2009): specification for thermostats for use in refrigerators, air conditioners, water coolers and beverage coolers.
31. IS 11561: 1986 (reaffirmed 2017): code of practice for testing of water cooling towers.
32. IS 11951: 2009: pump set for desert coolers.
33. IS 12249: 1987 (reaffirmed 2017): specification for desiccant driers.
34. IS/ISO 13261: Part 1: 1998 (reaffirmed 2017): sound power rating of air-conditioning and air-source heat pump equipment Part 1 non-ducted outdoor equipment.
35. IS 15750: 2006 (reaffirmed 2017): household frost-free refrigerating appliances - refrigerators cooled by internal forced air circulation - characteristics and test methods – specification.

## 2. ASHRAE STANDARDS

1. Standard 15-2013, Safety Standard for Refrigeration Systems (packaged w/ Standard 34-2013, Designation and Classification of Refrigerants)
2. Standard 16-1983 (RA 2014), Method of Testing for Rating Room Air Conditioners and Packaged Terminal Air Conditioners
3. Standard 17-2015, Method of Testing Capacity of Thermostatic Refrigerant Expansion Valves
4. Standard 18-2008 (RA 2013), Methods of Testing for Rating Drinking-Water Coolers with Self-Contained Mechanical Refrigeration
5. Standard 20-1997 (RA 2006), Method of Testing for Rating Remote Mechanical-Draft Air-Cooled Refrigerant Condensers
6. Standard 22-2014, Methods of Testing for Rating Water-Cooled Refrigerant Condensers
7. Standard 23.1-2010, Methods of Testing for Rating the Performance of Positive Displacement Refrigerant Compressors and Condensing Units That Operate at Subcritical Temperatures
8. Standard 23.2-2014, Methods of Test for Rating the Performance of Positive Displacement Compressors that Operate at Supercritical Pressures of the Refrigerants
9. Standard 24-2013, Methods of Testing for Rating Liquid Coolers
10. Standard 25-2001 (RA 2006), Methods of Testing Forced Convection and Natural Convection Air Coolers for Refrigeration
11. Standard 26-2010, Mechanical Refrigeration and Air-Conditioning Installations aboard Ship
12. Standard 28-1996 (RA 2010), Method of Testing Flow Capacity of Refrigerant Capillary Tubes
13. Standard 29-2015, Method of Testing Automatic Ice Makers
14. Standard 30-1995, Methods of Testing Liquid-Chilling Packages
15. Standard 32.1-2010, Methods of Testing for Rating Vending Machines for Bottled, Canned and Other Sealed Beverages

16. Standard 32.2-2003 (RA 2011), Methods of Testing for Rating Pre-Mix and Post-Mix Beverage Dispensing Equipment
17. Standard 33-2000, Methods of Testing Forced Circulation Air Cooling and Air Heating Coils
18. Standard 34-2013, Designation and Safety Classification of Refrigerants (packaged w/ Standard 15-2013, Safety Standard for Refrigeration Systems)
19. Standard 35-2014, Method of Testing Desiccants for Refrigerant Drying
20. Standard 37-2009, Methods of Testing for Rating Electronically Driven Unitary Air- Conditioning and Heat Pump Equipment
21. Standard 40-2014, Methods of Testing for Rating Heat-Operated Unitary
22. Air-Conditioning and Heat-Pump Equipment
23. Standard 41.1-2013, Standard Methods for Volatile Refrigerant Mass Flow Measurement Using Flow meters
24. Standard 41.2-1987 (RA 1992), Standard Methods for Laboratory Airflow Measurement
25. Standard 41.3-2014, Standard Method for Pressure Measurement
26. Standard 41.4-2015, Standard Method for Measuring the Proportion of Lubricant in Liquid Refrigerant
27. Standard 41.6-2014, Standard Method for Measurement of Moist Air Properties
28. Standard 41.7-2015, Method of Test for Measurement of Flow of Gas
29. Standard 41.8-1989, Standard Methods of Measurement of Flow of Liquids in Pipes Using Orifice Flowmeters
30. Standard 41.9-2011, Calorimeter Test Methods for Mass Flow Measurements of Volatile Refrigerants
31. Standard 41.10-2013, Standard Methods for Volatile Refrigerant Mass Flow Measurements Using Flowmeters
32. Standard 41.11-2014, Standard Methods for Volatile Refrigerant Mass Flow Measurements Using Flowmeters



33. Standard 51-2007, Laboratory Methods of Testing Fans for Aerodynamic Performance Rating
34. Standard 52.2-2012, Method of Testing General Ventilation Air-Cleaning Devices for Removal Efficiency by Particle Size
35. Standard 55-2013, Thermal Environmental Conditions for Human Occupancy
36. Standard 58-1986 (RA 2014), Method of Testing for Rating Room Air Conditioner and Packaged Terminal Air Conditioner Heating Capacity
37. Standard 62.1-2010, Ventilation for Acceptable Indoor Air Quality
38. Standard 90.1-2013 Appendix G: Performance Rating Method (Excerpt from ANSI/ASHRAE/IES Standard 90.1-2013 I-P)
39. Standard 62.1-2013, Ventilation for Acceptable Indoor Air Quality
40. Standard 62.2-2013, Ventilation and Acceptable Indoor Air Quality in Low-Rise Residential Buildings
41. Standard 63.1-1995 (RA 2001), Method of Testing Liquid Line Refrigerant Driers
42. Standard 63.2-1996 (RA 2010), Method of Testing Liquid Line Filter Drier Filtration Capability
43. Standard 64-2011, Methods of Testing Remote Mechanical-Draft Evaporative Refrigerant Condensers
44. Standard 68-1997, Laboratory Method of Testing to Determine the Sound Power in a Duct
45. Standard 70-2006 (RA 2011), Method of Testing for Rating the Performance of Air Outlets and Air Inlets
46. Standard 72-2014, Method of Testing Commercial Refrigerators and Freezers
47. Standard 78-1985 (RA 2007), Method of Testing Flow Capacity of Suction Line Filters and Filter-Driers
48. Standard 79-2015, Method of Testing for Rating Fan-Coil Conditioners
49. Standard 84-2013, Method of Testing Air-to-Air Heat/Energy Exchangers
50. Standard 86-2013, Methods of Testing the Floc Point of Refrigeration Grade Oils

51. Standard 90.1-2007, Energy Standard for Buildings Except Low-Rise Residential Buildings
52. Standard 90.1-2010, Energy Standard for Buildings Except Low-Rise Residential Buildings
53. Standard 90.1-2013, Energy Standard for Buildings Except Low-Rise Residential Buildings
54. Standard 90.2-2007, Energy-Efficient Design of Low-Rise Residential Buildings
55. Standard 93-2010 (RA 2014), Methods of Testing to Determine Thermal Performance of Solar Collectors
56. Standard 94.2-2010, Method of Testing Thermal Storage Devices with Electrical Input and Thermal Output Based on Thermal Performance
57. Standard 95-1987, Methods of Testing to Determine the Thermal Performance of Solar Domestic Water Heating Systems
58. Standard 96-1980 (RA 1989), Methods of Testing to Determine the Thermal Performance of Unglazed Flat-Plate Liquid- Type Solar Collectors
59. Standard 97-2007, Sealed Glass Tube Method to Test the Chemical Stability of Materials for Use within Refrigerant Systems
60. Standard 99-2006, Refrigeration Oil Description
61. Standard 100-2015, Energy Conservation in Existing Buildings
62. Standard 103-2007, Method of Testing for Annual Fuel Utilization Efficiency of Residential Central Furnaces and Boilers
63. Standard 105-2014, Standard Methods of Measuring, Expressing, and Comparing Building Energy Performance and Greenhouse Gas Emissions
64. Standard 110-1995, Method of Testing Performance of Laboratory Fume Hoods
65. Standard 111-2008, Practices for Measurement, Testing, Adjusting, and Balancing of Building Heating, Ventilation, Air-Conditioning and Refrigeration Systems
66. Standard 113-2013, Method of Testing for Room Air Diffusion
67. Standard 116-2010, Methods of Testing for Rating Seasonal Efficiency of Unitary Air Conditioners and Heat Pumps

68. Standard 118.1-2012, Method of Testing for Rating Commercial Gas, Electric, and Oil Service Water Heating Equipment
69. Standard 118.2-2006 (RA 2105), Method of Testing for Rating Residential Water Heaters
70. Standard 120-2008, Method of Testing to Determine Flow Resistance of HVAC Ducts and Fittings
71. Standard 124-2007, Methods of Testing for Rating Combination Space-Heating and Water-Heating Appliances
72. Standard 125-1992 (RA 2011), Method of Testing Thermal Energy Meters for Liquid Streams in HVAC Systems
73. Standard 127-2012, Method of Testing for Rating Computer and Data Processing Room Unitary Air Conditioners
74. Standard 128-2011, Method of Rating Unitary Spot Air Conditioners
75. Standard 129-1997 (RA 2002), Measuring Air Change Effectiveness
76. Standard 130-2008, Methods of Testing for Rating Ducted Air Terminal Units
77. Standard 13256-1: 1998 (RA 2012), Water-source Heat Pumps – Testing and Rating for Performance – Part 1: Water-to-air and Brine-to-Air Heat Pumps
78. Standard 13256-2: 1998 (RA 2012), Water-source Heat Pumps-Testing and Rating for Performance-Part 2: Water-to-water and Brine-to-water Heat Pumps
79. Standard 133-2015, Method of Testing Direct Evaporative Air Coolers
80. Standard 134-2005 (RA 2014), Graphic Symbols for Heating, Ventilating, Air-Conditioning, and Refrigerating Systems,
81. Standard 135-2012, BACNET Data Communication Protocol for Building Automation and Control Networks
82. Standard 135.1-2013, Method of Test for Conformance to BACNET
83. Standard 137-2013, Methods of Testing for Efficiency of Space-Conditioning/ Water-Heating Appliances that Include a De-super heater Water Heater
84. Standard 138-2013, Method of Testing for Rating Ceiling Panels for Sensible Heating and Cooling

85. Standard 139-2015, Method of Testing for Rating Desiccant Dehumidifiers Utilizing Heat for the Regeneration Process
86. Standard 140-2014, Standard Method of Test for the Evaluation of Building Energy Analysis Computer Programs
87. Standard 143-2015, Method of Test for Rating Indirect Evaporative Coolers
88. Standard 145.1-2015, Laboratory Test Method for Assessing the Performance of Gas-Phase Air-Cleaning Systems: Loose Granular Media
89. Standard 145.2-2011, Laboratory Test Method for Assessing the Performance of Gas-Phase Air Cleaning Systems: Air Cleaning Devices
90. Standard 146-2011, Methods of Testing and Rating Pool Heaters
91. Standard 147-2013, Reducing the Release of Halogenated Refrigerants from Refrigerating and Air-Conditioning Equipment and Systems
92. Standard 149-2013, Laboratory Methods of Testing Fans Used to Exhaust Smoke in Smoke Management Systems
93. Standard 150-2000 (RA 2014), Method of Testing the Performance of Cool Storage Systems
94. Standard 152-2014, Method of Test for Determining the Design and Seasonal Efficiencies of Residential Thermal Distribution Systems
95. Standard 153-2015, Method of Test for Mass Flow Capacity of Four-Way Refrigerant Reversing Valves
96. Standard 154-2011, Ventilation for Commercial Cooking Operations
97. Standard 158.1-2012, Methods of Testing Capacity of Refrigerant Solenoid Valves
98. Standard 158.2-2011, Method of Testing Capacity of Refrigerant Pressure Regulators
99. Standard 160-2009, Criteria for Moisture- Control Design Analysis in Buildings
100. Standard 161-2013, Air Quality within Commercial Aircraft
101. Standard 164.1-2012, Method of Testing for Residential Central-System Humidifiers
102. Standard 164.2-2012, Method of Test for Residential Self-Contained Humidifiers

103. Standard 164.3-2015, Method of Test for Commercial and Industrial Isothermal Humidifiers
104. Standard 169-2013, Climate Data for Building Design Standards
105. Standard 170-2013, Ventilation of Health Care Facilities
106. Standard 171-2008, Method of Testing Seismic Restraint Devices for HVAC&R Equipment
107. Standard 173-2012, Method of Test to Determine the Performance of Halocarbon Refrigerant Leak Detectors (BSR/ASHRAE Approved)
108. Standard 174-2009, Method of Test for Rating Desiccant-Based Dehumidification Equipment
109. Standard 180-2012, Standard Practice for Inspection and Maintenance of Commercial Building HVAC Systems (ACCA Approved)
110. Standard 181-2014, Methods of Testing for Rating Liquid-to-Liquid Heat Exchangers
111. Standard 182-2008 (RA 2013), Method of Testing Absorption Water-Chilling and Water-Heating Package
112. Standard 183-2007 (RA 2014), Peak Cooling and Heating Load Calculations in Buildings except Low-Rise Residential Buildings
113. Standard 185.1-2015, Method of Testing UV-C Lights for Use in Air-Handling Units or Air Ducts to Inactivate Airborne Microorganisms
114. Standard 185.2-2014, Method of Testing Ultraviolet Lamps for Use in HVAC&R Units or Air Ducts to Inactivate Microorganisms on Irradiated Surfaces
115. Standard 188-2015, Legionellosis: Risk Management for Building Water Systems
116. Standard 189.1-2011, Standard for the Design of High-Performance Green Buildings (USGBC and IES co-sponsored)
117. Standard 189.1-2014, Standard for the Design of High-Performance Green Buildings (USGBC and IES co-sponsored)
118. Standard 190-2013, Method of Testing for Rating Indoor Pool Dehumidifiers
119. Standard 193-2010 (RA 2014), Method of Test for Determining the Air tightness of HVAC Equipment

120. Standard 194-2012, Method of Test for Direct-Expansion Ground-Source Heat Pumps
121. Standard 195-2013, Method of Test for Rating Air Terminal Unit Controls
122. Standard 198-2013, Method of Test for Rating DX-Dedicated Outdoor Air Systems for Moisture Removal Capacity and Removal Efficiency
123. Standard 200-2015, Methods of Testing Chilled Beams
124. Standard 202-2013, Commissioning Process for Buildings and Systems
125. Standard 203-2014, Commissioning Process for Buildings and Systems (IES Co-sponsored)
126. Standard 206-2013, Method of Testing for Rating of Multipurpose Heat Pumps for Residential Space Conditioning and Water Heating



भारत सरकार  
अंतरिक्ष विभाग

एयर कंडीशनिंग और वेंटिलेशन कार्यों के लिए विनिर्देश  
(वातानुकूलन और संवातन कार्यों के लिए विनिर्देश)



जनवरी 2018  
सिविल इंजीनियरिंग प्रोग्राम कार्यालय  
इसरो मुख्यालय, बेंगलुरु

## अस्वीकरण (डिस्क्लेमर)

जब तक अन्यथा विशेष रूप से नहीं बताया जाए, यहां दी गई जानकारी को विभाग के इंजीनियरों और विभागीय कार्यों में भाग लेने वाले निविदाकारों को उपलब्ध कराया जा रहा है। विभाग इस पुस्तक में दी गई किसी भी जानकारी की सटीकता, पूर्णता, उपयोगिता या व्याख्या के लिए किसी भी कानूनी दायित्व या उत्तरदायित्व के लिए जिम्मेदार नहीं है।

यह पुस्तक अभिप्रेत उपयोग के अलावा व्यापार, विज्ञापन, सिफारिशों या किसी अन्य उद्देश्य के स्रोत के लिए इस्तेमाल करने के लिए अभिप्रेत नहीं है। व्यापार नाम, व्यापार चिह्न, निर्माता या अन्यथा किसी भी विशिष्ट वाणिज्यिक उत्पाद, प्रक्रिया और सेवा का संदर्भ देने का तात्पर्य विभाग द्वारा अनुमोदन, सिफारिश करना या समर्थन करना नहीं है।



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**एयर कंडीशनिंग और वेंटिलेशन  
कार्यों के लिए विनिर्देश**

**खंड - I**

**चिलर पैकेज**

## 1. जल शीतित पंच चिलर पैकेज

### 1.1 निर्माण:

प्रस्तावित पंच चिलर जल शीतित प्रकार के होंगे, जिसमें SOQ में निर्दिष्ट एकल/एकाधिक कंप्रेसरों के साथ वायुरोधी/अर्द्ध वायुरोधी (हर्मेटिक/सेमी हर्मेटिक) प्रत्यक्ष चालित पंच कंप्रेसर होंगे, जो वाष्पीकारक, कंडेन्सर, माइक्रोप्रोसेसर आधारित नियंत्रण, मोटर स्टार्टर आदि के साथ परिपूर्ण होंगे। चिलर को 3-फेज, 50Hz,  $415 \pm 10\%$  VAC आपूर्ति और R-134a /407c/410a प्रशीतक पर परिचालन के लिए उपयुक्त होना चाहिए। चिलर को पूरी तरह से कारखाने में असेम्बल किया जाएगा, एकल पैकेज में वायरिंग होगी, इनडोर ड्यूटी शुरूआत के लिए उपयुक्त होगा और सुरक्षा और ऑपरेटिंग नियंत्रण से परिपूर्ण होगा। चिलरों की जांच पूर्ण भार स्थितियों में कारखाने में चलाकर की जाएगी। पैकेज चिलरों के कूलर का चयन  $0.000018m^2 \text{ } ^\circ K/W$  के पानी की तरफ प्रदूषक (फॉउलिंग) कारक के लिए किया जाएगा। कंडेन्सरों (संघनित्रों) का चयन  $0.000044m^2 \text{ } ^\circ K/W$  के पानी की तरफ प्रदूषक (फॉउलिंग) कारक के लिए किया जाएगा। चिलर पैकेज का डिजाइन पर्याप्त संरचनात्मक क्षमता वाले पैनलों के साथ अधिकतम जंगरोधकता के लिए किया जाएगा। आधार को स्प्रे जस्ती चैनलों का उपयोग करके वेल्डयुक्त डिजाइन किया जाएगा। आधार और फ्रेम के भागों को पेंट किया जाएगा। जब तक अन्यथा निर्दिष्ट नहीं हो, चिलर पैकेज का न्यूनतम COP, IPLV और  $1kW/ TR$  SOQ में बताए अनुसार होगा।

चिलर AHRI 550/590 (I-P) और AHRI (SI) या समकक्ष के लागू मानकों के अनुसार प्रमाणित होंगे।

मशीन पर निर्माता के नाम और स्थान, प्रकार, मॉडल नं. व क्रमांक के साथ OEM के नाम की प्लेट होगी जिसमें पूर्ण पहचान, चिलर पैकेज के आयाम, परिचालन भार, कंपनी स्तर, रव स्तर, प्रशीतक का नाम, वोल्टेज, फेज़ और आवृत्ति, निर्माण की तारीख आदि लिखी होनी चाहिए। चिलरों के लिए  $1kW/TR$  vs. % लोड चार्ट प्रदान किया जाना है।

चिलरों का शोर स्तर यूनिट से लगभग 1m दूरी पर 85 dB(A) से अधिक नहीं होगा। चिलर के विभिन्न घटकों का संक्षिप्त विवरण नीचे दिया गया है।

## 1.2 कंप्रेसर (संपीडक):

कंप्रेसर सीधे पिंजरी चूषण गैस शीतित प्रेरण मोटर द्वारा संचालित होगा, और उसकी डिजाइन वायुरोधी/अर्ध-वायुरोधी होगी। कंप्रेसर के मेल और फीमेल रोटर के लिए डिजाइन के अनुसार पर्याप्त मात्रा में लोब होंगे और ये एकल या दोहरे डिजाइन वाले होंगे। विस्तारित सेवा काल के लिए डिजाइन सामग्रियों से रोटर संपर्क तत्वों (एलीमेंट) का निर्माण किया जाएगा। रोटर को सहारा देने और त्रिज्यीय भारों को अवशोषित करने के लिए कंप्रेसर को आवश्यक बेयरिंग के साथ दाब द्वारा ल्यूब्रिकेट (चिकनाया) किया जाएगा। कंप्रेसर के चूषण पर छलनी लगाई जाएगी, और यूनिट में तेल विभाजक और क्रैंककेस हीटर शामिल होगा। कंप्रेसर में क्षमता नियंत्रण प्रदान किया जाएगा। कंप्रेसर मोटर सभी तीन चरणों पर तापीय संरक्षण के साथ उच्च बलआघूर्ण, पिंजरी प्रेरण प्रकार की होंगी और उन्हें चूषण गैस द्वारा ठंडा किया जाएगा।

प्रत्येक कंप्रेसर में चूषण चेक वाल्व, चूषण फिल्टर और डिस्चार्ज चेक वाल्व होगा। कंप्रेसर क्षमता नियंत्रण विशेषतः प्रत्येक कंप्रेसर हाउसिंग के भीतर विद्युत संचालित, हाइड्रॉलिक रूप से प्रेरित एक भरोसेमंद स्लाइड वाल्व तंत्र द्वारा प्राप्त किया जाएगा। कंप्रेसर या वाष्पीकारक की सर्विस के लिए कंडेन्सर में प्रशीतक आवेश को संग्रह करने के लिए प्रत्येक कंप्रेसर के लिए निरावेश चेक वाल्व की आवश्यकता है। कंप्रेसर के सभी कनेक्शन पर वियोजन वाल्व लगाए जाएंगे ताकि

(ए) अन्य कंप्रेसर चल रहे हों तब एक को बदला जा सके और सर्विस कंप्रेसर के माध्यम से वाष्पीकारक में प्रशीतक संग्रह हो सके।

(बी) कंडेन्सर को पंप डाउन रिसीवर के रूप में इस्तेमाल कर सकें।

## 1.3 कंडेन्सर (संघनित्र):

कंडेन्सर बोल्ट निर्माण, सफाई योग्य, शेल और ट्यूब प्रकार के होंगे, जिसके साथ तांबे की ट्यूब होंगी जो यांत्रिक रूप से ट्यूब शीट पंखों में और बाह्य रूप से पंखों में विस्तारित होंगी। पास (मार्गों) की संख्या यथावश्यक हो सकती है। ट्यूब सफाई के लिए जल शीर्ष निकाले जाने वाले होने चाहिए। प्रत्येक शीर्ष में छिद्र और नाली प्लग होंगे।

जल शीतित कंडेन्सर को 97°F (36 °C) के संघनित तापमान के साथ 86°F (30°C) से 93°F (33.9°C) तक जल के न्यूनतम 3 US GPM/TR (11.4 LPM/TR) को संभालने में सक्षम होना होगा। यह यूनिट पूर्ण भार डिज़ाइन तापमान पर ठंडा पानी छोड़ते और कंडेन्सर पानी में प्रवेश करते हुए शीतन (रेफ्रिजरेशन) क्षमता के 10 से 20% से ठीक ऊपर उतारने में सक्षम होगी। यह यूनिट तप्त गैस बायपास के उपयोग के बिना, स्थिर कंप्रेसर परिचालन के साथ इस बिंदु पर निरंतर संचालन करने में सक्षम होगी। उस स्थान पर उपलब्ध पानी की गुणवत्ता का उल्लेख किया जाना चाहिए।

इन कंडेन्सरों में प्रशीतक छिद्र के प्रावधान के साथ दोहरे दाब निर्मुक्ति (मोचन) वाल्व होंगे।

निर्माता के कार्यस्थल पर चिलर परीक्षण के दौरान ताप विनियामकों और अन्य सभी घटकों को दाब परीक्षण के संदर्भ में परीक्षण प्रमाणपत्र प्रदान किया जाना है। ताप विनियामकों को सभी लागू मानकों का पालन करना होगा। हालांकि, आंतरिक और बाह्य रूप से खांचित और उच्च ताप स्थानांतरण संवृद्धि प्रकार की, तांबे की ट्यूब का उपयोग किया जाएगा। आदेश प्राप्त होने पर ट्यूबों की संख्या, ट्यूबों का व्यास, ट्यूबों का दाब और दाब गिरावट जैसे विवरण विभाग को प्रस्तुत करने होंगे।

#### **1.4 वाष्पीकारक (इवैपोरेटर):**

चिलर DX/आप्लावन प्रकार का होगा। कूलर ट्यूबों की सफाई और सर्विसिंग के लिए निकालने योग्य शीर्ष की आपूर्ति की जाएगी। प्रत्येक शीर्ष में छिद्र और नाली प्लग उपलब्ध कराए जाएंगे। आप्लावन - कूलर में अंतर्निहित वितरक (बिल्ट-इन डिस्ट्रीब्यूटर) होगा जो एक समान उबलने की क्रिया पैदा करने के लिए बंडल ट्यूब के तहत प्रशीतक को समान रूप से पहुंचा सके, और वाष्प वियोजन सुनिश्चित करने के लिए बाधा (बेफल) प्लेटें लगाई जाएंगी। यह शीतन (क्लिंग) एक तेल रिकवरी प्रणाली के साथ फिट की जाएगी। वाष्पीकारक को ASME दाब पोत कोड या समकक्ष के अनुसार तैयार किया जाएगा और स्प्रिंग भारयुक्त निर्मुक्ति वाल्व से लैस होगा।

वाष्पीकारक के शैल की तरफ प्रशीतक छिद्र प्रावधान के साथ एकल निर्मुक्ति वाल्व होना चाहिए।



## 1.5 प्रशीतक (रेफ्रिजरेंट) सर्किट:

प्रत्येक पैकेज चिलर में SOQ में निर्दिष्ट आंशिक भार दक्षता प्राप्त करने के लिए एकल/एकाधिक प्रशीतक सर्किट या टैंडम कंप्रेसर होंगे। प्रत्येक सर्किट में विस्तार वाल्व, साइट ग्लास, नमी सूचक, सोलनॉइड वाल्व, फिल्टर शुष्कक, तरल लाइन शट ऑफ वाल्व, आवेश और गेज कनेक्शन और निर्मुक्ति लाइन चेक वाल्व शामिल होंगे। तापस्थैतिक/इलेक्ट्रॉनिक विस्तार वाल्व/पायलट फ्लोट वाल्व द्वारा नियंत्रित सर्वो नियंत्रित मॉड्यूलिंग टाइप लगाया जाएगा ताकि वाष्पीकारक के लिए प्रशीतक प्रवाह को पूरी तरह से व्यवस्थित किया जा सके।

अनुमानित सुविधा में सर्विस के लिए निकालने वाले और प्रशीतक को कंडेन्सर में पंप किये जाने वाले कंप्रेसर शामिल हैं। इसमें संघनन को रोकने के लिए जहां आवश्यक हो वहां इन्सुलेशन लगाना शामिल किया जाएगा।

## 1.6 नियंत्रण पैनल:

माइक्रोप्रोसेसर आधारित यूनिट कंट्रोल सेंटर पूरी तरह से संवृत स्टील कैबिनेट में होना चाहिए। बिजली और सुरक्षा/संचालन नियंत्रण प्रदान किए जाएंगे। नियंत्रण केंद्र ठंडे पानी के तापमान नियंत्रण, कंप्रेसर और विस्तार वाल्व मॉड्यूलेशन को छोड़कर शुरू करने और बंद करने सहित सभी नियंत्रण और सुरक्षा कार्य करेगा। इसके अतिरिक्त, नियंत्रण केंद्र शुरूआती और संचालन के दौरान अधिभार से बचाने, फेज/बिजली हानि, फेज असंतुलन या फेज परावर्तन, ज्यादा/कम वोल्टेज आदि से कंप्रेसर मोटर की पूरी तरह से रक्षा करेगा। नियंत्रण केंद्र ठंडे पानी का तापमान निर्दिष्ट बिंदु के  $\pm 0.5 \text{ deg C}$  के बीच बनाए रखने की सुविधा प्रदान करेगा। नियंत्रण कक्ष पैकेज चिलर प्रणाली के रिमोट ऑपरेशन/मॉनिटरिंग के लिए उपयुक्त होगा।

संचालन के लिए पैक स्क्रू चिलर का चयन उन जगहों के परिवेश में किया जाएगा जहां चिलर स्थापित किया जा रहा है।

पैक चिलर के साथ प्रोएक्टिव माइक्रोकंप्यूटर नियंत्रक होगा जिसे असामान्य परिचालन परिस्थितियों के अनुकूलन, सहिष्णु और प्रारंभिक समय पर चरम स्थितियों का समायोजन करने के लिए सुसज्जित किया जाएगा।

इसके अतिरिक्त, माइक्रोप्रोसेसर आधारित नियंत्रण कक्ष में निम्नलिखित सुविधाएं उपलब्ध होंगी:

ए) पैनल उपयोगकर्ता के अनुकूल होगा और सरल अंग्रेजी भाषा में संदेश प्रदर्शित करेगा जिसके साथ अलग-अलग मापदंडों और बदलते सेट पॉइंट को देखने के लिए ऑपरेटर पैड होगा।

बी) माइक्रोप्रोसेसर पैनल को पूरी तरह से छेड़छाड़ मुक्त करने के लिए पासवर्ड से सुरक्षित किया जाएगा।

सी) पैनल में कैलेंडर/घड़ी होगी ताकि दैनिक शुरुआत - बंद करने और साप्ताहिक बंद करने को प्रोग्राम किया जा सके। पैनल कम से कम 6 खराबी शट डाउन लॉग करेगा जो शट डाउन के समय की तारीख और समय, शट डाउन के कारण और शट डाउन के समय महत्वपूर्ण पैरामीटर के साथ मेमोरी में संग्रह करेगा।

डी) माइक्रोप्रोसेसर आधारित नियंत्रण कक्ष ट्रांसड्यूसर के माध्यम से सक्शन, डिस्चार्ज और तेल के दाब और कंप्रेसर करंट पर नज़र रखेगा और यह दिन या रात के दौरान आसानी से देखने के लिए बैक-लिट लिक्विड क्रिस्टल स्क्रीन पर प्रदर्शित करेगा। इसे पूरी तरह से छेड़छाड़ मुक्त करने के लिए पासवर्ड से सुरक्षित किया जाएगा।

ई) यह प्रणाली यूनिट को समझदारी से बनाए रखेगी ताकि कंप्रेसर साइकिल चालन को न्यूनतम रखते हुए जल तापमान परिशुद्धता और स्थिरता को बनाए रखा जा सके।

एफ) पैनल में अनुकूली लॉजिक होगा जो यह सुनिश्चित करेगा कि खराब मौसम के दौरान जल शीतन यूनिट चलती रहे जब शीतन सर्वाधिक वांछित होता है।

जी) पैनल में पर्सनल कम्प्यूटर में इंटरकनेक्टिविटी के लिए एक इंटरफेस होगा ताकि किसी भी सुदूर स्थान से जल शीतन यूनिट आपरेशन की निगरानी की जा सके। माइक्रो-प्रोसेसर कंट्रोल पैनल को BACNET या MODBUS नेटवर्क जैसे मानक प्रोटोकॉल पर काम करना होगा।

पैनल को निम्नलिखित को प्रदर्शित करना होगा:

- गलत पासवर्ड संदेश।
- दिन, तारीख और समय।
- दैनिक चालू और बंद होने का समय।
- चिलर इनलेट और आउटलेट तापमान।
- कंडेन्सर जल इनलेट और आउटलेट तापमान।
- सक्शन, निर्मुक्ति और तेल दाब।

- सभी तीन फेज़ पर प्रत्येक कंप्रेसर मोटर करंट।
- सक्शन/निर्मुक्ति दाब का कट-आउट सेटिंग।
- एंटी-फ्रीज तापमान कट-आउट सेटिंग।
- कंप्रेसर शुरूआत और चालन स्थिति और कुल चालन समय।
- तरल रेखा परिनालिका वाल्व स्थिति।
- 6 खराबी से बंद होने वाली स्थितियां।
- प्रत्येक कंप्रेसर की एंटी-रीसायकल टाइमर स्थिति

## 1.7 इलेक्ट्रिक्स:

विद्युत नियंत्रण कक्ष को प्रारंभिक स्टार्ट-अप, सामान्य परिचालन और शटडाउन स्थितियों के दौरान पूरी तरह से स्वचालित संचालन के लिए वायरिंग की जाएगी। नियंत्रण प्रणाली में निम्नलिखित नियंत्रण और सुरक्षा उपकरण होंगे:

### 1.7.1 मैनुअल कंट्रोल:

- नियंत्रण सर्किट स्टॉप और स्टार्ट स्विच
- कंप्रेसर इनेबल स्विच

### 1.7.2 सुरक्षा नियंत्रण:

सॉलिड स्टेट कंप्रेसर मोटर स्टार्टर ओवरलोड (3 फेज) करता है, फेज/पावर क्षय, फेज असंतुलन या फेज रिवर्सल, ज्यादा/कम वोल्टेज आदि के लिए सुरक्षा।

- तेल का निम्न दाब
- उच्च सील तेल तापमान
- कम तेल स्तर ऑप्टिकल सेंसर
- उच्च कंडेन्सर दाब
- कम वाष्पीकारक दाब
- वाष्पीकारक जल शीतन संरक्षण
- ठंडे पानी के प्रवाह का क्षय

### 1.7.3 स्वचालित (ऑटोमैटिक) नियंत्रण:

- कंप्रेसर मोटर संवृद्धि संपर्कक
- संवृद्धि प्रारंभ टाइमर
- एंटी-रीसायकल टाइमर
- ऑयल संप हीटर इंटरलाक रिले

### 1.7.4 प्रशीतक नियंत्रण:

- परिमित मोटर प्रशीतक प्रवाह नियंत्रण
- वाष्पीकारक के लिए तरल प्रशीतक स्तर संवेदक
- कंप्रेसर लोड और अनलोड सोलेनॉइड वाल्व
- कंप्रेसर चूषण पर प्रशीतक नमी सेंसर (संवेदक)

### 1.7.5 रोशनी संकेत:

- पावर 'ऑन'
- उच्च मोटर तापमान
- कंप्रेसर उच्च तेल तापमान
- कंप्रेसर मोटर अधिभार
- उच्च/निम्न दाब, कम तेल और फ्रीज़ सुरक्षा।

नियंत्रण प्रणाली में एक प्रति-रीसायकल डिवाइस लगाया जाएगा। नियंत्रक को चालू होने के बीच में कंप्रेसर चालू होने को न्यूनतम अंतराल पर सीमित करना होगा। पैक चिलर को प्रत्येक कंप्रेसर के लिए रेलपेल शुरूआती प्रणाली के लिए यूनिट पर लगे सर्किट ब्रेकर, यूनिट पर लगे संपर्कक और समय देरी वायरिंग से सुसज्जित किया जाएगा। स्टार्टर कारखाने से ही लगे होंगे और अलग-अलग सर्किट ब्रेकर के साथ वायरिंग की जाएगी। यूनिट को वायरिंग की जाएगी ताकि पैक चिलर के लिए केवल क्षेत्र विद्युत कनेक्शन एकल तीन-फेज पावर टर्मिनल तक हो सके। मोटर कंट्रोल सेंटर में सर्किट ब्रेकर के साथ-साथ प्रति कंप्रेसर एक डिस्कनेक्ट स्विच और यूनिट फ्र्यूज/फ्र्यूज ब्लॉक भी शामिल किए जाने हैं।

### 1.8 अन्य विशेषताएं:

- एकल पॉइंट विद्युत पावर कनेक्शन, नियंत्रण विद्युत ट्रांसफार्मर, कम वोल्टेज और फेज विफलता रिले।
- कंप्रेसर ओवरलोड, उच्च मोटर तापमान, माइक्रो अलार्म, कंट्रोल पावर, और कंप्रेसर कंट्रोल सर्किट के लिए रोशनी संकेतक।
- प्रत्येक कंप्रेसर के लिए यूनिट पर लगे डिस्कनेक्ट और 400 से 575 वोल्ट और 3300/6600/11000 वोल्ट अनुप्रयोगों, यथा स्थिति, के लिए फ्यूज और फ्यूज ब्लॉक के साथ नियंत्रण सर्किट।

### 1.9 परिचालन लाभ, दक्षता और विश्वसनीयता:

- निर्माता को रोटरी स्कू कंप्रेसरों के निर्माण और अद्यतित तकनीकी प्रगति में पर्याप्त अनुभव रखना होगा।
- न्यूनतम घूमने वाले पुर्जों के साथ उच्च विश्वसनीयता के लिए सरल डिजाइन होगा।
- प्रत्येक कंप्रेसर के लिए अभिन्न उच्च दक्षता वाले तेल पृथकन के माध्यम से प्रत्येक कंप्रेसर के लिए निरंतर तेल प्रवाह को सुनिश्चित करना।
- कम कंप्रेसरों के साथ अधिक क्षमता पैदा करने वाले किफायती चक्र और माइक्रो कंप्यूटर-नियंत्रित चरणों के उपयोग के द्वारा उत्कृष्ट दक्षता और संपूर्ण ऊर्जा बचत करना।
- कम्प्यूटर से मिलान किए घटकों के माध्यम से अधिकतम निष्पादन।
- रेफ्रिजरेंट के साथ तेल को हटाने की गारंटी देने के लिए उच्च दक्षता तेल रिकवरी प्रणाली और पूर्ण और आंशिक भार दोनों पर अपनी अधिकतम दक्षता पर ताप विनियामक (एक्सचेंजर्स) को बनाए रखता है।
- लगाना आसान।
- एक अत्यंत संहत कार्य अन्वालोप के लिए जरूरी रोटरी स्कू कंप्रेसरों की साइड-बाय-साइड वाष्पीकारक/कंडेन्सर प्लस स्नग व्यवस्था।
- डिजाइन के परिणामस्वरूप बंद रहने के समय और श्रम व्यय दोनों में कम रखरखाव और पूर्ण मरम्मत लागत में कमी के कारण त्वरित पेबैक अवधि होगी।
- मॉनिटर किए गए कार्यों के माइक्रोप्रोसेसर प्रतिधारण के जरिए सरलीकृत समस्या निवारण।

सभी पैक चिलर पूरी तरह फैक्ट्री में असेम्बल होंगे, शिपमेंट से पहले निर्माता के कार्यस्थल पर 25%, 50%, 75% और 100% भार परिस्थितियों में पूर्ण संचालन प्रशीतक और तेल आवेश के साथ निष्पादन की जांच की जाएगी, स्थापना में आसानी और न्यूनतम फ़ील्ड स्टार्ट-अप समायोजन के लिए आवेशित और समायोजित किया जाएगा। परीक्षण मंच AHRI मानकों या समकक्ष के अनुसार होगा और परीक्षण भी परीक्षण और मूल्यांकन प्रक्रियाओं के अनुसार और विभाग की आवश्यकताओं के अनुसार किया जाएगा। प्री-शिपमेंट परीक्षण के दौरान चिलरों के IPLV आंकड़े प्रमाणित होंगे। AHRI मानक के अनुसार बिजली खपत पर (+) 5% सहायता और क्षमता पर (-) 5% सहायता लागू है। अलग-अलग घटकों के लिए परीक्षण प्रमाणपत्र उपलब्ध कराए जाएंगे। उच्च गुणवत्ता वाले ब्रेजिंग, दाब परीक्षण, तिहरी निकासी और रिसाव परीक्षण जैसी कठोर गुणवत्ता की जांच सुनिश्चित की जाएगी। विक्रेता संयंत्र कक्ष में निर्धारित जगह की जांच करेगा और रखरखाव के पहलुओं को ध्यान में रखकर उपकरणों को स्थापित करने के लिए इसकी पुष्टि करेगा।

1

$$\text{IPLV सूत्र} = \frac{0.01}{\text{-----}} + \frac{0.42}{\text{-----}} + \frac{0.45}{\text{-----}} + \frac{0.12}{\text{-----}}$$

A                      B                      C                      D

यहां A, B, C और D क्रमशः 100%, 75%, 50% और 25% भार बिन्दुओं पर KW/TR को दर्शाता है।

### 1.10 VFD विकल्प:

यदि VFD ड्राइव का विकल्प चुना गया है, तो चिलर को इन्वर्टर ड्यूटी कंप्रेसर मोटर और सुदूर माउन्ट किए VFD पैनल के साथ दिया जाएगा। VFD सतत टॉर्क (बल आघूर्ण) वाला होगा और सामान्य परिचालन के दौरान 60 सेकंड के लिए 110% टॉर्क देने में सक्षम होना चाहिए। सभी परिस्थितियों में उपयुक्त कैपेसिटर बैंकों/APFC पैनलों द्वारा 0.95 का शक्ति गुणक (पावर फैक्टर) बनाए रखा जाएगा। सभी परिचालन परिस्थितियों में स्थिर संचालन के

साथ अनुकूलित निष्पादन प्रदान करने के लिए यूनिट क्षमता नियंत्रण VFD और इनलेट गाइड फलक के संयुक्त कार्य द्वारा किया जाएगा।

आवृत्ति को स्वतः कम करने के लिए VFD में इनबिल्ट प्रोटेक्शन मोड की आवश्यकता होगी और मॉड्यूलन प्रक्रिया को तब समायोजित किया जाएगा जब इसे करंट या अधिक वोल्टेज आदि नाजुक स्थिति का पता लगेगा।

VFD में अधिभार के लिए इनबिल्ट इलेक्ट्रॉनिक थर्मल मोटर संरक्षण होगा। VFD को मोटर टर्मिनलों पर शॉर्ट सर्किट से संरक्षित किया जाएगा। इसके मुख्य फेज के नुकसान के लिए भी सुरक्षा होगी। VFD में इनबिल्ट LCD कीपैड डिस्प्ले होगा और मोटर करंट, वोल्टेज, आवृत्ति उत्पादन, आउटपुट kW इत्यादि पर जानकारी दिखाएगा।

### **1.11 सुरक्षा कोड/मानक:**

- ASME बॉयलर और प्रेशर वेसल कोड, खंड VIII भाग 1 "अनफायर्ड प्रेशर वेसल्स"
- ASME मानक B 31.5 प्रशीतन पाइपिंग
- ASHRAE मानक 15 मैकेनिकल रेफ्रिजेशन के लिए सुरक्षा कोड
- राष्ट्रीय इलेक्ट्रिक कोड और स्थानीय प्रदूषण नियंत्रण बोर्ड के नियम
- AHRI मानक 550/590-2012 "वाष्प संपीड़न चक्र का उपयोग करके जल-शीतक और ताप पम्प जल-तापन पैकेज की निष्पादन रेटिंग"

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## 2. वायु शीतित पंच चिलर पैकेज

### 2.1 निर्माण:

प्रस्तावित पैक पंच चिलर वायु शीतित प्रकार के होंगे, जिसमें SOQ में निर्दिष्ट एकल/एकाधिक कंप्रेसरों के साथ वायुरोधी/अर्द्ध वायुरोधी प्रत्यक्ष चालित पंच कंप्रेसर होंगे, जो वाष्पीकारक, कंडेन्सर, माइक्रोप्रोसेसर आधारित नियंत्रण, मोटर स्टार्टर आदि के साथ परिपूर्ण होंगे। चिलर को 3-फेज, 50 Hz,  $415 \pm 10\%$  V AC आपूर्ति और R-134a /407c /410a प्रशीतक पर परिचालन के लिए उपयुक्त होना चाहिए। चिलर को पूरी तरह से कारखाने में असेम्बल किया जाएगा, एकल पैकेज में वायरिंग की जाएगी जो आउटडोर इयूटी स्थापना के लिए उपयुक्त होगा और सुरक्षा और ऑपरेटिंग नियंत्रण से परिपूर्ण होगा। चिलरों को पूर्ण भार स्थितियों में कारखाने में चलाकर जांच की जाएगी। पैकेज चिलरों के चिलर का चयन  $0.000018m^2 \text{ } ^\circ K/W$  के पानी की तरफ प्रदूषक (फॉउलिंग) कारक के लिए किया जाएगा। चिलर पैकेज यूनिट का डिजाइन पर्याप्त संरचनात्मक क्षमता वाले पैनेलों के साथ अधिकतम जंगरोधकता के लिए किया जाएगा और सभी पैनेलों का निर्माण भारी गेज जस्टी स्टील से किया जाएगा। आधार और फ्रेम के भागों को पेंट किया जाएगा। जब तक अन्यथा निर्दिष्ट नहीं हो, चिलर पैकेज का न्यूनतम COP, IPLV और kW/ TR SOQ में बताए अनुसार होगा।

चिलर AHRI 550/590 (I-P) और AHRI (SI) या समकक्ष के लागू मानकों के अनुसार प्रमाणित होंगे।

मशीन पर निर्माता के नाम और स्थान, प्रकार, मॉडल नं. व क्रमांक के साथ OEM के नाम की प्लेट होगी जिसमें पूर्ण पहचान, चिलर पैकेज के आयाम, परिचालन भार, कंपनी स्तर, रव स्तर, प्रशीतक का नाम, वोल्टेज, फेज़ और आवृत्ति, निर्माण की तारीख आदि लिखी होनी चाहिए। चिलरों के लिए kW/TR vs. % लोड चार्ट प्रदान किया जाना है।

चिलरों का शोर स्तर यूनिट से लगभग 1m दूरी पर 90 dB(A) से अधिक नहीं होगा। चिलर के विभिन्न घटकों का संक्षिप्त विवरण नीचे दिया गया है।



## 2.2 कंप्रेसर (संपीडक):

कंप्रेसर सीधे पिंजरी चूषण गैस शीतित प्रेरण मोटर द्वारा संचालित होगा, और उसकी डिजाइन वायुरोधी/अर्ध-वायुरोधी होगी। कंप्रेसर के मेल और फीमेल रोटर के लिए डिजाइन के अनुसार पर्याप्त मात्रा में लोब होंगे और ये एकल या दोहरे डिजाइन होंगे। विस्तारित सेवा काल के लिए डिजाइन सामग्रियों से रोटर संपर्क तत्वों (एलीमेंट) का निर्माण किया जाएगा। रोटर को सहारा देने और त्रिज्यीय भारों को अवशोषित करने के लिए कंप्रेसर को आवश्यक बेयरिंग के साथ दाब द्वारा ल्यूब्रिकेट (चिकनाया) किया जाएगा। कंप्रेसर के चूषण पर छलनी लगाई जाएगी, और यूनिट में तेल विभाजक और क्रैंककेस हीटर शामिल होगा। कंप्रेसर में क्षमता नियंत्रण प्रदान की जाएगी। कंप्रेसर मोटर सभी तीन चरणों पर तापीय संरक्षण के साथ उच्च बलआघूर्ण, पिंजरी प्रेरण प्रकार की होंगी और उसे चूषण गैस द्वारा ठंडा किया जाएगा। कंप्रेसर जालीदार तेल विभाजक, तेल फिल्टर आदि के साथ निर्मित उच्च दक्षता स्नेहन (लुब्रिकेशन) प्रणाली प्रदान की जाएगी। कम्प्रेसर को उच्च निर्मुक्ति तापमान के लिए और मोटर के उच्च कुंडली तापमान के लिए तापमान संवेदक द्वारा संरक्षित किया जाएगा।

प्रत्येक कंप्रेसर में चूषण चेक वाल्व, चूषण फिल्टर और डिस्चार्ज चेक वाल्व होगा। कंप्रेसर क्षमता नियंत्रण विशेषतः प्रत्येक कॉम्प्रेसर हाउसिंग के भीतर विद्युत संचालित, हाइड्रॉलिक रूप से प्रेरित एक भरोसेमंद स्लाइड वाल्व तंत्र द्वारा प्राप्त किया जाएगा। कंप्रेसर या वाष्पीकारक की सर्विस के लिए कंडेन्सर में प्रशीतक आवेश को संग्रह करने के लिए प्रत्येक कंप्रेसर के लिए निर्मुक्ति चेक वाल्व की आवश्यकता है। कंप्रेसर के सभी कनेक्शन पर वियोजन वाल्व लगाए जाएंगे ताकि

(ए) अन्य कंप्रेसर चल रहे हों तब एक को बदला जा सके और सर्विस कंप्रेसर के माध्यम से वाष्पीकारक में प्रशीतक संग्रह हो सके।

(बी) कंडेन्सर को पंप डाउन रिसीवर के रूप में इस्तेमाल कर सकें।

## 2.3 कंडेन्सर:

निर्दिष्ट संघनन तापमान को पूरा करने के लिए निर्बाध तांबा ट्यूबों की कंडेन्सर कॉइल की पर्याप्त पंक्तियां, पंख और फलक क्षेत्र होगा। तरल फ्लैशिंग की संभावना को खत्म करने और दक्षता में वृद्धि के लिए इंटीग्रल उप-शीतन सर्किट प्रभावी ढंग से प्रदान किया जाएगा। कुंडली

का एल्यूमिनियम पंखों से निर्माण किया जायेगा, जिसे यांत्रिक रूप से निर्बाध तांबा ट्यूबों में बद्ध किया जाएगा, जिन्हें फिर साफ, निर्जलित और सील किया जाता है। यह सुनिश्चित किया जाएगा कि मौसमी कम परिवेशी तापमान किसी भी तरह से सिस्टम संचालन को बाधित नहीं करेगा। कंडेन्सर ट्यूब और पंखों को जंग से बचाने के लिए हाइड्रोफिलिक कोटिंग/प्रोप्रायटरी कोटिंग की जाएगी।

निर्दिष्ट स्थितियां प्राप्त करने के लिए उपयुक्त संख्या में कम शोर वाले कंडेन्सर पंखे लगाए जाएंगे। कंडेन्सर पंखे सीधे-संचालित प्रोपेलर टाइप कम शोर वाले पंखे होंगे जो हवा को ऊर्ध्व रूप से ऊपर की ओर फेंकेंगे। पंखा पूरी तरह से संवृत पंखा मोटर, न्यूनतम वर्ग F इन्सुलेशन के साथ 3 फेज प्रकार और IP-55 सुरक्षा के लिए उपयुक्त स्थायी रूप से चिकनाए बेयरिंग से संचालित होगा। कंडेन्सर पंखे को स्थिर और गतिशील रूप से संतुलित किया जाएगा और पंखे के छिद्र को PVC-लेपित स्टील तार गार्ड लगाया जाएगा। कंडेन्सर पंखों को उच्च परिवेश स्थितियों में बाहरी (आउटडोर) संचालन के लिए डिजाइन किया जाएगा।

निर्माता के कार्यस्थल पर चिलर परीक्षण के दौरान ताप विनियामकों और अन्य सभी घटकों को दाब परीक्षण के संदर्भ में परीक्षण प्रमाणपत्र प्रदान किया जाना है। ताप विनियामकों को सभी लागू मानकों का पालन करना होगा। हालांकि, आंतरिक और बाह्य रूप से खांचित और उच्च ताप स्थानांतरण संवृद्धि प्रकार की तांबे की ट्यूब का उपयोग किया जाएगा। आदेश प्राप्त होने पर ट्यूबों की संख्या, ट्यूबों का व्यास, ट्यूबों का दाब और दाब गिरावट जैसे विवरण विभाग को प्रस्तुत करने होंगे।

#### **2.4 वाष्पीकारक:**

वाष्पीकारक प्रत्यक्ष विस्तार/आप्लावन प्रकार, शैल और ट्यूब प्रकार का होगा। चिलर को सर्किट किया जाएगा ताकि प्रत्येक कंप्रेसर एक स्वतंत्र सर्किट से जुड़ जाए। एकाधिक सर्किट के मामले में पंखों के साथ उच्च निष्पादन वाले चिलर की पेशकश की जा सकती है। वाष्पीकारक को ASME दाब पोत कोड या समकक्ष के अनुसार तैयार किया जाएगा और स्प्रिंग भारयुक्त निर्मुक्ति वाल्व से लैस होगा।

वाष्पीकारक के शैल की तरफ प्रशीतक छिद्र प्रावधान के साथ एकल निर्मुक्ति वाल्व होना चाहिए।

आप्लावन - कूलर में अंतर्निहित वितरक (बिल्ट-इन डिस्ट्रीब्यूटर) होगा जो एक समान उबलने की क्रिया पैदा करने के लिए बंडल ट्यूब के तहत प्रशीतक को समान रूप से पहुंचा सके, और वाष्प पृथकन सुनिश्चित करने के लिए बाधा (बेफल) प्लेटें लगाई जाएंगी। यह शीतन (क्लिंग) एक तेल रिकवरी प्रणाली के साथ फिट की जाएगी।

## 2.5 प्रशीतक (रेफ्रिजरेंट) सर्किट:

प्रत्येक पैकेज चिलर में SOQ में निर्दिष्ट आंशिक भार दक्षता प्राप्त करने के लिए अनुसार एकल/एकाधिक प्रशीतक सर्किट या टैंडम कंप्रेसर होंगे। प्रत्येक सर्किट में विस्तार वाल्व, साइट ग्लास, नमी सूचक, सोलनॉइड वाल्व, फिल्टर शुष्कक, तरल लाइन शट ऑफ वाल्व, आवेश और गेज कनेक्शन और निर्मुक्त लाइन चेक वाल्व शामिल होंगे। तापस्थैतिक/इलेक्ट्रॉनिक विस्तार वाल्व/पायलट फ्लोट वाल्व द्वारा नियंत्रित सर्वो नियंत्रित मॉड्यूलिंग टाइप लगाया जाएगा ताकि वाष्पीकारक के लिए प्रशीतक प्रवाह को पूरी तरह से व्यवस्थित किया जा सके।

अनुमानित सुविधा में सर्विस के लिए निकालने वाला/वाले कंप्रेसर और प्रशीतक को कंडेन्सर में पंप किया जाना शामिल है। इसमें संघनन को रोकने के लिए जहां आवश्यक है वहां इन्सुलेशन लगाना शामिल किया जाएगा।

## 2.6 नियंत्रण पैनल (कंट्रोल पैनल):

माइक्रोप्रोसेसर आधारित यूनिट कंट्रोल सेंटर पूरी तरह से संवृत स्टील कैबिनेट में होना चाहिए। बिजली और सुरक्षा/संचालन नियंत्रण प्रदान किए जाएंगे। नियंत्रण केंद्र ठंडे पानी के तापमान नियंत्रण, कंप्रेसर और विस्तार वाल्व मॉड्यूलेशन कंडेन्सर पंखा अनुक्रमण, आदि को छोड़कर करना शुरू और बंद करना सहित सभी नियंत्रण और सुरक्षा कार्य करेगा। इसके अतिरिक्त, नियंत्रण केंद्र शुरूआत और संचालन के दौरान अधिभार से बचाने, फेज/पावर क्षय, फेज असंतुलन या फेज परावर्तन, ज्यादा/कम वोल्टेज आदि से कंप्रेसर मोटर की पूरी तरह से रक्षा करेगा। विक्रेता को नियंत्रण केंद्र की पूरी क्षमता का विवरण देना होगा। नियंत्रण केंद्र ठंडे पानी का तापमान निर्दिष्ट बिंदु के  $\pm 0.5 \text{ deg C}$  के बीच बनाए रखने की सुविधा प्रदान करेगा। नियंत्रण कक्ष पैकेज चिलर प्रणाली के रिमोट ऑपरेशन/मॉनिटरिंग के लिए उपयुक्त होगा। नियंत्रण कक्ष में बाहरी स्थापना के लिए मौसम प्रूफ घेरे में IP55 सुरक्षा प्रदान की जाएगी। इसके अलावा नियंत्रण कक्ष केंद्रीय DDC प्रणाली से इंटरकनेक्टिविटी के लिए उपयुक्त होगा।

संचालन के लिए पैक स्क्रू चिलर का चयन उन जगहों के परिवेश में किया जाएगा जहां चिलर स्थापित किया जा रहा है।

पैक चिलर के साथ प्रोएक्टिव माइक्रोकंप्यूटर नियंत्रक होगा जिसे असामान्य परिचालन परिस्थितियों के अनुकूलन, सहिष्णु और प्रारंभिक समय पर चरम स्थितियों का समायोजन करने के लिए सुसज्जित किया जाएगा।

इसके अतिरिक्त, माइक्रोप्रोसेसर आधारित नियंत्रण कक्ष में निम्नलिखित सुविधाएं उपलब्ध होंगी:

ए) पैनल उपयोगकर्ता के अनुकूल होगा और सरल अंग्रेजी भाषा में संदेश प्रदर्शित करेगा जिसके साथ अलग-अलग स्क्रीन और बदलते सेट पॉइंट को देखने के लिए 16 की वाला उंगलियों से चलाने वाला ऑपरेटर पैड होगा।

बी) माइक्रोप्रोसेसर पैनल को पूरी तरह से छेड़छाड़ मुक्त करने के लिए पासवर्ड से सुरक्षित किया जाएगा।

सी) पैनल में कैलेंडर/घड़ी होगी ताकि दैनिक शुरुआत - बंद करने और साप्ताहिक बंद करने को प्रोग्राम किया जा सके। पैनल कम से कम 6 खराबी शट डाउन लॉग करेगा जो शट डाउन के समय की तारीख और समय, शट डाउन के कारण और शट डाउन के समय महत्वपूर्ण पैरामीटर के साथ मेमोरी में संग्रह करेगा।

डी) माइक्रोप्रोसेसर आधारित नियंत्रण कक्ष ट्रांसड्यूसर के माध्यम से सक्शन, डिस्चार्ज और तेल दाब और कंप्रेसर करंट पर नज़र रखेगा और यह दिन या रात के दौरान आसानी से देखने के लिए बैक-लिट लिक्विड क्रिस्टल स्क्रीन पर प्रदर्शित करेगा। इसे पूरी तरह से छेड़छाड़ मुक्त करने के लिए पासवर्ड से सुरक्षित किया जाएगा।

ई) पैनल में अनुकूली लॉजिक होगा जो यह सुनिश्चित करेगा कि खराब मौसम के दौरान जल शीतन यूनिट चलती रहे जब शीतन सर्वाधिक वांछित होता है। कंप्रेसर स्टीपल क्षमता और पंखा मॉड्यूलन का प्रबंधन करना संभव होगा।

एफ) पैनल में पर्सनल कम्प्यूटर में इंटरकनेक्टिविटी के लिए एक इंटरफेस होगा ताकि किसी भी सुदूर स्थान से जल शीतन यूनिट आपरेशन की निगरानी की जा सके। माइक्रो-प्रोसेसर

कंट्रोल पैनल को BACNET या MODBUS नेटवर्क जैसे मानक प्रोटोकॉल पर काम करना होगा।

पैनल को निम्नलिखित को प्रदर्शित करना होगा:

- गलत पासवर्ड संदेश।
- दिन, तारीख और समय।
- दैनिक शुरूआत और बंद होने का समय।
- चिलर इनलेट और आउटलेट तापमान।
- सक्शन, निर्मुक्ति और तेल दाब।
- कंप्रेसर मोटर करंट।
- सक्शन/निर्मुक्ति दाब का कट-आउट सेटिंग।
- एंटी-फ्रीज तापमान कट-आउट सेटिंग।
- कंप्रेसर शुरूआत और चालन स्थिति और कुल चालन समय।
- तरल रेखा परिनालिका वाल्व स्थिति।
- 6 तक खराबी से बंद होने वाली स्थितियां।
- प्रत्येक कंप्रेसर की एंटी-रीसायकल टाइमर स्थिति।
- परिवेश का तापमान।

## 2.7 इलेक्ट्रिक्स:

पैकेज चिलर के लिए बिजली आपूर्ति पैनल चिलर पैकेज का हिस्सा होगा और बाहरी स्थापना के लिए मौसम सह्य घेरे में IP 55 सुरक्षा प्रदान करेगा। इस पैनल में कंप्रेसर, कंडेन्सर, करंट ओवरलोड और कारखाने की वायरिंग के लिए स्टार्टर होंगे। मुख्य पैनल में मुख्य स्विच इंटरलॉक दरवाजा लगाया जाएगा जो खोलने पर बिजली की आपूर्ति बंद कर देता है।

विद्युत नियंत्रण कक्ष को प्रारंभिक स्टार्ट-अप, सामान्य परिचालन और शटडाउन स्थितियों के दौरान पूरी तरह से स्वचालित संचालन के लिए वायरिंग की जाएगी। नियंत्रण प्रणाली में निम्नलिखित नियंत्रण और सुरक्षा उपकरण होंगे:

### 2.7.1 मैनुअल कंट्रोल:

- नियंत्रण सर्किट स्टॉप और स्टार्ट स्विच
- कंप्रेसर इनेबल स्विच

### 2.7.2 सुरक्षा नियंत्रण:

सॉलिड स्टेट कंप्रेसर मोटर स्टार्टर ओवरलोड (3 फेज) करता है, फेज/पावर क्षय, फेज असंतुलन या फेज रिवर्सल, ज्यादा/कम वोल्टेज आदि के लिए सुरक्षा।

- तेल का निम्न दाब
- उच्च सील तेल तापमान
- कम तेल स्तर ऑप्टिकल सेंसर
- उच्च कंडेन्सर दाब
- कम वाष्पीकारक दाब
- वाष्पीकारक जल शीतन संरक्षण
- ठंडे पानी के प्रवाह का क्षय

### 2.7.3 स्वचालित नियंत्रण:

- कंप्रेसर मोटर संवृद्धि संपर्कक
- संवृद्धि प्रारंभ टाइमर
- एंटी-रीसायकल टाइमर
- ऑयल संप हीटर इंटरलाक रिले

### 2.7.4 प्रशीतक नियंत्रण:

- परिमित मोटर प्रशीतक प्रवाह नियंत्रण
- वाष्पीकारक के लिए तरल प्रशीतक स्तर संवेदक
- कंप्रेसर लोड और अनलोड सोलेनॉइड वाल्व
- कंप्रेसर चूषण पर प्रशीतक नमी सेंसर (संवेदक)

### 2.7.5 रोशनी संकेत:

- पावर 'ऑन'
- उच्च मोटर तापमान
- कंप्रेसर उच्च तेल तापमान
- कंप्रेसर मोटर अधिभार
- उच्च/निम्न दाब, कम तेल और फ्रीज़ सुरक्षा।

नियंत्रण प्रणाली में एक प्रति-रीसायकल डिवाइस लगाया जाएगा। नियंत्रण को कंप्रेसर शुरूआत को शुरूआत के बीच न्यूनतम अंतराल पर सीमित करना होगा।

पैक चिलर को प्रत्येक कंप्रेसर के लिए रेलपेल शुरूआती प्रणाली के लिए यूनिट पर लगे सर्किट ब्रेकर, यूनिट पर लगे संपर्कक और समय देरी वायरिंग से सुसज्जित किया जाएगा। स्टार्टर कारखाने से ही लगे होंगे और अलग-अलग सर्किट ब्रेकर पर वायरिंग की जाएगी। यूनिट की वायरिंग की जाएगी ताकि पैक चिलर के लिए केवल क्षेत्र विद्युत कनेक्शन एकल तीन-फेज पावर टर्मिनल तक हो सके। मोटर कंट्रोल सेंटर में सर्किट ब्रेकर के साथ-साथ प्रति कंप्रेसर एक डिस्कनेक्ट स्विच और यूनिट फ्यूज़/फ्यूज़ ब्लॉक भी शामिल किए जाने हैं।

## 2.8 अन्य विशेषताएं:

- एकल पॉइंट विद्युत पावर कनेक्शन, नियंत्रण विद्युत ट्रांसफार्मर, कम वोल्टेज और फेज विफलता रिले।
- कंप्रेसर ओवरलोड, उच्च मोटर तापमान, माइक्रो अलार्म, कंट्रोल पावर, और कंप्रेसर कंट्रोल सर्किट के लिए रोशनी संकेतक।
- प्रत्येक कंप्रेसर के लिए यूनिट पर लगे डिस्कनेक्ट और 400 से 575 वोल्ट और 3300/6600/11000 वोल्ट अनुप्रयोगों, यथा स्थिति, के लिए फ्यूज़ और फ्यूज़ ब्लॉक के साथ नियंत्रण सर्किट।

## 2.9 परिचालन लाभ, दक्षता और विश्वसनीयता:

- निर्माता को रोटरी स्कू कंप्रेसरों के निर्माण और अद्यतित तकनीकी प्रगति में पर्याप्त अनुभव रखना होगा।
- न्यूनतम घूमने वाले पुर्जों के साथ उच्च विश्वसनीयता के लिए डिजाइन सरल होगा।
- प्रत्येक कंप्रेसर के लिए अभिन्न उच्च दक्षता वाले तेल पृथकन के माध्यम से प्रत्येक कंप्रेसर के लिए निरंतर तेल प्रवाह को सुनिश्चित करना।
- कम कंप्रेसरों के साथ अधिक क्षमता पैदा करने वाले किफायती चक्र और माइक्रो कंप्यूटर-नियंत्रित चरणों के उपयोग के द्वारा उत्कृष्ट दक्षता और संपूर्ण ऊर्जा बचत करना।
- कम्प्यूटर से मिलान किए घटकों के माध्यम से अधिकतम निष्पादन।





## 2.10 VFD विकल्प:

यदि VFD ड्राइव का विकल्प चुना गया है, तो चिलर को इन्वर्टर ड्यूटी कंप्रेसर मोटर और सुदूर माउन्ट किए VFD पैनल के साथ दिया जाएगा। VFD सतत टॉर्क वाला होगा और सामान्य परिचालन के दौरान 60 सेकंड के लिए 110% टॉर्क देने में सक्षम होना चाहिए। सभी परिस्थितियों में उपयुक्त कैपेसिटर बैंकों/APFC पैनलों द्वारा 0.95 का शक्ति गुणक (पावर फैक्टर) बनाए रखा जाएगा। सभी परिचालन परिस्थितियों में स्थिर संचालन के साथ अनुकूलित निष्पादन प्रदान करने के लिए यूनिट क्षमता नियंत्रण VFD और इनलेट गाइड फलक के संयुक्त कार्य द्वारा किया जाएगा।

आवृत्ति को स्वतः कम करने के लिए VFD में इनबिल्ट प्रोटेक्शन मोड की आवश्यकता होगी और मॉड्यूलन प्रक्रिया को तब एडजस्ट किया जाएगा जब इसे करंट या अधिक वोल्टेज आदि नाजुक स्थिति का पता लगेगा।

VFD में अधिभार के लिए इनबिल्ट इलेक्ट्रॉनिक थर्मल मोटर संरक्षण होगा। VFD को मोटर टर्मिनलों पर शॉर्ट सर्किट से संरक्षित किया जाएगा। इसके मुख्य फेज के नुकसान के लिए भी सुरक्षा होगी। VFD में इनबिल्ट LCD कीपैड डिस्प्ले होगा और मोटर करंट, वोल्टेज, आवृत्ति उत्पादन, आउटपुट kW इत्यादि पर जानकारी दिखाएगा।

## 2.11 सुरक्षा कोड/मानक:

- ASME बॉयलर और प्रेशर वेसल कोड, खंड VIII भाग 1 "अनफायर्ड प्रेशर वेसल्स"
- ASME मानक B 31.5 प्रशीतन पाइपिंग
- ASHRAE मानक 15 मैकेनिकल रेफ्रिजेशन के लिए सुरक्षा कोड
- राष्ट्रीय इलेक्ट्रिक कोड और स्थानीय प्रदूषण नियंत्रण बोर्ड के नियम
- AHRI मानक 550/590-2012 "वाष्प संपीड़न चक्र का उपयोग करके जल-शीतक और ताप पम्प जल-तापन पैकेज की निष्पादन रेटिंग"

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### 3. जल शीतित स्क्रॉल चिलर पैकेज

#### 3.1 निर्माण:

अनुसूची में निर्दिष्ट स्क्रॉल चिलर जल-शीतित होंगे, जिनमें वायुरोधी/अर्द्ध वायुरोधी कंप्रेसर शामिल होंगे। चिलर पैकेज को पूरी तरह से कारखाने में असेम्बल किया जाएगा, जिसमें मुख्य रूप से बहु स्क्रॉल कंप्रेसर, कंडेन्सर, चिलर, कंट्रोल पैनल, पाइपिंग, स्नेहन प्रणाली आदि शामिल होंगे। इन सबको एक यूनिट में असेम्बल किया जाएगा और यह संयंत्र कक्ष (प्लांट रूम) के अंदर स्थित होगा। यूनिट कैबिनेट का निर्माण उपयुक्त मोटाई वाले जस्ती स्टील से किया जाएगा। इस यूनिट को उपयुक्त आकार के वेल्डेड स्टील बेस फ्रेम स्ट्रक्चरल स्टील प्रोफाइल पर लगाया जाएगा, इसे MS से बनाया जाएगा और जंगरोधकता के लिए गैल्वेनाइज किया जाएगा। यूनिट को भवन संरचना से अलग करने के लिए यूनिट के लिए उपयुक्त कंपन आइसोलेटर (पृथक्त्र) लगाए जाएंगे। चिलर 3-फेज, 50 Hz,  $415 \pm 10\%$  V AC आपूर्ति और R-134a /407c /410a प्रशीतक पर परिचालन के लिए उपयुक्त होना चाहिए। पैकेज चिलरों के कूलर का चयन  $0.000018 \text{ m}^2 \text{ }^\circ\text{K/W}$  के पानी की तरफ प्रदूषक (फॉउलिंग) कारक के लिए किया जाएगा और जल शीतित कंडेनसरों (संघनित्रों) का चयन  $0.000044 \text{ m}^2 \text{ }^\circ\text{K/W}$  के पानी की तरफ प्रदूषक (फॉउलिंग) कारक के लिए किया जाएगा।

जब तक अन्यथा निर्दिष्ट नहीं हो, चिलर पैकेज का न्यूनतम COP, IPLV और kW/ TR SOQ में बताए अनुसार होगा। चिलर AHRI 550/590 (I-P) और AHRI (SI) या समकक्ष के लागू मानकों के अनुसार प्रमाणित होंगे।

मशीन पर निर्माता के नाम और स्थान, प्रकार, मॉडल नं. व क्रमांक के साथ OEM के नाम की प्लेट होगी जिसमें पूर्ण पहचान, चिलर पैकेज के आयाम, परिचालन भार, कंपन स्तर, शोर स्तर, प्रशीतक का नाम, वोल्टेज, फेज़ और आवृत्ति, निर्माण की तारीख आदि लिखी होनी चाहिए। चिलरों का शोर स्तर यूनिट से लगभग 1m दूरी पर 75 dB(A) से अधिक नहीं होगा।

#### 3.2 कंप्रेसर:

स्क्रॉल वाला कंप्रेसर पारिस्थितिकी के अनुकूल R134a/410a /407c जैसे रेफ्रिजरेंट के लिए उपयुक्त होगा, जो नियंत्रण, सहायक उपकरण के साथ परिपूर्ण होगा और यह अत्यधिक ऊर्जा

कुशल और शांत परिचालन के लिए डिज़ाइन किया जाएगा। यूनिट उस स्थान के परिवेश की स्थिति के लिए डिज़ाइन किया जाएगा जहां चिलर स्थापित किया जा रहा है। यूनिट के आंशिक भार परिचालन के दौरान, माइक्रोप्रोसेसर सुनिश्चित करता है कि भार को संभालने के लिए कम से कम कंप्रेसर चालू रहें ताकि बिजली की बचत हो।

### 3.3 कंडेन्सर (संघनित्र):

कंडेन्सर बोल्ट निर्मित, सफ़ाई योग्य, शेल और ट्यूब प्रकार के होंगे, जिसके साथ तांबे की ट्यूब होंगी जो यांत्रिक रूप से ट्यूब शीट पंखों में और बाह्य रूप से पंखों में विस्तारित होंगी। पास (मार्गों) की संख्या यथावश्यक हो सकती है। ट्यूब सफ़ाई के लिए जल शीर्ष निकाले जा सकने वाले होने चाहिए। प्रत्येक शीर्ष में छिद्र और नाली प्लग उपलब्ध कराए जाएंगे।

जल शीतित कंडेन्सर 97°F (36 °C) के संघनित तापमान के साथ 86°F (30 °C) से 93°F (33.9°C) तक जल के न्यूनतम 3 US GPM/TR (11.4 LPM/TR) को संभालने में सक्षम होंगे। यह यूनिट पूर्ण भार डिज़ाइन तापमान पर ठंडा पानी छोड़ते और कंडेन्सर पानी में प्रवेश करते हुए शीतन (रेफ्रिजरेशन) क्षमता के 10 से 20% से ठीक ऊपर उतारने में सक्षम होगी। यह यूनिट तप्त गैस बायपास के उपयोग के बिना, स्थिर कंप्रेसर परिचालन के साथ इस बिंदु पर निरंतर संचालन करने में सक्षम होगी। उस स्थान पर उपलब्ध पानी की गुणवत्ता का उल्लेख किया जाना चाहिए।

इन कंडेन्सरों में प्रशीतक छिद्र के प्रावधान के साथ दोहरे दाब निर्मुक्ति वाल्व होंगे।

निर्माता के कार्यस्थल पर चिलर परीक्षण के दौरान ताप विनियामकों और अन्य सभी घटकों को दबाव परीक्षण के संदर्भ में परीक्षण प्रमाणपत्र प्रदान किया जाना है। ताप विनियामकों को सभी लागू मानकों का पालन करना होगा। कंडेन्सर शेल और ट्यूब प्रकार के होंगे, जिसके साथ तांबे की ट्यूब होंगी जो यांत्रिक रूप से ट्यूब शीट पंखों में और बाह्य रूप से पंखों में विस्तारित होंगी। आदेश प्राप्त होने पर ट्यूबों की संख्या, ट्यूबों का व्यास, ट्यूबों का दबाव और दाब पात जैसे विवरण विभाग को प्रस्तुत करने होंगे।

### 3.4 वाष्पीकारक:

चिलर DX/आप्लावन प्रकार का होगा। कूलर ट्यूबों की सफ़ाई और सर्विसिंग के लिए निकालने योग्य शीर्ष की आपूर्ति की जाएगी। प्रत्येक शीर्ष में छिद्र और नाली प्लग उपलब्ध कराए

जाएंगे। आप्लावन - कूलर में अंतर्निहित वितरक (बिल्ट-इन डिस्ट्रीब्यूटर) होगा जो एक समान उबलने की क्रिया पैदा करने के लिए बंडल ट्यूब के तहत प्रशीतक को समान रूप से पहुंचा सके, और वाष्प पृथक्कन सुनिश्चित करने के लिए बाधा (बेफल) प्लेटें लगाई जाएंगी। इसे शीतन (क्लिंग) एक तेल रिकवरी प्रणाली के साथ फिट किया जाएगा।

### 3.5 प्रशीतक (रेफ्रिजरेंट) सर्किट:

रेफ्रिजरेंट R-134a/410a/407c के जैसे पर्यावरण अनुकूल होगा और रेफ्रिजरेंट पाइपिंग तांबे की होगी जिसके कंप्रेसर, कंडेन्सर और वाष्पीकारक के साथ अन्योन्यक्रिया करने के लिए TEV, पायलट संचालित सोलेनॉइड वाल्व जैसे आवश्यक नियंत्रण होंगे। तरल सह नमी संकेतक 20 चिलर पैकेज, फिल्टर शुष्कक, शट-ऑफ वाल्व और बाईपास वाल्व के साथ छलनी भी प्रदान की जाएगी।

### 3.6 नियंत्रण पैनल:

माइक्रोप्रोसेसर आधारित यूनिट कंट्रोल सेंटर पूरी तरह से संवृत स्टील कैबिनेट में होना चाहिए। बिजली और सुरक्षा/संचालन नियंत्रण प्रदान किए जाएंगे।

नियंत्रण केंद्र ठंडे पानी के तापमान नियंत्रण, कंप्रेसर और विस्तार वाल्व मॉड्यूलेशन कंडेन्सर पंखा अनुक्रमण, आदि को छोड़कर करना शुरू और बंद करना सहित सभी नियंत्रण और सुरक्षा कार्य करेगा। इसके अतिरिक्त, नियंत्रण केंद्र शुरूआती और संचालन के दौरान अधिभार से बचाने, फेज/विद्युत क्षय, फेज असंतुलन या फेज परावर्तन, ज्यादा/कम वोल्टेज आदि से कंप्रेसर मोटर की पूरी तरह से रक्षा करेगा। नियंत्रण केंद्र ठंडे पानी का तापमान निर्दिष्ट बिंदु के  $\pm 0.5 \text{ deg C}$  के बीच बनाए रखने की सुविधा प्रदान करेगा। नियंत्रण कक्ष पैकेज चिलर प्रणाली के रिमोट ऑपरेशन/मॉनिटरिंग के लिए उपयुक्त होगा।

संचालन के लिए पैक स्कू चिलर का चयन उन जगहों के परिवेश में किया जाएगा जहां चिलर स्थापित किया जा रहा है।

पैक चिलर के साथ प्रोएक्टिव माइक्रोकंप्यूटर नियंत्रक होगा जिसे असामान्य परिचालन परिस्थितियों के अनुकूलन, सहिष्णु और प्रारंभिक समय पर चरम स्थितियों का समायोजन करने के लिए सुसज्जित किया जाएगा।

इस पैनल में माइक्रोप्रोसेसर आधारित नियंत्रक होगा जो मुख्य रूप से निम्नलिखित कार्य करेगा:

ए) ठंडे पानी के आउटलेट सेट तापमान पर आधारित चिलर को ऑटो स्टॉप और रीस्टार्ट करना।

बी) कंप्रेसर चालू/बंद साइक्लिंग से बचने के लिए ऑटो रीसायकल टाइमर।

सी) उच्च दाब/कम दाब/स्थिरता तापमान/कम ठंडे पानी और कंडेन्सर जल प्रवाह/फेज असंतुलन-फेज रिवर्सल-ओवरलोड/कम-ज्यादा वोल्टेज पर कंप्रेसर की ट्रिपिंग।

डी) क्रैंक केस हीटर ऑपरेशन।

ई) ऑटो/मैनुअल मोड ऑपरेशन

एफ) पैनल उपयोगकर्ता के अनुकूल होगा और सरल अंग्रेजी भाषा में संदेश प्रदर्शित करेगा जिसके साथ अलग-अलग मापदंडों और बदलते सेट पॉइंट को देखने के लिए ऑपरेटर पैड होगा।

जी) पूरी तरह छेड़छाड़ मुक्त करने के लिए माइक्रोप्रोसेसर पैनल को पासवर्ड से सुरक्षित किया जाएगा।

एच) यह प्रणाली यूनिट को समझदारी से बनाए रखेगी ताकि कंप्रेसर साइकिल चालन को न्यूनतम रखते हुए जल तापमान परिशुद्धता और स्थिरता को बनाए रखा जा सके।

आइ) पैनल में अनुकूली लॉजिक होगा जो यह सुनिश्चित करेगा कि खराब मौसम के दौरान जल शीतन यूनिट चलती रहे जब शीतन सर्वाधिक वांछित होता है।

जे) पैनल में पर्सनल कम्प्यूटर में इंटरकनेक्टिविटी के लिए एक इंटरफेस होगा ताकि किसी भी सुदूर स्थान से पानी शीतन यूनिट आपरेशन की निगरानी की जा सके। माइक्रो-प्रोसेसर कंट्रोल पैनल को BACNET या MODBUS नेटवर्क जैसे मानक प्रोटोकॉल पर काम करना होगा।

निम्न LCD डिस्प्ले को नियंत्रण केंद्र के डिस्प्ले पैनल में न्यूनतम रूप में उपलब्ध कराया जाएगा:

ए) सक्शन दाब

बी) निर्मुक्ति दाब

सी) यूनिट द्वारा लिया गया करंट

डी) परिचालन अवधि

ई) खराबी और ट्रिप संकेत

एफ) तिथि, समय और विफलता के कारण के साथ अंतिम न्यूनतम 6 ट्रिप के लिए अलार्म पूर्ववृत्त

जी) सभी मापदंडों के निर्दिष्ट बिंदुओं को बदलना/देखना

एच) गलत पासवर्ड संदेश

आइ) दैनिक शुरू और बंद होने का समय

जे) चिलर इनलेट और आउटलेट तापमान।

के) कंडेन्सर पानी इनलेट और आउटलेट तापमान।

एल) एंटी-फ्रीज तापमान कट-आउट सेटिंग।

एम) कंप्रेसर शुरूआत और चालन स्थिति और कुल चालन समय।

### 3.7 इलेक्ट्रिक्स:

विद्युत नियंत्रण कक्षा की प्रारंभिक स्टार्ट-अप, सामान्य ऑपरेशन और शटडाउन स्थितियों के दौरान पूरी तरह से स्वचालित संचालन के लिए वायरिंग की जाएगी। नियंत्रण प्रणाली में एक प्रति-रीसायकल डिवाइस लगाया जाएगा। नियंत्रक को चालू होने के बीच में कंप्रेसर चालू होने को न्यूनतम अंतराल पर सीमित करना होगा। पैक चिलर को प्रत्येक कंप्रेसर के लिए आनन-फानन (इनरश) शुरूआती प्रणाली के लिए यूनिट पर लगे सर्किट ब्रेकर, यूनिट पर लगे संपर्कक और समय देरी वायरिंग से सुसज्जित किया जाएगा। स्टार्टर कारखाने से ही लगे होंगे और अलग-अलग सर्किट ब्रेकर पर वायरिंग की जाएगी। यूनिट की वायरिंग की जाएगी। ताकि पैक चिलर के लिए केवल क्षेत्र विद्युत कनेक्शन एकल तीन-फेज पावर टर्मिनल तक हो सके। मोटर कंट्रोल सेंटर में सर्किट ब्रेकर के साथ-साथ प्रति कंप्रेसर एक डिस्कनेक्ट स्विच और यूनिट फ्यूज/फ्यूज ब्लॉक भी शामिल किए जाने हैं।

नियंत्रण प्रणाली में निम्नलिखित नियंत्रण और सुरक्षा उपकरण होंगे:

### 3.7.1 मैनुअल कंट्रोल:

- नियंत्रण सर्किट स्टॉप और स्टार्ट स्विच
- कंप्रेसर इनेबल स्विच

### 3.7.2 सुरक्षा नियंत्रण:

- सॉलिड स्टेट कंप्रेसर मोटर स्टार्टर ओवरलोड (3 फेज) करता है, फेज/पावर क्षय, फेज असंतुलन या फेज रिवर्सल, ज्यादा/कम वोल्टेज आदि के लिए सुरक्षा।

तेल का निम्न दाब

- तेल का उच्च तापमान
- उच्च कंडेन्सर दाब
- निम्न वाष्पीकारक दाब
- वाष्पीकारक जल शीतन संरक्षण
- ठंडे जल प्रवाह का क्षय
- संघन जल प्रवाह का क्षय

### 3.7.3 स्वचालित नियंत्रण:

- कंप्रेसर मोटर संवृद्धि सम्पर्कक
- संवृद्धि प्रारंभ टाइमर
- एंटी-रीसायकल टाइमर
- ऑयल संप हीटर इंटरलाक रिले

## 3.8 ऑपरेटिंग लाभ, दक्षता और विश्वसनीयता:

- निर्माता को रोटरी स्कू कंप्रेसरों के निर्माण और अद्यतित तकनीकी प्रगति में पर्याप्त अनुभव रखना होगा।
- न्यूनतम घूमने वाले पुर्जों के साथ उच्च विश्वसनीयता के लिए डिजाइन सरल होगा।
- प्रत्येक कंप्रेसर के लिए अभिन्न उच्च दक्षता वाले तेल पृथकन के माध्यम से प्रत्येक कंप्रेसर के लिए निरंतर तेल प्रवाह को सुनिश्चित करना।

- कम कंप्रेसरों के साथ अधिक क्षमता पैदा करने वाले किफायती चक्र और माइक्रो कंप्यूटर-नियंत्रित चरण के उपयोग के द्वारा उत्कृष्ट दक्षता और संपूर्ण ऊर्जा बचत करना।
- कम्प्यूटर से मिलान किए घटकों के माध्यम से अधिकतम निष्पादन।
- रेफ्रिजरेंट के साथ तेल को हटाने की गारंटी देने के लिए उच्च दक्षता तेल रिकवरी प्रणाली और पूर्ण और आंशिक भार दोनों पर अपनी अधिकतम दक्षता पर ताप विनियामक (एक्सचेंजर्स) को बनाए रखता है।
- लगाना आसान।
- एक अत्यंत संहत कार्य अन्वालोप के लिए जरूरी रोटरी स्कू कंप्रेसरों के साथ में वाष्पीकारक/कंडेन्सर प्लस स्नग व्यवस्था।
- मॉनिटर किए गए कार्यों के माइक्रोप्रोसेसर प्रतिधारण के जरिए सरलीकृत समस्या निवारण।

### 3.9 अन्य विशेषताएं:

- प्रोग्रामिंग सुविधा के दुरुपयोग को रोकने के लिए सॉफ्टवेयर लॉक
- मेमोरी में न्यूनतम 6 पिछली खराबियों (न्यूनतम) को स्टोर करने का प्रावधान
- नियंत्रक BMS संगत होंगे। प्रोटोकॉल BACNET या MODBUS होगा।

### 3.10 सुरक्षा कोड/मानक:

- ASME बॉयलर और प्रेशर वेसल कोड, खंड VIII भाग 1 "अनफायर्ड प्रेशर वेसल्स"
- ASME मानक B 31.5 प्रशीतन पाइपिंग
- ASHRAE मानक 15 मैकेनिकल रेफ्रिजेशन के लिए सुरक्षा कोड
- राष्ट्रीय इलेक्ट्रिक कोड और स्थानीय प्रदूषण नियंत्रण बोर्ड के नियम
- AHRI मानक 550/590-2012 "वाष्प संपीड़न चक्र का उपयोग करके जल-शीतक और ताप पम्प जल-तापन पैकेज की निष्पादन रेटिंग"

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## 4. वायु शीतित स्क्रॉल चिलर पैकेज

### 4.1 निर्माण:

इस अनुसूची में निर्दिष्ट स्क्रॉल चिलर वायु शीतित प्रकार के होंगे, जिसमें वायुरोधी/अर्द्ध वायुरोधी स्क्रॉल कंप्रेसर होंगे। चिलर पैकेज को पूरी तरह से कारखाने में असेम्बल किया जाएगा, जिसमें मुख्यतः बहु-स्क्रॉल कंप्रेसर, कंडेन्सर, चिलर नियंत्रण पैनल, पाइपिंग, स्नेहन सिस्टम इत्यादि शामिल होंगे, सभी एक ही यूनिट में असेम्बल होंगे और बाहरी स्थल में रखा जाएगा। चिलर को 3-फेज, 50 Hz,  $415 \pm 10\%$  V AC आपूर्ति पर परिचालन के लिए उपयुक्त होना चाहिए। कठोर बाहरी मौसम की स्थिति का सामना करने के लिए यूनिट कैबिनेट का निर्माण उपयुक्त मोटाई वाले जस्ती स्टील से किया जाएगा। इस यूनिट को उपयुक्त आकार के वेल्डेड स्टील बेस फ्रेम स्ट्रक्चरल स्टील प्रोफाइल पर लगाया जाएगा, इसे MS से बनाया जाएगा और जंगरोधकता के लिए गैल्वेनाइज किया जाएगा। कंपन और शोर को कम करने के लिए उपयुक्त कंपन आइसोलेटर (पृथक्त्र) लगाए जाएंगे। पैकेज चिलरों के वाष्पीकारकों का चयन  $0.000018 \text{ m}^2 \text{ }^\circ\text{K/W}$  के पानी की तरफ प्रदूषक (फॉउलिंग) कारक के लिए किया जाएगा।

जब तक अन्यथा निर्दिष्ट नहीं हो, चिलर पैकेज का न्यूनतम COP, IPLV और  $\text{kW/TR SOQ}$  में बताए अनुसार होगा। चिलर AHRI 550/590 (I-P) और AHRI (SI) या समकक्ष के लागू मानकों के अनुसार प्रमाणित होंगे।

मशीन पर निर्माता के नाम और स्थान, प्रकार, मॉडल नं. व क्रमांक के साथ OEM के नाम की प्लेट होगी जिसमें पूर्ण पहचान, चिलर पैकेज के आयाम, परिचालन भार, कंपन स्तर, शोर स्तर, प्रशीतक का नाम, वोल्टेज, फेज़ और आवृत्ति, निर्माण की तारीख आदि लिखी होनी चाहिए। चिलरों के लिए  $\text{kW/TR vs. \%}$  लोड चार्ट प्रदान किया जाना है।

वायुशीतित चिलरों का शोर स्तर यूनिट से लगभग 1m दूरी पर 75 dB(A) से अधिक नहीं होगा। चिलर के विभिन्न घटकों का संक्षिप्त विवरण नीचे दिया गया है।

## 4.2 कंप्रेसर:

कंप्रेसर स्कॉल वाला होगा जो R134a/410a /407c जैसे पारिस्थितिकी के अनुकूल रेफ्रिजरेंट के लिए उपयुक्त होगा, जो नियंत्रण, सहायक उपकरण के साथ परिपूर्ण होगा और इसे अत्यधिक ऊर्जा कुशल और शांत आपरेशन के लिए डिज़ाइन किया जाएगा। यूनिट उस स्थान के परिवेश की स्थिति के लिए डिज़ाइन किया जाएगा जहां चिलर स्थापित किया जा रहा है। यूनिट के आंशिक भार परिचालन के दौरान, माइक्रोप्रोसेसर सुनिश्चित करता है कि भार को संभालने के लिए कम से कम कंप्रेसर चालू रहें ताकि बिजली की बचत हो।

कंप्रेसर के सभी कनेक्शन पर वियोजन वाल्व लगाए जाएंगे ताकि

(ए) अन्य कंप्रेसर चल रहे हों तब एक को बदला जा सके और सर्विस कंप्रेसर के माध्यम से वाष्पीकारक में प्रशीतक संग्रह हो सके।

(बी) कंडेन्सर को पंप डाउन रिसीवर के रूप में इस्तेमाल कर सकें।

## 4.3 कंडेन्सर (संघनित्र):

उच्च निष्पादन के लिए कंडेन्सर कॉइल के पंख लगे होंगे और संघनन बढ़ाने और बिजली की खपत को कम करने के लिए और अंदरूनी समेकित निर्बाध कॉपर ट्यूब लगायी जाएंगी। अधिकतम ताप हस्तांतरण दक्षता के लिए तांबे की ट्यूबों को एल्यूमीनियम पंखों से यांत्रिक रूप से जोड़ा जाता है। फैक्टरी में प्रत्येक कॉइल का दाब परीक्षण किया जाता है जो परिचालन दाब से 1.5 गुना से कम नहीं होता है। जंगरोधकता के लिए कंडेन्सर ट्यूब्स और पंख पर हाइड्रोफिलिक कोटिंग/प्रोप्रायटरी कोटिंग की जाएगी।

सीधे चालित प्रकारों के साथ चरम मौसमी स्थितियों का सामना करने के लिए कंडेन्सर पंखे का निर्माण डाई कास्ट एल्यूमीनियम हब से किया जाता है। न्यूनतम शोर और कंपन पर संचालित करने के लिए सभी पंख स्थैतिक और गतिशील रूप से संतुलित होते हैं। पंखे की पंखुड़ी का डिज़ाइन उपयुक्त पिच कोण से किया जाता है जिससे शोर स्तर न्यूनतम होता है।

## 4.4 वाष्पीकारक:

चिलर DX/आप्लावन प्रकार का होगा। कूलर ट्यूबों की सफाई और सर्विसिंग के लिए निकालने योग्य शीर्ष की आपूर्ति की जाएगी। प्रत्येक शीर्ष में छिद्र और नाली प्लग उपलब्ध कराए जाएंगे। आप्लावन - कूलर में अंतर्निहित वितरक (बिल्ट-इन डिस्ट्रीब्यूटर) होगा जो एक समान

उबलने की क्रिया पैदा करने के लिए बंडल ट्यूब के तहत प्रशीतक को समान रूप से पहुंचा सके, और वाष्प पृथकन सुनिश्चित करने के लिए बाधा (बेफल) प्लेटें लगाई जाएंगी। इसे शीतन (क्लिंग) तेल रिकवरी प्रणाली के साथ फिट किया जाएगा।

#### 4.5 प्रशीतक (रेफ्रिजरेंट) सर्किट:

रेफ्रिजरेंट R-134a/410a/407c के जैसे पर्यावरण अनुकूल होगा और रेफ्रिजरेंट पाइपिंग तांबे की होगी जिसमें कंप्रेसर, कंडेन्सर और वाष्पीकारक के साथ अन्योन्यक्रिया करने के लिए TEV, पायलट संचालित सोलेनॉइड वाल्व जैसे आवश्यक नियंत्रण होंगे। तरल सह नमी संकेतक, फिल्टर शुष्कक, शट-ऑफ वाल्व और बाईपास वाल्व के साथ छलनी भी प्रदान की जाएगी।

#### 4.6 नियंत्रण पैनल:

माइक्रोप्रोसेसर आधारित यूनिट कंट्रोल सेंटर पूरी तरह से संवृत स्टील कैबिनेट में होना चाहिए। सभी बिजली और सुरक्षा/संचालन नियंत्रण पैनल में प्रदान किए जाएंगे।

नियंत्रण केंद्र ठंडे पानी के तापमान नियंत्रण, कंप्रेसर और विस्तार वाल्व मॉड्यूलेशन कंडेन्सर पंखा अनुक्रमण, आदि को छोड़कर करना शुरू और बंद करना सहित सभी नियंत्रण और सुरक्षा कार्य करेगा। इसके अतिरिक्त, नियंत्रण केंद्र शुरूआती और संचालन के दौरान अधिभार से बचाने, फेज/पावर क्षय, फेज असंतुलन या फेज परावर्तन, ज्यादा/कम वोल्टेज आदि से कंप्रेसर मोटर की पूरी तरह से रक्षा करेगा। नियंत्रण केंद्र ठंडे पानी का तापमान निर्दिष्ट बिंदु के  $\pm 0.5 \text{ deg C}$  के बीच बनाए रखने की सुविधा प्रदान करेगा। नियंत्रण कक्ष पैकेज चिलर प्रणाली के रिमोट ऑपरेशन/मॉनिटरिंग के लिए उपयुक्त होगा।

पैक स्कॉल चिलर का चयन उन जगहों के परिवेश में किया जाएगा जहां चिलर स्थापित किया जा रहा है।

पैक चिलर को प्रोएक्टिव माइक्रोकॉन्ट्रोल नियंत्रक से असामान्य ऑपरेटिंग परिस्थितियों के अनुकूल, सहिष्णु और प्रारंभिक समय पर चरम स्थितियों का समायोजन करने के लिए सुसज्जित किया जाएगा।

पैनल में निम्नलिखित ऑपरेशन करने के लिए मुख्य रूप से एक माइक्रोप्रोसेसर आधारित नियंत्रक होगा।

ए) ठंडे पानी के आउटलेट सेट तापमान पर आधारित चिलर को ऑटो स्टॉप और रिस्टार्ट करना।

बी) कंप्रेसर चालू/बंद साइक्लिंग से बचने के लिए ऑटो रीसायकल टाइमर।

सी) उच्च दाब/कम दाब/स्थिरता तापमान/कम ठंडे पानी और कंडेन्सर जल प्रवाह/फेज असंतुलन-फेज रिवर्सल-ओवरलोड/कम-ज्यादा वोल्टेज पर कंप्रेसर की ट्रिपिंग

डी) क्रैंक केस हीटर ऑपरेशन

ई) ऑटो/मैनुअल मोड ऑपरेशन

एफ) पैनल उपयोगकर्ता के अनुकूल होगा और सरल अंग्रेजी भाषा में संदेश प्रदर्शित करेगा जिसके साथ अलग-अलग मापदंडों और बदलते सेट पॉइंट को देखने के लिए ऑपरेटर पैड होगा।

जी) माइक्रोप्रोसेसर पैनल को पूरी तरह से छेड़छाड़ मुक्त करने के लिए पासवर्ड से सुरक्षित किया जाएगा।

एच) यह प्रणाली यूनिट को समझदारी से बनाए रखेगी ताकि कंप्रेसर साइकिल चालन को न्यूनतम रखते हुए जल तापमान परिशुद्धता और स्थिरता को बनाए रखा जा सके।

आइ) पैनल में अनुकूली लॉजिक होगा जो यह सुनिश्चित करेगा कि खराब मौसम के दौरान जल शीतन यूनिट चलती रहे जब शीतन सर्वाधिक वांछित होता है।

जे) पैनल में पर्सनल कम्प्यूटर में इंटरकनेक्टिविटी के लिए एक इंटरफेस होगा ताकि किसी भी सुदूर स्थान से पानी शीतन यूनिट आपरेशन की निगरानी की जा सके। माइक्रो-प्रोसेसर कंट्रोल पैनल को BACNET या MODBUS नेटवर्क जैसे मानक प्रोटोकॉल पर काम करना होगा।

नियंत्रण केंद्र के डिस्प्ले पैनल में कम से कम निम्न LCD डिस्प्ले को उपलब्ध कराया जाएगा।

ए) सक्शन दाब

बी) निर्मुक्ति दाब

सी) यूनिट द्वारा लिया गया करंट

डी) परिचालन अवधि

ई) खराबी और ट्रिप संकेत

एफ) तिथि, समय और विफलता के कारण के साथ अंतिम न्यूनतम 6 ट्रिप के लिए अलार्म पूर्ववृत्त

जी) सभी मापदंडों के निर्दिष्ट बिंदुओं को बदलना/देखना

एच) गलत पासवर्ड संदेश

आइ) दैनिक शुरू और बंद होने का समय

जे) चिलर इनलेट और आउटलेट तापमान।

के) कंडेन्सर पानी इनलेट और आउटलेट तापमान।

एल) एंटी-फ्रीज तापमान कट-आउट सेटिंग।

एम) कंप्रेसर शुरूआत और चालन स्थिति और कुल चालन समय।

#### **4.7 इलेक्ट्रिक्स:**

विद्युत नियंत्रण कक्ष की प्रारंभिक स्टार्ट-अप, सामान्य ऑपरेशन और शटडाउन स्थितियों के दौरान पूरी तरह से स्वचालित संचालन के लिए वायरिंग की जाएगी। नियंत्रण प्रणाली में एक प्रति-रीसायकल डिवाइस लगाया जाएगा। नियंत्रक को चालू होने के बीच में कंप्रेसर चालू होने को न्यूनतम अंतराल पर सीमित करना होगा। पैक चिलर को प्रत्येक कंप्रेसर के लिए रेलपेल शुरूआती प्रणाली के लिए यूनिट पर लगे सर्किट ब्रेकर, यूनिट पर लगे संपर्कक और समय देरी वायर्ड से सुसज्जित किया जाएगा। स्टार्टर कारखाने से ही लगे होंगे और अलग-अलग सर्किट ब्रेकर पर वायरिंग की जाएगी। यूनिट की वायरिंग की जाएगी। ताकि पैक चिलर के लिए केवल

क्षेत्र विद्युत कनेक्शन एकल तीन-फेज पावर टर्मिनल तक हो सके। मोटर कंट्रोल सेंटर में सर्किट ब्रेकर के साथ-साथ प्रति कंप्रेसर एक डिस्कनेक्ट स्विच और यूनिट फ़्यूज/फ़्यूज ब्लॉक भी शामिल किए जाने हैं।

नियंत्रण प्रणाली में निम्नलिखित नियंत्रण और सुरक्षा उपकरण होंगे:

#### 4.7.1 मैनुअल कंट्रोल:

- नियंत्रण सर्किट स्टॉप और स्टार्ट स्विच
- कंप्रेसर इनेबल स्विच

#### 4.7.2 सुरक्षा नियंत्रण:

- सॉलिड स्टेट कंप्रेसर मोटर स्टार्टर ओवरलोड (3 फेज) करता है, फेज/पावर क्षय, फेज असंतुलन या फेज रिवर्सल, ज्यादा/कम वोल्टेज आदि के लिए सुरक्षा।
- तेल का निम्न दाब
- तेल का उच्च तापमान
- उच्च कंडेन्सर दाब
- निम्न वाष्पीकारक दाब
- वाष्पीकारक जल शीतन संरक्षण
- ठंडे जल प्रवाह का क्षय
- संघनक जल प्रवाह का क्षय

#### 4.7.3 स्वचालित नियंत्रण:

- कंप्रेसर मोटर संवृद्धि सम्पर्कक
- संवृद्धि प्रारंभ टाइमर
- एंटी-रीसायकल टाइमर
- ऑयल संप हीटर इंटरलाक रिले

#### 4.8 ऑपरेंटिंग लाभ, दक्षता और विश्वसनीयता:

- निर्माता को स्कॉल कंप्रेसरों के निर्माण और अद्यतित तकनीकी प्रगति में पर्याप्त अनुभव रखना होगा।
- डिजाइन न्यूनतम घूमने वाले पुर्जों के साथ उच्च विश्वसनीयता के लिए सरल होगा।
- प्रत्येक कंप्रेसर के लिए अभिन्न उच्च दक्षता वाले तेल पृथकन के माध्यम से प्रत्येक कंप्रेसर के लिए निरंतर तेल प्रवाह को सुनिश्चित करना।
- कम कंप्रेसरों के साथ अधिक क्षमता पैदा करने वाले किफायती चक्र और माइक्रो कंप्यूटर-नियंत्रित मंचन के उपयोग के द्वारा उत्कृष्ट दक्षता और संपूर्ण ऊर्जा बचत करना।
- कम्प्यूटर से मिलान किए घटकों के माध्यम से अधिकतम निष्पादन।
- लगाना आसान।
- एक अत्यंत संहत कार्य अन्वालोप के लिए जरूरी स्कॉल कंप्रेसरों की साइड-बाय-साइड वाष्पीकारक/कंडेन्सर प्लस स्नग व्यवस्था।
- मॉनिटर किए गए कार्यों के माइक्रोप्रोसेसर प्रतिधारण के जरिए सरलीकृत समस्या निवारण।

#### 4.9 अन्य विशेषताएं:

- प्रोग्रामिंग सुविधा के दुरुपयोग को रोकने के लिए सॉफ्टवेयर लॉक
- मेमोरी में न्यूनतम 6 पिछली खराबियों (न्यूनतम) को स्टोर करने का प्रावधान
- नियंत्रक BMS संगत होंगे। प्रोटोकॉल BACNET या MODBUS होगा।

#### 4.10 सुरक्षा कोड/मानक:

- ASME बॉयलर और प्रेशर वेसल कोड, खंड VIII भाग 1 "अनफायर्ड प्रेशर वेसल्स"
- ASME मानक B 31.5 प्रशीतन पाइपिंग
- ASHRAE मानक 15 मैकेनिकल रेफ्रिजेशन के लिए सुरक्षा कोड
- राष्ट्रीय इलेक्ट्रिक कोड और स्थानीय प्रदूषण नियंत्रण बोर्ड के नियम
- AHRI मानक 550/590-2012 "वाष्प संपीड़न चक्र का उपयोग करके जल-शीतक और ताप पम्प जल-तापन पैकेज की निष्पादन रेटिंग"

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## 5. अपकेन्द्री चिलर पैकेज

### 5.1 निर्माण:

अपकेन्द्री चिलर जल शीतित प्रकार के होंगे, जिसमें SOQ में निर्दिष्ट वायुरोधी/अर्द्ध वायुरोधी एकल/एकाधिक चरण अपकेन्द्री कंप्रेसर होंगे जो वाष्पीकारक, आपस में जोड़ने वाली प्रशीतक पाइपिंग, विस्तार उपकरण, इनलेट गाइड वैन और डिफ्यूजर, कंट्रोल पैनल, ठंडा पानी और कंडेन्सर जल कनेक्शन जैसे उपयुक्त लोड नियंत्रण तंत्र के साथ परिपूर्ण होगा। नियंत्रण पैनल में पूरी तरह से वायरिंग की जाएगी और नियंत्रक, स्टार्टर, विद्युत संरक्षण उपकरण इत्यादि जुड़े और इंटरलॉकिंग होंगे। चिलर की क्षमता, ठंडे पानी की प्रवाह दर, कंडेन्सर जल प्रवाह दर, बिजली इनपुट आवश्यकताएं, वोल्टेज इत्यादि अनुसूची में अन्यत्र निर्दिष्ट जैसी होंगी।

चिलरों को भार (लोड) स्थितियों में कारखाने में चलाकर जांच की जाएगी। चिलर पैकेज यूनिट का डिजाइन पर्याप्त संरचनात्मक क्षमता वाले पैनलों के साथ अधिकतम जंगरोधकता के लिए किया जाएगा। इस यूनिट को उपयुक्त आकार के वेल्डेड स्टील बेस फ्रेम स्ट्रक्चरल स्टील प्रोफाइल पर लगाया जाएगा, इसे MS से बनाया जाएगा और जंग प्रतिरोधकता के लिए गैल्वेनाइज किया जाएगा। कंपन और शोर को कम करने के लिए उपयुक्त कंपन आइसोलेटर (पृथक्त्र) लगाए जाएंगे। आधार और फ्रेम के भागों को पेंट किया जाएगा। जब तक अन्यथा निर्दिष्ट नहीं हो, चिलर पैकेज का न्यूनतम COP, IPLV और kW/ TR SOQ में बताए अनुसार होगा।

चिलर AHRI 550/590 (I-P) 2011 और and AHRI 551/591 (SI) 2011 या समकक्ष के लागू मानकों के अनुसार प्रमाणित होंगे।

मशीन पर निर्माता के नाम और स्थान, प्रकार, मॉडल नं. व क्रमांक के साथ OEM के नाम की प्लेट होगी जिसमें पूर्ण पहचान, चिलर पैकेज के आयाम, परिचालन भार, कंपन स्तर, रव स्तर, प्रशीतक का नाम, वोल्टेज, फेज़ और आवृत्ति, निर्माण की तारीख आदि लिखी होनी चाहिए। चिलरों के लिए kW/TR vs. % लोड चार्ट प्रदान किया जाना है।

चिलरों का शोर स्तर यूनिट से लगभग 1m दूरी पर 85 dB(A) से अधिक नहीं होगा। चिलर के विभिन्न घटकों का संक्षिप्त विवरण नीचे दिया गया है।



## 5.2 कंप्रेसर:

अपकेन्द्री कंप्रेसर वायुरोधी/अर्द्ध वायुरोधी प्रकार के होने चाहिए। वे निविदा अनुसूची में निर्दिष्ट के अनुसार एकल/एकाधिक चरण प्रकार के होंगे। प्रयुक्त प्रशीतक पर्यावरण के अनुकूल HFC-134a/ पाजिटिव दाब प्रशीतक होगा, जो इसी तरह के अनुप्रयोगों के लिए उपयुक्त है।

## 5.3 प्रेरक (इम्पेलर):

इम्पेलर की ढलाई हल्के वजन वाले और उच्च जंगरोधक क्षमता वाले विशेष अति उच्च घनत्व वाली एल्यूमीनियम मिश्र धातु से की जाएगी। इम्पेलर स्थिर और गतिशील रूप से संतुलित होगा और सभी भार पर विश्वसनीयता के लिए कारखाने में 125% की गति पर परीक्षण किया जाएगा।

## 5.4 ड्राइव ट्रेन:

गियर का उपयोग इम्पेलर की गति बढ़ाने के लिए किया जाएगा। गियर पेचदार होंगे, केस कठोरीकृत होंगे और स्नेहक नम वातावरण में काम करेंगे। गियर को जर्नल और थ्रस्ट बेयरिंग द्वारा सहारा दिया जाएगा।

## 5.5 स्नेहन प्रणाली:

प्रणाली में अभिन्न तेल पंप, तेल संप, बदलने योग्य तेल फिल्टर, तेल हीटर, साइट ग्लास आदि शामिल होंगे। उच्च मात्रात्मक दक्षता के तेल पंप का इस्तेमाल कंप्रेसर, गियर और मोटर में बेयरिंग स्नेहन बनाए रखने के लिए स्नेहन प्रणाली में आवश्यक तेल के दाब और प्रवाह बनाए रखने के लिए किया जाएगा। स्नेहन प्रणाली विश्वसनीय तेल रिकवरी प्रणाली के साथ परिपूर्ण होगी ताकि कूलर और अन्य स्थानों में एकत्रित तेल को तेल पंप में वापस लाया जा सके। तेल को पतला होने से रोकने के लिए शट डाउन अवधि के दौरान तेल तापमान बनाए रखने के लिए तेल हीटर लगाना होगा। चिलर के संचालन के दौरान तेल को ठंडा करने के लिए आवश्यक हीट एक्सचेंजर का इस्तेमाल किया जाएगा।

बिजली चले जाने/पंप की खराबी और तट नीचे होने के दौरान संचालित करने के लिए गुरुत्व के तहत पर्याप्त स्नेहक प्रवाह प्रदान करने के लिए एक आपातकालीन तेल भंडार विशेष रूप से प्रदान किया जाएगा।

### 5.6 क्षमता नियंत्रण:

यह इनलेट गाइड वैन का उपयोग करके प्राप्त किया जायेगा जो खोलने की डिग्री को समायोजित करते हैं, जिससे वॉल्यूम प्रवाह दर को समायोजित करते हैं। इसे व्यापक स्थिर ऑपरेटिंग रेंज के माध्यम से प्रशीतक प्रवाह को नियंत्रित करना होगा।

निरावेश पारण पर एक समायोज्य विसारक (यदि इस्तेमाल किया जाए तो) होगा ताकि कंप्रेसर के महोर्मि बिंदु को कम करने के लिए निर्मुक्ति गैस वेग को बढ़ाया जा सके। यूनिट को 100% से 20% तक क्षमता को व्यवस्थित करना होगा।

### 5.7 मोटर:

कंप्रेसर मोटर पिंजरी प्रेरण प्रकार की होगी। मोटर में कुशल शीतन प्रणाली होगी। मोटर कुंडली विश्वसनीय जंगरोधी इन्सुलेशन वाली होगी जो प्रशीतक और तेल के साथ संगत होगी। मोटर स्टेटर कुंडली में लगे तापमान सेंसर से संरक्षित की जाएगी।

### 5.8 वाष्पीकारक:

वाष्पीकारक अभिन्न पंखदार तांबा ट्यूब के साथ आप्लावन/DX प्रकार का होगा। चिलर क्षैतिज, शैल और ट्यूब प्रकार होंगे।

चिलर के शैल (खोल) को कार्बन स्टील शीट से फ्यूजन सीम वेल्डेड सीम के साथ बनाया जाएगा। ट्यूबों को स्टील ट्यूब शीट्स के खांचे में घुसाया जाएगा और निकला हुआ रखा जाएगा। ट्यूब तांबे के निर्बाध, उच्च कुशल, आंतरिक रूप से संवर्धित और बाहरी रूप से पंखदार होंगी। ट्यूब व्यास और मोटाई OEM के अनुसार होगी। ट्यूब शीटों के बीच आवश्यक ट्यूब सपोर्ट प्रदान करने के लिए मध्यवर्ती ट्यूब से सहारा प्रदान किया जाएगा।

चिलर को 0.000018 m<sup>2</sup> 0K/W के फाउलिंग कारक के लिए डिज़ाइन किया जाएगा। वाष्पीकरण शेल और ट्यूब साइड को कार्यकारी दाब से 1.5 गुना वायवीय दाब परीक्षण से गुजरना होगा।

चिलर को निविदा अनुसूची में विनिर्दिष्ट किए अनुसार डिज़ाइन किया जाएगा। वेंट और छिद्र प्लग पानी के बक्से में प्रदान किए जाएंगे। वाष्पीकारक के शेल साइड में रेफ्रिजरेंट वेंटिंग के प्रावधान के साथ दाब निर्मुक्ति (न्यूनक) वाल्व होगा। निविदा अनुसूची में विनिर्दिष्ट अनुसार जल कनेक्शन फ्लैज टाइप/ विक्टोरिक खांचे/समुद्री बॉक्स प्रकार का होगा।

चिलर न्यूनतम 13 मिमी मोटी बंद सेल इन्सुलेशन के साथ कारखाने से विद्युत-रोधित (इन्सुलेट) होगा।

### 5.9 कंडेन्सर:

कंडेन्सर क्षैतिज खोल प्रकार और ट्यूब जल शीतित प्रकार का होगा और निविदा अनुसूची में निर्दिष्ट अनुसार प्रशीतक के लिए, डिज़ाइन, निर्माण और परीक्षण किया जाएगा।

कंडेन्सर शेल कार्बन स्टील का बनेगा जिसमें फ्यूजन वेल्डेड सीम होगी। अंत प्लेटें कार्बन स्टील की होंगी। झुकाव और कंपन को रोकने के लिए स्टील से बनी मध्यवर्ती ट्यूब का सहारा दिया जाएगा। ट्यूब तांबे, निर्बाध, उच्च कुशल, आंतरिक रूप से संवर्धित और बाह्य रूप से पंखदार होंगी, निर्धारित स्टील ट्यूब शीट्स में यांत्रिक रूप से विस्तारित होंगी। ट्यूब व्यास और मोटाई OEM के अनुसार होगी। ट्यूब बक्सा निकालने योग्य होगा और आवश्यक छिद्र और छिद्र प्लग लगाए जाएंगे। निविदा अनुसूची के अनुसार कंडेन्सर एकल/दो/तीन पास प्रकार के होंगे। शेल साइड में रेफ्रिजरेंट वेंटिंग के प्रावधान के साथ दाब निर्मुक्ति वाल्व होगा।

कंडेन्सर की ताप अंतरण सतह को 0.000018 m<sup>2</sup> 0K/W के फाउलिंग कारक के लिए डिज़ाइन किया जाएगा। कंडेन्सर शेल और ट्यूब साइड को कार्यकारी दाब से 1.5 गुना वायवीय दाब परीक्षण से गुजरना होगा।

कंडेन्सर में चिलर के समग्र प्रशीतक प्रभाव और दक्षता को बढ़ाने के लिए कंडेन्सर के नीचे उप-कूलर लगाया जाएगा। कंडेन्सर शैल आयतन का डिज़ाइन पूरी पंप डाउन क्षमता के लिए प्रणाली में प्रशीतक के प्रवाह का एक गुना न्यूनतम रखने के लिए किया जाएगा।

निविदा अनुसूची में विनिर्दिष्ट अनुसार जल कनेक्शन फ्लैज/ विक्टॉलिक खांचे/समुद्री बॉक्स प्रकार का होगा। कंडेन्सर में पूर्ण पंप डाउन क्षमता की सुविधा के लिए प्रशीतन पृथकन वाल्व लगाया जाएगा।

#### 5.10 प्रशीतक सर्किट:

प्रशीतक सर्किट में तरल और निर्मुक्ति लाइन वाल्व, तेल फिल्टर, तेल लाइन पर बदलने योग्य फिल्टर/शुष्कक, तेल लाइन पर साइट ग्लास, वाष्पीकारक और कंडेन्सर पर दाब निर्मुक्ति वाल्व, प्रशीतक प्रवाह के लिए तरल लाइन कोण लाइन वाल्व शामिल होंगे। दो चरण वाले चिलरों के लिए ऊर्जादक्षक लगाया जाएगा।

#### 5.11 विद्युत और नियंत्रण पैनल:

विद्युत स्विच गियर, नियंत्रक, नियंत्रण सेंसर NEMA-1 कार के संलग्नक पैनल में रखे जाएंगे। पैनल आवरण पाउडर कोटिंग के साथ जस्ती स्टील का होगा। पैनल में बिजली और नियंत्रण उपकरणों को अलग-अलग रखने के लिए दो डिब्बे होंगे।

निविदा अनुसूची में दर्शाए विनिर्देशों के अनुसार कोई भी स्टार्टर हो सकता है।

कम वोल्टेज स्टार्टर (575 VAC तक)

ए. स्टार डेल्टा स्टार्टर

बी. सॉलिड स्टेट स्टार्टर

सी. परिवर्ती गति चालन

मध्यम वोल्टेज स्टार्टर (3 kV up से 13.8 kV तक)

ए. ऑटो ट्रांसफार्मर स्टार्टर

बी. सॉलिड स्टेट स्टार्टर

सी. परिवर्ती गति चालन

## 5.12 नियंत्रण प्रणाली:

चिलर में सक्रिय उन्नत माइक्रोप्रोसेसर आधारित नियंत्रक लगाया जाएगा। नियंत्रक को उपयोगकर्ता के अनुकूल टर्मिनल के साथ न्यूनतम 10" LED स्क्रीन वाला रंगीन टच स्क्रीन डिस्प्ले लगाया जाएगा। इलेक्ट्रॉनिक नियंत्रण प्रणाली लगातार विभिन्न मापदंडों पर निगरानी रखेगी और क्षमता का स्वतः समायोजन करेगी। ऑपरेटिंग और सुरक्षा नियंत्रण प्रदान किए जाएंगे। इसमें इनपुट/आउटपुट, पीसी इंटरफ़ेस, बीएमएस संचार पोर्ट निर्मित होंगे। पैरामीटर गैर-वाष्पशील स्मृति में संग्रहित किये जाएंगे। विभिन्न संचालन स्तरों के लिए पासवर्ड सुरक्षा होगी। सभी संदेश अंग्रेजी भाषा में और MKS/SI यूनिट में प्रदर्शित होंगे। नियंत्रक खुले प्रोटोकॉल BACNET/ MODBUS आदि के साथ BMS के द्वारा सभी डेटा की रिमोट मॉनिटरिंग करने के लिए सभी हार्डवेयर और सॉफ्टवेयर लगे होंगे। नियंत्रक RS485 लंबी दूरी अंतर संचार पोर्ट और USB पोर्ट के साथ पूरा होगा।

नियंत्रण प्रणाली में मानक पद्धति के अनुसार नियंत्रण, निष्पादन और सुरक्षा उपकरण शामिल होंगे।

- ए. मैनुअल/ऑटो कंट्रोल
- बी. प्रशीतक प्रवाह नियंत्रण
- सी. टच स्क्रीन पर सॉफ्ट संकेतक

मानक पद्धति के अनुसार नियंत्रक ऑपरेटिंग सूचना, सुरक्षा और निर्धारित बिंदुओं और सुरक्षा को प्रदर्शित करेगा। नियंत्रक खराबी के समय के साथ न्यूनतम 6 खराबी स्थितियों सभी महत्वपूर्ण सेंसर रीडिंग को रखने में पूरी तरह सक्षम होगा ताकि खराबी दूर करने के लिए तकनीशियनों की सहायता की जा सके।

## 5.13 गुणवत्ता आश्वासन:

- ए) चिलर निष्पादन AHRI 550/590 मानक नवीनतम संस्करण के अनुसार AHRI द्वारा प्रमाणित किया जाएगा।
- बी) यांत्रिक प्रशीतन के लिए ASHRAE मानक 15 सुरक्षा कोड।
- सी) रेफ्रिजेंट पाइपिंग के लिए ASME मानक।
- डी) दाब वाहिकाओं के लिए ASME मानक।

ई) चिलर का परीक्षण कारखाने में चलाकर किया जाएगा और क्षमता का मूल्यांकन किया जाएगा।

एफ) जब तक अन्यथा निर्दिष्ट नहीं हो, चिलर पैकेज का न्यूनतम COP, IPLV और kW/TR SOQ में बताए अनुसार होगा।

जी) चिलर AHRI 550/590 (I-P) और and AHRI (SI) या समकक्ष के लागू मानकों के अनुसार प्रमाणित होंगे।

#### 5.14 VFD विकल्प:

यदि VFD ड्राइव का विकल्प चुना गया हो, तो चिलर को इन्वर्टर ड्यूटी कंप्रेसर मोटर और सुदूर माउन्ट VFD पैनल के साथ लगाया जाएगा। VFD सतत टॉर्क वाला होगा और सामान्य परिचालन के दौरान 60 सेकंड के लिए 110% टॉर्क देने में सक्षम होना चाहिए। सभी परिस्थितियों में उपयुक्त कैपेसिटर बैंकों/APFC पैनलों द्वारा 0.95 का शक्ति गुणक (पावर फैक्टर) बनाए रखा जाएगा। सभी परिचालन परिस्थितियों में स्थिर संचालन के साथ अनुकूलित निष्पादन प्रदान करने के लिए यूनिट क्षमता नियंत्रण VFD और इनलेट गाइड फलक के संयुक्त कार्य द्वारा किया जाएगा।

आवृत्ति को स्वतः कम करने के लिए VFD में इनबिल्ट प्रोटेक्शन मोड की आवश्यकता होगी और मॉड्यूलन प्रक्रिया को तब समायोजित किया जाएगा जब इसे करंट या अधिक वोल्टेज आदि नाजुक स्थिति का पता लगेगा।

VFD में अधिभार के लिए इनबिल्ट इलेक्ट्रॉनिक थर्मल मोटर संरक्षण होगा। VFD को मोटर टर्मिनलों पर शॉर्ट सर्किट से संरक्षित किया जाएगा। इसके मुख्य फेज के नुकसान के लिए भी सुरक्षा होगी। VFD में इनबिल्ट LCD कीपैड डिस्प्ले होगा और मोटर करंट, वोल्टेज, आवृत्ति उत्पादन, आउटपुट kW इत्यादि पर जानकारी दिखाएगा।

### 5.15 चुंबकीय बेयरिंग के साथ अपकेन्द्री कंप्रेसर विकल्प:

चुंबकीय बेयरिंग वाले कंप्रेसर के साथ अपकेन्द्री चिलर तेल मुक्त प्रकार का होगा। कंप्रेसर HFC प्रशीतक का इस्तेमाल करेगा। कंप्रेसर एक मानक विशेषता के रूप में VFD को शामिल करेगा। कंप्रेसर संहत, कम शोर और कंपन स्तर के साथ अत्यधिक ऊर्जा कुशल होगा। कंप्रेसर में उच्च भाग भार क्षमता और असीम परिवर्ती क्षमता नियंत्रण होगा। चिलर में चुंबकीय बेयरिंग के बजाय कोई भी तेल स्नेहन सुविधा जैसे पंप, हीटर, कूलर आदि नहीं होंगी। चुंबकीय बेयरिंग में आवश्यक निकटता सेंसर, डिजिटल नियंत्रक, स्पंद चौड़ाई मॉड्यूलन आदि होंगे। कंप्रेसर में निर्मित सुविधा के रूप में सुरक्षा और संरक्षा के लिए आवश्यक सुविधा होगी।

### 5.16 सुरक्षा कोड/मानक:

- ASME बॉयलर और प्रेशर वेसल कोड, खंड VIII भाग 1 "अनफायर्ड प्रेशर वेसल्स"
- ASME मानक B 31.5 प्रशीतन पाइपिंग
- ASHRAE मानक 15 मैकेनिकल रेफ्रिजेशन के लिए सुरक्षा कोड
- राष्ट्रीय विद्युत कोड और स्थानीय प्रदूषण नियंत्रण बोर्ड के नियम
- AHRI मानक 550/590-2012 "वाष्प संपीड़न चक्र का उपयोग करके जल-शीतक और ताप पम्प जल-तापन पैकेज की निष्पादन रेटिंग"

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**एयर कंडीशनिंग और वेंटिलेशन  
कार्यों के लिए विनिर्देश**

**खंड - II**

**अपकेन्द्री पंप**



## 1. क्षैतिज विभाजित आवरण पंप

### 1.1 पंप निर्माण:

क्षैतिज विभाजन/अंत सक्शन पंप का निर्माण IS या समतुल्य मानकों के अनुसार होगा। प्रवाह दर, शीर्ष मोटर गति, दक्षता और बिजली की आवश्यकताओं के संबंध में निविदा अनुसूची देखें।

#### 1.1.1 आवरण (केसिंग):

पम्प आवरण भारी खंड के घने दाने वाले ढलवां लोहे का विभाजित आवरण प्रकार का होगा ताकि पाइपिंग या मोटर कनेक्शन को वियोजित किए बिना घूर्णन भागों की पूरी सर्विसिंग की जा सके। मोटर से पंप तक का कनेक्शन स्पेसर टाइप कपलिंग से किया जाएगा। चूषण पारण कुंडलित प्रकार का होगा ताकि इम्पेलर में आसानी से प्रविष्ट हो सके और दक्षता बढ़ सके।

#### 1.1.2 इम्पेलर:

इम्पेलर कांस्य या गनमेटल से बना, दोहरा चूषण, संवृत प्रकार और हाइड्रोलिक रूप से संतुलित होगा ताकि ऑपरेशन के दौरान कोई कंपन ना हो। इम्पेलर शाफ्ट से अच्छी तरह से जुड़ा होना चाहिए और विपरीत दिशा में घूमने सहित संचालन के दौरान ढीला होने से रोकने का प्रावधान किया जाएगा। इम्पेलर को बांधने वाले नट (यदि लगाए गए हों तो) टोपीदार होंगे और अंत चूषण के लिए सामान्य घूर्णन की दिशा में कसा जाएगा - दोहरे दांतेदार एकल प्रविष्टि, त्रिज्यीय प्रवाह हाइड्रोलिक रूप से संतुलित।

#### 1.1.3 घिसने वाले छल्ले (रिंग):

घिसने वाले छल्ले (रिंग) बदलने या मरम्मत करने योग्य होंगे। इन्हें घूर्णन के विपरीत कस कर लगाया जाएगा, दबाकर फिट किया जाएगा और पिन से लॉक किया जाएगा, फ्लैज और स्कू लगाया जाएगा।

#### 1.1.4 शाफ्ट:

शाफ्ट स्टेनलेस स्टील की सटीक मशीन की गई, सान की गई और फिनिश (परिष्कृत) होगी। गनमेटल आस्तीन (स्लीव) द्वारा संरक्षित की जाएगी। इसे इम्पेलर, कपलिंग और बेयरिंग व्यास पर संवृत सहयता के लिए फिनिश किया जाएगा। इम्पेलर, पुली और शाफ्ट आस्तीन को कुंजी/नट द्वारा शाफ्ट में सुरक्षित रूप से लगाया जाएगा।

शाफ्ट आकार की गणना अधिकतम संयुक्त अपरूपण और तन्यता तनन पर की जाएगी। यह अपरूपण तनन प्रत्यास्थ सीमा का 30 प्रतिशत या अंतिम तन्य शक्ति का 18 प्रतिशत, जो भी कम हो, होना चाहिए।

#### 1.1.5 शाफ्ट आस्तीन (स्लीव):

पंप में यांत्रिक सील लगाई जाएंगी। शाफ्ट की सुरक्षा के लिए लगाई गई शाफ्ट आस्तीन गनमेटल की होगी। शाफ्ट आस्तीन को ढीला होने से रोकने के लिए शाफ्ट को अच्छी तरह से लॉक या बंद किया जाएगा। घूर्णन शाफ्ट और शाफ्ट आस्तीन को मशीन किया जाएगा संकेंद्रित रोटेशन के लिए तैयार किया जाएगा।

#### 1.1.6 बेयरिंग:

ए) बेयरिंग बॉल, रोलर या आस्तीन प्रकार के हो सकते हैं। अक्षीय और त्रिज्यीय भार उठाने का प्रावधान किया जाएगा। तेल पात्र में तेल स्तर के संकेतक उपलब्ध कराए जाएंगे।

बी) जहां बेयरिंग में तरल की प्रवेश की संभावना हो, वहां पंप में जल विक्षेपक जैसी उपयुक्त निवारक व्यवस्था लगाई जाएगी।

सी) पंप के संरेखण को बाधित किए बिना बेयरिंग तक आसानी से पहुंचना सुलभ होगा।

#### 1.1.7 कपलिंग (युग्मक):

पंप में पंप ड्राइवर को बाधित किए बिना लचीला स्पेसर प्रकार का कपलिंग लगाया जाएगा। सभी युग्मित पंपों के लिए कपलिंग गार्ड, विस्तारित धातु से बने और बेस प्लेट के साथ लगाकर सुसज्जित किया जाएगा।

### 1.1.8 मोटर:

पंप के लिए मोटर IE3 या बेहतर दक्षता के साथ उपयुक्त रेटिंग वाली होगी। बेस (आधार) ढलवां लोहे वाला, TEFC द्वारा डिजाइन वाला होगा। मोटर 415 +/- 10% वोल्ट, 3 फेज़, 50 Hz AC बिजली की आपूर्ति के लिए उपयुक्त होगी।

### 1.1.9 आधार (बेस) प्लेट:

पंप और मोटर के लिए आम आधार प्लेट एक स्थान पर होगी और यह ढलवां लोहे या वेल्डेड स्टील से बनी होगी। ग्राउटिंग के लिए उपयुक्त छेद दिए जाएंगे और वे इस तरह स्थित होंगे कि पंप और मोटर को बाधित किए बिना आधार लगाया जा सके। ठेकेदार द्वारा सभी पंपों और मोटरों को आधार प्लेटों में ठीक से संरेखण, बोल्ट और डावेल किया जाएगा। न्यूनतम 15 मिमी व्यास की ड्रेन पाइपिंग लगाने के लिए पंप नाली कनेक्शन और बेस प्लेट के बीच पर्याप्त स्थान रखा जाएगा। पंप के साथ उपयुक्त नाली पैन या फंसे नाली कनेक्शन के साथ रिम प्रकार बेस प्लेटों की आपूर्ति की जाएंगी।

## 1.2 स्थापना:

कंक्रीट नींव में लगे सामान्य मृदु स्टील बेस फ्रेम पर पंप और मोटर लगाई जाएगी। लगाने की व्यवस्था को शॉप ड्राइंग पर दिखाया जाएगा।

### 1.2.1 स्नेहन (ल्यूब्रिकेशन):

पूरी प्रणाली की स्थापना के बाद और परीक्षण से पहले, निर्माता के निर्देशों के अनुसार ही पंप को ल्यूब्रिकेट किया जाएगा।

### 1.2.2 पंप संरेखण:

परीक्षण से पहले सभी पंप 0.05 मिमी के भीतर डायल सूचक के साथ संरेखित किए जाएंगे।

## 1.3 पेंटिंग:

सभी पंप, मोटर और बेस की आपूर्ति अनुमोदित फिनिश के साथ की जाएंगी। लदान या स्थापना के दौरान पेंट की खराब हो जाने पर खनिज स्पिरिट से साफ किया जाएगा, वायर ब्रश

लगाया जाएगा और प्रभावित क्षेत्रों पर ठीक किया जाएगा, फिर आसपास के क्षेत्रों से मेल खाने के लिए इनेमल पेंट की परत लगाई जाएगी।

#### **1.4 निष्पादन डेटा:**

पम्प निष्पादन वक्र और ऑपरेटिंग बिंदुओं के साथ बिजली की खपत को स्पष्ट रूप से निर्दिष्ट किया जाएगा, और स्थापना के परीक्षण और कमीशन के समय सत्यापित किया जाएगा। पंप को निष्पादन वक्र के सपाट हिस्से पर सर्वोत्तम दक्षता बिंदु के लिए चुना जाएगा।

## 2. अंत चूषण युग्मित अपकेन्द्री पंप

### 2.1 पंप निर्माण:

अंत चूषण युग्मित अपकेन्द्री पंप का निर्माण IS या समतुल्य मानकों के अनुसार होगा। पम्प बैक पुल आउट प्रकार का होगा, अंत-चूषण डिज़ाइन मोटर के लिए लंबा युग्मित होगा। प्रवाह दर, शीर्ष मोटर गति, दक्षता और बिजली की आवश्यकताओं के संबंध में निविदा अनुसूची देखें।

#### 2.1.1 आवरण (केसिंग):

पम्प आवरण ढलवां लोहे का होगा, जो 16 bar (232 PSI) कार्यकारी दाब के लिए उपयुक्त होगा और को 17 bar (250 PSI) तक के दाब के लिए तन्य लोहे से बना होगा। आवरण को हाइड्रोस्टैटिक रूप से 150% अधिकतम कार्यकारी दाब के लिए परीक्षण किया जाएगा। आवरण को त्रिज्यी रूप से विभाजित किया जाएगा ताकि पाइप कनेक्शनों को बाधित किए बिना घूर्णन एलीमेंट को हटाया जा सके। आवरण के ड्रिल और टेप कनेक्शन लगाया जाएगा। ड्रिल और टैप किए गए दाब गेज कनेक्शन के साथ सक्शन और डिस्चार्ज कनेक्शन लगाए जाएंगे।

#### 2.1.2 इम्पेलर:

इम्पेलर कांसे का हाइड्रोलिक रूप से संतुलित, पूरी तरह से संवृत प्रकार और शाफ्ट से बंधे, स्टफिंग बक्से वाला होगा आवरण के साथ अभिन्न और जलरोधी होगा। शाफ्ट आस्तीन गन मेटल की होगी जो यांत्रिक सील क्षेत्र की पूरी लंबाई में फैली होगी।

#### 2.1.3 यांत्रिक सील:

मैकेनिकल सील एकल स्प्रिंग इनसाइड प्रकार की होगी जिसका कार्बन फलक सिलिकॉन कार्बाइड O-रिंग माउन्ट सीट के विरुद्ध घूमेगा। स्टेनलेस स्टील स्प्रिंग और हार्डवेयर के साथ EPDM (इथिलीन प्रोपलीने डायने मोनोमर) इलास्टोमर लगाया जाएगा।

#### **2.1.4 मोटर:**

पंप के लिए मोटर IE3 या बेहतर दक्षता के साथ उपयुक्त रेटिंग वाली होगी। बेस (आधार) ढलवां लोहे वाला, TEFC द्वारा डिजाइन वाला पंप का अभिन्न अंग होगा। मोटर 415+/-10% वोल्ट, 3 फेज़, 50 Hz AC बिजली की आपूर्ति के लिए उपयुक्त होगी।

#### **2.2 स्थापना:**

कंक्रीट में लगे सामान्य मृदु स्टील बेस फ्रेम पर पंप लगाया जाएगा। लगाने की व्यवस्था को शॉप ड्राइंग पर दिखाया जाएगा।

#### **2.3 पेंटिंग:**

सभी पंप, मोटर और बेस की आपूर्ति अनुमोदित फिनिश के साथ की जाएंगी। लदान या स्थापना के दौरान पेंट के खराब हो जाने पर खनिज स्पिरिट से साफ किया जाएगा, वायर ब्रश लगाया जाएगा और प्रभावित क्षेत्रों पर ठीक किया जाएगा, फिर आसपास के क्षेत्रों से मेल खाने के लिए इनेमल पेंट की परत लगाई जाएगी।

#### **2.4 निष्पादन डेटा:**

पम्प निष्पादन वक्र और ऑपरेटिंग बिंदुओं के साथ बिजली की खपत को स्पष्ट रूप से निर्दिष्ट किया जाए, और स्थापना के परीक्षण और कमीशन के समय सत्यापित किया जाएगा। पंप को निष्पादन वक्र के सपाट हिस्से पर सर्वोत्तम दक्षता बिंदु के लिए चुना जाएगा।

### 3. ऊर्ध्वाधर इनलाइन विभाजित पंप

#### 3.1 पम्प निर्माण:

ऊर्ध्वाधर इनलाइन विभाजन पंप का निर्माण IS या समतुल्य मानकों के अनुसार होगा। प्रवाह दर, शीर्ष मोटर गति, दक्षता और बिजली की आवश्यकताओं के संबंध में निविदा अनुसूची देखें।

##### 3.1.1 पम्प आवरण:

65 deg C (PN 16 फ्लैज रेटिंग) पर 12.00 bar के नीचे कार्यकारी दाब के लिए लोहा ढालें। सील फ्लश और गेज कनेक्शन के लिए सक्शन और डिस्चार्ज कनेक्शन को फ्लैज, ड्रिल और टेप किया जाएगा। गेज, फ्लश और नाली कनेक्शन के लिए पृथक ड्रिल और टेप छिद्र प्रदान किए जाएंगे। इष्टतम सक्शन निष्पादन और शांत संचालन के लिए लिबरल इनलेट पेसेजवेज और सीधी वेन दी जाएंगी। रिब को वॉल्यूट के साथ अभिन्न रूप से ढालना होगा। मशीन की गई सतह को फर्श का सहारा स्वीकार करना होगा। कड़े औद्योगिक तापमान और दाब अनुप्रयोगों को पूरा करने के लिए सीमित आवरण वाला गैस्केट होगा।

आधे आवरण और बेयरिंग हाउसिंग को हटाने से पाइपिंग कनेक्शन को बाधित किए बिना के घूर्णन असेंबली को हटाने देना होगा। आवरण इस तरह डिजाइन किया जाएगा कि आवरण को संशोधित किए बिना क्षैतिज आरोहण किया जा सके।

##### 3.1.2 इम्पेलर:

इम्पेलर कांसे का बना होगा और पूरी तरह से संवृत प्रकार का होगा। यह आसान कंपन-मुक्त संचालन सुनिश्चित करने के लिए गतिशील रूप से संतुलित होगा।

##### 3.1.3 शाफ्ट:

कम कार्बन थोटल बुशिंग के साथ स्टेनलेस स्टील पंप शाफ्ट लगाएं।

### 3.1.4 युग्मन (कपलिंग):

ढलवां लोहे का विभाजित प्रकार कठोर स्पेसर प्रकार का परिशुद्धता छिद्रित और डिजाइन किया गया ताकि बेयरिंग लोड को कम किया जा सके। यांत्रिक सील पर शाफ्ट विक्षेपण 0.05 मिमी T.I.R तक सीमित होगा। यांत्रिक सील; कपलिंग को विभाजित किया जाएगा ताकि पंप और मोटर शाफ्ट से अलग किया जा सके, पंप या मोटर को बाधित किए बिना सभी यांत्रिक सील घटकों को बदलने के लिए शाफ्ट के बीच पर्याप्त जगह छोड़ दी जाएगी। युग्मन गार्ड के प्रवेश छिद्र को पूरी तरह से संवृत किया जाएगा।

### 3.1.5 यांत्रिक सील:

मल्टी स्प्रिंग संतुलित प्रकार के अंदर स्टेनलेस स्टील की होगी, जिसके साथ कार्बन घूर्णन फलक, सिलिकॉन कार्बाइड स्थिर सीट, विटोन गौण सील होगी। यह मोटर को बाधित किए बिना सुलभ और आसानी से बदली जाने वाली होगी। स्टेनलेस स्टील हार्डवेयर के साथ कांस्य ग्लैंड प्लेट लगाएं। सील फलक पर तरल और मैनुअल वेंट के साथ सील चैंबर का पाजिटिव निकास सुनिश्चित करने के लिए कारखाने में लगाया फ्लश कनेक्शन प्रदान करें।

सभी विभाजित युग्मित पंपों में सील चैंबर थोटल बुशिंग लगाया जाएगा। आवश्यक होने पर फ्लश लाइन फिटिंग सील करें: कार्यकारी दाब का सामना करने के लिए मैकेनिकल सील में एक 50-माइक्रोन फिल्टर कार्ट्रिज और फ्लोटिंग बॉल प्रकार के दृश्य प्रवाह सूचक की फ्लश लाइन में आपूर्ति करें।

प्रत्येक फ्लैज पर 360 डिग्री रजिस्टर के साथ ऊर्ध्वाधर इन-लाइन ऑपरेशन भारी बेलनाकार ब्रैकेट के लिए पूरी तरह से संवृत पंखा शीतित (TEFC) घेरे के साथ उच्च दक्षता पिंजरी प्रेरण मोटर में पंप और मोटर शाफ्ट रन आउट का कठोर यूनियन को 0.025 मिमी T.I.R (कुल संकेतक रीडिंग) तक सीमित करेगा।

### 3.2 स्थापना:

आपूर्ति किए गए वर्टिकल इन-लाइन पंप पाइपवर्क के अभिन्न घटक होंगे, जड़त्व आधार, जड़त्व बेस स्प्रिंग, लचीले पाइप कनेक्टर, फ़ील्ड ग्राउटिंग और संरेखण की आवश्यकता को खत्म करेंगे। पंप, पाइपिंग और फिटिंग के वजन के लिए आकार वाले पाइप हैंगर एकमात्र



सहारे हैं जिनकी आवश्यकता होगी। प्रत्येक पाइप लैग के तहत कंपन पृथकन पैड के साथ पाइप स्टूल स्थापित किये जा सकते हैं।

### **3.3 रखरखाव:**

मैकेनिकल सील किसी भी पंप में महत्वपूर्ण सर्विस आइटम है। अक्षीय विभाजन स्पेसर युग्मन को हटाने से पंप और मोटर शाफ्ट के बीच के परिणामी अंतराल के द्वारा अन्य पंप घटकों या मोटर कनेक्शन को बाधित किए बिना सभी यांत्रिक सील घटकों को सर्विसिंग के लिए निकालना संभव होना चाहिए। कठोर युग्मन को पुनःलगाने से यूनिट घूर्णन असेम्बली को कारखाने के संरेखण विनिर्देशों के अनुसार होना चाहिए।

### **3.4 स्नेहन:**

पूरी प्रणाली की स्थापना के बाद और परीक्षण से पहले, निर्माता के निर्देशों के अनुसार ही पंप को लूब्रिकेट किया जाएगा।

### **3.5 पंप संरेखण:**

परीक्षण से पहले सभी पंप 0.05 मिमी के भीतर डायल सूचक के साथ संरेखित किए जाएंगे।

### **3.6 पेंटिंग:**

सभी पंप, मोटर और बेस की आपूर्ति अनुमोदित फिनिश के साथ की जाएंगी। लदान या स्थापना के दौरान पेंट खराब हो जाने पर खनिज स्पिरिट से साफ किया जाएगा, वायर ब्रश लगाया जाएगा और प्रभावित क्षेत्रों पर ठीक किया जाएगा, फिर आसपास के क्षेत्रों से मेल खाने के लिए इनेमल पेंट की परत लगाई जाएगी।

### **3.7 निष्पादन डेटा:**

पम्प निष्पादन वक्र और ऑपरेटिंग बिंदुओं के साथ बिजली की खपत को स्पष्ट रूप से निर्दिष्ट किया जाए, और स्थापना के परीक्षण और कमीशन के समय सत्यापित किया जाएगा। पंप को निष्पादन वक्र के सपाट हिस्से पर सर्वोत्तम दक्षता बिंदु के लिए चुना जाएगा।

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**एयर कंडीशनिंग और वेंटिलेशन  
कार्यों के लिए विनिर्देश**

**खंड - III**  
**शीतन (क्लिंग) टॉवर**

## 1. प्रेरित ड्राफ्ट FRP कूलिंग टॉवर

शीतन टावर SOQ में इंगित क्षमता के लिए उपयुक्त प्रेरित ड्राफ्ट FRP शीतन टॉवर होंगे और प्रत्यक्ष चालित ढलवां एल्यूमीनियम/फाइबर प्रबलित प्लास्टिक (FRP) अक्षीय प्रवाह पंखे, पूरी तरह से स्टार्टर के साथ पर्याप्त क्षमता की मौसम प्रूफ मोटर, जंगरोधी PVC भरे और इनलेट द्वार, बहाव निरसक, गर्म पानी वितरण कक्ष और नलिकाएं, बहाव निरसक ठंडे पानी बेसिन आदि से परिपूर्ण होगा।

कूलिंग टॉवर हल्के वजनी, मॉड्यूलर निर्माण और जंगरोधी होंगे। निविदा ड्राइंग के अनुसार शीतन टावर स्थापित की जाएगी। टावर की पूरी स्थापना के लिए जरूरी उपयुक्त पेडेस्टल सहारा और स्टील ग्रिलेज को A/C विक्रेताओं के कार्य में शामिल किया जाएगा और आवश्यकतानुसार पूरा किया जाएगा।

कूलिंग टॉवर का डिजाइन उस स्थान की परिवेशी स्थिति के लिए उपयुक्त होगा जहां टॉवर स्थापित होना है। कूलिंग टॉवर के गर्त में अधिमानतः चार मिनट की न्यूनतम अवधि के लिए जल संग्रहण क्षमता होगी।

सभी PVC भरत एक स्वचालित जल निकासी प्रणाली के साथ दोहरे मुड़े हुए होंगे, जिससे न्यूनतम दाब गिरावट और कटाव के सामने अच्छा संरक्षण होता है। वे स्वतः प्रक्रिया से चिपके हुए रहते हैं। भरत को 65 डिग्री सेल्सियस के तापमान के सामने टिके रहना होगा। उच्च दक्षता निर्मित ड्रिफ्ट एलिमिनेटर मानक डिजाइन स्थितियों के तहत 0.2% की अधिकतम बहाव क्षति सुनिश्चित करेगा। उप-वितरण पाइप कठोर PVC/ CPVC से 4 kg/cm<sup>2</sup> के परीक्षण-दाब के साथ बने होने चाहिए।

पैनल और मुख्य गर्त लंबे समय तक चलने वाले जंगरोधी फाइबर ग्लास के होंगे और विभिन्न रंगों में उपलब्ध होंगे। बेहतर गुणवत्ता वाले आइसोपैथैलिक राल और FRP मैटिंग घटकों को मजबूत बनाते हैं, ताकि वे वायु दाब, UV किरणों और जल उपचार रसायन आदि का सामना कर सकें।

अक्षीय प्रवाह पंखे स्थैतिक रूप से संतुलित होते हैं और नवीनतम मानकों के अनुसार ही बनाए जाते हैं। सभी मोटर IP 55 के साथ मानक TEFC की हैं, और मूल निर्माताओं द्वारा गारंटी दी जाती है।

क्लिंग टॉवर को निम्नलिखित न्यूनतम विनिर्देशों को पूरा करना होगा:

- टाइप: SOQ में दर्शाए अनुसार प्रेरित ड्राफ्ट काउंटर फ्लो/क्रॉस फ्लो
- वितरण: गुरुत्व प्रवाह (स्थिर)/मुख्य शीर्ष और शाखा सहायक प्रणाली
- पंखा सामग्री और प्रकार: ढलवां एल्यूमिनियम/FRP, अक्षीय प्रवाह
- प्रकार: प्रेरण प्रकार, पिंजरी (IP55), TEAO, IE3 या बेहतर कुशल
- टॉवर संरचना और बेसिन: फाइबर ग्लास
- भरत: UV स्थिरीकरण के साथ उच्च दक्षता PVC भरत पैक
- बहाव उन्मूलन: PVC
- भरत सहारा: तप्त निमज्जित जस्ती फ्रेम
- बर्ड स्क्रीन: तप्त निमज्जित जस्ती फ्रेम
- वितरण सहायता: तप्त निमज्जित जस्ती फ्रेम
- हार्डवेयर: स्टेनलेस स्टील
- नम बल्ब एप्रोच: 3 deg C
  - वाष्पीकरण क्षय: 0.96%
- बहाव क्षय: 0.2% से अधिक नहीं
- कुल पानी का नुकसान: अधिकतम 1.16% (बाहरी बहाव के बिना)

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**एयर कंडीशनिंग और वेंटिलेशन  
कार्यों के लिए विनिर्देश**

**खंड - IV**

**AC कार्यों के लिए पाइपिंग**

## 1. पूर्व-रोधक (प्री-इन्सुलेट) पाइपिंग

### 1.1 सामान्य:

1. इस खंड के दायरे में पूर्ण स्थापना के लिए जरूरी सभी जल प्रवाह पाइपिंग के निर्माण, आपूर्ति और बिछाने और वेंलिंग, पाइप फिटिंग और वाल्व, परीक्षण और संतुलन शामिल हैं।
2. पाइप के आकार अलग-अलग तरल प्रवाह की आवश्यकता के अनुसार होंगे। विभिन्न पाइप के आकार निविदा दस्तावेज की ड्रॉइंग और SOQ के अनुसार होंगे।
3. सभी पूर्व-पृथक ठंडे पानी/खारी पाइपिंग का डिजाइन तापमान (-)5°C से 30 °C के बीच होगा। सभी सीधे टुकड़े, एलबो, टी, रेड्यूसर, एंकर और अन्य सहायक उपकरण इस तरह डिजाइन किए जाएंगे ताकि पानी या नमी इन्शुलेशन में न जा सके और कारखाने में निर्मित, रोधित और जैकेट किया जाएगा।
4. सभी एलबो, टी, रेड्यूसर, एंकर और अन्य सहायक उपकरण इस तरह डिजाइन किए जाएंगे ताकि फ़ील्ड जोड़ केवल पाइप के सीधे हिस्से में बनाया जा सकें।
5. पाइपिंग सिस्टम को ASME B 31.1 के अनुसार डिजाइन, निर्मित और स्थापित किया जाएगा।
6. पूर्व-पृथक पाइपिंग की स्थापना पूर्व-पृथक पाइप निर्माता के निर्देशों के अनुसार होगी।

### 1.2 कार्बन स्टील सर्विस पाइप:

1. पाइप व्यास, मोटाई, IS कोड नीचे दी गई तालिका के अनुसार होगा।

पाइप का आकार	वॉल मोटाई और विनिर्माण मानक
150 मिमी और कम	IS 1239 के अनुसार हैवी ड्यूटी कार्बन पाइप

200 मिमी	IS 3589 2001 के अनुसार न्यूनतम 6 मिमी
300 मिमी	IS 3589 2001 के अनुसार न्यूनतम 6 मिमी
400 मिमी	IS 3589 2001 के अनुसार न्यूनतम 6 मिमी
500 मिमी	IS 3589 2001 के अनुसार न्यूनतम 6 मिमी
650 मिमी	IS 3589 2001 के अनुसार न्यूनतम 6 मिमी
800 मिमी	IS 3589 2001 के अनुसार न्यूनतम 8 मिमी

2. पाइप फिटिंग सामग्री मध्यम भार ASTM A234, ASTM A105 या ASTM A53 वाली यथा लागू विद्युत रोधी वेल्डिंग (ERW) होनी चाहिए। बट-वेल्ड फिटिंग ASME B 16.9 के अनुसार होंगे। सॉकेट वेल्ड फिटिंग ASME B 16.11 के अनुसार होंगे।

3. पाइप एलबो लंबे त्रिज्या वाले होंगे, ASME B 31.1 के अनुसार 1.5D न्यूनतम मध्यरेखा त्रिज्या या 2D मध्यरेखा त्रिज्या के लिए बने होंगे।

4. MSS SP-97 के अनुसार पूर्ण और न्यूनन टी फोर्जित टी होंगी या अंतरंग रूप से प्रबलित फोर्जित शाखा आउटलेट फिटिंग बनाई जाएगी या वेल्ड-ओ-लेट्स का उपयोग टी को न्यूनन करने के लिए किया जा सकता है।

### 1.3 सर्विस पाइप निर्माण:

1. सभी एलबो, टी, रेड्यूसर, एंकर और अन्य सहायक उपकरण इस तरह डिजाइन किए जाएंगे ताकि फील्ड जोड़ केवल पाइप के सीधे हिस्से में बनाया जा सकें।

2. सभी सर्विस पाइप वेल्डिंग ASME B 31.1 के अनुसार होनी चाहिए।

3. सभी वेल्ड प्रक्रियाएं और वेल्डर ASME खंड IX के अनुसार योग्य होंगे।

4. वेल्ड प्रक्रियाएं, प्रक्रिया योग्यताएं और वेल्डर योग्यताएं अनुमोदन के लिए प्रस्तुत की जाएंगी।

5. उचित संबंधन सुनिश्चित करने के लिए, सर्विस पाइप जंग, तेल, ग्रीस, धूल, नमी और अन्य दूषित पदार्थों से मुक्त होना चाहिए।

#### 1.4 इन्सुलेशन:

इन्सुलेशन सामग्री निविदा अनुसूची में निर्दिष्ट के अनुसार होगी।

##### 1.4.1 पॉल्युरिथेन फोम इन्सुलेशन (PUF)

1. इन्सुलेशन को सर्विस पाइप और जैकेट के बीच के कुंडलाकार स्थान को पूरी तरह से भरना होगा और दोनों से जोड़ा जाएगा। इन्सुलेशन उच्च दबाव इंजेक्शन मशीन पर किया जाएगा। प्रवाह की दिशाएं पाइपों पर चिह्नित की जाएंगी।

2. पाइपिंग में SOQ में बताए अनुसार वाल्व स्ट्रेनर, मापन उपकरण आदि शामिल होंगे। जहां आवश्यक हो वहां पाइपिंग उपयुक्त सहारे के साथ परिपूर्ण की जाएंगी। पाइप स्थापित होने और दाब परीक्षण करने के बाद, निर्माता/कंपनी की सिफारिशों के अनुसार जोड़/फिटिंग को पृथक किया जाएगा और आवश्यकतानुसार पूरा किया जाएगा।

3. बाहरी जैकेट सर्विस खाइयों के अंदर स्थापित करने वाले पाइपों के लिए 600 मिमी व्यास तक के आकार के लिए 0.6 मिमी लॉक सीम सर्पिल GI किया जाएगा और पाइप को भूमि में दबाने के लिए उच्च घनत्व वाले पॉलीथीन (HDPE) वाल होगा।

4. BS 476 के मुताबिक इन्सुलेशन O श्रेणी का होगा।

5. PUF इन्सुलेशन गुण ASTM C1029, कठोर सेलुलर पॉलीयूरेथन थर्मल इन्सुलेशन के लिए प्रयुक्त स्प्रे के लिए निर्दिष्टीकरण के अनुसार होगा। सामान्य तौर पर, PUF इन्सुलेशन निम्नलिखित विनिर्देशों के अनुसार होगा:

गुण	मान	परीक्षण का तरीका
ऊष्मीय चालकता	$\leq 0.023 \text{W/m } ^\circ\text{C}$	ASTM C518
संपीड्य क्षमता	$\geq 300 \text{kPa}$	ASTM D1621
संवृत सेल सामग्री	$\geq 88\%$	ASTM D6226



6. इन्सुलेशन की न्यूनतम मोटाई निम्न तालिका के अनुसार होगी:

पाइप का आकार	न्यूनतम इन्सुलेशन मोटाई
32 मिमी तक	25 मिमी
40 से 150 मिमी व्यास	30 मिमी
200 मिमी	50 मिमी
300 मिमी	50 मिमी
650 मिमी	75 मिमी

7. निर्माता को यह सुनिश्चित करना चाहिए कि फोम को सर्विस पाइप और जैकेट दोनों के बांधा जाएगा।

8. फोम इंजेक्शन निर्माण के मामले में, HDPE कसिंग को आंतरिक रूप से पॉलीयूरेथेन फोम और HDPE जैकेट के बीच इष्टतम बंधन के संबंधों के लिए उपचारित किया जाना चाहिए।

#### 1.4.2 पॉली - आइसोस्यानूरेट इन्सुलेशन:

1. इन्सुलेशन को सर्विस पाइप और इन्सुलेशन जैकेट के बीच के कुंडलाकार स्थान को पूरी तरह से भरना होगा। वाष्प बाधक और इन्सुलेशन जैकेट लगाने से पहले रिक्तियों के लिए अग्नि रेटित पॉली - आइसोस्यानूरेट इन्सुलेशन का आंखों से निरीक्षण किया किया जाएगा। प्रवाह की दिशाएं पाइपों पर चिह्नित की जाएंगी।

2. 200 मिमी और अधिक आकार वाले पाइपों के लिए अग्नि रेटित पॉली - आइसोस्यानूरेट इन्सुलेशन को सीधे सर्विस पाइप पर स्प्रे करके लगाया जाएगा।

3. 150 मिमी और कम आकार वाले पाइपों के लिए और फिटिंग के अग्नि रेटित पॉली - आइसोस्यानूरेट इन्सुलेशन को, सर्विस पाइप और इन्सुलेशन जैकेट के बीच कुंडलीय स्थान में डाला जा सकता है।

4. BS 476 के मुताबिक इन्सुलेशन O श्रेणी का होगा।

5. सर्विस पाइप इन्सुलेशन कठोर, संवृत सेल अग्नि रेटित पॉली-आइसोस्यानूरेट इन्सुलेशन होगा जिसमें तालिका में नीचे सूचीबद्ध न्यूनतम गुण होंगे।

गुण	मान	परीक्षण का तरीका
ऊष्मीय चालकता	$\leq 0.026 \text{W/m}^2\text{C}$	ASTM C518
संपीड्य क्षमता	$\geq 300 \text{kPa}$	ASTM D1621
संवृत सेल सामग्री	$\geq 88\%$	ASTM D6226
अग्नि रेटिट	श्रेणी 1	BS 476, Part 7

6. न्यूनतम इन्सुलेशन मोटाई निम्न होगी:

पाइप का आकार	न्यूनतम इन्सुलेशन मोटाई
150 मिमी तक	30 मिमी
200 मिमी	50 मिमी
300 मिमी	50 मिमी
400 मिमी	50 मिमी
500 मिमी	75 मिमी
650 मिमी	75 मिमी
800 मिमी	100 मिमी

### 1.5 बाहरी जैकेट आवश्यकताएं:

1. बाहरी जैकेट सर्विस खाइयों के अंदर स्थापित करने वाले पाइपों के लिए 600 मिमी व्यास तक के आकार के लिए 0.6 एमएम लॉक सीम सर्पिल GI किया जाएगा और पाइप को भूमि में दबाने के लिए उच्च घनत्व वाले पॉलीथीलीन (HDPE) वाला होगा। सीधे जोड़ों और सभी फिटिंग दोनों के लिए बाहरी जैकेट लगाया जाएगा। HDPE जैकेट के मामले में, यह ASTM D3350 के न्यूनतम सेल वर्गीकरण PE 345444C के अनुसार होगा और न्यूनतम मोटाई 3 मिमी से 300 मिमी तक और न्यूनतम 5 मिमी से 650 मिमी/800 मिमी होगी।

2. GI बाहरी जैकेट के मामले में, स्टेनलेस पट्टियों का उपयोग करके उसे भी लगाया जाएगा। आपूर्तिकर्ता की सिफारिश के अनुसार अंतराल रखा जाएगा।

3. GI जैकेट के नीचे ग्लास प्रबलित एल्यूमीनियम वाष्प अवरोधक लगाया जाएगा। वाष्प अवरोधक BS 476 भाग 7 के अनुसार श्रेणी 1 अग्नि रेटित होगी।

4. फिटिंग के लिए जैकेट को एकसाथ संचरित, रिविट या स्क्रू लगाया जाएगा और इस तरह लगाया जाएगा कि वाष्प अवरोधक क्षतिग्रस्त नहीं हो जाए।

5. 900 मिमी या इससे अधिक आकार वाले पाइप की फिटिंग के लिए फाइबर ग्लास प्रबलित प्लास्टिक (FRP) जैकेट का इस्तेमाल किया जा सकता है। फिटिंग के लिए FRP जैकेट सीमलेस होगा, चोप स्प्रे को लगाया जाएगा।

### 1.6 स्थापना और गुणवत्ता की आवश्यकताएं:

1. इस विनिर्देश का अनुपालन सुनिश्चित करने के लिए पूर्व-पृथक पाइप निर्माता के पास गुणवत्ता आश्वासन कार्यक्रम होगा।

2. सभी सर्विस पाइप वेल्ड्स का गैर-विनाशकारी परीक्षण ASME B 31.1 के अनुसार किया जाएगा।

3. अग्नि रेटित पॉली-आइसोसैयानूरेट इन्सुलेशन की गुणवत्ता सुनिश्चित करने के लिए निम्नांकित परीक्षण किए जाएंगे। अनुपालन दिखाने के लिए परीक्षण रिपोर्ट प्रदान की जाएंगी।

ए. ऊष्मीय चालकता

बी. संपीड्य क्षमता

सी. संवृत सेल सामग्री

4. सभी सामग्रियों का कारखाने में निरीक्षण किया जाएगा और सावधानीपूर्वक लोड किया जाएगा और जॉब साइट तक पहुंचने में होने वाले नुकसान को रोकने के लिए बांधा जाएगा। सामग्री प्राप्त होने के बाद, इसे स्पष्ट रूप से निरीक्षण किया जाएगा और सभी संबंधित दस्तावेजों की जांच की जाएगी।

5. नुकसान से बचने के लिए उचित देखभाल और हैंडलिंग तकनीकें अपनाई जाएंगी।

6. पाइपिंग यूनिट को संभालने के लिए निम्नलिखित निर्देश पालन किया जाए:

ए. हैंडलिंग के सभी चरणों के दौरान प्रत्येक पाइपिंग यूनिट को नायलॉन स्लिंग से सहारा दें।

बी. किसी भी पाइपिंग यूनिट को संभालने के लिए हुक, स्टील केबल या चेन का उपयोग न करें।

सी. किसी भी समय कठोर सतहों पर पाइपिंग यूनिटों का ना टकराएं।

डी. पाइपिंग यूनिटों को संभालने के लिए फोर्कलिफ्ट का उपयोग न करें।

7. यदि संभव हो तो, हैंडलिंग के दौरान पाइपिंग यूनिटों के अधिकतम नियंत्रण के लिए स्प्रेडर बार का उपयोग करें।

### 1.7 पाइपिंग यूनिट:

1. सभी पाइपिंग यूनिटों को गोदाम या गर्म स्थल में या उच्च भूमि पर रखें ताकि पाइप सिरों में पानी प्रवेश नहीं कर सके।

2. जब स्टैकिंग किया जाता है, तो पाइपिंग यूनिटों को उसी तरह स्टैक करें जैसी वे प्राप्त हुई थी।

3. पाइप के परतों के बीच रनर के रूप में लकड़ी के ढांचे का उपयोग करना चाहिए।

4. तीन (3) टीयर से अधिक ऊंचाई तक यूनिटों यूनिट को स्टॉक ना करें। परतों के बीच फोम या अन्य पैडिंग का उपयोग करें।

5. यदि पाइपिंग यूनिटों के सिरे को प्लास्टिक के कवर और/या प्लास्टिक पाइप के अंत कैप के साथ भेजा गया हो, तो पाइपिंग यूनिटों को रखते समय उन्हें नहीं हटाएं।

6. शिपिंग या हैंडलिंग में अगर कोईभी सुरक्षात्मक कवर क्षतिग्रस्त हो गया हो, तो आवश्यकतानुसार सुरक्षात्मक प्लास्टिक के कवर लगा देने चाहिए।

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## 2. शीतित और कंडेन्सर जल पाइपिंग

### 2.1 कार्यक्षेत्र:

इस खंड के दायरे में निविदा दस्तावेज की ड्रॉइंग के अनुसार पूर्ण स्थापना के लिए जरूरी सभी जल प्रवाह पाइपिंग के निर्माण, आपूर्ति और बिछाने और वेल्डिंग, पाइप फिटिंग और वाल्व, परीक्षण और संतुलन शामिल हैं। पाइप के आकार अलग-अलग तरल प्रवाह की आवश्यकता के अनुसार होंगे। विभिन्न पाइप के आकार निविदा दस्तावेज की ड्रॉइंग और SOQ के अनुसार होंगे। फिटिंग और वाल्व सहित सभी पाइपिंग लागू भारतीय मानक SOQ के अनुसार होंगे। पाइप SOQ में दर्शाए अनुसार ERW/सीमलेस होंगे।

### 2.2 शीतित और कंडेन्सर जल पाइपिंग

1. ठंडे पानी और कंडेन्सर पानी के सभी पाइप और फिटिंग MS (भारी श्रेणी) की होगी जो 150 मिमी व्यास तक के पाइप के आकार के लिए IS 1239 की पुष्टि करेंगे। 200 मिमी व्यास और अधिक के पाइप के आकार के लिए IS 3589 के अनुसार होगी, जिसकी 650 व्यास तक के लिए न्यूनतम मोटाई जब तक स्पष्ट नहीं किया गया हो 6 मिमी होगी और 650 व्यास से अधिक के पाइप के लिए जब तक स्पष्ट नहीं किया गया हो 8 मिमी मोटाई होगी। पाइप सिस्टम में सभी जोड़ आम तौर पर वेल्डिंग द्वारा लगाए जाएंगे, जब तक अन्यथा उल्लेख नहीं किया जाए या साइट पर निर्देशित किया जाए। सभी वेल्डिंग प्रशिक्षित वेल्डर द्वारा की जाएंगी और प्रासंगिक IS या समकक्ष मानकों के अनुसार मृदु स्टील के मैनुअल धातु वेल्डिंग के लिए भारतीय मानक कोड प्रक्रिया के बिल्कुल अनुरूप होंगे। कंडेन्सर और ठंडे पानी की लाइन में संयंत्र के कमरे पर 40 मिमी आकार के त्वरित भराई कनेक्शन व्यवस्था होनी चाहिए जिसके साथ पूर्ण मार्ग वाल्व और उसी आकार की निकासी लाइन होनी चाहिए।

2. सभी पाइप और उनके स्टील के आधारों को पूरी तरह से साफ किया जाएगा और स्थापित करने से पहले लाल आक्साइड रंग का एक प्राथमिक कोट लगाया जाएगा। ठंडे पानी की सभी पाइपिंग करीने से ढाले 48 kg/cum घनत्व वाले PUF ब्लॉक या 65 मिमी मोटाई के सागौन लकड़ी के ब्लॉक पर टिकी रहेंगी जिन्हें पाइप की त्रिज्या में खांचे के साथ और

MS एंगल्स/चैनल पर बिठाया जाएगा। सभी वेल्डेड पाइपिंग को साइट पर अनुमोदन करवाना होगा।

3. पाइपिंग सिस्टम के लिए फिटिंग उपयुक्त दाब रेटिंग की लचीली ढलाई वाली होगी। वेल्डेड पाइपिंग पर उपयोग की जाने वाली फिटिंग वेल्डेबल प्रकार की होनी चाहिए।

4. टी-ऑफ कनेक्शन समान या घटती टी के जरिए होंगे, अन्यथा मुख्य पाइप में वेल्डेड फेरुलों का इस्तेमाल किया जाएगा। मुख्य पाइप की दीवारों के ड्रिलिंग और टैपिंग का सहारा नहीं होना चाहिए।

5. निविदा ड्रॉइंग में दिखाए अनुसार निम्न विनिर्देशों के अनुरूप बॉल वाल्व, तितली वाल्व, ग्लोब वाल्व लगाए जाएंगे:

आकार	निर्माण	सिरे
15 से 40 मिमी	गन मेटल	स्कू लगे
50 मिमी और अधिक	कांस्य या गन धातु या नाइट्रेल रबड़ का का भाग ढलवां लोहा स्पिंडल और वाल्व सीट (तितली वाल्व के मामले में)	फ्लैज लगे

6. सभी वाल्व प्रासंगिक IS या समकक्ष मानकों के अनुरूप हैवी ड्यूटी (मजबूत) वाले होंगे। जब तक अन्यथा निर्दिष्ट नहीं किया जाए, वाल्व में नॉन-राइजिंग स्पिंडल होंगी और ये कम से कम 6 किलोग्राम प्रति वर्ग सेमी गेज कार्यकारी दाब के लिए उपयुक्त होंगी।

7. तितली वाल्व पृथक वाल्वों का कार्य करेगा और काले नाइट्राइल सीट के साथ ढलवां लोहे की बॉडी (निकाय) बनायी जाएगी। सभी तितली वाल्व लॉकिंग उपकरणों के साथ प्रदान किये जाएंगे। 300 मिमी व्यास और अधिक वाले वाल्व गियर संचालित होंगे।

8. सभी AHU और चिलरों में दाब गिरावट मापने की निर्मित सुविधा के साथ संतुलन/नियंत्रण वाल्व लगाए जाएंगे। पानी का प्रवाह मॉनिटर स्क्रीन पर डेटा निष्पादन के साथ ऑनलाइन हाइड्रोनिक संतुलन प्रणाली द्वारा मापा जाएगा।

9. फ्लैज स्लिप पर उत्थापित फलक प्रकार के होंगे। फ्लैज की आपूर्ति में बोल्ट और नट और उपयुक्त एस्बेस्टस/फाइबर रबड़ प्रविष्टि गास्केट (न्यूनतम 3 मिमी मोटी) की आपूर्ति शामिल हैं।

10. नॉन-रिटर्न (चेक) वाल्व IS 778 और IS 5312 के अनुरूप ड्रॉइंग में दिखाए अनुसार और निम्नलिखित विनिर्देशों के अनुसार लगाए जाएंगे।

आकार	निर्माण	सिरे
10 से 40 मिमी	गन मैटल	स्कू लगे
50 मिमी से 150 मिमी	ढलवां लोहा या गन मैटल या नाइट्रेल रबड़ का का भाग ढलवां लोहा स्पिंडल और वाल्व सीट (तितली वाल्व के मामले में)	फ्लैज प्रकार के
200 मिमी से 450 मिमी	बॉडी ढलवां लोहा, प्लेट	13% क्रोम ओवरले के साथ फ्लैज कार्बन स्टील

11. स्प्रिंग और कब्जे/स्टॉप पिन SS 304 के होंगे और अग्निरोधक सामग्री वाले होंगे। वाल्व कम से कम 16 किलोग्राम प्रति वर्ग सेमी गेज कार्यकारी दाब के लिए उपयुक्त होंगे।

12. नॉन-रिटर्न वाल्व स्विंग चेक वाल्व होंगे, जिन्हें सामान्यतः सभी जल सेवाओं में इस्तेमाल किया जाता है। क्षैतिज रन में लिफ्ट प्रकार के वाल्व का उपयोग किया जा सकता है वाल्व कम से कम 16 किलोग्राम प्रति वर्ग सेमी गेज कार्यकारी दाब के लिए उपयुक्त होंगे।

13. स्ट्रेनर 'Y' प्रकार या ड्रॉइंग में दिखाए अनुसार पॉट स्ट्रेनर जैसे होंगे, जो तितली वाल्व के लिए निर्दिष्ट परीक्षण दाब के लिए डिजाइन वाली ढलाई बॉडी वाले होंगे। स्ट्रेनर में 3 मिमी छिद्रों के साथ कांस्य स्क्रीन होगी। मुख्य पाइपों को बाधित किए बिना स्क्रीन हटाने

योग्य और बदलने योग्य होगी। सभी स्ट्रेनर को अलग-अलग वाल्व लगाए जाएंगे जिससे सिस्टम को खाली किए बिना स्ट्रेनर साफ हो सके। प्रत्येक पंप के इनलेट साइड (सक्शन पर) पर, और निविदा ड्रॉइंग में दिखाए अनुसार स्ट्रेनर लगाए जाएंगे।

14. पॉट स्ट्रेनर को MS शीट से निम्नांकित कांस्य/SS 304 टोकरी के आकार के अनुसार तैयार किया जाएगा:

पाइप आकार (मिमी)	पॉट व्यास (मिमी)	पॉट Ht (मिमी)	टोकरी व्यास (मिमी)	टोकरी Ht	टोकरी की मोटाई
50	300	400	200	240	24 गेज
80	350	450	250	250	
100	450	500	300	280	
125	500	600	330	340	22 गेज
150	540	700	360	390	
200	610	815	400	470	
250	800	955	550	510	
300	1000	1105	750	580	
350	1190	1300	895	678	20 गेज
400	1350	1500	1020	785	
450	1518	1700	1060	890	
500	1690	1800	1100	900	

15. पॉट स्ट्रेनर 100 मिमी व्यास तक की MS प्लेट से बनाया जाएगा, पाइप 6 मिमी मोटी MS शीट, 8 मिमी मोटाई के 125 मिमी से 300 मिमी व्यास और 12 मिमी मोटाई से ऊपर के लिए बड़े आकार के पाइप से बनाये जाएंगे। सभी स्ट्रेनर का आकार ऐसा होगा कि छिद्रित पात्र से न्यूनतम प्रतिरोध प्रदान कर सके और आकार दी गई तालिका के अनुसार होगा।



16. पाइप बैंड 150 मिमी व्यास तक पूर्वनिर्मित होंगे। साइट पर बने गए पाइप बैंड के बैंड खंड 15 डिग्री कोण से अधिक नहीं होंगे। इस प्रकार 6 वेल्डिंग जोड़ों के साथ 90° बैंड लगाए जाएंगे। पाइपों को विद्युत आरा/लोहा आरी से ही काटा जाना चाहिए, इसके बाद V-खांचा बनाने के लिए हाथ से घिसा जाएगा।

17. ठंडे पानी वाली सभी पाइपिंग और फिटिंग का दाब परीक्षण किया जाएगा, फिर "इन्सुलेशन" खंड में वर्णित इन्सुलेशन किया जाएगा।

18. सभी शीतित/कंडेन्सर पानी पाइपिंग स्थापित करने के बाद; नीचे दिए गए खंड 2.5 के अनुसार सिस्टम का दाब परीक्षण किया जाएगा। पाइपिंग, फिटिंग और आधारों को लाल ऑक्साइड रंग के एक कोट और 3-3 मिलों की दो फिनिश कोट के साथ पेंट किए जाएंगे, इनमें से प्रत्येक अनुमोदित रंग का IS 2379 के अनुरूप सिंथेटिक इनेमल पेंट होगा (शीतित पानी की पाइपिंग के मामले में, पाइप के इन्सुलेशन के बाद पेंट किया जाएगा)। पाइपों में द्रव प्रवाह की दिशा स्पष्ट रूप से तीरों के निशान के साथ चिह्नित की जाएगी।

19. शीतित और कंडेन्सर पानी की पाइपिंग में अनुमार्ग में उच्चतम बिंदु और न्यूनतम बिंदु पर क्रमशः उपयुक्त आकार के ऑटो एयर वेंट और गन मेटल ड्रेन वाल्व लगाए जाएंगे। वायु वेंट की सर्विस में आसानी के लिए 15 मिमी व्यास पाइप कनेक्शन, नाली पाइप कनेक्शन और अंतर्निर्मित पृथकन लगाया जाएगा।

### 2.3 कंडेन्सेट और ड्रेन पाइपिंग

1. ठंडे पानी (मेकअप), निकास और घनीभूत निकास के लिए इस्तेमाल किए जाने वाले सभी पाइप अनुमोदित कंपनी के होंगे और फिटिंग IS 4736 या जस्ती इस्पात श्रेणी B (मध्यम श्रेणी) के अनुसार प्रासंगिक IS कोड के अनुरूप होगी।

2. पाइप प्रणाली में सभी जोड़ों को सख्त नहीं होने वाले स्नेहक से बनी सीलिंग सामग्री के द्वारा स्कू से कसा जाएगा और/या 3 मिमी 3 प्लाई रबड़ गॉस्केट का उपयोग करके फ्लैज के जरिए फिटिंग किया जाएगा। पाइप की चूड़ियां और फ्लैज प्रासंगिक IS या समकक्ष मानकों के अनुसार होंगे।

3. सभी पाइप और उनके स्टील के आधारों को पूरी तरह से साफ किया जाएगा और स्थापित करने से पहले लाल आक्साइड रंग का एक प्राथमिक कोट लगाया जाएगा।

4. फिटिंग पाइपिंग सिस्टम के लिए उचित दाब रेटिंग का इस्पात 'मध्यम श्रेणी' की लचीली ढलाई वाली होगी। फ्लैंज स्वीकृत मेक का होगा। आवश्यकता के अनुसार फ्लैंज की आपूर्ति बोल्ट, वाशर और गॉस्केट शामिल होंगे। भविष्य में पाइपिंग की सफाई और सर्विसिंग के लिए पर्याप्त संख्या में फ्लैंज और यूनियन लगाए जाएंगे। टी-ऑफ कनेक्शन सब जगह समान या घटती टी के होंगे। सभी उपकरण और वाल्व कनेक्शन या किसी भी अन्य मेटिंग पाइप के कनेक्शन 50 मिमी व्यास तक के लिए यूनियन/कसे हुए फ्लैंज द्वारा होंगे और बड़े व्यास के लिए कसे हुए फ्लैंज से, या मेटिंग कनेक्शन के लिए, यथावश्यक, होंगे।

5. ठंडे पानी वाली सभी पाइपिंग और फिटिंग का दाब परीक्षण किया जाएगा, फिर "इन्सुलेशन" खंड में वर्णित इन्सुलेशन किया जाएगा।

6. पाइपिंग लग जाने, परीक्षण करने और कम से कम तीन दिनों तक आठ-आठ घंटे चलने के बाद, सभी पाइपिंग और पाइप आधारों पर लाल आक्साइड रंग की एक कोट और अनुमोदित रंग सिंथेटिक इनेमल पेंट IS 2379 के अनुरूप तीन मिल (0.0762 मिमी) के दो-दो कोट लगाए जाएंगे।

7. पाइपों में द्रव प्रवाह की दिशा स्पष्ट रूप से तीरों के निशान के साथ चिह्नित की जाएगी।

## 2.4 पाइपिंग की स्थापना:

1. निविदा ड्रॉइंग में पाइपों के आकार और स्थान की रूपरेखा दर्शाई गई है। कार्य मिलने पर ठेकेदार, विस्तृत कार्यकारी ड्रॉइंग तैयार करेगा जिसमें अनुप्रस्थ-काट, अनुदैर्घ्य खंड, फिटिंग का विवरण, पृथक और नियंत्रण वाल्व, नाली और वायु ऑटो वेंट वाल्व और सभी पाइपों के आधार दर्शाए जाएंगे। विक्रेता को भवनों और अन्य संरचनाओं के विशिष्ट छिद्रों को ध्यान में रखना चाहिए जिनके द्वारा पाइप गुजरने के लिए डिज़ाइन किया गया है।

2. पाइपिंग को उचित सहारा दिया जाएगा, या स्टैंड, क्लैंप, हैंगर से लटकाया जाएगा जैसा कि निर्दिष्ट और आवश्यक होगा। ठेकेदार पर्याप्त रूप से सभी ब्रेकट, सैडल, लंगर, क्लैंप और हैंगर को डिजाइन करेगा, और उनकी संरचनात्मक पर्याप्तता के लिए जिम्मेदार होगा।

3. पाइप के आधार स्टील के होंगे, ऊंचाई के लिए समायोज्य होंगे और जंगरोधी पेंट प्राइमर लगाया जाएगा और फिनिश कोट काली होगी। पाइप और क्लैंप अलग-अलग सामग्री के हों, तो पाइप आधार के अंतराल के बीच एक गैसकेट लगाई जाएगी जो निम्नलिखित से अधिक नहीं होगी:

पाइप आकार	ROD व्यास (मिमी)	बेस आधार
125 मिमी तक	10	क्लैंप आधार
150 मिमी से 200 मिमी	15	ISMC 75
250 मिमी	20	ISMC 150 *
300 मिमी	22	ISMC 150 *
350, 400 मिमी	25	ISMC 150 *
450, 500 मिमी	32	ISMC 150 *
600 मिमी	32	ISMC 200 *

\* तल से लगे आधार को प्राथमिकता दी जाएगी।

पाइप आकार	आधारों के बीच अंतराल
40 मिमी तक	1.5 मीटर

50 से 150 मिमी	2.0 मीटर
150 मिमी से अधिक	2.5 मीटर

4. ऊर्ध्वाधर राइज़र (उद्वाही) दीवारों और स्तंभ लाइनों के समानांतर होंगे और सीधे और लंबवत होंगे। फर्श से फर्श तक गुजरने वाले राइज़र प्रत्येक मंजिल पर पाइप से जुड़े क्लैंप या कॉलर और 15 मिमी मोटे रबड़ पैड या किसी लचीली सामग्री पर अवलंबित होंगे। जहां पाइप छत फर्श से गुजरते हों, वहां जल रिसाव को रोकने के लिए उपयुक्त जोड़ लगाया जाएगा। राइज़र में सबसे निम्न स्थल पर उपयुक्त सफाई द्वार होगा और उच्चतम स्थल पर हवादार छिद्र होगा।

5. जहां पाइप दीवारों और स्लैब से गुजरते हैं, वहां पाइपों की तुलना में 50 मिमी बड़े व्यास वाली पाइप आस्तीन लगाई जाएगी, और कुंडलीदार जगह फाइबर ग्लास से भरी जाएगी और रिटेनर रिंग के साथ फिनिश की जाएगी।

6. इन्सुलेशन वाली पाइपिंग को इस तरह से सहारा दिया जाएगा जिससे इन्सुलेशन पर अनुचित दाब नहीं डालें। इन्सुलेशन और क्लैम्प, सैडल या रोलर के बीच 14-गेज (2 मिमी) धातु की शीट लगाई जाएगी, जिसका जिसमें क्लैम्प, सैडल या रोलर के दोनों तरफ के कम से कम 150 मीटर तक विस्तार होगा।

7. सभी पाइप कार्य कारीगर की तरह करना होगा, जिससे मौजूदा सेवाओं, इमारतों, छतों और संरचनाएं न्यूनतम बाधित हों। अन्य एजेंसियों के कामकाज से परामर्श करके पूरी पाइपिंग का आयोजन किया जाएगा, जिससे प्रत्येक क्षेत्र के लिए पाइप आधार, पाइप बिछाने और दाब परीक्षण एक बार में ही कर लिया जाए।

8. विभिन्न पाइपों को लगाने के लिए फर्श स्लैब में कट-आउट ड्रॉइंग में दर्शाए गए हैं। ठेकेदार सावधानीपूर्वक दिए गए कट-आउटों की जांच करेगा और स्पष्ट रूप से ड्रॉइंग में दिखाए गए उन कट-आउटों को इंगित करेगा जो आवश्यकताओं के अनुरूप नहीं हैं।

9. ठेकेदार यह सुनिश्चित करेगा कि पाइप सहारे के लिए उपलब्ध क्लैंप, ब्रैकेट, क्लैम्प सैडल और हैंगर पर्याप्त हैं। पाइपिंग लेआउट पाइपों में विस्तार और संकुचन के लिए उचित ध्यान रखेगा, और जहां आवश्यकता होगी विस्तार लूप शामिल करेगा।

10. सभी पाइपों को IS 554 के अनुसार आवश्यक आकारों में बिल्कुल सही काटा जाएगा और बिछाने से पहले बर्न हटाए जाएंगे। पाइपिंग के खुले सिरे बंद किये जाएंगे क्योंकि पाइप विजातीय पदार्थ के प्रवेश से बचने के लिए लगाए गए हैं। जहां रेड्यूसर (लघुकारी) क्षैतिज रनों में बनाये जाते हैं, वहां पाइपिंग से मुक्त रूप से निकासी के लिए संकेंद्रित रेड्यूसर का उपयोग किया जाएगा। ऊर्ध्वाधर पाइपों में, गाढ़े रेड्यूसर का उपयोग किया जाएगा।

11. सभी वेल्डेड पाइपों की भविष्य में सफाई की सुविधा के लिए निर्माण के लिए अनुमोदित ड्रॉइंग में दिखाए अनुसार दोनों सिरों पर बोल्ट फ़्लैन्ज के साथ 1.5 मीटर लंबे फ़्लैन्ज निरीक्षण टुकड़े लगाए जाएंगे जिनकी दूरी केंद्र से केंद्र तक में 30 मीटर से अधिक नहीं होगी।

12. सभी दबाए पाइपों को 100 मिमी कंक्रीट तल पर बिछाया जाएगा और पाइप को तकनीकी विनिर्देश के इन्सुलेशन खंड के अनुसार इन्सुलेशन करना होगा।

13. दबाई पाइपिंग को पाइप के ऊपर से 300 मिमी तक भरा जाएगा और फिर पत्थर मुक्त मिट्टी से भरना होगा और क्षेत्र को मजबूत करने के लिए इसे जमाया (संहत किया) जाएगा।

14. उचित रखरखाव के लिए दबाई पाइपिंग के लिए वाल्व को चिनाई वाले वाल्व कक्ष के साथ लगाया जाना चाहिए।

15. वायु निकासी के लिए पाइपिंग सिस्टम में सभी निर्दिष्ट बिंदुओं पर ऑटो/मैनुअल वायु निकासी वाल्व लगाए जाएंगे। रखरखाव में आसानी के लिए सभी वाल्व नाली कनेक्शन और नॉन-रिटर्न वाल्व के साथ 20 मिमी/15 मिमी पाइप आकार के होंगे। वायु वाल्वों से निर्मुक्ति निकटतम नाली या संप तक समान आकार की मृदु स्टील या जस्ती स्टील पाइप पाइप के द्वारा की जाएगी। सभी पाइप नाली बिंदु की ओर खड़े किये जाएंगे।

16. निविदा में निर्दिष्ट SS सुई वाल्व के साथ दाब गेज ठंडे पानी/कंडेन्सर पानी पंपों की आपूर्ति के चूषण और निर्मुक्ति पर लगाए जाएंगे और ड्रॉइंग में दिखाये और अनुसूची में शामिल के अनुसार एयर हैंडलिंग यूनिटों पर, चिलरों पर और कंडेन्सर पर वापस आना होगा। दाब परीक्षण के दौरान दाब गेज की सुरक्षा का ध्यान रखना होगा।

17. प्रत्येक एयर हैंडलिंग यूनिट पर तापमान गेज प्रदान किया जाएगा आपूर्ति और वापसी ठंडा पानी लाइन, चिलर्स पर, और कंडेन्सर, जैसा कि निविदा ड्रॉइंग में दिखाया गया है और मात्रा के अनुसूची में शामिल है।

## 2.5 परीक्षण और संतुलन:

1. सभी पाइपिंग को कम से कम 24 घंटे की अवधि के लिए अधिकतम ऑपरेटिंग दाब गेज से कम से कम 1.5 गुना के हाइड्रोस्टैटिक परीक्षण दाब के लिए परीक्षण किया जाएगा। परीक्षण के दौरान प्रकट जोड़ों में सभी लीक और खराबी ठीक की जाएगी और साइट पर अनुमोदित करवाई जाएगी।

2. उपरोक्त दाब परीक्षण के बाद पाइपिंग की मरम्मत की पुनः जांच उसी तरीके से की जाएगी।

3. सिस्टम का परीक्षण खंडों में किया जा सकता है और इस तरह के खंडों को सुरक्षित रूप से ढंका जाएगा, फिर पूरे सिस्टम का पुनः परीक्षण किया जाएगा।

4. ठेकेदार साइट पर सभी अन्य एजेंसियों को पाइपिंग के एक खंड या खंडों का परीक्षण करने के अपने इरादे के लिए पर्याप्त सूचना देगा और सभी परीक्षणों को विभाग के प्रतिनिधि द्वारा देखा और दर्ज किया जाएगा।

5. ठेकेदार को यह सुनिश्चित करना होगा कि संबंधित प्रणाली में सभी कॉइल और अन्य ताप विनिमय उपकरणों के जरिए द्रव की उचित शांत परिसंचरण प्राप्त किया जायेगा। अनुचित परिसंचरणों के मामले में, ठेकेदार खराब कनेक्शनों को ठीक करेगा। विक्रेता आवश्यकता के अनुसार फर्श और दीवारों को उखाड़ने और पुनः ठीक करने सहित, उपरोक्त सुधारों को ठीक करने का सारा खर्च उठाएगा।

6. ठेकेदार परीक्षण करने के लिए और सफाई और परीक्षण के परिणामस्वरूप निकले पानी को हटाने के लिए आवश्यक सभी सामग्री, उपकरण, उपकरण, उपकरणों, सेवाओं और श्रम प्रदान करेगा।

7. स्थापित करने के बाद, सभी जल-प्रणाली को अलग-अलग एयर हैंडलिंग यूनिटों और पंखा कुंडली यूनिट को शीतल कुंडली में निर्दिष्ट, उद्धृत या निर्देश के अनुसार पानी की मात्रा को वितरित करने के लिए समायोजित और संतुलित करना होगा।

8. संतुलन के लिए उपलब्ध कराई गई संतुलन कॉक से जल सर्किट समायोजित किया जाएगा; संतुलन पूरा होने के बाद इन्हें स्थायी रूप से चिह्नित किया जाएगा ताकि बाधित होने पर वे अपने सही स्थिति पर बहाल किए जा सकें।

9. पूर्ण प्रमाणित संतुलन रिपोर्ट मूल्यांकन और अनुमोदन के लिए प्रस्तुत की जाएगी। अनुमोदन के बाद, संतुलन रिपोर्ट की चार प्रतियां पूरी आरेखण और दस्तावेजों के साथ प्रस्तुत की जाएंगी।

10. सर्विस क्षेत्रों में खुले पाइपों और इन्सुलेशन सतह/आवरण पर स्पष्ट रूप से चिह्नित नाम और तीरों के साथ अनुमोदित रंग लगाया जाएगा।

## **2.6 शीतित जल पाइप इन्सुलेशन:**

ठंडे पानी के पाइपों के लिए इन्सुलेशन के लिए सामग्री निविदा अनुसूची में निर्दिष्ट के अनुसार होगी।

### **2.6.1 नाइट्राइल रबड़ का प्रयोग करके इन्सुलेशन:**

#### **ए) इन्सुलेशन सामग्री:**

1. इन्सुलेशन सामग्री संवृत सेल इलास्टोमेरिक नाइट्राइल रबड़ की होगी।
2. इलास्टोमेरिक नाइट्राइल रबड़ की तापीय चालकता  $0^{\circ}\text{C}$  के औसत तापमान पर  $0.035\text{W}/(\text{m}\cdot\text{K})$  से अधिक नहीं होगी।

3. इन्सुलेशन में अग्निरोधी निष्पादन इस तरह होगा कि यह BS 476 भाग 7 के अनुसार कक्षा 1 पार करे, कक्षा 'O' फायर श्रेणी की आवश्यकता को पूरा करने के लिए BS 476 भाग 6 के अनुसार आग प्रसार की आवश्यकता को पार करे।

4. यह स्व-शामक होना चाहिए, ड्रिप नहीं करना चाहिए और लपटों को नहीं फैलाना चाहिए।

5. बिना किसी आवरण के इन्सुलेशन सामग्री के लिए नमी प्रसार रोधी कारक या 'μ' मान न्यूनतम 7,000 होगा।

#### बी) अनुशंसित आसंजक:

1. आसंजक विशेष रूप से पाइप इन्सुलेशन में लगाने के लिए तैयार किया जाएगा और इन्सुलेशन निर्माता द्वारा आपूर्ति की जाएगी।

2. आसंजक बेंजीन से मुक्त विलायक आधारित रबड़ इन्सुलेशन आसंजक होगा।

3. यह छिद्रिल और अछिद्रिल सतहों के लिए उत्कृष्ट बंधनकारी होना चाहिए।

4. आसंजक उष्णकटिबंधीय परिस्थितियों के लिए त्वरित सूखने के लक्षण वाला होगा और इसका सर्विस तापमान  $-25^{\circ}\text{C}$  to  $+90^{\circ}\text{C}$  होगा।

#### 5. गुणधर्म:

श्यानता @ $30^{\circ}\text{C}$	:	3500 - 4000 cps
विशिष्ट गुरुत्व	:	0.89 - 0.92 g/cc
घनत्व	:	$0.085 \text{ kg/m}^3 + 0.01$
ज्वलन बिंदु	:	$> 10^{\circ}\text{C}$
व्यापकता	:	बंधनकारी सामग्री/लीटर का 4-5 वर्ग मीटर
सूखने का समय	:	7 - 8 मिनट
टैक अवधारण अवधि	:	25 मिनट



## 2.6.2 इन्सुलेशन सामग्री के बाहरी आवरण के लिए बॉन्डेड उपचारित बुना ग्लास फाइबर

1. तापमान रेंज: 0°C to +105°C कुल मिलाकर (बेस उत्पाद के बावजूद)  
रंग: काला

2. उपचार: कपड़े को कुरकुरा और गैर-पाइपिंग गुण देने के लिए, आसान स्थापना में मदद करने के लिए, फाइबर कटाव को कम करने, सुंदर दिखने और घर्षण प्रतिरोध के लिए जल आधारित ऐक्रेलिक बाइंडर से उपचार किया जाएगा।। फाइबर छलकाव/धागा फंसाव न्यूनतम होना चाहिए।

3. गुण:

घनत्व: 200 +/- 20 GSM

तन्य शक्ति: 275 +/- 25 kg/50 mm (न्यूनतम)

मोटाई: 0.18 मिमी/7 मिल

प्रकार: सॉल्वेंट आधारित ऐक्रेलिक आसंजक

छीलने की ताकत: 1000 gm/25 mm (न्यूनतम) - (स्टील आसंजक)

मोटाई:

भीतरी पाइप का (NB)	वांछित मोटाई	1 ली परत की मोटाई (मिमी)	2 री परत की मोटाई (मिमी)	श्रेणी 'O' नाइट्राइल रबड़ (स्व आस्तीन/पूर्व-कट शीट)
25	32	32	N/A	एक परत में कंपनी बद्ध कपड़े के साथ स्व-आस्तीन श्रेणी 'O' नाइट्राइल

32	32	32	N/A	एक परत में कंपनी बद्ध कपड़े के साथ स्व-आस्तीन श्रेणी 'O' नाइट्राइल
40	32	32	N/A	एक परत में कंपनी बद्ध कपड़े के साथ स्व-आस्तीन श्रेणी 'O' नाइट्राइल
50	38	32	6	1ली परत स्व-आस्तीन ट्यूबिंग और 2री परत निर्माता बद्ध उपचारित बुना ग्लास फाइबर कवर
65	38	32	6	1ली परत स्व-आस्तीन ट्यूबिंग और 2री परत निर्माता बद्ध उपचारित बुना ग्लास फाइबर कवर
80	38	32	6	1ली परत स्व-आस्तीन ट्यूबिंग और 2री परत निर्माता बद्ध उपचारित बुना ग्लास फाइबर कवर
100	38	32	6	1ली परत स्व-आस्तीन ट्यूबिंग और 2री परत निर्माता बद्ध उपचारित बुना ग्लास फाइबर कवर
125	44	19	25	1ली और 2री परत निर्माता प्रीकट (उपयोग के लिए तैयार) शीट और रेडीमेड निर्माता की आपूर्ति उपचारित बुना ग्लास फाइबर कवर की 3री परत (एक अलग परत के रूप में)।
150	44	19	25	1ली और 2री परत निर्माता प्री-कट (उपयोग के लिए तैयार) शीट और रेडीमेड निर्माता की आपूर्ति उपचारित बुना ग्लास फाइबर कवर की 3री परत (एक अलग परत के रूप में)।

200	44	19	25	1ली और 2री परत निर्माता प्री-कट (उपयोग के लिए तैयार) शीट और रेडीमेड निर्माता की आपूर्ति उपचारित बुना ग्लास फाइबर कवर की 3री परत (एक अलग परत के रूप में)।
250	44	19	25	1ली और 2री परत निर्माता प्री-कट (उपयोग के लिए तैयार) शीट और रेडीमेड निर्माता की आपूर्ति उपचारित बुना ग्लास फाइबर कवर की 3री परत (एक अलग परत के रूप में)।
300	50	25	25	1ली और 2री परत निर्माता प्री-कट (उपयोग के लिए तैयार) शीट और रेडीमेड निर्माता की आपूर्ति उपचारित बुना ग्लास फाइबर कवर की 3री परत (एक अलग परत के रूप में)।
350	50	25	25	1ली और 2री परत निर्माता प्री-कट (उपयोग के लिए तैयार) शीट और रेडीमेड निर्माता की आपूर्ति उपचारित बुना ग्लास फाइबर कवर की 3री परत (एक अलग परत के रूप में)।
400	50	25	25	1ली और 2री परत निर्माता प्री-कट (उपयोग के लिए तैयार) शीट और रेडीमेड निर्माता की आपूर्ति उपचारित बुना ग्लास फाइबर कवर की 3री परत (एक अलग परत के रूप में)।

450	50	25	25	1ली और 2री परत निर्माता प्रीकट (उपयोग के लिए तैयार) शीट और रेडीमेड निर्माता की आपूर्ति उपचारित बुना ग्लास फाइबर कवर की 3री परत (एक अलग परत के रूप में)।
500	50	25	25	1ली और 2री परत निर्माता प्री-कट (उपयोग के लिए तैयार) शीट और रेडीमेड निर्माता की आपूर्ति उपचारित बुना ग्लास फाइबर कवर की 3री परत (एक अलग परत के रूप में)।

### 2.6.3 नाइट्राइल रबड़ शीट्स/रोल का प्रयोग करके इन्सुलेशन:

#### ए. सामग्री:

1. इन्सुलेशन सामग्री संवृत सेल इलोस्टोमेरिक नाइट्राइल रबड़ की होगी।
2. इलोस्टोमेरिक नाइट्राइल रबड़ की तापीय चालकता 00C के औसत तापमान पर 0.035 W/ (m.K) से अधिक नहीं होगी।
3. इन्सुलेशन में अग्निरोधी निष्पादन इस तरह होगा कि यह BS 476 भाग 7 के अनुसार कक्षा 1 पार करे, कक्षा 'O' फायर श्रेणी की आवश्यकता को पूरा करने के लिए BS 476 भाग 6 के अनुसार आग प्रसार की आवश्यकता को पार करे।
4. यह स्व-शामक होना चाहिए, ड्रिप नहीं करना चाहिए और लपटों को नहीं फैलाना चाहिए।
5. बिना किसी आवरण के इन्सुलेशन सामग्री के लिए नमी प्रसार रोधी कारक या ' $\mu$ ' मान न्यूनतम 7,000 होगा।

**बी) अनुशंसित आसंजक:**

1. आसंजक विशेष रूप से पाइप इन्सुलेशन में लगाने के लिए तैयार किया जाएगा और इन्सुलेशन निर्माता द्वारा आपूर्ति की जाएगी।
2. आसंजक बेंजीन से मुक्त विलायक आधारित रबड़ इन्सुलेशन आसंजक होगा।
3. यह छिद्रिल और अछिद्रिल सतहों के लिए उत्कृष्ट बंधनकारी होना चाहिए।
4. आसंजक उष्णकटिबंधीय परिस्थितियों के लिए त्वरित सूखने के लक्षण वाला होगा और इसका सर्विस तापमान  $-25^{\circ}\text{C}$  to  $+90^{\circ}\text{C}$  होगा।

**5. गुणधर्म:**

श्यानता @ $30^{\circ}\text{C}$	:	3500 - 4000 cps
विशिष्ट गुरुत्व	:	0.89 - 0.92 g/cc
घनत्व	:	$0.085 \text{ kg/m}^3 + 0.01$
ज्वलन बिंदु	:	$> 10^{\circ}\text{C}$
व्यापकता	:	बंधनकारी सामग्री/लीटर का 4-5 वर्ग मीटर
सूखने का समय	:	7 - 8 मिनट
टैक अवधारण अवधि	:	25 मिनट

**सी. इन्सुलेशन सामग्री के बाहरी आवरण के लिए बॉन्डेड उपचारित बुना ग्लास फाइबर**

1. तापमान रेंज:  $0^{\circ}\text{C}$  to  $+105^{\circ}\text{C}$  कुल मिलाकर (बेस उत्पाद के बावजूद)  
रंग: काला

2. उपचार: कपड़े को कुरकुरा और गैर-पाइपिंग गुण देने के लिए, आसान स्थापना में मदद करने के लिए, फाइबर कटाव को कम करने, सुंदर दिखने और घर्षण प्रतिरोध के लिए जल आधारित ऐक्रेलिक बाइंडर से उपचार किया जाएगा। फाइबर छलकाव/धागा फंसाव न्यूनतम होना चाहिए।

3. गुण:

घनत्व: 200 +/- 20 GSM

तन्य शक्ति: 275 +/- 25 kg/50 mm (न्यूनतम)

मोटाई: 0.18 मिमी/7 मिल

प्रकार: सॉल्वेंट आधारित एक्रिलिक आसंजक

छीलने की ताकत: 1000 gm/25 mm (न्यूनतम) - (स्टील आसंजक)

4. इन्सुलेशन की मोटाई:

भीतरी पाइप का (NB)	वांछित मोटाई	1ली परत की मोटाई (मिमी)	2 री परत की मोटाई (मिमी)	श्रेणी 'O' नाइट्राइल रबड़ (स्व आस्तीन/प्री-कट शीट)
25	32	32	N/A	एक परत में कंपनी बद्ध कपड़े के साथ स्व-आस्तीन श्रेणी 'O' नाइट्राइल और इसके ऊपर एपोकसी राल के साथ FRP अस्तर की 2 परतें

32	32	32	N/A	एक परत में कंपनी बद्ध कपड़े के साथ स्व-आस्तीन श्रेणी 'O' नाइट्राइल और इसके ऊपर एपोकसी राल के साथ FRP अस्तर की 2 परतें
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40	32	32	N/A	एक परत में कंपनी बद्ध कपड़े के साथ स्व-आस्तीन श्रेणी 'O' नाइट्राइल और इसके ऊपर एपोकसी राल के साथ FRP अस्तर की 2 परतें
50	38	32	6	1ली परत स्व-आस्तीन ट्यूबिंग और 2री परत निर्माता बद्ध उपचारित बुना ग्लास फाइबर कवर और इसके ऊपर एपोकसी राल के साथ FRP अस्तर की 2 परतें
65	38	32	6	1ली परत स्व-आस्तीन ट्यूबिंग और 2री परत निर्माता बद्ध उपचारित बुना ग्लास फाइबर कवर और इसके ऊपर एपोकसी राल के साथ FRP अस्तर की 2 परतें
80	38	32	6	1ली परत स्व-आस्तीन ट्यूबिंग और 2री परत निर्माता बद्ध उपचारित बुना ग्लास फाइबर कवर और इसके ऊपर एपोकसी राल के साथ FRP अस्तर की 2 परतें
100	38	32	6	1ली परत स्व-आस्तीन ट्यूबिंग और 2री परत निर्माता बद्ध उपचारित बुना ग्लास फाइबर कवर और इसके ऊपर एपोकसी राल के साथ FRP अस्तर की 2 परतें

125	44	19	25	<p>1ली और 2री परत निर्माता प्री-कट (उपयोग के लिए तैयार) शीट और रेडीमेड निर्माता की आपूर्ति</p> <p>बद्ध उपचारित बुने ग्लास फाइबर कवर की 3री परत (एक अलग परत के रूप में) और इसके ऊपर एपोकसी राल के साथ FRP अस्तर की 2 परतें</p>
150	44	19	25	<p>1ली और 2री परत निर्माता प्री-कट (उपयोग के लिए तैयार) शीट और रेडीमेड निर्माता की आपूर्ति</p> <p>बद्ध उपचारित बुने ग्लास फाइबर कवर की 3री परत (एक अलग परत के रूप में) और इसके ऊपर एपोकसी राल के साथ FRP अस्तर की 2 परतें</p>
200	44	19	25	<p>1ली और 2री परत निर्माता प्री-कट (उपयोग के लिए तैयार) शीट और रेडीमेड निर्माता की आपूर्ति</p> <p>बद्ध उपचारित बुने ग्लास फाइबर कवर की 3री परत (एक अलग परत के रूप में) और इसके ऊपर एपोकसी राल के साथ FRP अस्तर की 2 परतें</p>



250	44	19	25	<p>1ली और 2री परत निर्माता प्री-कट (उपयोग के लिए तैयार) शीट और रेडीमेड निर्माता की आपूर्ति</p> <p>बद्ध उपचारित बुने ग्लास फाइबर कवर की 3री परत (एक अलग परत के रूप में) और इसके ऊपर एपोकसी राल के साथ FRP अस्तर की 2 परतें</p>
300	50	25	25	<p>1ली और 2री परत निर्माता प्री-कट (उपयोग के लिए तैयार) शीट और रेडीमेड निर्माता की आपूर्ति</p> <p>बद्ध उपचारित बुने ग्लास फाइबर कवर की 3री परत (एक अलग परत के रूप में) और इसके ऊपर एपोकसी राल के साथ FRP अस्तर की 2 परतें</p>
350	50	25	25	<p>1ली और 2री परत निर्माता प्री-कट (उपयोग के लिए तैयार) शीट और रेडीमेड निर्माता की आपूर्ति</p> <p>बद्ध उपचारित बुने ग्लास फाइबर कवर की 3री परत (एक अलग परत के रूप में) और इसके ऊपर एपोकसी राल के साथ FRP अस्तर की 2 परतें</p>

400	50	25	25	<p>1ली और 2री परत निर्माता प्री-कट (उपयोग के लिए तैयार) शीट और रेडीमेड निर्माता की आपूर्ति</p> <p>बद्ध उपचारित बुने ग्लास फाइबर कवर की 3री परत (एक अलग परत के रूप में) और इसके ऊपर एपोकसी राल के साथ FRP अस्तर की 2 परतें</p>
450	50	25	25	<p>1ली और 2री परत निर्माता प्री-कट (उपयोग के लिए तैयार) शीट और रेडीमेड निर्माता की आपूर्ति</p> <p>बद्ध उपचारित बुने ग्लास फाइबर कवर की 3री परत (एक अलग परत के रूप में) और इसके ऊपर एपोकसी राल के साथ FRP अस्तर की 2 परतें</p>
500	50	25	25	<p>1ली और 2री परत निर्माता प्री-कट (उपयोग के लिए तैयार) शीट और रेडीमेड निर्माता की आपूर्ति</p> <p>बद्ध उपचारित बुने ग्लास फाइबर कवर की 3री परत (एक अलग परत के रूप में) और इसके ऊपर एपोकसी राल के साथ FRP अस्तर की 2 परतें</p>

#### 2.6.4 PUF/कठोर फिनोलिक फोम (फिनोथर्म):

1. मोटाई निम्नानुसार होगी:

- 32 मिमी व्यास वाले पाइप के लिए - न्यूनतम 25 मिमी मोटी पाइप खंड
- 40 मिमी से 125 मिमी व्यास वाले पाइप के लिए - न्यूनतम 30 मिमी पाइप खंड
- 150 मिमी व्यास और उससे अधिक के पाइप के लिए - न्यूनतम 50 मिमी पाइप

2. खाइयों के अंदर चलने वाले पाइपों के लिए, चिकन तार जाली के साथ इन्सुलेशन को कवर करने के बाद न्यूनतम 15 मिमी मोटा सीमेंट प्लास्टर किया जाएगा। सीमेंट आधारित जलरोधी पेंट लगाया जाएगा।

3. प्लांट कक्ष के अंदर चलने वाले पाइप और फाल्स सीलिंग के ऊपर भवन के लिए, इन्सुलेशन के ऊपर न्यूनतम 28 SWG मोटाई का एल्यूमिनियम आवरण लगाया जाएगा।

4. इस्तेमाल करने वाला आसंजक अग्निरोधी और विशेष रूप से पाइप के लिए तैयार किया जाएगा और इन्सुलेशन निर्माता द्वारा आपूर्ति की जाएगी। इसमें बद्धता गुण उत्कृष्ट होंगे और यह  $-5^{\circ} \text{C}$  to  $+ 85^{\circ} \text{C}$  के सर्विस तापमान के लिए उपयुक्त होगा।

5. PUF/कठोर फिनोलिक फोम निम्नलिखित के अनुरूप होगा:

- थर्मल चालकता ( $<0.023 \text{ w/m }^{\circ}\text{K}$ )
- संपीड्य क्षमता
- संवृत सेल सामग्री ( $<88\%$ )

### 2.6.5 रॉकवूल खंडों के साथ इन्सुलेशन:

1. मोटाई निम्नानुसार होगी:

- 32 मिमी व्यास वाले पाइप के लिए - न्यूनतम 40 मिमी मोटी पाइप खंड
- 40 मिमी से 125 मिमी व्यास वाले पाइप के लिए - न्यूनतम 50 मिमी पाइप खंड
- 150 मिमी व्यास और उससे अधिक के पाइप के लिए - न्यूनतम 75 मिमी पाइप

2. इन्सुलेशन के ऊपर न्यूनतम 28 SWG मोटाई का एल्यूमिनियम आवरण लगाया जाएगा।

3. इस्तेमाल करने वाला आसंजक अग्निरोधी और विशेष रूप से पाइप के लिए तैयार किया जाएगा और इन्सुलेशन निर्माता द्वारा आपूर्ति की जाएगी। इसमें बद्धता गुण उत्कृष्ट होंगे और यह  $-5^{\circ} \text{C}$  to  $+ 85^{\circ} \text{C}$  के सर्विस तापमान के लिए उपयुक्त होगा।

4. रॉकवूल इन्सुलेशन निम्नलिखित के अनुरूप होगा:

- थर्मल चालकता ( $<0.034 \text{ w/m }^{\circ}\text{K}$ )

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**एयर कंडीशनिंग और वेंटिलेशन  
कार्यों के लिए विनिर्देश**

**खंड - VI**  
**विस्तार टैंक**

## 1. खुला विस्तार टैंक

### 1.1 GRP पैनल टैंक:

विस्तार टैंक अन्यत्र निर्दिष्ट विनिर्देशों के अनुसार वर्णित आकार के खंड निर्माण वाले होंगे और IS 14399 (भाग I) अंकन वाले मॉड्यूलर तप्त संपीडन ढाले GRP पैनलों की असेम्बली के द्वारा बनाए जाएंगे।

फ्लैज पर पैनल की न्यूनतम मोटाई 9 मिमी होगी और शेल के केंद्रीय हिस्से में न्यूनतम 3 मिमी होगी। जहां आवश्यक हो, इनलेट, आउटलेट ओवरफ्लो और निकासी कनेक्शन को समायोजित करने के लिए चपटे पैनलों का उपयोग किया जाएगा। फ्लैज पर चपटे पैनलों की मोटाई 11.5 मिमी और चपटे हिस्से पर न्यूनतम 3 मिमी होगी।

सभी पैनलों को 40 मिमी मोटी पॉलीयूरेथेन फोम से इन्सुलेट किया जाएगा जिसके साथ बाहरी तरफ 2 मिमी मोटी FRP/GRP सुरक्षात्मक परत लगाई जाएगी। पैनलों में हाइड्रोस्टेटिक दाब को झेलने के लिए पर्याप्त शक्ति और कठोरता होनी चाहिए। पैनल के बीच के जोड़ों की जलरोधकता सुनिश्चित करने के लिए बंद सेल PVC फोम के बने गॉस्केट का उपयोग करके सील किया जाएगा।

पैनलों को बांधने के लिए इस्तेमाल किया जाने वाला हार्डवेयर तप्त निमज्जित जस्ती उच्च तन्यता वाली स्टील होगा। सभी फास्टर, फ्लैज आधार 'C' चैनल और धातु कठोरक और बांधने वाली छड़ें (1.5 मीटर से अधिक गहरी टैंकों के लिए इस्तेमाल किया) तप्त निमज्जित जस्ती वाले होंगे और संग्रहीत पानी के संपर्क से बचने के लिए बाह्य रूप से इस्तेमाल किया जाएगा।

प्रभारी अभियंता (इंजीनियर) के निर्देश के अनुसार इनलेट और आउटलेट नाली और अतिप्रवाह निष्पल PVC या MS के लगाए जाएंगे। हालांकि, नोज़ल की सामग्री, आकार और विशिष्टताओं को टैंक की आपूर्ति से पहले पूर्व निर्धारित किया जाएगा। विस्तार टैंक में फ्लोट वाल्व असेंबली होगी और मैनहोल ताला-युक्त कवर के साथ होगा।

## 2. बंद विस्तार टैंक

टैंक बदलने योग्य मज़बूत ब्यूटाइल रबड़ ब्लेडर के साथ पूर्व आवेशित स्टील (इस्पात) विस्तार टैंक होगा। टैंक ऊर्ध्वाधर होगा और उपयुक्त आकार का होगा और इसे ASME बॉयलर और दाब पोत कोड के खंड VIII के अनुसार निर्मित किया जाएगा और इसे 10 Kg/Cm<sup>2</sup> के लिए रेट किया जाएगा और इसे 15Kg/Cm<sup>2</sup> के परीक्षण दाब झेलना होगा। (इस परीक्षण के लिए परीक्षण प्रमाण पत्र प्रस्तुत किया जाएगा)। टैंक ऊर्ध्वाधर स्थापना के लिए उठाने वाले छल्लों से और एक फर्श पर रखने वाले स्कर्ट के साथ फिट किया जाएगा। टैंक में एक दाब निर्मुक्ति वाल्व लगाया जाएगा जिसे सिस्टम में स्थिर शीर्ष के बराबर दाब पर सेट किया जाएगा। टैंक में पृथकन वाल्वों के साथ वायु भरने और जल संयोजन निकासी का प्रावधान होगा।

विफलता से बचने के लिए ब्लेडर लचीला, बदलने योग्य और टैंक के दोनों तरफ से पकड़ने वाला होगा। ब्लेडर को नायलॉन के साथ ब्यूटाइल से प्रबलित किया जाएगा और इसकी न्यूनतम अवधि 5 साल होगी।

3000 लीटर से अधिक बड़े टैंकों के लिए, टैंक में ब्लेडर की विफलता का पता लगाने के लिए साइट ग्लास और स्तर सूचक होगा और जल चार्जिंग से पहले वायु दाब को पढ़ने के लिए मिजेट पॉपपेट वाल्व के साथ दाब गेज लगाया जाएगा। टैंक को SOQ में बताए गए पदार्थों से इन्सुलेट किया जाएगा।

**एयर कंडीशनिंग और वेंटिलेशन  
कार्यों के लिए विनिर्देश**

**खंड - VI  
एयर हैंडलिंग यनिट**



## 1. दोहरी स्किन वाली एयर हैंडलिंग यूनिट

### 1.1 हाउसिंग/ (केसिंग) आवरण:

एयर हैंडलिंग यूनिट ड्रॉ-थू प्रकार की होगी, जिसमें निविदा SOQ में वर्णित अनुसार फिल्टर खंड, रिटर्न एयर/फ्रेश एयर मिक्सिंग खंड, कूलिंग कॉइल खंड, पंखा खंड इत्यादि शामिल हैं। विभिन्न खंडों को स्वनिर्भर मॉड्यूलर ढांचे के साथ असेम्बल किया जाता है जो जंगरोधी एक्सट्रूडेड एल्यूमीनियम प्रोफाइल से निर्मित होता है जो ढले हुए उच्च तन्यता प्रबलित प्लास्टिक से जुड़ा होता है और विभिन्न खंडों के लिए एक प्रबल, मजबूत और स्वावलंबी ढांचा प्रदान करने के लिए असेम्बल किया जाएगा। पूरे मॉड्यूल को भारी जस्ती इस्पात चैनल/खंडीय एल्यूमीनियम मिश्र धातु आधार फ्रेम की सतत बीम पर लगाया जाता है। फ्रेम को AHU बनाने वाले घटकों और फिटिंग को सहारा देने में सक्षम होंगे और संचालन परिस्थितियों में एयर सिस्टम के भीतर दाब को झेलने में सक्षम होगा।

प्रत्येक मॉड्यूल का आवरण बाहरी सतह के लिए न्यूनतम 0.6 मिमी मोटी प्री-लेपित GSS और आंतरिक सतह के लिए न्यूनतम 0.6 मिमी मोटी सादी GSS/0.8 मिमी मोटी एल्यूमिनियम/SS शीट से दोहरी सतह निर्मित निर्माण होगा जिसमें निविदा SOQ में निर्दिष्ट के अनुसार बीच में 40 किलो/सह घनत्व का न्यूनतम 40 मिमी/23 मिमी मोटी PUF के साथ इन्सुलेशन सैंडविच किया जाएगा। इन पैनलों के जोड़ों को वायुरोधी बनाने के लिए बीच में एल्यूमीनियम फ्रेम के अंतर्निर्मित खांचे में लगी लकड़ी के सॉफ्ट रबड़/नियोप्रीन गैसकेट के साथ ढांचे पर कसा जाएगा। विभिन्न खंडों के लिए नायलॉन या एल्यूमीनियम डाई से बने मजबूत कब्जों और ताले, रोशनी, सीमक/इंटरलॉक स्विच, साइट ग्लास, बेल्ट रक्षक यथा लागू के साथ उपयुक्त हवारोधी अभिगम दरवाजे/पैनल लगाए जाएंगे।

बाहर स्थापित यूनिटों को एल्यूमीनियम से निर्मित ढालू मौसम सह्य छतरी (कैनोपी) से संरक्षित होंगी और साइड पैनलों को बारिश के पानी से बचाने के लिए यूनिट को सभी तरफ से ढंकी होंगी।

क्लीन रूम (स्वच्छ कक्ष) AHU के लिए, बाहर निकले एल्यूमीनियम फलक और बाई पास डैम्पर की व्यवस्था की जाएगी। बाईपास क्षेत्र निविदा SOQ में बताये अनुसार होगा।

मिश्रण बॉक्स की आवश्यकता वाले AHU को ताजा और रिटर्न वायु अवमंदकों (डैम्पर) के साथ परिपूर्ण होंगे। अवमंदक विपरीत ब्लेड प्रकार के होंगे। ब्लेड बाहर निकले एल्यूमीनियम मिश्र धातु फ्रेम से बने एरोफोइल खंड से बना होगा। अवमंदक ब्लेड को स्थिति में लॉक करने के लिए बैकेलाइट घुंडी के साथ मैनुअल अवमंदक लगाया जाएगा। जहां भी मोटर चालित आपरेशन के लिए निर्दिष्ट हो वहां लिंक किया जाएगा। ब्लेड लपेटन को कम करने के लिए अवमंदक फ्रेम खंडीय होंगे। संवृत स्थिति में होने पर अवमंदक के माध्यम से हवा का रिसाव न्यूनतम होगा और अधिकतम डिजाइन हवा का कुल दाब में अधिमानतः अधिकतम डिजाइन हवा के प्रवाह दर का 1.5% से अधिक नहीं होगा।

संघनित पानी को तेजी से हटाने की सुविधा के लिए आवश्यक ढाल के साथ न्यूनतम 1.0 मिमी स्टेनलेस स्टील वेल्डेड जोड़ों का एक टुकड़े वाले निकास पैन का निर्माण किया जाएगा। निकास पैन में कुंडली को खिसकाने के लिए आवश्यक आधार लगाया जाएगा। नाली के दोनों किनारों पर आउटलेट लगाया जाएगा। निकास पैन कुंडली के आकार से बड़ा होगा ताकि कुंडली झुकाव और अन्य नियंत्रण यूनिटों से संघनित पानी एकत्र किया जा सके। सम्पूर्ण असेम्बली को इन्सुलेट किए तल पैनल पर रखा जाएगा।

आवरण में तापीय ब्रेक प्रोफाइल और अन्य सभी आवश्यक डिजाइन विशेषताएं शामिल होंगी ताकि यह सुनिश्चित हो सके कि सभी मौसमों के दौरान संघनन नहीं हो।

## 1.2 पंखा और मोटर असेंबली:

पंखा-मोटर असेंबली को एल्यूमीनियम प्रोफाइल से बने एक अलग आधार फ्रेम पर आवरण के अंदर रखा जाएगा और स्प्रिंग प्रकार के कंपन पृथक्त्रों पर स्थापित किया जाएगा। पंखे के पहिये और हाउसिंग को भारी गेज स्टील से निर्मित किया जाएगा। पंखों को स्थैतिक और गतिशील रूप से संतुलित होना चाहिए और 100,000 घंटे की संचालन अवधि वाले सीलबंद बेयरिंग होंगे। पंखे DIDW एयरोफोइल/पश्च/अग्र वक्रित होंगे (जैसा कि निविदा SOQ में निर्दिष्ट है)। पंखा शाफ्ट ठोस निर्माण और EN -8 स्टील का होगा। पूरी हाउसिंग को कंपन पृथक्कन के लिए उपयुक्त पैड के साथ अल्युमिनियम चैनल ढांचे पर रखा जाएगा। पंखे की मोटरों को बेल्ट चालित मोटरों के मामले में आसान बेल्ट टेंशन के लिए स्लाइड रेल पर AHU आवरण के अंदर लगाया जाएगा। पंखे के लिए ड्राइव के लिए बोल्ट और समायोज्य मोटर पुली के साथ बेल्ट ड्राइव लगाया जाएगा। बेल्ट तेल प्रतिरोधी प्रकार की होंगी। उपयुक्त कंपन पृथक्त्रों के माध्यम से आवरण में आधार फ्रेम स्थापित किया जाएगा। जहां भी VFD के साथ

इस्तेमाल करना हो, मोटर उसके लिए उपयुक्त होनी चाहिए और कम गति पर तापमान नहीं बढ़ना चाहिए। पंखों से आउटलेट वेग 550 मीटर/मिनट से अधिक नहीं होगा।

निविदा/SOQ में विनिर्दिष्ट हो तो AHU में अतिरिक्त मोटर और पुली/बेल्ट के साथ स्टैंडबाय ड्राइव व्यवस्था शामिल होगी। AHU के लिए मोटरों की दक्षता IE3 श्रेणी स्तर या बेहतर होगी।

वैकल्पिक रूप से, अन्यथा SOQ में निर्दिष्ट न हो तो प्लग पंखे के साथ मोटर स्वीकार की जाती हैं।

स्वच्छ कक्ष AHU की सभी फिनिश, स्वच्छ कक्ष अनुप्रयोग के लिए पंखा-मोटर असेम्बली सहित संगत होंगी।

### 1.3 शीतन/ताप कॉयल:

ठंडे/गर्म पानी की कॉइल न्यूनतम 12 मिमी व्यास ट्यूबों और न्यूनतम 0.43 मिमी मोटी या निविदा अनुसूची में निर्दिष्ट के अनुसार होंगी जिसके जस्ता लेपित स्टील फ्रेम में असेम्बल तांबा ट्यूबों के साथ ज्या तरंग एल्यूमीनियम पंख के साथ बंधे होंगे। ठंडी/गर्म कॉइल हाइड्रोफोबिक कोटिंग के साथ असेम्बल तांबा ट्यूबों में मजबूती से आबद्ध होंगी। फलक और सतह क्षेत्र ऐसा होगा कि प्रत्येक यूनिट से रेटेड क्षमता सुनिश्चित हो सके और इस तरह का होगा कि प्रत्येक कॉइल में वायु वेग 153 मीटर प्रति मिनट से अधिक न हो। अंत प्लेटें 1.2 मिमी मोटी (न्यूनतम) स्टेनलेस स्टील से बनी होंगी। कॉइल को उचित जल निकासी के लिए यूनिट के आवरण में खड़ा किया जाएगा। प्रत्येक कॉइल को न्यूनतम दो घंटों के लिए पानी में डुबो कर 21 kg /Sq.cm वायु दाब पर फैक्ट्री में परीक्षण किया जाएगा। पंखों के साथ न्यूनतम तापीय संपर्क प्रतिरोध के लिए बुलेट को गुजारकर यांत्रिक रूप से ट्यूब का विस्तार किया जाएगा। शीतन कॉइल में न्यूनतम 433 पंख प्रति मीटर (FPM) होंगे और तापन कॉइल में न्यूनतम 315 पंख प्रति मीटर (FPM) होंगे या SOQ में विनिर्दिष्ट के अनुसार होंगे। साफ फिनिश हासिल करने के लिए कॉपर बैंड को कॉइल को सीधे पकड़े रखकर झलाई की जाएगी।

### 1.4 फिल्टर:

AHU के फिल्टर खंड में अपस्ट्रीम की ओर MERV-8, MERV-13, डाउनस्ट्रीम की ओर सुपरफाइन (अर्ध HEPA) और HEPA फिल्टर शामिल हैं, जो आवश्यकतानुसार और निविदा SOQ में निर्दिष्ट के अनुसार और निम्नलिखित विनिर्देशों को पूरा करेंगे:

### ए) MERV-8 फिल्टर:

MERV-8 प्री-फिल्टर EN-779 के अनुसार G4/EU4 ग्रेड का, नॉनवुवन सिंथेटिक मीडिया धोने योग्य के साथ फ्लैज प्रकार का होगा, 10 माइक्रोन नीचे तक 85% की औसत अवरुद्धता होगी। मीडिया की विशेषता अपेक्षाकृत कम प्रतिरोध और दोनों तरफ HDPE जाली के साथ उच्च धूल धारण क्षमता है, GI छड़ों के साथ चुन्नटदार आधार के साथ चुन्नटदार डिजाइन और पॉलीयुरेथेन से बनी आसंजक सामग्री है। फिल्टर का आकार फ्लैज सहित 650x610x300 मिमी होगा। प्रभावी निस्स्यंदन क्षेत्र -550x 550 मिमी होगा। निर्माण की सामग्री- एल्यूमिनियम। फिल्टरों की कुल संख्या का आकार AHU द्वारा कैटर किए जाने वाले आकार और वायु मात्रा के आधार पर निर्धारित की जाएगी।

### बी) MERV -13 फिल्टर:

MERV-13 फाइन-फिल्टर EN-779 के अनुसार F7/EU7 ग्रेड का, नॉनवुवन सिंथेटिक मीडिया धोने योग्य के साथ फ्लैज प्रकार का होगा, औसत दक्षता 85 से 90% की होगी। 3 माइक्रोन के लिए दक्षता न्यूनतम 98% होगी। मीडिया की विशेषता अपेक्षाकृत कम प्रतिरोध और दोनों तरफ HDPE जाली के साथ उच्च धूल धारण क्षमता है, GI छड़ों के साथ चुन्नटदार आधार के साथ चुन्नटदार डिजाइन और पॉलीयुरेथेन से बनी आसंजक सामग्री है। फिल्टर का आकार फ्लैज सहित 610mm x 610mm x 300 mm या 610mm x 610mm x 150 mm होगा। प्रभावी निस्स्यंदन क्षेत्र -550x 550 मिमी होगा। निर्माण की सामग्री- एल्यूमिनियम। फिल्टरों की कुल संख्या का आकार AHU द्वारा कैटर किए जाने वाले आकार और वायु मात्रा के आधार पर निर्धारित की जाएगी। फिल्टर मध्यम क्षेत्र न्यूनतम 8 वर्ग मीटर होगा। फिल्टर के माध्यम से वायु मात्रा और प्रारंभिक दाब पात SOQ में निर्दिष्ट के अनुसार होगा।

### सी) सुपरफ़ाइन या अर्ध HEPA फिल्टर:

जब तक अन्यथा निर्दिष्ट नहीं किया जाए सुपरफ़ाइन फिल्टर H-11 मीडिया के साथ 0.3 माइक्रोन पर 95% की न्यूनतम दक्षता के अनुरूप EN 1822, फ्लैज प्रकार, आयातित ग्लास फाइबर मीडिया, एल्यूमिनियम सेपरेटर फिल्टर द्वारा समान दूरी पर चुन्नटदार आधार के साथ चुन्नटदार डिजाइन वाला होगा। फिल्टर का आकार फ्लैज सहित 610mm x 610mm x 300 mm या 610mm x 610mm x 150 mm होगा। प्रभावी निस्स्यंदन क्षेत्र -550x 550 मिमी होगा। निर्माण की सामग्री- एल्यूमिनियम। फिल्टरों की कुल संख्या का आकार AHU द्वारा पूरे किए जाने वाले आकार और वायु मात्रा के आधार पर

निर्धारित की जाएगी। फिल्टर माध्यम क्षेत्र न्यूनतम 12 वर्ग मीटर होगा। फिल्टर के माध्यम से वायु मात्रा और प्रारंभिक दाब पात SOQ में निर्दिष्ट के अनुसार होगा।

### डी) HEPA फिल्टर:

जब तक अन्यथा निर्दिष्ट नहीं किया जाए HEPA फिल्टर H-13 मीडिया के साथ 0.3 माइक्रोन पर 99.97% की न्यूनतम दक्षता के साथ EN 1822 अनुरूप, फ्लैज प्रकार, आयातित ग्लास फाइबर मीडिया, एल्यूमीनियम सेपरेटर फिल्टर द्वारा समान दूरी पर चुन्नटदार आधार के साथ चुन्नटदार डिजाइन वाला होगा। फिल्टर का आकार फ्लैज सहित 610mm x 610mm x 300 mm या 610mm x 610mm x 150 mm होगा। प्रभावी निस्संदन क्षेत्र -550x 550 मिमी होगा। निर्माण की सामग्री- एल्यूमिनियम। फिल्टरों की कुल संख्या का आकार AHU द्वारा पूरे किए जाने वाले आकार और वायु मात्रा के आधार पर निर्धारित की जाएगी। फिल्टर माध्यम क्षेत्र न्यूनतम 20 वर्ग मीटर होगा। फिल्टर के माध्यम से वायु मात्रा और प्रारंभिक दाब पात SOQ में निर्दिष्ट के अनुसार होगा।

### 1.5 आइसोलेटर (पृथक्त्र):

सभी मंजिलों पर लगी वायु हैंडलिंग यूनिटों में कंपनी आइसोलेटर लगाए जाएंगे। छत स्थान के भीतर लगाए AHU कंपनी पृथक्त्र के माध्यम से लटकाया जाएगा। न्यूनतम 90% कंपनी पृथक्त्र क्षमता के साथ उपयुक्त कंपनी आइसोलेटर लगाए जाएंगे।

### 1.6 सहायक उपकरण (एक्सेसरीज):

प्रत्येक एयर हैंडलिंग यूनिट में ठंडी कॉइल में उच्चतम बिंदु पर वायु छिद्र और कॉइल के तल पर निकास प्लग दिया जाएगा। इसके अलावा, मात्रा अनुसूची में बताए अनुसार एयर हैंडलिंग यूनिट पर निम्नलिखित सहायक उपकरणों की आवश्यकता होगी:

ए) आपूर्ति वायु पंखे के आउटलेट पर दोहरा लचीला कनेक्शन। लचीला कनेक्शन अग्निरोधक और लिंट फ्री सामग्री का होगा।

बी) आधार फ्रेम और पेडेस्टल के बीच रिब्ड रबड़ पैड के रूप में कंपनी आइसोलेटर लगाए जाएंगे।

## 1.7 निष्पादन डेटा

एयर हैंडलिंग यूनिटों का चयन इस हिसाब से किया जाएगा कि उपकरण में सबसे कम शोर स्तर हो। स्पष्ट रूप से इंगित पंखा निष्पादन रेटिंग और ऑपरेटिंग बिंदुओं के साथ विद्युत खपत के डेटा निविदा के साथ या निष्पादन चरण के दौरान प्रस्तुत किया जाएगा और स्थापना के परीक्षण और चालू होने के समय में सत्यापित किया जाएगा।

## 1.8 परीक्षण:

विभिन्न एयर हैंडलिंग यूनिट मॉडलों की शीतन/तापन क्षमता को हवा के प्रवाह और कॉइल में आने और निकलने वाली हवा के सूखे और नम बल्ब तापमान के मापन से गणना की जाएगी तथा निर्धारित क्षमता के अनुसार होगी। प्रवाह मापन का अंशांकन सटीक होगा। गणना किए गए परिणाम निर्दिष्ट क्षमताओं और उद्धृत रेटिंग के अनुरूप होंगे। बिजली की खपत आने वाले वोल्टेज और इनपुट करंट की मापन से गणना की जाएगी।

AHU के डिजाइन निविदा अनुसूची/SOQ में निर्दिष्ट तकनीकी मापदंडों को पूरा करने के लिए तैयार किए जाएंगे।

सभी AHU निम्नलिखित मानकों के संबंध में 1886 या समकक्ष मानकों के अनुरूप होंगे:

तापीय संचरण के लिए श्रेणी T2

तापीय ब्रिजिंग कारक के लिए श्रेणी TB2

वायु रिसाव कारक के लिए श्रेणी L1

आवरण क्षमता के लिए श्रेणी D1

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## 2. एयर हैंडलिंग वेंटिलेशन यूनिट

### 2.1 हाउसिंग/आवरण (दोहरा आवरण):

एयर हैंडलिंग वेंटिलेशन यूनिट छत/फर्श लगाने के लिए उपयुक्त होगी। AHU ढांचा ढाले हुए उच्च तन्यता प्रबलित प्लास्टिक से जुड़े बाहर निकले एल्यूमीनियम खंडों का होगा और विभिन्न खंडों के लिए प्रबल, मजबूत और स्व-सहायताकारी ढांचा प्रदान करने के लिए असेम्बल किया जाएगा। प्रत्येक खंड अपने स्वयं के स्वतंत्र आधार के साथ पूर्ण होगा और उठाने के लिए छेदों का प्रावधान के साथ 14 गेज गैल्वनी शीट स्टील चैनलों और एल्यूमीनियम डाई-कास्ट लैंग पर लगाया जाएगा।

प्रत्येक मॉड्यूल का आवरण बाहरी सतह के लिए न्यूनतम 0.6 मिमी मोटी प्री-लेपित GSS और आंतरिक सतह के लिए न्यूनतम 0.6 मिमी मोटी सादे GSS/0.8 मिमी मोटी एल्यूमिनियम/SS शीट से दोहरी सतह निर्मित निर्माण होगा जिसमें निविदा SOQ में निर्दिष्ट के अनुसार बीच में  $40 \pm 2$  किलो/सह घनत्व का न्यूनतम 40/23 मिमी मोटी PUF के साथ इन्सुलेशन सैंडविच किया जाएगा। GI शीट्स पर जस्ता जमाव शीट का न्यूनतम 120 ग्राम/वर्ग मीटर होगा। इन पैनलों को जोड़ों को वायुरोधी बनाने के लिए बीच में एल्यूमीनियम फ्रेम के अंतर्निर्मित खांचे में लगी लकड़ी के सॉफ्ट रबड़/नियोप्रीन गैसकेट के साथ ढांचे पर कसा जाएगा। प्रत्येक खंडे के लिए ढांचे को जोड़ों को वायुरोधी करने के लिए बीच में नरम रबड़ गैसकेट के साथ जोड़ा जाएगा। विभिन्न खंडों के लिए नायलॉन या एल्यूमीनियम डाई से बने मजबूत कब्जों और ताले, के साथ उपयुक्त वायुरोधी अभिगम दरवाजे/पैनल लगाए जाएंगे। रखरखाव के लिए विभिन्न पैनलों तक पहुंचने के लिए एल्यूमीनियम डाई से बने कब्जों और सिटकनी के साथ उपयुक्त दरवाजे लगाए जाएंगे। एक्सेस पैनल के साथ सुरक्षा स्क्रीन लगाई जाएगी। पूरी हाउसिंग को स्टील चैनल ढांचे पर रखा जाएगा।

### 2.2 हाउसिंग/आवरण (एकल आवरण):

यूनिट खंडीय/ ऐकिक, एक आवरण से निर्मित होगी, जिसमें पंखा खंड, शीतन कॉइल के साथ कॉइल खंड, फिल्टर खंड और इंसुलेटेड निकास पैनल होगा। प्रत्येक खंड गैल्विनाइजिंग स्प्रे के साथ 16-गेज GI/MS शीट स्टील का होगा, सभी वेल्डेड/बोल्ट निर्मित, संरचनात्मक भागों के साथ पर्याप्त रूप से प्रबलित और रखरखाव के लिए सुरक्षा स्क्रीन के साथ अभिगम पैनल

लगाया जाएगा। आधार पैनलों का निर्माण उपयुक्त बंधित गढ़ी स्टील शीट्स से किया जाएगा। पंखा खंडों में हटाने योग्य पैनलों को सभी आंतरिक हिस्सों तक और जब यूनिट को विघटित करना हो तब पहुंच प्रदान करना होगा। पंखा खंड पैनल को "ध्वानिक अस्तर" खंड के अनुसार आंतरिक रूप से 25 मिमी मोटी राल आबद्ध फाइबर ग्लास का अस्तर लगाना होगा। ड्रिप ट्रे के कवर को कम से कम 20/25 माइक्रोन जस्ती के शीट स्टील में जस्ती होना चाहिए।

### 2.3 पंखा और मोटर असेंबली:

पंखा-मोटर असेंबली को एल्यूमीनियम प्रोफाइल से बने एक अलग आधार फ्रेम पर आवरण के अंदर रखा जाएगा और स्प्रिंग प्रकार के कंपन पृथक्त्रों पर स्थापित किया जाएगा। पंखों को स्थैतिक और गतिशील रूप से संतुलित होना चाहिए और 40,000 घंटे की संचालन अवधि वाले सीलबंद बेयरिंग होंगे। पंखा शाफ्ट ठोस निर्माण और EN -8 स्टील का होगा। पूरी हाउसिंग को कम्पन पृथक्कन के लिए उपयुक्त पैड के साथ अल्युमिनियम चैनल ढांचे पर रखा जाएगा। पंखे DIDW एयरोफोइल/पश्च/अग्र वक्रित होंगे जैसा कि निविदा SOQ में निर्दिष्ट है। पंखों से आउटलेट वेग 550 मीटर/मिनट से अधिक नहीं होगा। पंखा खंड में एक प्रवेश द्वार और एक सीमा स्विच लगाया जाएगा। प्रवेश द्वार को पंखा मोटर के साथ इंटरलॉक किया जाएगा। पंखे की मोटरों को बेल्ट चालित मोटरों के मामले में आसान बेल्ट टेंशन के लिए स्लाइड रेल पर AHU आवरण के अंदर लगाया जाएगा और मोटर दक्षता श्रेणी IE3 स्तर या बेहतर होगी। पंखे के लिए ड्राइव के लिए बोल्ट और समायोज्य मोटर पुली के साथ बेल्ट ड्राइव लगाया जाएगा। बेल्ट तेल प्रतिरोधी प्रकार की होंगी। उपयुक्त कंपन पृथक्त्रों के माध्यम से आवरण में आधार फ्रेम स्थापित किया जाएगा। जहां भी VFD के साथ इस्तेमाल करना हो, मोटर VFDC पंखे के लिए उपयुक्त होनी चाहिए और कम गति पर तापमान नहीं बढ़ना चाहिए।

### 2.4 आइसोलेटर (पृथक्त्र):

सभी मंजिलों पर लगी वायु हैंडलिंग यूनिटों में कंपन आइसोलेटर लगाए जाएंगे। छत स्थान के भीतर लगाए AHU कंपन पृथक्कन के माध्यम से लटकाया जाएगा। न्यूनतम 90% कंपन पृथक्कन क्षमता के लिए कंपन आइसोलेटर कुशनुमा खुट माउंट/स्प्रिंग प्रकार के होंगे।

### 2.5 पेंटिंग:

लदान या स्थापना के दौरान पेंट की खराब हो जाने पर खनिज स्पिरिट से साफ किया जाएगा, वायर ब्रश लगाया जाएगा और प्रभावित क्षेत्रों पर ठीक किया जाएगा, फिर आसपास के क्षेत्रों से मिलान करने के लिए इनेमल पेंट की परत लगाई जाएगी।



## 2.6 निष्पादन डेटा

उपकरण के सबसे कम शोर स्तर के लिए एयर हैंडलिंग यूनिटों का चयन किया जाएगा। स्पष्ट रूप से इंगित पंखा निष्पादन रेटिंग और ऑपरेटिंग बिंदुओं के साथ विद्युत खपत के डेटा निविदा के साथ या निष्पादन चरण के दौरान प्रस्तुत किया जाएगा और स्थापना के परीक्षण और चालू होने के समय में सत्यापित किया जाएगा।

## 2.7 परीक्षण:

अंशाकन उपकरणों का उपयोग करके सटीक वायु प्रवाह मापन करना होगा। गणना किए गए परिणाम निर्दिष्ट क्षमताओं और उद्धृत रेटिंग के अनुरूप होंगे। बिजली की खपत आने वाले वोल्टेज और इनपुट करंट की मापन से गणना की जाएगी।

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### 3. वेंटिलेशन के लिए ट्यूब अक्षीय पंखे

#### 3.1 अक्षीय पंखे:

अक्षीय पंखे मोटर, मोटर माउंट, सीधे चालित और कंपन पृथकन प्रकार, निलंबन व्यवस्था आदि के साथ यथावश्यक पूरे करने होंगे। ये पंखे कार पार्क वेंटिलेशन/सीढ़ियों के दाब/लिफ्ट/लिफ्ट लॉबी के दाब के लिए ताजा हवा के लिए उपयुक्त होंगे।

#### 3.2 आवरण:

अक्षीय पंखे के आवरण का निर्माण DIN EN ISO 1461 या समकक्ष के अनुसार भारी गेज वाली शीट स्टील से किया जाएगा। पंखा आवरण और मोटर माउंट का निर्माण वेल्डित स्टील से होगा। आवरण को EUROVENT या वाहिका (डक्ट) कनेक्शन के लिए उपयुक्त समकक्ष मानकों के अनुसार उच्च कठोरता के लिए दोनों सिरों पर स्पन फ्लेंज करना चाहिए। छत निलंबन के लिए आधार ब्रेकट को हैंगर बोल्ट से जोड़ने के लिए आवरण को वेल्ड किया जाएगा। चिनाई शाफ्ट के अंदर लगाने के लिए अक्षीय पंखे को स्प्रिंग लोड किए हैंगर का उपयोग करके निलंबित किया जाएगा, जैसा कि निविदा ड्रॉइंग/SOQ में दर्शाया गया है। उपयुक्त कंपनरोधी माउंटिंग लगाई जाएगी। जंग से बचाने के लिए आवरण पर तप्त निमज्जित जस्ता चढ़ाया जाएगा। आवरण की लंबाई पंखे और मोटर असेम्बली की लंबाई से अधिक होगी।

#### 3.3 इम्पेलर:

अक्षीय पंखे का आवरण डाई कास्ट एल्यूमीनियम से बनाया जाएगा। इम्पेलर ब्लेड के प्रोफाइल एयरोफोइल प्रकार की होनी चाहिए ताकि उच्च दक्षता और कम शोर स्तर प्राप्त किया जा सके। इम्पेलर ISO 1940 के अनुसार स्थैतिक और गतिशील रूप से संतुलित होना चाहिए। पंखे का चयन पंखा पिच कोण के साथ सर्वोत्तम दक्षता बिंदु के आधार पर किया जाएगा जो साइट पर संभावित पंखा गति समायोजन करने के लिए पंखा पिच कोण की उपलब्ध पूर्ण श्रेणी से मध्यम श्रेणी में चयनित किया जाएगा। असेम्बली से पहले सभी एल्यूमीनियम कास्ट घटकों का X-रे किया जाता है।

### 3.4 पंखा मोटर:

पंखा मोटर IE3 या बेहतर ऊर्जा दक्षता की होगी, पिंजरी, पूरी तरह से संवृत, पंखा शीतित, मानक फ्रेम, निरंतर ड्यूटी, कुंडलिनी प्रकार 415V±10%/ 3 ph./50 Hz के लिए उपयुक्त, IEC 60034-5 या सुरक्षा की मात्रा के लिए समकक्ष और या तापीय मूल्यांकन के लिए IEC 60085 या समतुल्य के अनुसार IP55 के साथ F श्रेणी के इन्सुलेशन के साथ AC बिजली की आपूर्ति वाली होगी। पंखा-मोटर परिवर्ती स्पीड ड्राइव के लिए उपयुक्त होंगी।

पंखे का चयन अधिकतम दक्षता या न्यूनतम हॉर्स पावर के लिए किया जाएगा। मोटर का डिजाइन विशेष रूप से कम शोर वाले ऑपरेशन के लिए किया जाएगा। मोटर बेयरिंग को पूरी इस्तेमाल अवधि के लिए लुब्रीकेट किया जाएगा और वह पूरी तरह से रखरखाव मुक्त होना चाहिए जिसे परिवाहित हवा के अधिकतम तापमान पर किसी भी स्थापना स्थिति में इस्तेमाल किया जा सकता है। बेयरिंग की इस्तेमाल अवधि कम से कम 40000 घंटे होनी चाहिए।

मोटर कंड्यूट बॉक्स को पंखा आवरण के बाहरी भाग पर लगाया जाएगा, और मोटर से कंड्यूट बॉक्स तक लेड तार लचीली धातु के कंड्यूट में संवृत करके हवा की धारा से सुरक्षित किया जाएगा। ट्रांसमिशन (पारेषण) में कम नुकसान के लिए पंखा सीधा चलाया जाएगा और कार्बन स्टील सामग्री के विस्तारित मोटर शाफ्ट पर रखा जाएगा।

उत्कृष्ट जंगरोधकता के लिए सभी फिक्सिंग/आधार जस्ता लेपित होने चाहिए।

सभी मोटर आधार प्लेट प्रकार के होंगे ताकि वायुप्रवाह में न्यूनतम गतिरोध आए। इन क्षेत्रों का इम्पेलर से अंतराल सावधानीपूर्वक रखा जाए ताकि शोर कम से कम हो।

### 3.5 कंपन पृथकन:

पंखे और मोटर की असेम्बली को अपरूपी प्रकार के रबड़ के कंपन पृथकन के निलंबन से निलंबित किया जाएगा।

### 3.6 सहायक उपकरण (एक्सेसरीज):

निम्नलिखित सहायक उपकरण लगाए जाएंगे: (जहां भी लागू हो)

- स्थैतिक दाब हासिल करने के लिए आउटलेट शंकु।
- उपयुक्त तार रक्षक के साथ बैल माउथ इनलेट (यदि डक्ट इनलेट नहीं किया गया हो तो)

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## 4. अक्षीय धूम छितराव पंखे

### 4.1 अक्षीय पंखे:

अक्षीय पंखे मोटर, मोटर माउंट, सीधे चालित और कंपन पृथकन प्रकार, निलंबन व्यवस्था आदि के साथ यथावश्यक परिपूर्ण होंगे। ये पंखे धूम निकास से निपटने के लिए उपयुक्त होंगे जो 300 Deg. C तापमान तक का हो सकता है और EN 12101-3 या समकक्ष के अनुसार 2 घंटे तक की अवधि के लिए होगा।

### 4.2 आवरण:

अक्षीय पंखे के आवरण का निर्माण DIN EN ISO 1461 या समकक्ष के अनुसार भारी गेज वाली शीट स्टील से किया जाएगा। पंखा आवरण और मोटर माउंट का निर्माण वेल्डित स्टील से होगा। आवरण को EUROVENT या वाहिका (डक्ट) कनेक्शन के लिए उपयुक्त समकक्ष मानकों के अनुसार उच्च कठोरता के लिए दोनों सिरों पर स्पन फ्लैज करना चाहिए। छत निलंबन के लिए आधार ब्रेकट को को हैंगर बोल्ट से जोड़ने के लिए आवरण को वेल्ड किया जाएगा। चिनाई शाफ्ट के अंदर लगाने के लिए अक्षीय पंखे को स्प्रिंग लोड किए हैंगर का उपयोग करके निलंबित किया जाएगा, जैसा कि निविदा ड्रॉइंग/SOQ में दर्शाया गया है। उपयुक्त कंपनरोधी माउंटिंग लगाई जाएगी। जंग से बचाने के लिए आवरण पर तप्त निमज्जित जस्ता चढ़ाया जाएगा। आवरण की लंबाई पंखे और मोटर असेम्बली की लंबाई से अधिक होगी।

### 4.3 इम्पेलर:

अक्षीय पंखे का आवरण डाई कास्ट एल्यूमीनियम से बनाया जाएगा। इम्पेलर ब्लेड के प्रोफाइल एयरोफोइल प्रकार की होनी चाहिए ताकि उच्च दक्षता और कम शोर स्तर प्राप्त किया जा सके। इम्पेलर ISO 1940 के अनुसार स्थैतिक और गतिशील रूप से संतुलित होना चाहिए। पंखे का चयन पंखा पिच कोण के साथ सर्वोत्तम दक्षता बिंदु के आधार पर किया जाएगा जो साइट पर संभावित पंखा गति समायोजन करने के लिए पंखा पिच कोण की उपलब्ध पूर्ण श्रेणी से मध्यम श्रेणी में चयनित किया जाएगा। असेम्बली से पहले सभी एल्यूमीनियम कास्ट घटकों का X-रे किया जाता है।

#### 4.4 पंखा मोटर:

पंखा मोटर IE3 या बेहतर ऊर्जा दक्षता की होगी, पिंजरी, पूरी तरह से संवृत, पंखा शीतित, मानक फ्रेम, निरंतर ड्यूटी, कुंडलिनी प्रकार 415V±10%/ 3 ph./50 Hz के लिए उपयुक्त, IEC 60034-5 या सुरक्षा की मात्रा के लिए समकक्ष और या तापीय मूल्यांकन के लिए IEC 60085 या समतुल्य के अनुसार IP55 के साथ H श्रेणी के इन्सुलेशन के साथ AC बिजली की आपूर्ति वाली होगी। पंखा-मोटर परिवर्ती स्पीड ड्राइव के लिए उपयुक्त होंगी।

पंखे की गति 3000 RPM तक हो सकती है। पंखे का चयन अधिकतम दक्षता या न्यूनतम हॉर्स पावर के लिए किया जाएगा। मोटर का डिजाइन विशेष रूप से कम शोर वाले ऑपरेशन के लिए किया जाएगा। मोटर बेयरिंग को पूरी इस्तेमाल अवधि के लिए लुब्रीकेट किया जाएगा और पूरी तरह से रखरखाव मुक्त होना चाहिए जिसे परिवहित हवा के अधिकतम तापमान पर किसी भी स्थापना स्थिति में इस्तेमाल किया जा सकता है। बेयरिंग की इस्तेमाल अवधि कम से कम 40000 घंटे होनी चाहिए।

मोटर कंड्यूट बॉक्स को पंखा आवरण के बाहरी भाग पर लगाया जाएगा, और मोटर से कंड्यूट बॉक्स तक लेड तार लचीली धातु के कंड्यूट में संवृत करके हवा की धारा से सुरक्षित किया जाएगा। ट्रांसमिशन (पारेषण) में कम नुकसान के लिए पंखा सीधा चलाया जाएगा और कार्बन स्टील सामग्री के विस्तारित मोटर शाफ्ट पर रखा जाएगा।

उत्कृष्ट जंगरोधकता के लिए सभी फिक्सिंग/आधार जस्ता लेपित होने चाहिए।

सभी मोटर आधार प्लेट प्रकार के होंगे ताकि वायुप्रवाह में न्यूनतम गतिरोध आए। इन क्षेत्रों का इम्पेलर से अंतराल सावधानीपूर्वक रखा जाए ताकि शोर कम से कम हो।

#### 4.5 कंपन पृथकन:

पंखे और मोटर की असेम्बली को अपरूपी प्रकार के रबड़ के कंपन पृथकन के निलंबन से निलंबित किया जाएगा।

#### 4.6 सहायक उपकरण:

निम्नलिखित सहायक उपकरण लगाए जाएंगे: (जहां भी लागू हो)

- स्थैतिक दाब हासिल करने के लिए आउटलेट शंकु।
- उपयुक्त तार रक्षक के साथ बैल माउथ इनलेट (यदि डक्ट इनलेट नहीं किया गया हो तो)

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## 5. जेट पंखा

### 5.1 संरचना:

पंखे को फैक्टरी असेम्बल रूप में दिया जाना चाहिए, जिसमें कम वायु मात्रा के साथ वेंटिलेशन के उच्च निष्पादन की विशेषता होनी चाहिए। प्रत्येक यूनिट में सुरक्षात्मक स्क्रीन, इनलेट और आउटलेट निर्मुक्ति नोजल दोनों के लिए साइलेंसर, टर्मिनल बॉक्स और माउन्टिंग आर्म के साथ इनलेट बेल माउथ होगा।

### 5.2 पंखा:

एक अनोखी उच्च दक्षता वाली एरोफोइल खंड ब्लेड में समायोज्य पिच कोण तन्यता के लिए समतल हब और क्लैप-प्लेट होगी। शोर स्तर कम पैदा करने के लिए पतले एरोफोइल खंडों के लिए इम्पेलर सटीक डाई-कास्ट होगा। प्रत्येक कास्ट एल्यूमीनियम घटक को असेम्बली से पहले वास्तविक समय रेडियोग्राफी निरीक्षण का उपयोग करके एक्स-रे किया जाएगा। यदि निर्दिष्ट किया गया हो तो यह सुविधा उत्पाद दायित्व कानून के खिलाफ गुणवत्ता कास्टिंग का प्रमाण प्रदान करेगी।

एरोफोइल पंखा इम्पेलर में निष्पादन की दक्षता का अनुकूलन करने और शोर पैदा होने को कम करने के लिए एक अद्वितीय वायुगतिकीय खंड ब्लेड होगी। हल्की वजनी असेंबली प्राप्त करने के लिए सटीक डाई कास्ट बनाने की तकनीकों से पतले खंड प्राप्त किये जाएंगे। (सटीक डाई कास्ट एल्यूमीनियम हब और क्लैप-प्लेट समान दूरी पर रखे जाएंगे, पूरी तरह से समायोज्य, उच्च दाब डाई कास्ट एरोफोइल खंड ब्लेड)

गुणवत्ता सुनिश्चित करने के लिए मशीनिंग से पहले और एक घंटे के लिए 300 Deg C पर ऑपरेशन के लिए उपयुक्त होने के लिए सभी घूर्णन एल्यूमीनियम घटकों की एक्स-रे जांच की जाएगी।



### 5.3 घटक विनिर्देश:

#### ए. केसिंग:

बाह्य रूप से लगाए प्री-वायर्ड विद्युत टर्मिनल बॉक्स के साथ पूरा किया गया लंबा केस फॉर्म, या वाहिका (डक्ट) या प्लेट स्थापना के लिए छोटा केस। केसिंग इंटैग्रल प्री-ड्रिल फ्लेंज के साथ शीट स्टील से स्पिन की जाएगी, पूरी तरह से वेल्डित सीम होगी और जिस पर उत्कृष्ट स्थायित्व के लिए निर्माण के बाद तप्त निमज्जित जस्ता चढ़ाया जाएगा।

#### बी. मोटर:

पिंजरी प्रकार, H श्रेणी से इन्सुलेट, बेयरिंग को व्यापक तापमान ग्रीस से लुब्रिकेट, कुंजी वाला शाफ्ट और IP55 के लिए मौसमरोधी होगी। (अधिकांश एकल फेज मोटरों पर अतितप्त सुरक्षा उपलब्ध कराई जाएगी)।

F22 फ्रेम तक के आकार के लिए तीन फेज मोटर पर डेल्टा/स्टार पुनर्संयोजन द्वारा गति संचालन उपलब्ध होगा। छः कुंडलिनी वाले टर्मिनलों के माध्यम से एकल कुंडलिनी से पुनर्संयोजन के द्वारा दो गतियां प्राप्त की जा सकती हैं ताकि दो अलग-अलग ध्रुव संख्याएं प्रदान की जा सकें। आवश्यक गति देने के लिए अधिकांश एकल फेज पंखे पर अभिन्न प्री-वायर्ड संधारित्र या मोटर की दोहरी कुंडली है जिसमें अपेक्षित ध्रुवों की दो अलग-अलग पृथक कुंडलिनी हैं।

निष्पादन को स्वतंत्र रूप से AMCA द्वारा अनुमोदित किया जाएगा और ISO 5801 स्थापना श्रेणी D के अनुसार स्थापित किया गया है, वायु निष्पादन का परीक्षण करने की पद्धति और शोर परीक्षण की विधि प्रासंगिक IS या समकक्ष मानकों के अनुसार होगी।

#### सी. निर्मुक्ति नोजल:

नोजल वायुगतिकीय रूप से एल्यूमीनियम की गोल आकार की बनी होगी और उसकी पॉलिशिंग कोट से फिनिश की जाएगी।

#### **डी. साइलेंसर (इनलेट और आउटलेट):**

साइलेंसर आवरण 1.0 मिमी मोटे और 710 मिमी लंबे (न्यूनतम) शीतित मिल स्टील से बनता है। यह बाहरी आवरण पर बेक किए इनेमल से लेपित होता है। आवरण के अंदर 25 मिमी मोटे रेशेदार कांच और पंच स्टेनलेस स्टील शीट से फिनिश की जाएगी।

#### **ई. इनलेट बेल माउथ:**

बेल माउथ एल्यूमीनियम 3003 से बना होता है और पारदर्शी पेंट किया जाता है। इसका आकार पंखे के इनलेट में वायु प्रक्षोभ को कम करने के लिए बनाया जाता है।

#### **एफ. सुरक्षात्मक बर्ड स्क्रीन:**

यह स्क्रीन क्रोम लेपित से बनी सर्कल स्क्रीन होगी।

#### **जी. टर्मिनल बॉक्स:**

बॉक्स को उच्च तापमान प्रकार के संकेत लैंप से लैस किया जाएगा। मोटर तक जाने वाले तार को अग्नि सुरक्षा के लिए फाइबर ग्लास ट्यूब से संवृत किया जाएगा। इसे अग्निशमन सीलेंट से सील कर दिया जाएगा और सभी आंतरिक तारों और घटकों को संबंधित IS या समकक्ष मानकों के अनुसार परीक्षण किया जाएगा।

#### **एच. माउन्टिंग आर्म:**

माउन्टिंग आर्म को हवा का 180 डिग्री कोण क्षैतिज की निर्मुक्ति और 90 डिग्री ऊर्ध्वाधर का समायोजन करने दिया जाएगा।

#### **आई. ध्वानिक डेटा:**

उद्धृत ध्वनि स्तर उन परीक्षणों पर आधारित होंगे जिन्हें प्रत्येक निष्पादन चार्ट पर वर्णित स्पेक्ट्रम संशोधन का उपयोग करके AMCA और ब्रिटिश मानक के द्वारा निर्माता द्वारा खुद की प्रमाणित प्रयोगशाला द्वारा किया जाएगा, पंखे के लिए एक गैर-भारित ध्वनि पावर स्पेक्ट्रम प्राप्त किया जाएगा।

### **जे. गैर-ओवरलोडिंग:**

पंखे में गैर-ओवरलोडिंग विशेषता होगी; चरम पावर इनपुट सामान्य ऑपरेटिंग दबावों की सीमा के भीतर होता है और यह हमेशा मोटर रेटिंग से अधिक हो जाता है।

### **के. परीक्षण:**

निष्पादन डेटा को अंतरराष्ट्रीय स्तर पर मान्यता प्राप्त मानक के अनुसार प्राप्त किया गया है - वायुगतिकीय निष्पादन के लिए ISO 5801 इंस्टालेशन श्रेणी D (AMCA अनुमोदित) और ध्वानिक निष्पादन के लिए प्रासंगिक IS या समतुल्य मानक।

### **एल. फिक्सिंग:**

सभी फिक्सिंग को उत्कृष्ट जंगरोधकता प्रदान करने के लिए जैविक आधारित जस्ता कोटिंग से संरक्षित किया जाता है।

### **एम. जेंटवेंट पंखे के लिए यथावश्यक सहायक उपकरण:**

- माउन्टिंग फीट
- इम्पेलर और मोटर साइड गार्ड
- पॉड के साथ 710 मिमी लंबाई (न्यूनतम) वाले दो साइलेंसर
- अनुकूल फ्लैज
- बेलमाउथ इनलेट

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**एयर कंडीशनिंग और वेंटिलेशन  
कार्यों के लिए विनिर्देश**

**खंड- VII**

**पैकेज यूनिट**

## 1. परिशुद्ध (सटीक) पैकेज यूनिट

### 1.1 सामान्य:

परिशुद्ध (सटीक) एयर कंडीशनिंग यूनिट (वायु-शीतित) उच्च संवेदनशील शीतन क्षमता और स्व-निहित ऐकिक पैकेज वाली एयर कंडीशनर होगी। यूनिट की विशेषताओं में कम चालन लागत होगी जिसे घटकों के सटीक चयन के साथ अत्याधुनिक डिजाइन के माध्यम से हासिल किया जाएगा।

परिशुद्ध यूनिट SOQ में निर्दिष्ट DX/दोहरे द्रव/ठंडे पानी प्रकार की होगी।

मानक रखरखाव करने के लिए यूनिट के सभी उपकरणों तक पहुंच प्रदान की जाएगी। सभी अलग-अलग घटकों और साथ ही पैक यूनिट, पूरे के पूरे प्रासंगिक मानकों के अनुसार या SOQ में निर्दिष्ट के अनुसार परीक्षण की जाएगी।

पंखा खंड, कॉइल खंड इत्यादि के लिए ताप-ध्वानिक अस्तर आवश्यकतानुसार उपलब्ध कराए जाएंगे और यूनिट से 1m के भीतर इनडोर और बाहरी यूनिट का शोर स्तर क्रमशः dB(A) और 75 dB(A) से अधिक नहीं होगा।

### 1.2 कैबिनेट निर्माण:

यूनिट को सामान्य मैनुअल और मैकेनिकल हैंडलिंग, परिवहन और उपयोग में टिके रहने के लिए पर्याप्त शक्ति और कठोरता के साथ निर्माण किया जाएगा। PAC घटकों को रखने वाला कैबिनेट कम से कम 16 गेज (1.29 मिमी) स्टील शीट का होगा और फर्श पर रखने के लिए उपयुक्त होगा। यह कैबिनेट बेहतर कठोरता और पैनल संरक्षण के लिए रिबेट से निर्मित किया जाएगा। कैबिनेट को जंग रोकथाम पेंट के 2 कोट लगाए जाएंगे।

### 1.3 कंप्रेसर:

कंप्रेसर नवीनतम पीढ़ी के वायु-रोधी स्क्रॉल प्रकार के होंगे जिनकी विशेषता उच्च COP की है और R-410a/R-407c के लिए उपयुक्त हैं। कंप्रेसर उपयुक्त कंपन पृथकन माउंटिंग पर माउंट किया जाएगा और चूषण और निर्मुक्ति सर्विस वाल्व, उच्च-निम्न दाब सुरक्षा नियंत्रण और अंतर्निहित ओवरलोड संरक्षण के साथ परिपूर्ण होगा। पंप डाउन नियंत्रण के साथ तरल लाइन परिनालिका वाल्व प्रदान लगाया जाएगा। निम्न दाब स्विच में स्वतः रीसेट होगा, जबकि उच्च

दाब स्विच मैनुअल रीसेट से सुसज्जित होगा। कंप्रेसर पर्याप्त अश्व शक्ति की चूषण गैस शीतित मोटर द्वारा संचालित किया जाएगा और स्टार्टर के साथ परिपूर्ण होगा। मोटर 415 V±10%, 50 Hz, 3 फेज बिजली की आपूर्ति पर ऑपरेशन के लिए उपयुक्त होगी। कंप्रेसर के लिए आवश्यक क्रैंककेस हीटर लगाया जाएगा। मोटर कुंडलिनी थर्मोस्टेट को अधिमानतः कंप्रेसर मोटर के लिए स्थापित किया जाएगा।

#### 1.4 वाष्पीकारक कॉइल:

शीतन कॉइल सीधे विस्तारित प्रकार की होगी जो न्यूनतम 12 मिमी OD सीमलेस तांबा ट्यूबों से बनी होगी और एल्यूमीनियम पंखों से परिपूर्ण होगी जिनकी संख्या 500 ±10 प्रति मीटर से कम नहीं होगी। शीतन कॉइल का बड़ा फलक क्षेत्र और पर्याप्त पंक्तियां होंगी के पास शीतन भार का उच्च संवेदनशील ताप को संभाला जा सके। शीतन कॉइल सर्किट में समान भरण के लिए प्रशीतक वितरक स्थापित किया जाएगा। स्टेनलेस स्टील से बने इंसुलेट निकास पैन और निकास पाइपिंग कंडेनसेट के समुचित निकास के लिए लगाया जाएगा। शीतन कॉइल को तल मंजिल हवा के वितरण के लिए उपयुक्त के रूप में चुना जाना चाहिए और यह हवा के वितरण के लिए आवश्यक हवा के वितरण/शीर्ष स्त्राव/साइड डिस्चार्ज के लिए सर्वर कमरे के लिए आवश्यक हवा के तापमान पर आधारित होगी, जिसमें वांछित आंतरिक परिस्थितियों को बनाए रखा जा सके।

#### 1.5 प्रशीतन सर्किट:

रेफ्रिजरेंट पाइपिंग पर्याप्त क्षमता के इलेक्ट्रॉनिक विस्तार वाल्व (EEV) के साथ भारी गेज वाले तांबे की होगी और आवश्यकता के अनुसार परिपूर्ण होगी, यदि वांछित हो तो गेज को ठीक करने के लिए शट ऑफ वाल्व और HP/LP गेज पोर्ट होंगे। EEV शीतन चक्र का सटीक नियंत्रण और ऊर्जा दक्षता सुनिश्चित करेगा।

सुरक्षा प्लग के साथ तरल रिसीवर को यूनिट के भीतर भंडारण के रूप में कार्य करने के लिए लगाया जाएगा, प्रशीतक मात्रा भिन्नता को अवशोषित करने और आवेश सटीकता में अधिक सहायता को सक्षम करने के लिए स्थापित किया जाएगा। सर्किट में लिक्विड लाइन सोलेनॉइड वाल्व और गैर रिटर्न वाल्व को डिस्पोजर लाइन में शामिल किया जाएगा ताकि लंबी पाइपिंग और कंप्रेसर के सुरक्षित संचालन का ध्यान रखा जा सके।

## 1.6 वाष्पीकारक पंखा:

प्रणाली के स्थैतिक दाब को संभालने के लिए और निविदा अनुसूची में निर्दिष्ट हवा की आवश्यक मात्रा प्रदान करने के लिए जड़त्व के कम आघूर्ण के साथ एकल इनलेट पश्चवर्ती वक्रित अपकेन्द्री पंखा लगाया जाएगा। सीधे युग्मित इलेक्ट्रॉनिक रूप से परिवर्तित (EC) विद्युत मोटर नियंत्रक के माध्यम से गति समायोजन का अवसर प्रदान करती है और विद्युत मोटर कुंडलिनी के अंदर ताप संरक्षण के साथ परिपूर्ण होगी।

स्थैतिक दाब और हवा की मात्रा पर विचार करके पर्याप्त अश्व शक्ति की ड्राइव मोटर की पेशकश की जाएगी। मोटर स्टार्टर को यूनिट के अंदर स्थापित किया जाएगा। इम्पेलर को स्थैतिक रूप से और गतिशील रूप से शांत कंपन मुक्त संचालन के लिए चिकनाए बेयरिंग के साथ संतुलित किया जाएगा। कंपन संचरण को कम करने के लिए पंखे की मोटर व्यवस्था को कंपनरोधी आधार पर रखा जाएगा।

## 1.7 निस्स्यंदन (फिल्ट्रेशन):

आपूर्ति हवा के स्तर को छानने के लिए न्यूनतम MERV-8/ EU 4 फिल्टर मीडिया ग्रेड के आवश्यक धोने योग्य एयर-फिल्टर यूनिट में शामिल किए जाएंगे। पंखे की परिचालन स्थितियों को नियंत्रित करने के लिए दो दाब स्विच वाला कम वायु प्रवाह और अवरुद्ध फिल्टर अलार्म प्रदान लगाए जाएंगे।

## 1.8 रिमोट एयर कूल्ड कंडेन्सर:

कंडेन्सर बड़े फलक क्षेत्र वाले होंगे जिनमें एक या दोहरी सर्किट ताप एक्सचेंजर द्वारा एल्यूमीनियम पंख वाले हाइड्रोफिलिक लेपित कॉपर ट्यूबों के साथ अभिन्न सब-कूलिंग सर्किट के साथ पूरा किया गया है, जो उपयुक्त कम गति वाले अक्षीय प्रवाह पंखा और मोटर, प्रशीतक पाइप कनेक्शन, मेटलिक फ्रेम इत्यादि के साथ हैं, सभी एक कैबिनेट में पहले से लगाए होंगे, जो पेंट किए गए होंगे। यूनिट को एल्यूमीनियम मौसम कवच से कवर किया जाएगा जो कंडेन्सर पर पश्चिम दिशा में सौर किरणों को सीधे गिरने से रोकने के लिए उपयुक्त रूप से डिजाइन किया जाएगा। कंडेन्सर पूरे वर्ष के दौरान बाहरी इयूटी और संचालन

के लिए उपयुक्त होगा। कंडेन्सर के स्टील फ्रेम को न्यूनतम 100 माइक्रोन की मोटाई की कोटिंग के साथ तप्त निमज्जित जस्ता चढ़ाया जाएगा।

अलग-अलग परिस्थितियों में यूनिट के संचालन के लिए दूरस्थ कंडेन्सर के लिए पंखा गति नियंत्रक लगाना होगा।

### 1.9 आर्द्रिकरण और निरार्द्रिकरण:

सटीक यूनिट में निम्नलिखित वाली आर्द्रिकरण और निरार्द्रिकरण विशेषताएं होंगी:

1. ओवरहीटिंग की स्थिति में बिजली की आपूर्ति बंद करने और अलार्म ट्रिगर करने के लिए के लिए पूर्ण थर्मोस्टेट सुरक्षा के साथ एल्यूमीनियम-पंखदार हीटिंग एलिमेंट (ट्यूबलर हीटर डिज़ाइन के साथ) के साथ पर्याप्त क्षमता का विद्युत तापन। तापन सिस्टम निर्धारित बिंदु तक पहुंचने और बनाए रखने के लिए हवा को गर्म करने और सापेक्ष आर्द्रता को कम करने के लिए निरार्द्रिकरण चरण में भी दोहरा उद्देश्य पूरा करता है।

2. इसे ADP को बदलकर निरार्द्रिकरण प्राप्त करना भी संभव करना होगा।

3. नमी के सटीक नियंत्रण के लिए उपयुक्त भाप प्रकार का आर्द्रिकारक प्रदान किया जाएगा।

4. आर्द्रिकरण और निरार्द्रिकरण के लिए सहायक उपकरणों को सटीक नमी स्थितियों को बनाए रखने, कम ऊर्जा खपत और घटकों का अधिक स्थायित्व सुनिश्चित करेगा

### 1.10 माइक्रोप्रोसेसर नियंत्रण प्रणाली:

यूनिट के साथ नवीनतम माइक्रोप्रोसेसर आधारित नियंत्रक प्रदान किया जाएगा जो पूरे वर्ष AC क्षेत्रों की आंतरिक डिज़ाइन स्थितियों को बनाए रखने के लिए AC सिस्टम की निगरानी, प्रदर्शित और संचालन करता है। यह मॉड्यूलर विस्तार योग्य नियंत्रक कंप्यूटर के साथ संगत होना चाहिए। नियंत्रक को सामान्य तापमान और सामान्य नमी की सूचना के लिए उपयुक्त इलेक्ट्रॉनिक सेंसर प्रदान किया जाएगा। तापमान और आर्द्रता इनपुट के आधार पर हीटर और आर्द्रताकारक को नियंत्रक के माध्यम से प्रेरित किया जाएगा। माइक्रोप्रोसेसर आधारित नियंत्रण प्रणाली निम्न की निगरानी और प्रोग्रामिंग कर सकेगी:

- सामान्य तापमान और आर्द्रता



- निर्धारित बिन्दु सामान्य तापमान और नमी।
- सिस्टम की स्थिति।
- यूनिट के प्रत्येक एकल घटक की स्थिति।
- वर्तमान ऑपरेटिंग मोड (शीतन, तापन, निरार्द्रिकरण, आर्द्रिकरण)
- दिनांक, समय और पहचान प्रदर्श
- यूनिट कार्य अवधि।
- न्यूनतम 6 खराबी अलार्म

इसके अतिरिक्त, नियंत्रक उच्च/निम्न तापमान, कंप्रेसर, उच्च दाब/निम्न दाब, शून्य वायु प्रवाह, निम्न आर्द्रताकारक पानी को इंगित करने के लिए आवश्यक अलार्म प्रदान करेगा। नियंत्रक को संचालित करना आसान होना चाहिए और वांछित होने पर पैरामीटर को संशोधित करने के लिए पुश बटन लगाया जाएगा। यूनिट के पास सभी रिमोट बिल्डिंग मैनेजमेंट सिस्टम से कनेक्ट होने के लिए सभी आवश्यक इंटरफेस होंगे ताकि रिमोट टर्मिनल से पैरामीटर मॉनिटर/प्रोग्राम किए जा सकें। संचार के लिए प्रोटोकॉल BACNET या MODBUS जैसे मानक वाले होंगे।

निम्नलिखित अलार्म को माइक्रोप्रोसेसर यूनिट की स्क्रीन पर प्रदर्शित किया जाएगा:

- वायु प्रवाह क्षय
- कंप्रेसर निम्न दाब
- कंप्रेसर उच्च दाब
- उच्च/निम्न सामान्य तापमान
- उच्च/निम्न सामान्य आर्द्रता
- फिल्टर अवरुद्ध अलार्म

### 1.11 विद्युत स्विचबोर्ड:

विद्युत पैनल को वायु प्रवाह से पृथक डिब्बे में रखा जाएगा और सुरक्षा ताले द्वारा संरक्षित किया जाएगा और 73/23/EEC निर्देश और अन्य प्रासंगिक मानकों के अनुसार बनाया जाएगा। इस यूनिट को  $415V \pm 10\%$  -3Ph-50Hz बिजली की आपूर्ति के लिए डिजाइन किया जाएगा। सभी उपकरणों के मोटर स्टार्टर यूनिट के भीतर ही लगाए जाएंगे। सभी विद्युत उपकरणों के लिए स्विचगियर, आर्द्रताकारक विद्युत पैनल में लगाए जाएंगे और एकल फेज निवारकों और अधिभार रिले के साथ परिपूर्ण होंगे। बिजली चले जाने के बाद स्वतः रीस्टार्ट की सुविधा प्रदान करनी होगी। सुरक्षा को ध्यान में रखते हुए नियमों के अनुसार यूनिट के पास मैनुअल विद्युत डिस्कनेक्ट लगाया जाएगा। स्विचबोर्ड में पृथकन ट्रांसफार्मर के साथ 24 V AC निम्न वोल्टेज माध्यमिक सर्किट, जीवित घटकों से सुरक्षा के लिए प्लास्टिक इन्सुलेट स्क्रीन, यांत्रिक इंटरलॉक के साथ सामान्य पृथकन, सुरक्षा और नियंत्रण संपर्कों के लिए तापचुंबकीय सर्किट ब्रेकर शामिल होंगे।

सुरक्षा सर्किट की निरंतरता, इन्सुलेशन प्रतिरोध और वोल्टेज (परावैद्युत क्षमता) परीक्षण की जांच के लिए सभी यूनिट को सुरक्षा परीक्षण चक्र से गुजरना होगा।

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## 2. पैकेज एयर कंडीशनर

अंकित शीतन क्षमता के एयर कूल्ड पैक टाइप एयर कंडिशनर में वायु-रोधी स्क्रॉल कंप्रेसर, एयर कूल्ड कंडेन्सर, एल्यूमीनियम पंख के साथ तांबा कॉइल की न्यूनतम 3 पंक्तियों के साथ वाष्पीकारक शीतित कॉइल, एल्यूमीनियम पंख, ब्लोअर और मोटर, थर्मोस्टेट, कंप्रेसरों की मोटरों के लिए कंडेन्सर और ब्लोअर लोड रिले और एकल चरण निवारक, HDPE फ़िल्टर, रिटर्न एयर स्लॉट और संबद्ध प्रशीतक पाइपिंग सभी को (कंडेन्सर यूनिट को छोड़कर) शीट मेटल कैबिनेट में रखा जाएगा और पेंट किया जाएगा। कंप्रेसर और वाष्पीकारक वाली इनडोर यूनिट पैक यूनिट कक्ष में स्थापित की जाएंगी।

कंडेन्सर यूनिट बड़े फलक क्षेत्र वाली होंगी जिनमें एल्यूमीनियम पंख के साथ तांबा कॉइल की न्यूनतम 3 पंक्तियां, अभिन्न उप शीतन सर्किट, प्रशीतक रिसेवर, उपयुक्त पंखा और मोटर, प्रशीतक पाइप कनेक्शन, धातु के ढांचे आदि के साथ एक कैबिनेट में पहले से वायरिंग किए होंगे, जो पेंट किए गए होंगे, यूनिट को एल्यूमीनियम मौसम कवच से कवर किया जाएगा जो कंडेन्सर पर पश्चिम दिशा में सौर किरणों को सीधे गिरने से रोकने के लिए उपयुक्त रूप से डिजाइन किया जाएगा और कंडेन्सर पूरे वर्ष के दौरान बाहरी ड्यूटी और संचालन के लिए उपयुक्त होगा।

यूनिट को उस स्थान के परिवेश की स्थिति के लिए डिजाइन किया जाएगा जहां यूनिट स्थापित की जा रही है। यूनिट को  $415 \pm 10\% V$ , 50 Hz, AC आपूर्ति पर संचालित करने के लिए डिजाइन किया जाएगा और IS:8148/76 के अनुसार होंगे।

प्रत्येक यूनिट को SOQ में बताए अनुसार वायु मात्रा देने में सक्षम होना चाहिए। यूनिट में HP/LP कट आउट, ओवरलोड रिले आदि जैसे नियंत्रण शामिल होने चाहिए। यूनिट के 1 मीटर के भीतर इनडोर और आउटडोर यूनिट का शोर स्तर 70 dB(A) से अधिक नहीं होगा।

प्रशीतित सर्किट R-407c या समतुल्य ईको-फ्रेंडली प्रशीतक होगा। आवश्यकतानुसार उपयुक्त नाइट्रेल रबड़ थर्मल इन्सुलेशन के साथ तांबे की प्रशीतक पाइपिंग प्रदान की जानी चाहिए। क्षैतिज प्रशीतक पाइप को यांत्रिक रूप से संरक्षित किया जाएगा, जहां भी जमीन पर बिछे हों। कंडेन्सिंग यूनिटों को वाष्पीकारक/कंप्रेसर पैकेज से जुड़ी होंगी और प्रशीतक पाइपिंग में प्रशीतक लाइनों के पृथकन के लिए आवश्यक सर्विस वाल्व शामिल होना चाहिए। प्रत्येक पैकेज यूनिट ऑपरेशन में पूरी तरह से स्वचालित होगी।

आउटडोर कंडेन्सर यूनिट के संरचनात्मक भागों सहित MS भागों पर 75-100 माइक्रोन की कोटिंग मोटाई के साथ गरम डुबकी जस्ती/इपॉक्सी कोटिंग होगी। जंग से बचाने के लिए हाइड्रोफोबिक कोटिंग (नील पंख/स्वर्ण पंख) लगाई जाएगी।

प्रत्येक पैकेज यूनिट के साथ नवीनतम माइक्रोप्रोसेसर आधारित नियंत्रक प्रणाली लगाई जाएगी और ऑपरेशन पूरी तरह से स्वचालित होंगे। बिजली चले जाने के बाद बिजली आने पर स्वतः रीस्टार्ट पैकेज यूनिट की एक अंतर्निहित विशेषता होगी। वापसी हवा का तापमान, पैकेज यूनिट की स्थिति, फॉल्ट/ट्रिप संकेत जैसे मापदंडों का प्रदर्श पैकेज यूनिट के साथ प्रदान किये जाएंगे।

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**एयर कंडीशनिंग और वेंटिलेशन  
कार्यों के लिए विनिर्देश**

**खंड- VIII  
VRF प्रणाली**

## 1. परिवर्ती प्रशीतक (रेफ्रिजरेंट) प्रवाह (VRF) यूनिट

### 1.1 सामान्य:

VRF प्रणाली प्रत्यक्ष विस्तार सिद्धांत पर कार्य करती है, जहां परिसर के सभी इनडोर यूनिट एक छत/फर्श पर लगी वायु शीतित आउटडोर यूनिट से जुड़ी होंगी। परिसर को सटीक ठंडा होने की आवश्यकता को पूरा करने के लिए VRF प्रणाली में प्रशीतक अलग-अलग होता है। पूर्ण भार अर्थात् VRF/VRV AC प्रणाली के 100% भार पर निष्पादन गुणांक (COP) SOQ में विनिर्दिष्ट के अनुसार होगा।

इनडोर स्प्लिट AC यूनिट सामान्य रूप से IS: 1391 - 1992, भाग - II के अनुरूप होंगी। इनमें एयर कूल्ड कंडेंसर, रेफ्रिजरेंट कंप्रेसर, इंटरकनेक्टिंग रेफ्रिजरेंट पाइपिंग, कंडेनसेट ड्रेन कनेक्शन, थर्मोस्टेट इत्यादि जैसी मानक विशेषताएं होंगी, ताकि प्रणाली को पूर्ण और निरापद और संतोषजनक संचालन मुहैया कराया जा सके। ये यूनिट औद्योगिक वातावरण के तहत काम करने के लिए उपयुक्त होंगी और सतत कार्य के लिए उपयुक्त होंगी।

प्रत्येक मॉड्यूलर आउटडोर यूनिट में उच्च विश्वसनीयता, बेहतर कार्य अवधि, बेहतर बैकअप और ड्यूटी चालन उद्देश्य के लिए इनवर्टर/डिजिटल स्क्रॉल प्रकार कंप्रेसरों से लैस किया जा सकता है। यह प्रणाली इनवर्टर कंप्रेसर के मामले में इनवर्टर कंप्रेसर के द्वारा और डिजिटल स्क्रॉल कंप्रेसर के मामले में अक्षीय अनुपालन के जरिए शीतन और तापन भार में बदलावों का पालन करने के लिए कंप्रेसर की घूर्णन गति को बदलने में सक्षम होगी।

आउटडोर यूनिट सभी प्रकार की इनडोर यूनिट के मिश्रण कनेक्शन के लिए उपयुक्त होंगी।

निम्नलिखित प्रकार की आउटडोर यूनिट प्रणाली से जुड़ी होंगी:

- छत पर लगी कैसेट प्रकार की
- छत पर लगी डक्ट प्रकार की
- दीवार पर लगी उच्च दीवार यूनिट
- फर्श पर खड़े प्रकार की इनडोर यूनिट

इनडोर यूनिट और आउटडोर यूनिट के बीच प्रशीतक पाइपिंग को बिना किसी तेल पाश (ट्रेप) के न्यूनतम 70 मीटर स्तर के अंतर के साथ 1000 मीटर तक विस्तार करना संभव होगा। इनडोर यूनिट से इनडोर यूनिट के बीच का स्तर अंतर 30 मीटर होगा।

जब तक अन्यथा निर्दिष्ट नहीं किया गया हो, गति भिन्नता/क्षमता मॉड्यूलन के लिए न्यूनतम 1 कंप्रेसर इन्वर्टर प्रकार का होगा।

VRF प्रणाली के प्रमुख घटकों में निम्न शामिल होंगे:

1. कंप्रेसर
2. एयर कूल्ड कंडेंसर
3. कंडेन्सर पंखा
4. इवेपोरेटर (वाष्पीकारक)
5. वाष्पीकारक पंखा
6. फ़िल्टर
7. नियंत्रण
8. प्रशीतक सर्किट
9. इलैक्ट्रिक्स (वैद्युतिकी)

## 1.2 आउटडोर यूनिट (ODU):

1. आउटडोर यूनिट को कारखाने में भारी गेज के मृदु स्टील पैनलों से निर्मित मौसम सह्य आवरण के साथ असेम्बल किया जाएगा और बेक्ड इनेमल फिनिश के साथ लेपित किया जाएगा। यूनिट को सभी आवश्यक नियंत्रणों के साथ पूरी तरह से फैक्टरी वायरिंग के साथ परीक्षण किया जाना चाहिए।
2. इसमें बेहतर स्थिरता और उपकरण की लंबी कालावधि के लिए कई कंप्रेसर स्विचिंग शुरूआती अनुक्रम के लिए इयूटी साइकिलिंग भी प्रदान की जानी चाहिए।
3. आउटडोर यूनिट मॉड्यूलर डिजाइन की होगी और साथ-साथ इंस्टॉलेशन करने देना चाहिए।
4. यूनिट में अपने स्वयं का माइक्रोप्रोसेसर कंट्रोल पैनल लगाया जाएगा।

5. आउटडोर यूनिट को जंगरोधी पेंट किया जाएगा और गैलबेरियम स्टील बेस प्लेट पर रखा जाएगा।

6. मशीन में उचित सर्किट/ब्रिज के जरिये कॉइल सतह का अधिक प्रभावी ढंग से उपयोग करने के लिए एक उप-ठंडी सुविधा होनी चाहिए जिससे वह लंबी पाइपिंग से प्रशीतक के फ्लशिंग को रोक देता है, इस प्रभाव के चलते ऊर्जा बचत होती है।

7. आउटडोर यूनिट में दाब क्षति को कम करने के लिए सर्पिल निर्मुक्ति वायु प्रवाह के लिए, एयरो फिटिंग ग्रिल के साथ कम शोर, हवाई सर्पिल डिजाइन वाला पंखा फिट किया जाना चाहिए और बेहतर दक्षता के लिए उचित उच्च दक्षता वाली पंख मोटर फिट होनी चाहिए।

8. संघनक यूनिट को कई इनडोर यूनिट से कनेक्ट होने पर सुरक्षित रूप से संचालित करने के लिए डिज़ाइन किया जाएगा।

9. निर्बाध शीतन सुविधा के लिए यूनिट को बैकअप संचालन करने देना चाहिए। कंप्रेसर विफलता, सेंसर विफलता, ODU पंखा/मोटर विफलता के दौरान ऑटो बैकअप आवश्यक होगा।

### **1.3 कंप्रेसर:**

1. कंप्रेसर अत्यधिक दक्ष रोटरी/स्क़्रॉल प्रकार का होगा और इनवर्टर/डिजिटल नियंत्रण में सक्षम होगा। इनवर्टर/डिजिटल कंप्रेसर शीतन या तापन भार की आवश्यकता में भिन्नता के अनुसार गति/विनियमित करेगा।

2. कंप्रेसर लगातार संचालन करने में सक्षम होगा।

3. कंप्रेसर के सभी भागों को पर्याप्त रूप से चिकनाया जाएगा। कंप्रेसर आवरण में तेल हीटर लगाया जाएगा।

### **1.4 हीट एक्सचेंजर:**

1. हीट एक्सचेंजर का निर्माण तांबे की ट्यूब से किया जाएगा जो क्रॉस फ़ैन कॉइल बनाने के लिए यांत्रिक रूप से एल्यूमीनियम पंखों से बंधे होंगे। कम बाईपास देते हुए सबसे अच्छे हवाई



संपर्क के लिए ट्यूब को कंपित डिजाइन में व्यवस्थित किया जाएगा। एल्यूमीनियम पंख को जंगरोधी राल फिल्म द्वारा कवर किया जाएगा।

2. यूनिट में E-पास गर्मी एक्सचेंजर लगाया जाना चाहिए ताकि हीट एक्सचेंजर के मार्ग को अनुकूलित करने और कंडेन्सर की बेहतर दक्षता प्राप्त की जा सके।

3. यूनिट में ऊर्ध्वाधर निर्मुक्ति के लिए व्यवस्थित आवश्यक संख्या में प्रत्यक्ष संचालित कम शोर स्तर प्रोपेलर प्रकार पंखे लगाए जाएंगे। प्रत्येक पंखे के लिए एक सुरक्षा कवच होगा।

### **1.5 प्रशीतक सर्किट:**

प्रशीतक सर्किट में द्रव और गैस बंद वाल्व और कंडेंसर के अंत में एक सोलेनॉइड (परिनालिका) वाल्व शामिल होगा। उपकरण में उचित प्रशीतक वितरण के लिए निर्मित प्रशीतक स्थिरीकरण नियंत्रण होना चाहिए। सिस्टम का सुरक्षित संचालन सुनिश्चित करने के लिए सभी जरूरी सुरक्षा उपकरण प्रदान किए जाएंगे।

### **1.6 सुरक्षा उपकरण:**

सिस्टम के सुरक्षित संचालन के लिए सभी जरूरी सुरक्षा उपकरण लगाए जाएंगे। निम्नलिखित सुरक्षा उपकरण आउटडोर यूनिट का हिस्सा होंगे

- उच्च दाब स्विच,
- फ्यूज,
- पंखा ड्राइव अधिभार रक्षक,
- गलनीय प्लग,
- अधिभार रिले,
- कंप्रेसर के लिए ओवरलोड संरक्षण

### **1.7 तेल रिकवरी सिस्टम:**

यूनिट तेल रिकवरी प्रणाली से लैस की जाएगी ताकि लंबी प्रशीतन पाइपिंग लंबाई के साथ

स्थिर संचालन सुनिश्चित किया जा सके। कम चिकनाहट से बचने के लिए सिस्टम में तेल संतुलन सर्किट लगाया जाना चाहिए।

### 1.8 इनडोर यूनिट (IDU) सामान्य विनिर्देश:

आम तौर पर इनडोर यूनिट का प्रकार, क्षमता और स्थान SOQ में बताए अनुसार होगा। प्रत्येक इनडोर यूनिट में इलेक्ट्रॉनिक विस्तार वाल्व होगा जो कमरे के लोड की भिन्नता के आधार पर तापमान को महसूस करता है और तदनुसार प्रतिक्रिया देने के लिए बाहरी मॉड्यूल को संदेश देता है।

1. इनडोर यूनिट SOQ में बताए अनुसार फर्श पर लगाने वाली/उच्च दीवार/कैसेट/डक्टेबल प्रकार की होगी।
2. यूनिट में पूर्व-फिल्टर, पंखा खंड और DX-कॉइल खंड शामिल हैं।
3. यूनिट की हाउसिंग हल्का वजनी पाउडर लेपित जस्ती स्टील की होगा।
4. यूनिट में हवा की आपूर्ति और वापसी के लिए एक बाहरी आवरण होगा
5. इनडोर यूनिट के पते को व्यक्तिगत और समूह नियंत्रण के लिए स्वचालित रूप से सेट किया जाएगा। केंद्रीकृत नियंत्रण के लिए यह LCD डिस्प्ले पैनल के साथ एक दूरस्थ नियंत्रक द्वारा निर्धारित किया जाएगा।
6. पंखा प्रणाली में कम शोर और कंपन मुक्त संचालन सुनिश्चित करने के लिए दोहरा चूषण, वायुगतिकीय डिजाइन टर्बो, बहु ब्लेड प्रकार, स्थैतिक और गतिशील रूप से संतुलित होगा। पंखा सीधे संचालित प्रकार होगा, हाउसिंग पर आधारित सीधे मोटर शाफ्ट पर लगा होगा।
7. शीतक कॉइल निर्बाध कॉपर ट्यूबों से बनाई जाएगी और लगातार एल्यूमिनियम पंख होंगे। पंख कॉलर से अलग होंगे जो अभिन्न अंग होगा। ट्यूब को एयरफ्लो की दिशा में क्रमबद्ध किया जाएगा। पंखों के साथ न्यूनतम तापीय संपर्क प्रतिरोध के लिए ट्यूबों को

हाइड्रॉलिक/यांत्रिक रूप से विस्तारित किया जाएगा। प्रत्येक कॉइल का पानी के नीचे 21 kg/m<sup>2</sup> वायु के दाब में फैक्टरी में परीक्षण किया जाएगा।

8. यूनिट में एक अभिन्न रूप से ढाला प्लास्टिक/एल्यूमिनियम फ्रेम पर सफाई योग्य फिल्टर लगा होगा। फिल्टर आसानी से सर्विस करने लायक होगा।

9. प्रत्येक इनडोर यूनिट में डिजाइन सामान्य तापमान को बनाए रखने के लिए कम्प्यूटरीकृत PID नियंत्रण होगा। प्रत्येक यूनिट को शीतन और तापन के लिए माइक्रोप्रोसेसर थर्मोस्टेट लगाया जाएगा।

10. प्रत्येक यूनिट में वायरलेस LCD प्रकार रिमोट कंट्रोलर लगा होगा। दूरस्थ नियंत्रक आसान रखरखाव के लिए नवीनतम खराबी कोड को याद रखेगा। नियंत्रक में आसान और त्वरित रखरखाव और सर्विस के लिए स्व-नैदानिक विशेषताएं होंगी। नियंत्रक आवश्यकता के अनुसार पंखा गति और स्विंग फ्लैप के कोण को अलग-अलग रूप से बदलने में सक्षम होगा।

#### 1.8.1 छत पर लगाई कैसेट प्रकार की यूनिट:

1. यूनिट छत पर लगाने वाली होगी। यूनिट में पूर्व-फिल्टर, पंखा खंड और DX-कॉइल खंड शामिल होगा। यूनिट की हाउसिंग पाउडर लेपित जस्ती शीट स्टील की होगी। बॉडी हल्के वजन वाली होगी और चार कोनों से लटकाई जा सकेगी।

2. यूनिट में हवा की आपूर्ति और वापसी के लिए एक बाहरी आकर्षक पैनल होगा। यूनिट के साइडों में चारों तरफ आपूर्ति के लिए वायु ग्रिल और केंद्र में वापसी वायु ग्रिल होगी।

3. प्रत्येक यूनिट में उच्च लिफ्ट निकास पंप, ताजा हवा लेने का प्रावधान, कम गैस का पता लगाने वाली प्रणाली और बहुत कम ऑपरेटिंग ध्वनि होगी।

4. क्षमता में अंतर के बावजूद सभी इनडोर यूनिट में सौंदर्य एकरूपता की दृष्टि से समान सजावटी पैनल होना चाहिए। इसमें शाखा नलिकाओं को जोड़ने का प्रावधान होना चाहिए। यूनिट में घनीभूत निकासी पंप लगाया जाएगा।

### 1.8.2 छत पर लगाने वाली वाहिका प्रकार की यूनिट:

1. यूनिट छत पर लगाने के लिए उपयुक्त होगी। यूनिट में पूर्व-फिल्टर, पंखा खंड और DX-कॉइल खंड शामिल होगा। यूनिट की हाउसिंग पाउडर लेपित जस्ती शीट स्टील की होगी। यूनिट में वाहिका व्यवस्था के लिए उच्च स्थैतिक पंखा होगा।

### 1.8.3 छत निलंबित प्रकार:

1. यूनिट फाल्स सीलिंग के ऊपर छत से निलंबित व्यवस्था के लिए उपयुक्त होगी।
2. यूनिट में पूर्व फिल्टर, पंखा खंड और DX कॉइल खंड शामिल हैं। यूनिट में पूर्व-फिल्टर, पंखा खंड और DX-कॉइल खंड शामिल होगा। यूनिट की हाउसिंग हल्के भार वाले पाउडर लेपित जस्ती शीट स्टील की होगी।

### 1.8.4 उच्च दीवार पर लगाने वाली यूनिट:

1. यूनिट दीवार पर लगाने वाली होगी। यूनिट में पूर्व-फिल्टर, पंखा खंड और DX-कॉइल खंड शामिल होगा। यूनिट की हाउसिंग हल्के भार वाले पाउडर लेपित जस्ती शीट स्टील/ ढाले प्लास्टिक की होगी।
2. किसी भी आंतरिक सजावट में सुसंगत डिजाइन और कॉम्पैक्ट आवरण के साथ यूनिट का बाहरी आवरण आकर्षक होगा।

### 1.8.5 छत पर लगाने वाले अंतर्निहित प्रकार:

1. डिजाइन अवधारणा, आंतरिक सजावट आदि जैसी विभिन्न आवश्यकताओं को पूरा करने के लिए वैकल्पिक किटों के पूर्ण लाइन-अप के साथ विभिन्न व्यवस्था के लिए उपयुक्त होने के

लिए यूनिट बहुत लचीली होगी। यूनिट में पूर्व-फिल्टर, पंखा खंड और DX-कॉइल खंड शामिल होगा। यूनिट की हाउसिंग हल्के भार वाले पाउडर लेपित जस्ती शीट स्टील की होगी। प्रत्येक यूनिट में वैकल्पिक उच्च लिफ्ट निकास पंप होगा।

### 1.9 केंद्रीयकृत प्रकार का रिमोट कंट्रोलर:

इस प्रणाली के साथ बहुक्रिया कॉम्पैक्ट केंद्रीयकृत नियंत्रक लगाया जाएगा। यह निम्नलिखित सभी कार्यों के साथ सभी इनडोर यूनिट को नियंत्रित करने में सक्षम होगा:

1. एक क्षेत्र या समूह या पृथक यूनिट के रूप में एयर कंडीशनर को चालू करना/बंद करना।
2. प्रत्येक इनडोर यूनिट या क्षेत्र के लिए तापमान सेटिंग।
3. तापमान नियंत्रण मोड के बीच स्विच करना, पंखा गति और एयरफ्लो की दिशा की ओर स्विच करना, अलग-अलग रिमोट नियंत्रक संचालन को सक्षम करना/अक्षम करना।
4. अलग-अलग इनडोर यूनिट के संचालन मोड और तापमान की सेटिंग, रखरखाव की जानकारी और परेशानी-हल करने की जानकारी जैसे आपरेशन मोड को मॉनिटर करना।
5. एयर कंडीशनर संचालन का पूर्ववृत्त दर्शाना।
6. विभिन्न समय-सूची के लिए प्रावधान के साथ वार्षिक समय-सूची कार्यों के माध्यम से दैनिक प्रबंधन स्वचालन।
7. नियंत्रक के पास व्यापक स्क्रीन उपयोगकर्ता के अनुकूल प्रदर्श होगा और इनडोर यूनिट से 100 मीटर की दूरी तक गैर-ध्रुवी 2 तार ट्रांसमिशन केबल द्वारा वायरिंग की जा सकती है।

### 1.10 प्रशीतक:

1. रेफ्रिजेंट SOQ में विनिर्दिष्ट के अनुसार और गैर-HCFC रेफ्रिजेंट होना चाहिए।

2. पूरी संघनक यूनिट और वाष्पीकारक यूनिट को कारखाने में असेम्बल और परीक्षण किया जाना चाहिए। यूनिट को कारखाने से ही शुरुआती प्रशीतक आवेश के साथ आना चाहिए। प्रशीतक की अतिरिक्त आवश्यकता होने पर साइट पर मुफ्त में डाला जायेगा और उपकरण में खराबी या निष्पादन के दौरान कारीगरी के कारण हुई प्रशीतक की कमी को पूरा किया जाएगा।

### 1.11 रेफ्रिजेंट पाइपिंग:

1. इस प्रणाली के लिए सभी प्रशीतक पाइपिंग को 18 SWG की न्यूनतम मोटाई के साथ नरम सीमलेस कठोरता से खींचे गए (कठोर कर्षित) तांबा पाइपों से, तांबे की फिटिंग्स और चांदी से झले जोड़ों से बनाया जाएगा। प्रशीतित पाइपिंग व्यवस्था एयर कंडीशनिंग उद्योग के भीतर अच्छी पद्धतियों के अनुसार होगी, और चार्ज कनेक्शन, चूषण लाइन इन्सुलेशन और सामान्य रूप से उचित प्रशीतक सर्किट के हिस्से के रूप में अन्य सभी वस्तुएं शामिल होंगी।

2. तांबे की पाइपिंग में सभी जोड़ों को कम तापमान की झलाई और चांदी की टंकाई का उपयोग करके टांकों का होना चाहिए। किसी भी तांबे के पाइप या फिटिंग को जोड़ने होने से पहले, इसके अंदरूनी हिस्से को इसकी पूरी लंबाई में तार या केबल के साथ साफ कपड़ा डालकर पूरी तरह से साफ किया जाएगा। जोड़ लगाने के दौरान पाइपिंग को लगातार साफ रखा जाना चाहिए।

3. रेफ्रिजेंट पाइपिंग की स्थापना के बाद कार्यकारी दाब के 1.5 गुना दाब पर परीक्षण किया जाएगा।

4. सभी प्रशीतक पाइपों को ठीक से लगाया जाएगा और उस पर डाले गए भार को वहन करने के लिए आधार के लिए सम्मिलित या पर्याप्त आकार और संख्या में इनसर्ट या एंकर फास्टरों के माध्यम से भवन संरचना में लगाया जाएगा ।

### 1.12 निकास पाइपिंग:

इनडोर यूनिटों के कंडेनसेट (संघनन) को निकासी पैन में कंडेनसेट के किसी भी संचय को रोकने के लिए डिज़ाइन की गई ठीक से स्थापित निकास पाइपिंग के माध्यम से निकाला

जाएगा। निकासी पाइपिंग को जलरोधी चूड़ीदार कनेक्शन के साथ न्यूनतम 6 kg/cm<sup>2</sup> दाब रेटिंग के कठोर पीवीसी पाइप का बनाया जाना चाहिए जो इनडोर यूनिट से उपयुक्त निकास बिंदु तक जाएगा। पूर्ण निकास पाइपिंग को सटीक स्थापना और लीक प्रूफ सीलेंट/आसंजक का इस्तेमाल करके रिसाव रहित और जलरोधी बनाया जाएगा।

### 1.13 इन्सुलेशन:

चूषण और तरल लाइन का इन्सुलेशन पाइप खंड लचीला, संवृत सेल इलास्टोमेरिक, एल्यूमिनियम फॉयल से कवर करके 40.0 kg/m<sup>3</sup> से अधिक घनत्व के साथ नाइट्राइल रबड़ इन्सुलेशन से किया जाएगा। पूरी प्रशीतक पाइपिंग को इन्सुलेट किया जाएगा और मौसमी संरक्षण प्रदान किया जाएगा। संघनन से बचने के लिए निकास पाइप को भी इन्सुलेट किया जाएगा।

### 1.14 नियंत्रण और इंस्ट्रुमेंटेशन:

अनुक्रमिक चालू/बंद करने के लिए AC में उपयुक्त नियंत्रण/कॉन्टैक्टर/थर्मोस्टेट लगाया जाएगा, अर्थात् कंप्रेसर आखिर में चालू होगा और पहले बंद होगा।

सभी जरूरी इंटरलॉकिंग और अलार्म सर्किट की व्यवस्था की जाएगी जिससे उपकरणों की खराबी या किसी संभावित परिचालन गलतियों के कारण AC को किसी भी संभावित नुकसान से बचाया जा सके।

### 1.15 वैद्युतिकी:

कंप्रेसर और पंखा मोटर के लिए नियंत्रण रिले और उच्च-कम दाब कट आउट के साथ संपर्कक युक्त विद्युत नियंत्रण बॉक्स लगाया जाएगा। मुख्य लाइन और नियंत्रण बॉक्स और इनडोर/आउटडोर यूनिट और नियंत्रण बॉक्स के बीच विद्युत वायरिंग मानक पद्धति के अनुसार की जाएगी।

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एयर कंडीशनिंग और वेंटिलेशन  
कार्यों के लिए विनिर्देश

**खंड- IX**

यूनिटरी (ऐकिक) एयर कंडीशनर



## 1. डक्टेबल स्प्लिट यूनिट

उपयुक्त क्षमता की डक्टेबल स्प्लिट एयर कंडीशनिंग यूनिट प्रदान की जाएगी, जिसमें R 407c/R410a या समकक्ष पर्यावरण-अनुकूल प्रशीतक के साथ एक इनडोर और एक आउटडोर यूनिट शामिल होगी।

1. आउटडोर यूनिट  $415 \pm 10$  % V, 3 फेज, 50 Hz AC की आपूर्ति पर उपयुक्त संचालन के लिए और भली भांति बंद सील स्क्रॉल कंप्रेसर, प्रोपेलर टाइप पंखे, स्थायी विभाजन कैपेसिटर टाइप पंखा मोटर, और एयर कूल्ड कंडेनसर तांबा ट्यूब और एल्यूमिनियम पंख, सभी पाउडर में लेपित शीट धातु कैबिनेट में रखे जाएंगे। बाहरी यूनिट को उस स्थान पर परिवेशी स्थिति के लिए उपयुक्त होना चाहिए जहां यूनिट स्थापित की जा रही है। बाहरी यूनिट का का शोर स्तर यूनिट से लगभग 1m दूरी पर 70 dB(A) से अधिक नहीं होगा। जुड़वां कंप्रेसर वाली यूनिट पेश की जा सकती हैं।

2. इनडोर यूनिट में बहु गति नियंत्रण के साथ उपयुक्त क्षमता वाली मोटर द्वारा संचालित DIDW अग्रवर्ती वक्रित अपकेन्द्री पंखा, सिंथेटिक मीडिया फिल्टर और कॉपर ट्यूब एल्यूमिनियम पंख वाष्पीकरणक कॉइल की कम से कम 3 पंक्तियां सभी पाउडर में लेपित शीट धातु कैबिनेट में रखे जाएंगे। पंखे द्वारा वितरित हवा की क्षमता SOQ में बताए अनुसार होगी। पंखे का चयन उपकरण और नलिका के माध्यम से नुकसान पर काबू पाने के लिए पर्याप्त स्थैतिक दाब के लिए किया जाएगा।

3. संपूर्ण यूनिट को ध्वानिक रूप से उपयुक्ततः इन्सुलेट किया जाएगा। इनडोर यूनिट का शोर स्तर यूनिट से लगभग 1m दूरी पर 55 dB(A) से अधिक नहीं होगा।

4. जहां आवश्यक हो, वहां सक्शन लाइनों के लिए कठोर पाइप इन्सुलेशन सहित आउटडोर और इनडोर यूनिट के बीच परस्पर जुड़ी तांबा प्रशीतक पाइपिंग लगाई जाएगी। जमीन पर बिछे क्षैतिज रेफ्रिजरेट पाइपों को यांत्रिक रूप से संरक्षित किया जाएगा।

5. एक बहु गति पंखा नियंत्रण के साथ थर्मोस्टेट की उपयुक्त संख्या जैसे नियंत्रण।

6. इनडोर यूनिट के लिए सहायक ब्रेकट।

7. प्रत्येक यूनिट के साथ माइक्रोप्रोसेसर आधारित नियंत्रण प्रणाली प्रदान की जाएगी और इसका संचालन पूरी तरह से स्वचालित होगा। सभी मोटर में उपयुक्त स्टार्टर लगाए जाएंगे और बाहरी यूनिट के भीतर आसानी से स्थित होंगे। इस यूनिट को माइक्रोप्रोसेसर आधारित पैनल के साथ प्रदान किया जाएगा जिसमें माइक्रोप्रोसेसर आधारित मोटर सुरक्षा डिवाइस लगा होगा जिसमें अधिभार रिले, एकल फेज निवारक, फेज उलटाव संरक्षण, शॉर्ट सर्किट संरक्षण, HP/LP कटआउट आदि शामिल हैं और स्प्लिट यूनिट के संचालन को नियंत्रित करेगा। पैनल में सामान्य तापमान, सेट बिंदु तापमान, लिए गए करंट, स्थिति संकेत, खराबी प्रदर्श और ट्रिप संकेत के लिए LED डिस्प्ले प्रदान किया जाएगा। ऑटो अनुक्रम प्रारंभ और ऑटो अनुक्रम बंद पूर्व निर्धारित समय देरी के साथ प्रदान किया जाएगा। बिजली चले जाने के बाद बिजली के आने पर ऑटो स्टार्ट की इनबिल्ट सुविधा होगी।

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## 2. कैसेट स्प्लिट यूनिट

इन्वर्टर/नियत गति कैसेट स्प्लिट A/C यूनिट की आपूर्ति, हरेक की क्षमता SOQ में निर्दिष्ट के अनुसार होगी जो R410a/407c या समकक्ष पर्यावरण-अनुकूल प्रशीतक के साथ एकल/तीन फेज A/C आपूर्ति पर संचालन के लिए उपयुक्त होगी।

1. प्रत्येक स्प्लिट टाइप A/C यूनिट में आउटडोर यूनिट होगी जो उस स्थान के लिए उपयुक्त होगी जहां यूनिट स्थापित की जा रही है और छत पर लगाने के लिए उपयुक्त कैसेट टाइप इनडोर यूनिट होगी।

2. आउटडोर (संघनक) यूनिट की GI/पाउडर कोटिंग से फिनिशिंग की जाएगी और इसमें भली भांति बंद सील सक्शन गैस कूल्ड कंप्रेसर, अधिभार संरक्षण, पर्याप्त गहरी पंक्तियां और बड़े फलक क्षेत्र वाले तांबे से बनी वायु शीतित कंडेन्सर कॉइल, प्रोपेलर टाइप पंखे के साथ फिट और उचित मोटर, सर्विस वाल्व की व्यवस्था, प्रशीतक फिल्टर आदि सभी शीट धातु कैबिनेट में रखे रखे जाएंगे।

3. उच्च दीवार पर लगने वाली इनडोर (कक्ष) यूनिट में तांबे की बनी वाष्पीकारक कॉइल, होगी जिसमें पर्याप्त गहरी पंक्तियां होंगी, जिसमें गंदगी पाश के साथ बाहर निकालकर धोने वाली नायलॉन वायर जाली/HDPE फिल्टर होंगे, मोटर की शाफ्ट पर लगाई गयी और स्क़ॉल में रखी गई स्थैतिक और गतिशील रूप से संतुलित ब्लोअर यूनिट होगी।

4. सभी यूनिट के लिए पुश बटन के साथ चयनकर्ता नियंत्रण यूनिट, बहु गति पंखा संचालन के लिए चयनकर्ता स्विच प्रदान किया जाएगा। चौतरफा समायोज्य वायु प्रवाह की दिशा व्यवस्था के साथ गैर-संक्षारक सामग्री से बने हवाई ग्रिल की आपूर्ति।

5. स्प्लिट यूनिट में निम्नलिखित विशेषताएं होंगी:

- ऑटो मोड ऑपरेशन
- स्लीप मोड ऑपरेशन
- मेमोरी बैकअप के साथ ऑटो सेटिंग
- समय देरी सुविधा
- ऑटो स्टार्ट

- प्रोग्रामनीय टाइमर
- निकासी पंप के माध्यम से संघनित पानी की स्वचालित जल निकासी

6. यूनिट में थर्मोस्टेट जैसे उपयुक्त नियंत्रण होंगे और आवश्यकतानुसार संपूर्ण होंगे।

7. AC क्षेत्रों के अंदर यूनिट में कम शोर स्तर आवश्यक है (लगभग 45 dB(A))। निर्माता इनडोर यूनिट से 1 मीटर पर dB(A) में औसत शोर स्तर इंगित करेंगे।

8. इन्वर्टर चालित कंप्रेसर के मामले में आंतरिक स्थितियों को गति भिन्नता के जरिये बनाए रखा जाएगा।

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### 3. उच्च दीवार स्प्लिट यूनिट

उच्च दीवार स्प्लिट टाइप A/C यूनिट फिक्स्ड/इन्वर्टर प्रकार की SOQ में निर्दिष्ट के अनुसार अंकित क्षमता की होगा जो R 32/ R410a या समकक्ष पर्यावरण-अनुकूल प्रशीतक के साथ 230 V±10%, 50 Hz, एकल फेज A/C आपूर्ति पर संचालन के लिए उपयुक्त होगी।

1. प्रत्येक स्प्लिट टाइप A/C यूनिट में आउटडोर यूनिट होगी जो उस स्थान की परिवेशी मौसम की स्थितियों के लिए उपयुक्त होगी जहां यूनिट स्थापित की जा रही है और आकर्षक बाहरी कैबिनेट के साथ उच्च दीवार पर लगी इनडोर यूनिट होगी। दोनों यूनिट प्रशीतक (तांबे) ट्यूबिंग के माध्यम से जुड़ी होंगी और संतोषजनक संचालन के लिए विद्युत वायरिंग के साथ संपूर्ण होंगी और आवश्यकता के अनुरूप संचालित होंगी। जमीन पर बिछे रेफ्रिजरेंट पाइपों को यांत्रिक रूप से संरक्षित किया जाएगा।

2. आउटडोर (संघनक) यूनिट की GI/पाउडर कोटिंग से फिनिशिंग की जाएगी और इसमें भली भांति बंद सील सक्शन गैस कूल्ड कंप्रेसर, अधिभार संरक्षण, पर्याप्त गहरी पंक्तियां और बड़े फलक क्षेत्र वाले तांबे से बनी वायु शीतित कंडेन्सर कॉइल, प्रोपेलर टाइप पंखे के साथ फिट और उचित मोटर, सर्विस वाल्व की व्यवस्था, प्रशीतक फिल्टर आदि सभी शीट धातु कैबिनेट में रखे रखे जाएंगे।

3. उच्च दीवार पर लगने वाली इनडोर (कक्ष) यूनिट में तांबे की बनी वाष्पीकारक कॉइल, होगी जिसमें पर्याप्त गहरी पंक्तियां होंगी, जिसमें गंदगी पाश के साथ बाहर निकालकर धोने वाली नायलॉन वायर जाली/HDPE फिल्टर होंगे, मोटर की शाफ्ट पर लगाई गयी और स्क़ॉल में रखी गई स्थैतिक और गतिशील रूप से संतुलित ब्लोअर यूनिट होगी।

4. सभी यूनिट के लिए पुश बटन के साथ चयनकर्ता नियंत्रण यूनिट, बहु गति पंखा संचालन के लिए चयनकर्ता स्विच प्रदान किया जाएगा।

5. समायोज्य वायु प्रवाह की दिशा व्यवस्था के साथ गैर-संक्षारक सामग्री से बने हवाई ग्रिल की आपूर्ति जिसके साथ विक्षेपण लूवर और आवश्यकतानुसार संपूर्ण होगा। स्प्लिट यूनिट में निम्नलिखित विशेषताएं होंगी:

- ऑटो मोड ऑपरेशन
- स्लीप मोड ऑपरेशन
- मेमोरी बैकअप के साथ ऑटो सेटिंग
- समय देरी सुविधा
- ऑटो स्टार्ट
- प्रोग्रामनीय टाइमर

6. यूनिट में थर्मोस्टेट जैसे उपयुक्त नियंत्रण होंगे और आवश्यकतानुसार संपूर्ण होंगे।

7. इनडोर यूनिट से निकास पाइप सहमत निकास बिंदु तक जाएगा। प्रशीतक पाइपिंग के बीच में कोई जोड़ नहीं होगा और चूषण लाइनों को इलास्टोमेरिक नाइट्राइल फोम पाइप इन्सुलेशन से इन्सुलेट किया जाएगा।

8. AC क्षेत्रों के अंदर यूनिट में कम शोर स्तर आवश्यक है (लगभग 45 dB(A))। निर्माता इनडोर यूनिट से 1 मीटर पर dB(A) में औसत शोर स्तर इंगित करेंगे। इनडोर यूनिट के कैबिनेट की फिनिश को प्रभारी इंजीनियर द्वारा अनुमोदित किया जाएगा।

9. स्प्लिट AC यूनिट ऊर्जा कुशल होगी और SOQ में निर्दिष्ट स्टार रेटिंग की होगी, निश्चित गति यूनिटों के मामले में ऊर्जा दक्षता ब्यूरो (नवीनतम) द्वारा प्रमाणित के अनुसार होगी।

10. स्प्लिट AC यूनिट के विनिर्देश, परीक्षण और क्षमता IS 1391 (भाग I और भाग II) के अनुरूप होगी।

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**एयर कंडीशनिंग और वेंटिलेशन  
कार्यों के लिए विनिर्देश**

**खंड- X**

स्वच्छ कक्ष (क्लीन रूम) सहायक उपकरण (एक्सेसरीज)

## 1. एयर शॉवर

स्वच्छ कक्ष (क्लीन रूम) एयर शॉवर का डिजाइन, स्थापना, परीक्षण और कमीशन ISO 14644 के अनुसार होगा।

### 1.1 विनिर्देश:

1. निर्माण की सामग्री: SOQ में बताए अनुसार SS 304/CRCA पाउडर लेपित (पाउडर कोटिंग 60 माइक्रोन से कम नहीं), SS की मोटाई न्यूनतम 18-गेज (ठीक से सुदृढ़) होगी। एयर शावर में इस्तेमाल की जाने वाली अन्य सभी सामग्री SOQ में निर्दिष्ट श्रेणी के लिए स्वच्छ कक्ष के अनुरूप होनी चाहिए।
2. आकार आंतरिक: (न्यूनतम) SOQ में निर्दिष्ट के अनुसार होगा।
3. प्रकार: परिपूर्ण यूनिट को सीधे मौजूदा क्लीन रूम फ्लोर पर माउंट किया जाना है।
4. नलिका: क्लीन रूम में प्रवेश करने वाले व्यक्तियों से कुशलतापूर्वक कण हटाने के लिए 1220 मीटर/मिनट (लगभग) की न्यूनतम वायु वेग के साथ उचित हवा के प्रवाह के लिए SS 304 के पर्याप्त ऊपरी और साइड की दीवारों के लिए नोज़ल का प्रावधान।
5. दरवाजे: स्पष्ट साइट ग्लास और उचित हैंडल के साथ एल्यूमीनियम एनोड किया गया दरवाजा पैनल (न्यूनतम 800 मिमी चौड़ाई)। डोर क्लोजर के साथ आसानी से दरवाजे को खोलना और बंद करना।
6. निस्संदन पूर्व-फिल्टर: 10 माइक्रोन और बड़े आकार के कणों को हटाने के लिए धूल



गार्ड/पूर्व-फिल्टर। फिल्टर की दक्षता न्यूनतम 50% होगी

अंतिम निस्स्यंदन: HEPA फ़िल्टर - 0.3 माइक्रोन और बड़े कणों पर 99.99% दक्षता पर मूल्यांकन।

7. ब्लोअर/मोटर: गतिक रूप से संतुलित पंखा/ब्लोअर, दीर्घावधि संचालन के लिए शोर और कंपन मुक्त।
8. नियंत्रण प्रणाली: एयर शावर संचालन के स्वतः नियंत्रण के लिए और 10-180 सेकंड तक के समय के समायोजन के लिए प्रोग्रामिंग योग्य तर्क नियंत्रण (पीएलसी)/सॉलिड स्टेट नियंत्रक।
9. ऑपरेशन का तरीका: क्लीन रूम में प्रवेश के लिए और बाहर निकलने के लिए एयर शावर का प्रयोग किया जाना है। एयर शावर को केवल क्लीन रूम में प्रवेश करते समय काम करना चाहिए ना कि क्लीन रूम से बाहर निकलते समय।
10. प्रकाश: एयर शावर में पर्याप्त प्रकाश के लिए LED प्रकाश व्यवस्था।
11. अन्य विशेषताएं:
1. दरवाजे में माइक्रो-स्विच का उपयोग करके वायु प्रवाह को सक्रिय करना।
  2. प्रवेश और निकास के लिए चुंबकीय प्रणाली के साथ इंटरलॉक द्वार।
  3. उचित स्थान पर आपातकालीन दरवाजा खोलने का स्विच।
  4. द्वार संवेदक, थ्रू बीम सेंसर, हूटर सिस्टम इंगित आपात स्थिति, सभी कार्यरत प्रकाशित खिड़कियों के लिए प्रदर्श के साथ ASLC (अनुप्रयोग विशिष्ट लॉजिक नियंत्रण), सभी स्विचों को निष्क्रिय करने के लिए दूरस्थ तंत्र।
  5. SOQ में दिया गया हो तो एयर शावर के लिए दरवाजा लॉकिंग प्रावधान प्रदान किया जाएगा।

12. विद्युत और उपयोगिताएं: 3 फेज, 415V±10%.

13. पैकिंग : क्लीन रूम के लायक पैकिंग ताकि धूल और अन्य दूषित पदार्थों से एयर शावर की रक्षा कर सकें।

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## 2. टर्मिनल फिल्टर

### 2.1 ISO श्रेणी 3 और श्रेणी 4 क्लीन रूम के लिए ULPA फिल्टर:

1. ISO श्रेणी 3 और श्रेणी 4 क्लीन रूम की छत प्रणाली में ULPA फिल्टर शामिल होंगे, जो दाबयुक्त फिल्टर कक्ष पर लगे होंगे या हुड वाले होंगे जो लचीली वाहिकाओं (डक्ट) के माध्यम से वाहिकाओं से जुड़े होंगे जैसा कि प्रतिबिंबित छत योजना पर दर्शाया गया है।
2. इन फिल्टरों का इस्तेमाल टर्मिनल वायु वितरण डिवाइस के रूप में किया जाएगा। वायु आपूर्ति कक्ष को T-ग्रिड में दाबयुक्त कक्ष में स्थापित किया जाएगा जो वायु वाहिकाओं की आपूर्ति से जुड़ा हो जाएगा।
3. ये फिल्टर EN 1822 के अनुसार ULPA फिल्टरों की U15 श्रेणी के होंगे जिनकी दक्षता 99.9995% की और नीचे 0.12 माइक्रोन तक होगी।
4. फिल्टर के माध्यम से वायु वेग  $130 \pm 5\%$  Pa या बेहतर के प्रारंभिक दाब पात 0.45m/s होगा।
5. फिल्टर मीडिया तप्त गलित पृथक्त्र के साथ ग्लास फाइबर का होगा।
6. फिल्टर में विस्तारित शीट मेटल फेस गार्ड होगा। फलक गार्ड हल्के सफेद रंग में पाउडर लेपित किया जाएगा।
7. फिल्टर में अंतहीन पॉलीयूरीथेन D-प्रोफाइल, आउटलेट में बाहरी प्रोफाइल सील में तरल डालकर ठोस करना होगा।
8. सभी फिल्टर का EN 1822 के अनुसार अलग-अलग परीक्षण किया जाएगा और कम्प्यूटरीकृत स्कैन परीक्षण रिपोर्ट प्रत्येक फिल्टर के साथ होनी चाहिए।
9. फिल्टर चाकू की धार वाला होगा जिसे रिसावमुक्त जोड़ों के लिए जेल से भरे टी-ग्रिड में लगाया जाएगा।
10. फिल्टर मीडिया बाहर निकले एल्यूमीनियम सेल साइडों से आबद्ध किए जाएंगे।

11. आपूर्ति आवरण कारखाने में फ़िल्टर सेल की तरफ लगाया जाएगा।

12. क्लीन रूम की तरफ देखने वाले ULPA फिल्टर के निचले फलक में SS छिद्रित शीट लगाई जाएगी और यह छत ग्रिड प्रणाली के फलक के साथ संरेखित की जाएगी।

## 2.2 ISO श्रेणी 5 क्लीन रूम के लिए HEPA फ़िल्टर:

1. ISO श्रेणी 5 क्लीन रूम की छत प्रणाली में HEPA फिल्टर शामिल होंगे, जो दाबयुक्त फिल्टर कक्ष पर लगे होंगे या हुड वाले होंगे जो लचीली वाहिकाओं के माध्यम से वाहिकाओं जुड़े होंगे जैसा कि प्रतिबिंबित छत योजना पर दर्शाया गया है।

2. इन फिल्टरों का इस्तेमाल टर्मिनल वायु वितरण डिवाइस के रूप में किया जाएगा। वायु आपूर्ति कक्ष को T-ग्रिड में दाबयुक्त कक्ष में स्थापित किया जाएगा जो हवा नलिकाओं की आपूर्ति से जुड़ा होगा।

3. ये फिल्टर EN 1822 के अनुसार HEPA फिल्टरों की H14 श्रेणी के होंगे जिनकी दक्षता 99.9995% की और नीचे 0.3 माइक्रोन तक होगी। फिल्टर मध्यम क्षेत्र न्यूनतम 20 वर्ग मीटर होगा।

4. फिल्टर के माध्यम से वायु वेग  $130 \pm 5\%$  Pa या बेहतर के प्रारंभिक दाब पात 0.45m/s होगा।

5. फिल्टर मीडिया तप्त गलित पृथक्त्र के साथ ग्लास फाइबर का होगा।

6. फिल्टर में विस्तारित शीट मेटल फेस गार्ड होगा। फलक गार्ड हल्के सफेद रंग में पाउडर लेपित किया जाएगा।

7. फिल्टर में अंतहीन पॉलीयूरीथेन D-प्रोफाइल, आउटलेट में बाहरी प्रोफाइल सील में तरल डालकर ठोस करना होगा।

8. सभी फिल्टर का EN 1822 के अनुसार अलग-अलग परीक्षण किया जाएगा और कम्प्यूटरीकृत स्कैन परीक्षण रिपोर्ट प्रत्येक फिल्टर के साथ होनी चाहिए।

9. फिल्टर गैस्केट प्रकार/चाकू की धार वाले होंगे जैसा SOQ में दर्शाया गया है जिन्हें T-ग्रिड में स्थापित किया जाएगा। रिसाव मुक्त जोड़ों के लिए पकड़े रखने की व्यवस्था (क्लैम्प और बोल्ट) के साथ फिल्टर परिपूर्ण होंगे।
10. फिल्टर मीडिया बाहर निकले एल्यूमीनियम सेल साइडों के लिए आबद्ध किए जाएंगे।
11. आपूर्ति आवरण कारखाने में फिल्टर सेल साइडों पर लगाया जाएगा।
12. बाहर निकले एल्यूमीनियम फ्रेम का फलक छत ग्रिड प्रणाली फलक के साथ संरेखित करेगा। एपॉक्सी लेपित स्टील के साथ फेसगार्ड प्रदान किया जाएगा।

### 2.3 ISO श्रेणी 5,6,7 क्लीन रूम के लिए टर्मिनल HEPA फिल्टर:

1. माइयुलर चलने योग्य फाल्स सीलिंग पर लगे टर्मिनल HEPA फिल्टर माइयुलर हुड वाले होंगे जो लचीली वाहिकाओं के माध्यम से वाहिकाओं जुड़े होंगे जैसा कि प्रतिबिंबित छत योजना पर दर्शाया गया है।
2. इन फिल्टरों का इस्तेमाल टर्मिनल वायु वितरण डिवाइस के रूप में किया जाएगा। HEPA फिल्टर माइयुलर लगाने के लिए फाल्स सीलिंग में उपयुक्त कट-आउट प्रदान किए जाएंगे। GI कॉलर या लचीली वाहिकाओं के माध्यम से पृथक डंपर के साथ वायु वाहिकाओं को आपूर्ति करने के लिए जोड़ा जाएगा।
3. ये फिल्टर EN 1822 के अनुसार HEPA फिल्टरों की H14 श्रेणी के होंगे जिनकी दक्षता 99.9995% की और नीचे 0.3 माइक्रोन तक होगी। फिल्टर मध्यम क्षेत्र न्यूनतम 20 वर्ग मीटर होगा।
4. फिल्टर के माध्यम से वायु वेग  $130 \pm 5\%$  Pa या बेहतर के प्रारंभिक दाब पात 0.45m/s होगा।
5. फिल्टर मीडिया तप्त गलित पृथक्त्र के साथ ग्लास फाइबर का होगा।
6. फिल्टर में विस्तारित शीट मेटल फेस गार्ड होगा। फलक गार्ड हल्के सफेद रंग में पाउडर लेपित किया जाएगा।

7. फिल्टर में अंतहीन पॉलीयूरीथेन D-प्रोफाइल, आउटलेट में बाहरी प्रोफाइल सील में तरल डालकर ठोस करना होगा।
8. सभी फिल्टर का EN 1822 के अनुसार अलग-अलग परीक्षण किया जाएगा और कम्प्यूटरीकृत स्कैन परीक्षण रिपोर्ट प्रत्येक फिल्टर के साथ होनी चाहिए।
9. फिल्टर गैस्केट प्रकार के/चाकू की धार वाले होंगे जैसा SOQ में दर्शाया गया है जिन्हें T-ग्रिड में स्थापित किया जाएगा। रिसाव मुक्त जोड़ों के लिए पकड़े रखने की व्यवस्था (क्लैम्प और बोल्ट) के साथ फिल्टर परिपूर्ण होंगे।
10. सभी फिल्टर मॉड्यूल 300 मिमी (12") व्यास इनलेट कॉलर और 1.5 एमएम (0.062") मोटी एल्यूमीनियम (न्यूनतम) के गढ़े अभिन्न आपूर्ति आवरण के साथ परिपूर्ण होगा जिसमें सतह के शीर्ष पर खड़े व्यक्ति भार उठाने की क्षमता होगी।
11. फिल्टर मीडिया बाहर निकले एल्यूमीनियम सेल साइडों से आबद्ध किए जाएंगे।
12. आपूर्ति आवरण कारखाने में फिल्टर सेल साइडों पर लगाया जाएगा।
13. HEPA फिल्टर का फलक बाहर निकले एल्यूमीनियम फ्रेम के साथ प्रदान किया जाएगा और छत ग्रिड प्रणाली फलक के साथ संरेखित करेगा। एपॉक्सी लेपित स्टील के साथ फेसगार्ड प्रदान किया जाएगा।

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### 3. ISO श्रेणी 3, 4 और 5 क्लीन रूम के लिए एल्युमिनियम मॉड्यूलर पैनल सिस्टम:

#### 3.1 मॉड्यूलर दीवार पैनल:

क्लीन रूम के दीवार पैनल चिकना, स्वच्छ, गैर-दूषित, लचीला, आसानी से बदलने योग्य, मॉड्यूलर, अप्रगामी, आकर्षक और वायुरोधी होंगे।

मॉड्यूलर पैनल के लिए विनिर्देश निम्नानुसार होंगे:

1. न्यूनतम 44 मिमी मोटी (अंकित) एल्युमिनियम हनीकॉम्ब कोर पैनल, स्टड विहीन (गैर-संरचनात्मक) दीवार प्रणाली।
2. पैनलों में ऊर्ध्वाधर जोड़ों को एनोडाइज, एल्युमिनियम बैटन स्ट्रिप्स/वर्टिकल पोस्ट पाउडर लेपित का उपयोग करके सुरक्षित किया जाना है जो स्वच्छ कमरे की दीवार प्रणाली से मेल खाते हों।
3. सभी दीवार पैनल प्रतिस्थैतिक संरक्षण वाले एल्युमिनियम हनी कॉम्ब कोर के साथ बाहरी सतहों पर एल्युमिनियम आवरण वाले दोहरे आवरण (0.8 मिमी मोटी) के होंगे, जिसकी सतह प्रतिरोधकता  $10^6 - 10^9$  मेगा ओम होगी और शून्यांकन गैसिंग वाली होगी। सभी दीवार पैनल मानक डिजाइनर सफेद रंग में पाउडर कोट और एपॉक्सी फिनिश वाले होंगे।
4. दीवार प्रणाली को अपनी वायु सील और संरचनात्मक अखंडता बनाए रखते हुए आसानी से पाइप, नलिका और उपकरण प्रवेश और दरवाजों को समायोजित करना चाहिए।
5. इस प्रणाली को मुक्त खड़ी दीवार के रूप में निष्पादन करने में सक्षम होना चाहिए।
6. दीवार प्रणाली को गैस्केट शीर्ष ट्रैक (निलंबित छत से बंधे हुए) और गैस्केट फर्श ट्रैक असेम्बली का उपयोग करते हुए अपनी जगह पर रहना चाहिए।
7. ISO श्रेणी 3,4 और 5 के सभी स्वच्छ कक्षाओं में दीवार प्रणाली की ऊंचाई निविदा ड्राइंग/SOQ में बताए अनुसार होगी।
8. शीर्ष ट्रैक, फर्श ट्रैक, बैटन स्ट्रिप्स, कॉर्नर पोस्ट, दीवारों के सिरे, ऊर्ध्वाधर पोस्ट आदि जैसे सभी फ्रेमन भाग दीवार पैनल सिस्टम से मेल खाते हुए डिजाइनर व्हाइट फिनिश में बाहर निकले एल्युमिनियम के बने होंगे।
9. SOQ/निविदा ड्राइंग में दर्शाए अनुसार दीवार पैनल में दृश्य पैनल लगाए जाएंगे।

### 3.2 माँड्यूलर दरवाजे:

1. क्लीन रूम दीवार पैनल/सिस्टम में संबद्ध हार्डवेयर के साथ सभी दरवाजे शामिल होंगे।
2. क्लीन रूम के दरवाजे एल्यूमिनियम (AI) निर्मित, फलश विन्यास, स्विंग प्रकार, दोहरे आवरण, AI फ्रेम और क्लीन रूम वॉल सिस्टम के साथ मेल खाते हुए पाउडर लेपित, छिपे डोर क्लोजर, हैंडल, लॉक सेट जिसमें दृश्य पैनलों के साथ एक या दोनों तरफ से प्रवेश के विकल्प वाले होंगे। दृश्य पैनल को परिष्कृत फर्श स्तर से 1200 मिमी ऊपर रखना होगा और दृश्य पैनल का आकार SOQ के अनुसार होगा।
3. क्लीन रूम वॉल सिस्टम/दरवाजों में लॉक सेट के साथ 6 मिमी स्पष्ट टेम्परित ग्लास वाले दृश्य पैनल और अन्य आवश्यक हार्डवेयर शामिल होंगे।
4. मजबूत कांच और दीवार पैनलों के बीच सभी जोड़ों को बंद किया जाना है।

### 3.3 अभिगम (एक्सेस) तल प्रणाली:

1. क्लीन रूम एक्सेस फ्लोर सिस्टम हटाने योग्य उठा हुआ एक्सेस सिस्टम होगा, जिसमें यांत्रिक सर्विस लाइन, विद्युत कन्ड्यूट को समायोजित करने के लिए फर्श के नीचे स्थान प्रदान करने के लिए और वायु आपूर्ति और वापसी कक्ष के रूप में कार्य करने के लिए समायोज्य पेडेस्टल पर छिद्रित फर्श टाइलों की असेम्बली लगाई जाएगी।
2. फर्श सिस्टम स्ट्रिंगर-विहीन, विद्युतस्थैतिक विदारी (ESD) संचालनकीय प्रकार का होगा और इसमें डाइ-कास्ट एल्यूमीनियम छिद्रित (डैंपर के साथ यथावश्यक) टाइल, ठोस SS -304 निर्माण के साथ समायोज्य पैडस्टल शामिल होंगे।
3. फर्श टाइल का आकार 600 x 600 x 50 मिमी मोटा है।
4. उठाए गए फर्श की ऊंचाई SOQ में निर्दिष्ट के अनुसार होगी।
5. फर्श टाइल निम्न भार को उठाने में सक्षम होंगी:
  - विक्षेपण  $\leq$  2.0 मिमी के साथ केंद्रित भार  $\geq$  650 किलो
  - विक्षेपण  $\leq$  1.0 मिमी के साथ एकसमान भार  $\geq$  1250 किलो/वर्ग मीटर
  - विक्षेपण  $\leq$  0.5 मिमी के साथ रोलिंग भार  $\geq$  200 किलोग्राम/वर्ग मीटर
  - केंद्र में अंतिम लोड  $\geq$  1575 किग्रा/6.45 वर्ग मीटर



6. फर्श टाइलें स्थिर चालकीय विनाइल के साथ AI डाई कास्ट निर्मित, अदहनीय रसायन और न्यूनतम 2 मिमी मोटाई के अपघर्षक प्रतिरोधी आवरण की होंगी। फर्श टाइल सिस्टम प्रतिरोधकता का न्यूनतम मान  $1.5 \times 10^5$  ओम के और टाइल की ऊपरी संरचना और निचली संरचना के बीच अधिकतम मान  $2 \times 10^7$  ओम होगा।
7. स्थिर चालकीय विनाइल कोटिंग टाइल एक टुकड़े में से निर्मित की जाएगी।
8. डैंपर वाली फर्श टाइलें क्लीन रूम में एकदिशीय प्रवाह को चेक/ठीक करेगी।
9. सभी टाइल पूरी तरह से अदली-बदली करने योग्य और उठाने वाले उपकरण से आसानी से हटाई जा सकने वाली होंगी।
10. पेडेस्टल को लोड वहन विशेषता के संबंध में पैनल विनिर्देशों के अनुसार होंगे। पेडेस्टल असेंबली को विरूपण के बिना 2250 किलो अक्षीय भार वहन करने में सक्षम होंगे।
11. पेडेस्टल कठोरता से खींची गई एल्युमिनियम ट्यूब से बनाए जाएंगे।
12. फ्लोर सिस्टम पेडेस्टल और टाइल सभी दिशाओं में पार्श्विक रूप से स्थिर रहेंगी जिसमें अतिरिक्त फ्रेमन या स्ट्रिंगर्स के उपयोग के बिना पैनल रखे या हटाए जाएंगे।
13. पैडस्टल का समायोजन चूड़ीदार छड़ के भाग और  $\pm 25$  मिमी ऊपर उठे कॉलर द्वारा किया जाना है। AI डाई कास्ट निर्मित पैडस्टल शीर्ष को पार्श्व संचलन को रोकने के लिए पैनलों और पैडस्टल के सकारात्मक इंटरलॉकिंग प्रदान करना चाहिए।
14. पेडेस्टल शीर्ष के साथ चालकीय विनाइल ग्राउंडिंग पैड लगाया जाना है।
15. पेडेस्टल को ऊर्ध्व रूप से सही होना है, पैनल के आकार के अनुरूप होने के लिए केन्द्रों पर स्थित होना है जिसे साथ फिनिश ऊंचाई के नुकसान को रोकने के लिए लॉकिंग डिवाइस से लैस होना है।
16. फ्लोर सिस्टम की स्थापना में यथावश्यक फर्श के नीचे कक्ष बाधक शामिल होंगे, जिसमें सभी फर्श पेडेस्टल को गाड़ना और आपसी संयोजन के लिए अर्थ क्लैंप और तांबे का नंगा तार प्रदान करना और उपयुक्त अनुप्रस्थ काट के PVC इंसुलेट किए तांबे के अर्थ (भूसंपर्क) केबल से उप-फैब में सिस्टम अर्थ से जोड़ना शामिल है।

### 3.4 छत प्रणाली:

क्लीन रूम छत प्रणाली में छत ग्रिड, ULPA/ HEPA फिल्टर, फ्लेक्सिबल डक्ट वर्क और लाइटिंग शामिल होंगे।

#### 3.5.1 छत वाली ग्रिड:

1. क्लीन रूम छत प्रणाली को क्लीन रूम में 100% कवरेज (ULPA या HEPA) के साथ टर्मिनल फिल्टर स्थापित करने के लिए कठोर ढांचा प्रदान करना होगा। छत ग्रिड मजबूत होगी जिसके ऊपर चला जा सके।

2. छत ग्रिड 2" (न्यूनतम) मजबूत, उलटी "T" ग्रिड प्रणाली होगी।

3. छत ग्रिड का बाहर निकले एल्यूमीनियम निर्माण किया जाएगा जिसे क्लीन रूम दीवार प्रणाली से मैच करने के लिए सफेद पाउडर से लेपित किया जाएगा।

4. ग्रिड सिस्टम में "होल्ड-डाउन" उपकरण शामिल होंगे, सभी फिल्टर छत मॉड्यूल और रिक्त छत पैनलों में इस्तेमाल किया जाएगा और और हार्डवेयर का इस्तेमाल सभी जोड़ों के निलंबित स्थलों पर किया जाएगा।

5. छत ग्रिड के आकार में टर्मिनल फिल्टर/रिक्त छत पैनल आदि को समायोजित करने के लिए SOQ के अनुसार मानक आकार यानी 1200 मिमी x 600 मिमी या 600 मिमी x 600 मिमी होगा।

6. छत ग्रिड में अलग-अलग छत की लंबाई शामिल होगी जो क्रूसिफॉर्म खंडों से आपस में जुड़ी होंगी, जो स्प्रींकलर, तारों की लाइन आदि के लिए ग्रिड के माध्यम से कनेक्शन करने देते हैं।

7. छत ग्रिड को लीक प्रूफ फिल्टर ग्रिड सिस्टम प्रदान करना चाहिए।

8. T-ग्रिड छत प्रणाली को जेल सील प्रकार (रिसावरोधी जोड़ प्रदान करने के लिए जेल से भरी फाल्स सीलिंग ग्रिड) के लिए डिजाइन किया जाएगा और आपूर्ति वायु कक्ष में ULPA/HEPA चाकू की धार वाले टर्मिनल फिल्टर को समायोजित करने में सक्षम होगा।

9. छत ग्रिड पर टीयर ड्रॉप लाइट फिक्चर लगाए जाएंगे।

10. छत ग्रिड में यथावश्यक, रिक्त छत पैनल में लगाए जाएंगे।

11. सभी रिक्त छत पैनल एल्यूमीनियम की ओर देखते हुए 6.35 मिमी (1/4") मोटे एल्यूमीनियम हनी कॉम्ब के होंगे। खुली हनी कॉम्ब सामग्री को कवर करने के लिए सभी किनारों को मोड़ा जाएगा। रिक्त छत पैनलों की फिनिश क्लीन रूम दीवार प्रणाली में मेल खाएगी।

12. ग्रिड प्रणाली को 8-10 मिमी चूड़ीदार रॉड और लॉकिंग नट के साथ टर्न बक्कल (समतल करने के लिए) का उपयोग करके निलंबित किया जाएगा।

13. समग्र छत ग्रिड 3 मीटर में  $\pm 1.5$  मिमी के भीतर समतल किया जाएगा और पूरे कमरे में  $\pm 2.5$  मिमी से अधिक नहीं होगा।

14. छत ग्रिड को अग्नि छिड़काव, विद्युत लाइनों आदि सहित सभी प्रवेश के आसपास वायुरोधी सील को समायोजित करना होगा। सिस्टम की पूर्व-ड्रिल किया जाएगा, ताकि क्षेत्र में असेम्बली को आसानी से ले जाया जा सके।

### 3.5.2 दाबयुक्त कक्ष के लिए चलने योग्य फाल्स सीलिंग:

1. मजबूत चलने योग्य AI हनीकॉम्ब छत पैनल SOQ के अनुसार का अंकित आयाम 1200 मिमी x 600 मिमी या 600 मिमी x 600 मिमी के होंगे, 'डिजाइनर व्हाइट' फिनिश के साथ न्यूनतम '44 मिमी मोटी एल्यूमीनियम हनीकॉम्ब कोर का उपयोग करके दोनों तरफ न्यूनतम 0.5 मिमी मोटी स्टील के आवरण के साथ, स्थिर अवक्षेप्य फिनिश और आवश्यकता के अनुसार परिपूर्ण किया जाएगा।

2. चलने योग्य फाल्स सीलिंग दोहरे आवरण की पूरी तरह से फ्लश प्रकार के छत पैनलों की होगी जो कोर सामग्री के रूप में एल्यूमीनियम हनीकॉम्ब के साथ SOQ के अनुसार दोनों तरफ न्यूनतम 0.5 मिमी मोटी स्टील दोहरे आवरण Epoxy/पाउडर लेपित होगी।

3. फाल्स सीलिंग ग्रिड में HEPA फ़िल्टर मॉड्यूल, लाइट फिक्स्चर और स्पिंकलर शीर्ष लगाने का प्रावधान किया जाएगा, फाल्स सीलिंग में टीयर ड्रॉप लाइट फिक्स्चर को समुचित रूप से

लगाने के लिए और फाल्स सीलिंग सतह पर लगी व्हाइट लाइट फिक्स्चर में अनुक्रमित स्कू लगाए जाएंगे।

4. चलने योग्य फाल्स सीलिंग को 90 किलो वजन के लिए डिजाइन किया जाएगा जिसका विक्षेपण 0.5 मिमी से अधिक नहीं होगा।

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## 4. ISO श्रेणी 6, 7 और 8 के GI पाउडर लेपित मॉड्यूलर दीवार पैनल

### 4.1. दीवार पैनल:

1. दीवार पैनल BOQ/निविदा में निर्दिष्ट से दोहरी मोटाई वाले आवरण के होंगे, जिन्हें गुणवत्ता वाली PUF सामग्री से सैंडविच किया जाएगा जिसका घनत्व मुख्य सामग्री के रूप में 38 किलो/cum से कम नहीं होगा।

2. अंदरूनी और बाहरी आवरण पाउडर लेपित इस्पात शीट का होगा, पैनल के अंदरूनी और बाहरी आवरण की मोटाई 0.8 मिमी से कम पाउडर लेपित स्टील शीट की नहीं होगी और जस्ता कोटिंग के साथ तप्त डूबी जस्ती पैनल के दोनों तरफ 120 ग्राम/वर्गमीटर से कम नहीं होगी। पैनल चिकनी फिनिश के होंगे और पैनल के दोनों तरफ एपाँक्सी पॉलिएस्टर पाउडर लेपित होगा, हल्का सफेद रंग, कोटिंग की मोटाई प्राइमर और फिनिश कोट सहित 50 माइक्रोन से कम नहीं होगी। पैनल को पील ऑफ फिल्म से कवर किया जाएगा ताकि परिवहन और भंडारण के दौरान सामग्री की खरोंच और रगड़ से सुरक्षा सुनिश्चित की जा सके।

3. दीवार पैनलों में एक तरफ धंसा हुआ मेल किनारा होगा और दूसरी तरफ रोल से बना फीमेल किनारा होगा, जिससे इंटरलॉक बनता है, इस प्रकार पैनल फिनिश और स्नग इन्सुलेशन के लिए इन्सुलेशन फिट को सुनिश्चित किया जाता है। पैनल को किसी भी उपयुक्त लम्बाई की न्यूनतम चौड़ाई से निर्मित किया जाएगा जो 1100 मिमी से कम नहीं होगी जैसा कि सतत लम्बाई लैमिनेशन में आवश्यक होता है। सभी दीवार जोड़ों को सतत लम्बाई लैमिनेशन में आवश्यक लंबाई से भरना होगा। सभी दीवार जोड़ों को उपयुक्त सीलेंट सामग्री से भर दिया जाएगा।

4. जहां भी ड्राइंग में कमरे के दरवाजे दिखाए गए हैं वहां फर्श से छत तक पैनल के बीच उपयुक्त सुदृढीकरण किया जाएगा। दीवार पैनलों में निविदा/BOQ में निर्दिष्ट और इंगित के अनुसार रिटर्न एयर राइजर होंगे।

### 4.2. फाल्स सीलिंग ग्रिड प्रणाली:

1. फाल्स सीलिंग ग्रिड मजबूत चलने योग्य सीलिंग ग्रिड प्रणाली होंगी जिसमें पैनल, हुड वाले HEPA फिल्टर मॉड्यूल, लाइट फिक्स्चर इत्यादि को लगाने के लिए एल्यूमीनियम

ऐनोडाइज की सतह से बाहर निकले T-ग्रिड, दीवार एंगल, सस्पेंडर रॉड, टर्नबकल, नट, बोल्ट, एंकर फास्टनर आदि शामिल होंगे और सीलिंग ग्रिड प्रणाली की कीमत को फाल्स सीलिंग के लिए उद्धृत दर में शामिल माना जाएगा। फाल्स सीलिंग के लिए मुख्य "T" पट्टी की चौड़ाई एल्यूमीनियम ऐनोडाइज की सतह से बाहर निकले 55 मिमी से कम नहीं होगी। सीलिंग ग्रिड विन्यास 1200 मिमी लम्बाई और 600 मिमी चौड़ाई का होगा और हुड वाले HEPA फ़िल्टर मॉड्यूल, लाइट फिक्स्चर आदि लगाने के लिए उपयुक्त होगा।

2. सभी निलंबित सामग्री जस्ती फिनिश की होगी। सीलिंग ग्रिड प्रणाली चलने योग्य फाल्स सीलिंग के लिए उपयुक्त होगी।

3. सीलिंग ग्रिड हुड वाले HEPA फिल्टर के अलग-अलग मॉड्यूल, सप्लाई और रिटर्न एयर डिफ्यूज़र, लाइट फिक्स्चर, रिक्त पैनल इत्यादि को समायोजित करने के लिए उपयुक्त होगा, और पीवीसी गैस्केट के शुद्ध नियोप्रिन के साथ प्रदान किया जाएगा।

#### 4.3 फाल्स सीलिंग रिक्त पैनल:

1. सीलिंग पैनल BOQ/निविदा में निर्दिष्ट से दोहरे आवरण और मोटाई वाले होंगे, स्व-शामक गुणवत्ता वाली PUF सामग्री के साथ सैंडविच किया जाएगा जिसका घनत्व गुणवत्ता वाली सामग्री के रूप में 38 किलो/cum से कम नहीं होगा। अंदरूनी और बाहरी आवरण पाउडर लेपित इस्पात शीट का होगा, पैनल के अंदरूनी और बाहरी आवरण की मोटाई 0.8 मिमी से कम पाउडर लेपित स्टील शीट की नहीं होगी और जस्ता कोटिंग के साथ तप्त डूबी जस्ती पैनल के दोनों तरफ 120 ग्राम/वर्गमीटर से कम नहीं होगी। पैनल के दोनों तरफ चिकनी फिनिश होगी होंगे और पैनल के दोनों तरफ हल्का सफेद रंग होगा, कोटिंग की मोटाई प्राइमर और फिनिश कोट सहित 50 माइक्रोन से कम नहीं होगी। पैनल को पील ऑफ फिल्म से कवर किया जाएगा ताकि परिवहन और भंडारण के दौरान सामग्री की खरोंच और रगड़ से सुरक्षा सुनिश्चित की जा सके।

2. सीलिंग पैनलों में एक तरफ धंसा हुआ मेल किनारा होगा और दूसरी तरफ रोल से बना फीमेल किनारा होगा, जिससे इंटरलॉक बनता है, इस प्रकार पैनल फिनिश और स्नग इन्सुलेशन फिट लिए इन्सुलेशन फिट को सुनिश्चित किया जाता है। पैनल को किसी भी उपयुक्त लम्बाई की न्यूनतम चौड़ाई से निर्मित किया जाएगा जो 1100 मिमी से कम

नहीं होगी जैसा कि सतत लम्बाई लैमिनेशन में आवश्यक होता है। सभी दीवार जोड़ों को सतत लम्बाई लैमिनेशन में आवश्यक लंबाई से भरना होगा।

3. फाल्स सीलिंग के शीर्ष पर रखरखाव के लिए फाल्स सीलिंग के लिए आवश्यक सर्विस/ट्रेप दरवाजे लगाए जाएंगे।

4. छत और दीवार पैनलों, दीवार पैनलों और दीवार पैनलों के बीच सभी जोड़ों और कोने, माँड्यूलर क्लीन रूम के फर्श के लिए दीवार पैनल एल्यूमीनियम R 50 कोटिंग को वही पैनल फिनिश और रंग किया जाएगा।

#### 4.4 दरवाजे:

1. PUF इन्फिल के साथ दरवाजा पत्ती के लिए 0.80 मिमी GI शीट से बनी 44 मिमी पत्ती मोटाई के साथ GI पाउडर लेपित दोहरे आवरण वाले के दरवाजे और 1.20 मिमी मोटी GI पाउडर लेपित प्रोफाइल के साथ बनाया गया दरवाजा फ्रेम।

2. दरवाजों को दोनों तरफ दीवार पैनल सिस्टम में फ्लश फिट करने के लिए डिज़ाइन किया जाता है और विभिन्न आयामों में आपूर्ति की जाती है। 50 मिमी की फ्रेम चौड़ाई और 46 मिमी की शटर चौड़ाई होगी। दरवाजों में सभी सहायक उपकरण, मानक आर्म डोर क्लोजर शामिल हैं।

3. दरवाजों के सामान में SS D हैंडल बैक टू बैक/एक तरफ SSD हैंडल और एक तरफ SS पुश प्लेट, दोनों साइड चाबी ऑपरेशन के साथ डेड लॉक, SS बॉल बेयरिंग कब्जे, 300 मिमी ऊंचाई तक की SS किक प्लेट 0.8 मिमी मोटी, डोर क्लोजर और डोर क्लोजर स्टॉपर, छुपी हुई बॉटम ड्रॉप सील, दोहरी पत्ती के दरवाजे के लिए छुपा हुआ फ्लश बोल्ट, 5 मिमी/6 मिमी मोटे टफन कांच के साथ BOQ/निविदा में निर्दिष्ट आयामों के अनुसार दोहरे शीशे वाले दृश्य पैनल शामिल होंगे।

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## 5. माँड्यूलर पार्टीशन/सीलिंग के साथ पंखा फिल्टर यूनिट

1. नियंत्रित डिस्चार्ज वेग पर एकदिशीय आपूर्ति वायु प्रदान करने के लिए पंखा फिल्टर यूनिट (FFU) की आपूर्ति की जाएगी। यूनिट में SOQ में विनिर्दिष्ट उच्च दक्षता वाले HEPA या ULPA फिल्टर शामिल होंगे।
2. यह यूनिट IEST-RP-CC022.2 या प्रासंगिक मानकों के अनुसार यूनिट के अग्र भाग से 27.4 मीटर/मिनट ( $\pm 4.6$ mpm) मापित 304 mm के औसत वेग पर परीक्षित फिल्टर की गई हवा प्रदान करेगी।
3. IEST-RP-CC022.2 या प्रासंगिक मानकों के अनुसार 27.4 मीटर/मिनट औसत फलक वेग पर फिल्टर फलक 762 मिमी पर मापित करने पर से FFU ध्वनि स्तर 55 dB(A) से कम होगा।
4. यूनिट कारखाने में सील होगी और परीक्षण किया जाएगा ताकि सुनिश्चित किया जा सके कि कोई वायु रिसाव नहीं हो रहा है।
5. कक्ष सामग्री एल्यूमीनियम/304 स्टेनलेस स्टील की होगी और यह 108 किलोग्राम तक चलने योग्य होगी।
6. अग्र भाग सामग्री पाउडर-लेपित पेंट फिनिश/एल्यूमिनियम/304 स्टेनलेस स्टील के साथ धातु ग्रिल विस्तार वाली होगी।
7. छत के ऊपर संरचनात्मक सहारे के लिए यूनिट को सुरक्षित करने के लिए विसारक कक्ष में प्रत्येक कक्ष कोने पर चार आईबोल्ट होंगे।
8. 51% मुक्त-क्षेत्र छिद्रित वितरण प्लेट को लगाने और हटाने में आसानी के लिए अग्र भाग से एंटी-स्लिप वाले क्वार्टर-टर्न फास्टनरों, स्नैप-इन रिटेनर और स्टेनलेस स्टील रिटेनर केबल्स का इस्तेमाल किया जाएगा।
9. इनलेट डक्ट/बिना डक्ट वाले अनुप्रयोग के लिए मानक गोल या वैकल्पिक आयताकार कॉलर वाले होंगे।
10. लटकाने के लिए आई बोल्ट कक्ष के ऊपरी चार कोनों पर लगाएंगे जाएंगे और प्रत्येक 23-23 किलोग्राम को सहारा देने में सक्षम होना चाहिए।



11. फिल्टर फ्रेम और बॉर्डर के बीच लीक-टाइट सील प्रदान करने के लिए यूरेथेन ज़ेल से भरी अभिन्न गुहिका के साथ बाहर निकले एल्यूमीनियम में फिल्टर को लगाया जाएगा।
12. पूर्व फिल्टर 25-30% MERV 4 धोने योग्य होगा।
13. अंतिम फिल्टर 0.30  $\mu\text{m}$  कण पर 99.997% दक्षता युक्त उच्च क्षमता कण हवा (HEPA) वाला फिल्टर होगा, जिसमें 30.5 मीटर/मिनट पर 11.43mm wg का शुरुआती दाब पात होगा। अति-निम्न प्रवेश वायु (ULPA) फिल्टर 0.12  $\mu\text{m}$  कण पर 99.9995% दक्षता वाला होगा, जिसमें 30.5 मीटर/मिनट पर 13.46 mm wg का प्रारंभिक दाब पात होगा।
14. फिल्टर कमरे की ओर हटाने योग्य और बदलने योग्य या बेंच टॉप हटाने योग्य और बदले जाने योग्य होगा।
15. बेंच शीर्ष बदलने योग्य फिल्टर की आपूर्ति बाहर निकले एल्यूमीनियम केंद्र विभाजक में कमरे की तरफ से प्रवेश स्थिर दाब के साथ की जाएगी।
16. सभी एल्यूमीनियम घटकों पर B12 व्हाइट बेक्ड-ऑन पाउडर कोट फिनिश होगी। पेंट फिल्म की मोटाई कम से कम 2.0 mils (0.05 mm) होगी।
17. सभी एल्यूमीनियम घटकों की मिल फिनिश होगी और सभी स्टेनलेस स्टील घटकों पर 2B मिल फिनिश होगी।
18. अपकेन्द्री प्रकार के पंखा की आपूर्ति मोटर/ब्लोअर असेंबली को विसारक कक्ष से अलग करने के लिए रबड़ माउन्ट के साथ की जाएगी।
19. पंखा सीधे ड्राइव के साथ, अग्र वक्रित/पश्च वक्रित इम्पेलर के साथ धातु निर्मित होगा। प्लास्टिक निर्माण स्वीकार्य नहीं होगा।
20. पंखा मोटर स्थायी स्प्लिट कैपेसिटर (PSC)/इलेक्ट्रिक कम्प्यूटेड मोटर (ECM) होगी।
21. 220 V $\pm$ 10% बिजली की आपूर्ति के साथ उपयोग के लिए लगभग 2 मीटर बिजली कॉर्ड की आपूर्ति की जाएगी।
22. दीवार पर लगे को PSC सॉलिड स्टेट/ECM मानक गति नियंत्रक प्रदान किया जाना है।

### 23. मोटर स्थिति LED:

- विसारक को खोले बिना मोटर ऑपरेंटिंग स्थिति निर्धारित करने के लिए अधिग्रहित क्षेत्र से LED सूचक लाइट दिखाई देगी।
- सामान्य मोटर ऑपरेशन को इंगित करने के लिए मोटर LED हरे रंग की होगी, और यूनिट स्थैतिक दाब 5.08 mm wg से अधिक होगा।
- मोटर का संचालन न होने पर मोटर LED हरी से लाल हो जाएगी, और यूनिट का स्थैतिक दाब 5.08 mm wg से कम हो जाएगा।

**नोट:** उपलब्ध बिजली की आपूर्ति 220 V $\pm$ 10%, 50 Hz या 415 $\pm$ 10%, 50Hz होगी।

24. यूनिट का डिजाइन माँड्यूलर होगा और SOQ में बताए अनुसार 1200 मिमी x 600 मिमी/ 600 मिमी x 600 मिमी के मानक "T"-बार छत ग्रिड में फिट होगा।

25. यूनिट संघीय मानक 209 के अनुसार "श्रेणी 100" और पटलीय प्रवाह के लिए ISO मानक के अनुसार विनिर्देशों को पूरा करेगी।

26. यूनिट कंपन स्तर 0.09 mils (0.0023 mm) से कम होगा।

27. प्रणाली में हवा के उचित प्रवाह के लिए विशेष वायुरोधी प्रणाली अंतर्निहित होगी।

28. पूर्ण यूनिट (वैकल्पिक सामान को छोड़कर) की कुल ऊंचाई 330 मिमी से कम होगी।

29. पंखा कक्ष का निर्माण हाउसिंग निलंबन के लिए चार कोनों में 64 एमएम 20 चूड़ी बिठाने के साथ 1.6 मिमी एल्यूमीनियम से किया जाएगा।

30. फिल्टर हाउसिंग का निर्माण 1.6 मिमी मोटे एल्यूमीनियम से किया जाएगा।

31. पंखा और फिल्टर दोनों हाउसिंग की मिल फिनिश (बाहरी भाग पॉलीयूरेथेन पेंट किया-वैकल्पिक) और सील वायुरोधक होगी।

32. फिल्टर फलक गार्ड एपॉक्सी लेपित विस्तृत स्टील का होगा।

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**एयर कंडीशनिंग और वेंटिलेशन  
कार्यों के लिए विनिर्देश**

**खंड- XI**

**डक्टिंग और संबद्ध सहायक उपकरण**

## 1. डक्टींग

डक्ट (वाहिनी) का निर्माण जस्ता स्टील शीट श्रेणी VIII/एल्यूमिनियम/SS/पॉलीविनायल क्लोराइड (PVC) लेपित स्टील शीट्स से निविदाओं में विनिर्दिष्ट के अनुसार किया जाएगा।

1. जस्ता की लाइट कोटिंग IS: 277 के अनुरूप होगी जिसके साथ मिल परीक्षण प्रमाणपत्र होगा। गैल्वनाइजिंग 120 ग्राम/वर्गमीटर का होगा या अन्यथा निविदा में निर्दिष्ट (दोनों तरफ की कुल कोटिंग) के अनुसार होगा। इसके अलावा, अगर आवश्यक समझा जाए, तो मालिक के साइट प्रतिनिधि द्वारा यादृच्छिक रूप से चयनित कच्चे माल के नमूने, ठेकेदार के खर्च पर मोटाई और जस्ता कोटिंग के लिए अनुमोदन और परीक्षण किया जाएगा।

2. कारखाने में डक्ट के मामले में G.I. कच्चे माल को काँइल रूप (शीट के बजाय) में इस्तेमाल किया जाना चाहिए ताकि आनुप्रस्थ-काट के किसी भी आयाम के बावजूद किनारों पर अनुदैर्घ्य जोड़ों को सीमित किया जा सके।

3. एल्यूमीनियम सामग्री नवीनतम IS: 737 के अनुरूप होगी।

4. स्टेनलेस स्टील IS: 6911 के अनुरूप होगी।

5. पॉलिविनायल क्लोराइड लेपित शीट, दोनों तरफ या एक तरफ धातु शीट पर 0.2 मिमी की न्यूनतम मोटाई के पॉलिविनायल क्लोराइड (विनायल क्लोराइड राल) परत की लेमिनेटिंग या कोटिंग द्वारा निर्मित की जाएगी और बेस धातु IS: 277 के अनुरूप GI शीट की होगी।

### 1.1 आयताकार डक्टींग:

जब तक अन्यथा निर्दिष्ट नहीं जाए, तब तक डक्टींग सिस्टम के निर्माण, स्थापन, परीक्षण और निष्पादन IS: 655 के नवीनतम मानकों/ SMACNA नवीनतम मानकों

("HVAC डक्ट निर्माण मानक-धातु और प्रत्यास्थ-दूसरा संस्करण SMACNA) के अनुरूप होगा।

### 1.1.1 डक्ट कनेक्टर और सहायक उपकरण:

सभी अनुप्रस्थ डक्ट कनेक्टर (फ्लेंज/क्लैट) और सहायक उपकरण/संबंधित हार्डवेयर जैसी सहायक प्रणाली जस्ता-लेपित (जस्ती) होनी चाहिए।

### 1.1.2 निर्माण मानक:

सीधे खंडों, टैपर, एल्बो, ब्रांचेज, शो पीस, कॉलर, टर्मिनल बक्से और अन्य परिवर्तन पीस सहित सभी डक्ट कार्य फैक्टरी में ही किया जाना चाहिए। समानता के लिए आवश्यक मशीनों की गुणवत्ता और आपूर्ति को गति प्रदान करने के लिए निम्नलिखित मशीनों और प्रक्रियाओं का उपयोग करके निर्माण करना होगा। कॉइल लाइनों को केवल आवश्यक डक्ट कठोरता और कम रिसाव की विशेषताओं को प्राप्त करने के लिए कोनों/मुड़े हुए किनारों पर अनुदैर्घ्य सीवन के स्थान को सुनिश्चित करने के लिए है। कोई अनुदैर्घ्य सीवन डक्ट के किसी भी फलक की तरफ नहीं की जाएगी। मुड़ी हुई लाइनों पर खांचों के आयाम, स्थान और खांचों के आयामों की आवश्यक सटीकता के लिए CNC प्रोफाइल कटर पर सभी डक्ट, परिवर्तन टुकड़े और फिटिंग बनाई जानी चाहिए। सभी किनारों को लॉक फॉर्मर, फ्लेंज और किनारों को धुंधला करने के लिए रोलर का प्रयोग करके मशीन द्वारा उपचारित किया जाना है। पिट्सबर्ग लॉक में अंतर्निर्मित सीलेंट लगाने के लिए सीलेंट वितरण उपकरण, जहां अनुदैर्घ्य जोड़ों की सील निर्दिष्ट की गई हो, इसका इस्तेमाल किया जाएगा।

### 1.1.3 गेज का चयन:

डक्ट के निर्माण का चयन डक्ट के आंतरिक दाब के आधार पर किया जाएगा। आयताकार डक्ट की छोटी तरफ की मोटाई डक्ट के लंबे तरफ के समान होगी। विभिन्न डक्ट की मोटाई निम्नलिखित तालिकाओं के अनुसार होगी:

तालिका 1: जस्ती स्टील शीट डक्ट के लिए शीट की मोटाई

दाब के द्वारा डक्ट का वर्गीकरण (1)	निम्न दाब डक्ट (2)	मध्यम दाब डक्ट और उच्च दाब डक्ट (3)	शीट की मोटाई, न्यूनतम मिमी (4)
डक्ट का लंबा किनारा	$l \leq 450$	---	0.5
	$450 < l \leq 750$	---	0.6
	$750 < l \leq 1500$	$l \leq 450$	0.8
	$1500 < l \leq 2200$	$450 < l \leq 1200$	1.0
	$2200 < l$	$1200 < l$	1.2

तालिका 2: स्टैनलैस स्टील शीट डक्ट के लिए शीट की मोटाई

दाब के द्वारा डक्ट का वर्गीकरण (1)	निम्न दाब डक्ट (2)	मध्यम दाब डक्ट और उच्च दाब डक्ट (3)	शीट की मोटाई, न्यूनतम मिमी (4)
डक्ट का लंबा किनारा	$l \leq 750$	---	0.5
	$750 < l \leq 1500$	---	0.6
	$1500 < l \leq 2200$	$l \leq 450$	0.8
	$2200 < l$	$450 < l \leq 1200$	1.0
	---	$1200 < l$	1.2

तालिका 3: कठोर पॉलीविनायल क्लोराइड डक्ट के लिए शीट की मोटाई

दाब के द्वारा डक्ट का वर्गीकरण (1)	निम्न दाब डक्ट और मध्यम दाब डक्ट	उच्च दाब डक्ट Pa		शीट की मोटाई, न्यूनतम मिमी
डक्ट का लंबा किनारा	$p \leq 1000$ (2)	$1000 < p \leq 1500$ (3)	$1500 < p \leq 2000$ (4)	(5)
	$l \leq 500$	$l \leq 500$	---	3
	$5000 < l \leq 1000$	---	$l \leq 500$	4
	$1000 < l \leq 2000$	$500 < l \leq 2000$	$500 < l \leq 2000$	5
	$2000 < l$	$2000 < l$	$2000 < l$	6

तालिका 4: एलुमिनियम डक्ट के लिए शीट की मोटाई

दाब के द्वारा डक्ट का वर्गीकरण (1)	निम्न दाब डक्ट (2)	मध्यम दाब डक्ट और उच्च दाब डक्ट (3)	शीट की मोटाई, न्यूनतम मिमी (4)
डक्ट का लंबा किनारा	$l \leq 450$	---	0.8
	$450 < l \leq 750$	---	0.8
	$750 < l \leq 1500$	$l \leq 450$	1.0
	$1500 < l \leq 2200$	$450 < l \leq 1200$	1.5
	$2200 < l$	$1200 < l$	1.8

तालिका 5: जस्ती स्टील शीट डक्ट और स्टैनलैस शीट डक्ट के लिए शीट की मोटाई

दाब के द्वारा डक्ट का वर्गीकरण (1)	निम्न दाब डक्ट (2)	मध्यम दाब डक्ट और उच्च दाब डक्ट (3)	शीट की मोटाई, न्यूनतम मिमी (4)
डक्ट का आंतरिक व्यास (d), मिमी	$d \leq 500$	---	0.5
	$500 < d \leq 630$	---	0.6
	---	$d \leq 450$	0.8
	---	$450 < d \leq 630$	1.0

तालिका 6: वृत्ताकार सर्पिल जस्ती स्टील शीट डक्ट के लिए शीट की मोटाई

दाब के द्वारा डक्ट का वर्गीकरण (1)	निम्न दाब डक्ट (2)	मध्यम दाब डक्ट और उच्च दाब डक्ट (3)	शीट की मोटाई, न्यूनतम मिमी (4)
डक्ट का आंतरिक व्यास (d), मिमी	$d \leq 450$	$d \leq 200$	0.5
	$450 < d \leq 710$	$200 < d \leq 560$	0.6
	$710 < d \leq 1000$	$560 < d \leq 1000$	0.8
	$1000 < d$	$800 < d \leq 1000$	1.0
	---	$1\ 000 < d$	1.2



## तालिका 7: वृत्ताकार सर्पिल स्टैनलैस शीट डक्ट के लिए शीट की मोटाई

दाब के द्वारा डक्ट का वर्गीकरण (1)	निम्न दाब डक्ट (2)	मध्यम दाब डक्ट और उच्च दाब डक्ट (3)	शीट की मोटाई, न्यूनतम मिमी (4)
डक्ट का आंतरिक व्यास (d), मिमी	$d \leq 560$	$d \leq 250$	0.5
	$560 < d \leq 800$	$250 < d \leq 560$	0.6
	$800 < d \leq 1000$	$560 < d \leq 800$	0.8
	$1000 < d$	$800 < d \leq 1000$	1.0
	---	$1000 < d$	1.2

### 1.1.4 ट्रांसवर्स (अनुप्रस्थ) कनेक्टर:

सभी अनुप्रस्थ कनेक्टर IS: 655 / SMACNA नवीनतम मानकों के अनुसार होंगे। जब तक अन्यथा निर्दिष्ट नहीं किया जाए, सामान्यतः, OEM 4-बोल्ट स्लिप-फ्लैज सिस्टम या 4-बोल्ट सिस्टम के समतुल्य निर्मित सीलेंट के साथ यदि कोई हो रिसाव से बचने के लिए अतिरिक्त सीलेंट का उपयोग किया जाएगा। अनुप्रस्थ कनेक्टर की विशिष्ट श्रेणी और दिए गए डक्ट के आयामों के लिए डक्ट गेज 250 Pa दाब श्रेणी का होगा सभी मेटिंग फ्लैज जोड़ों के बीच अविषाक्त, AC -अनुप्रयुक्त ग्रेड P.E. (पाली एथीलीन) या पीवीसी गैस्केटिंग आवश्यक है। गैसकेट आकार फ्लैज निर्माता की विशिष्टता के अनुरूप होना चाहिए।

### 1.1.5 डक्ट निर्माण:

1. निर्मित डक्ट आयाम अनुमोदित ड्रॉइंग के अनुसार होना चाहिए और किसी भी अंतर से बचने के लिए सभी जोड़ने वाले खंडों को आयामी रूप से मिलान किया जाए।
2. आयामी सहायता: सभी निर्मित आयाम निर्दिष्ट आयाम के 1.0 मिमी के भीतर होंगे। आवश्यक लंबवतता प्राप्त करने के लिए, अनुमेय सहायता सहिष्णुता 1.0 मिमी प्रति मीटर होगी।

3. प्रत्येक डक्ट टुकड़े को रंग कोड वाले स्टीकर से पहचाना जाना चाहिए जिसमें विशिष्ट भाग संख्या, कार्य का नाम, ड्रॉइंग संख्या, डक्ट आकार और गेज दिखाया जाता है।
4. डक्ट भीतर से सीधी और चिकनी होंगी। अनुदैर्घ्य सीवन केवल कोनों पर ही वायुरोधी होगी और वायुरोधकता सुनिश्चित करने के लिए SMACNA पद्धति के अनुसार पिट्सबर्ग या स्नैप बटन पंच वाली होंगी।
5. डक्ट के आयामों और आकार में परिवर्तन क्रमिक (1: 4 और 1: 7 के बीच) होंगे। टर्निंग वेन या वायु स्प्लिटर सभी बैंड में लगाए जाएंगे और डक्ट कॉलर का डिज़ाइन इस तरह किया जाएगा बिना किसी विशेष प्रक्षोभ के हवा घूम सके।

#### 1.1.6 स्थापना:

1. निर्माण के दौरान, ठेकेदार अस्थायी रूप से शीट मेटल कवर से डक्ट के छिद्र को बंद कर देगा जिससे मलबा डक्ट में नहीं जा सके और छिद्र सीधा और चौकोर बना रहे।
2. यह सुनिश्चित करने के लिए बहुत सावधानी बरती जाएगी कि डक्ट कार्य बाहर और ऊंचाई की सीमा तक नहीं बढ़ाना चाहिए जैसा कि ड्रॉइंग में दिया गया है।
3. सभी डक्ट कार्य उच्च गुणवत्ता वाले अनुमोदित गैल्वनाइज्ड शीट स्टील का होगा जिसकी डक्ट को मोड़ने या निर्माण करने पर दरार नहीं पड़ने या नहीं उखड़ने की गारंटी होगी। सभी जोड़ वायुरोधी होंगे और उन्हें हवा के प्रवाह की दिशा में बनाया जाएगा।
4. IS और SMACNA मानकों के अनुसार जहां जरूरी हो, वहां डक्ट को संरचित भागों के साथ प्रबलित किया जाएगा, और उन्हें अपने स्थान पर रखा जाएगा ताकि डक्ट को अपने आधार पर कंपन से बचा जा सके।
5. वायु 45 डिग्री या उससे अधिक के सभी मोड़ों में वक्रित धातु ब्लेड या वैन शामिल होंगे, ताकि हवा को आकस्मिक प्रक्षोभ के बिना आकस्मिक मुड़ने दिया जा सके। शोर या कंपन को रोकने के लिए टर्निंग वेन को अच्छी तरह से कसा जाएगा।
6. डक्ट कार्य आकार और स्थिति में भिन्न होगा ताकि निर्माण स्थल पर वास्तविक स्थितियों को फिट हो सके। सभी परिवर्तन प्रभारी अभियंता द्वारा अनुमोदित किए जाएंगे। ठेकेदार साइट पर सभी मापनों की जांच करेगा और प्रभारी अभियंता को निर्माण कार्य से पहले अपने काम को पूरा करने में किसी भी कठिनाई के बारे में सूचित करेगा।

7. स्पंज रबड़ या 6 मिमी अधिकतम मोटाई के अनुमोदित समान गैसकेट डक्ट फ्लैज के बीच के साथ-साथ शीट धातु डक्ट के सभी कनेक्शनों के बीच दीवारों, फर्श कॉलम, हीटर केसिंग और फ़िल्टर केसिंग के बीच लगाई जाएंगी। शीट मेटल कनेक्शन दीवारों और फर्शों को लकड़ी के भागों के माध्यम से किया जाएगा जिन्हें एंकर बोल्ट के साथ भवन संरचना में गाड़ा जाएगा और उनके साथ शीट कसी जाएगी।
8. फ्लैज ब्रैसिंग और आधार डक्ट निर्माता से लिए जाएंगे। डैम्पर ब्लेड और एक्सेस पैनल जैसे सहायक उपकरण उचित मोटाई की सामग्री के होंगे और फिनिश निकटवर्ती डक्टिंग जैसी होगी, जैसा कि निर्दिष्ट किया गया है।
9. जोड़, सीवन, आस्तीन, स्प्लिटर, शाखाएं, ले-ऑफ और आधार, विनिर्देश के अनुसार डक्ट विवरण के अनुसार या प्रभारी अभियंता द्वारा तय किए अनुसार होंगे।
10. बोल्ट या रिवेटिंग की आवश्यकता वाले जोड़ों को हेक्सागोन नट और बोल्ट, स्टोव बोल्ट या बक बोल्ट, रिवेट या क्लोज्ड सेन्टर टॉप रिवेट या स्पाॅट वेल्डिंग द्वारा लगाया जा सकता है। सेल्फ-टेपिंग स्क्रू का इस्तेमाल नहीं किया जाना चाहिए। सभी जोड़ सामग्री की फिनिश यथावश्यक कैडमियम प्लेटिंग या जस्ती की होगी।
11. अग्निशामक लचीले जोड़ों को सभी पंखों के चूषण और वितरण के साथ फिट किया जाना है। सामग्री आमतौर पर दोहरे भारी कैनवास की होती है या प्रभारी इंजीनियर द्वारा निर्देशित की जाती है। सभी वृत्ताकार स्पिगॉट पर लचीली सामग्री को खराब या समायोज्य स्क्रू या टॉगल फिटिंग के साथ स्क्रू या क्लिप बैंड से लगाया जाना है। आयताकार डक्ट के लिए सामग्री फ्लैज होना चाहिए और बैकिंग फ्लैट के साथ बोल्ट की जानी है या बैकिंग फ्लैट के साथ मैटिंग फ्लैज के साथ बोल्ट की जानी है।
12. लचीले जोड़ों को 75 मिमी से कम नहीं होना चाहिए और फलकों के बीच 250 मिमी से अधिक नहीं होना चाहिए। डक्ट कार्य इस तरीके से और ऐसे समय में किया जाना चाहिए ताकि अन्य एजेंसियों, विशेषकर बॉक्सिंग या फाल्स सीलिंग ठेकेदारों के काम में बाधा या देरी ना हो।
13. ईट या चिनाई से गुजरने वाली डक्ट के लिए छिद्र के भीतर लकड़ी का ढांचा प्रदान किया जाएगा। क्रॉसिंग डक्ट में लकड़ी के ढांचा के प्रत्येक किनारे पर भारी फ्लैज, कॉलर होंगे, ताकि डक्ट को रिसाव-रोधी बनाया जा सके।

यह कार्य अपने सभी भागों और विवरणों में विभाग के अनुमोदन से किया जाएगा। इमारत में बीम, पाइप या अन्य अवरोधों के लिए सभी आवश्यक भत्ते और प्रावधान ठेकेदार द्वारा किए जाएंगे, भले ही वे ड्राइंग में दिखाए गए हैं या नहीं। जहां बीम या अन्य संरचनात्मक कार्य, नलसाजी या अन्य पाइपों और कंड्यूट से बचना आवश्यक हो, वहां साइट की आवश्यकता के मुताबिक, डक्ट को एक तरफ बदल दिया जाएगा, विभाजित किया जाएगा या एक तरफ घुमा दिया जाएगा (आवश्यक अनुप्रस्थ-काट क्षेत्र बनाए रखा जायेगा)। यदि ड्राइंग पर दिखाए अनुसार डक्ट को नहीं ले जाया जा सकता हो, तो ठेकेदार अन्य सेवाओं के अनुसार उपलब्ध किसी भी रास्ते से और सलाहकार/ग्राहक प्रभारी के अनुमोदन के अनुसार आवश्यक स्थल के बीच डक्ट स्थापित करेगा।

सभी डक्ट कार्य का आधार भवन निर्माण से स्वतंत्र होगा। सभी क्षैतिज डक्ट को कठोरता से और अच्छी तरह से अनुमोदित तरीके से सहारा दिया जाएगा, जिसे जस्ती इस्पात की छड़ और गैल्वनाइज्ड स्टील एंगल/चैनल या ब्रेकट की एक जोड़ी से से बने ट्रेपेज हेंगर को डक्ट के नीचे गैल्वनाइज्ड स्टील छड़ द्वारा जोड़ा जाएगा। आधारों के बीच की दूरी 2.0 मीटर से अधिक नहीं होनी चाहिए। सभी खड़े डक्ट कार्य को प्रत्येक मंजिल स्लैब पर संरचनात्मक भागों द्वारा सहारा दिया जाएगा। स्लैब कास्टिंग के समय स्लैब में छोड़े गए स्टील सन्निविष्ट प्लेट के माध्यम से डक्ट का आधार हो सकता है। हेंगर छड़ को पार करने के लिए छेद के साथ जस्ती स्टील क्लेट प्लेटों को वेल्ड किया जाएगा। जस्ती इस्पात की छड़ के बने ट्रेपेज हेंगर को इन क्लेट के माध्यम से लटका दिया जाएगा। जहां भी धातु सन्निविष्ट प्लेटों का उपयोग संभव नहीं हो, वहां डक्ट का आधार विद्युत चालित बंदूक द्वारा कंक्रीट स्लैब में संचालित डैश/एंकर फास्टर के माध्यम से किया जाएगा। हेंगर छड़ों को तब क्लेट के माध्यम से लटकाए जाएगा या पूरी तरह से चूड़ीदार जस्ती वाली छड़ें लंगर फास्टरों में स्क्रू की जा सकती हैं। परामर्शदाता/ग्राहक प्रभारी के अनुमोदन के बाद फर की छत पर डक्टिंग को ऊपर स्लैब या बीम से सहारा दिया जाना चाहिए। किसी भी मामले में किसी भी डक्ट को फाल्स सीलिंग के हेंगर का सहारा नहीं दिया जाएगा या फाल्स सीलिंग पर टिकाने नहीं दिया जाएगा। जड़ या फर्श खाली स्थानों में सभी धातु का काम समय से किया जाएगा ताकि इमारत में अन्य ठेकेदार के काम में कोई देरी ना हो।

सभी तरह की संचालन परिस्थितियों में सभी डक्ट कंपनी से पूरी तरह से मुक्त होंगी। जब भी डक्ट कार्य को पंखे, एयर हैंडलिंग यूनिट या ब्लोअर कॉइल यूनिट से जोड़ा जाता है तब डक्ट में कंपनी हो सकता है, अतः डक्ट को यूनिट डिस्चार्ज पर स्थित एक लचीला कनेक्शन लगाना

चाहिए। लचीले कनेक्शन को आगमंदक लचीली भारी कैनवास आस्तीन से बनाना होगा जो कम से कम 10 सेमी लंबी हो और दोनों तरफ से अच्छी तरह से आबद्ध हो और बोल्ट लगा हो। आस्तीन को चिकना बनाया जाएगा और जोड़ने वाले डक्ट कार्य को लचीले कनेक्शन के दोनों तरफ स्वतंत्र आधार द्वारा सख्ती से टिकाया जाएगा। लचीला कनेक्शन स्थापना के बिंदु पर दाब के लिए उपयुक्त होगा। डक्ट फाल्स सीलिंग पर नहीं टिका होगा और नीचे से समतल पर होगा। टेपर के टुकड़े शीर्ष से टेपर होंगे।

### 1.1.7 डक्ट के लिए हैंगर:

डक्ट आकार (मिमी)	अंतराल (m)	खांचेदार/MS एंगल का आकार (मिमी x मिमी)	छड़ व्यास का आकार (मिमी)
Up to 750	2.4	1.6 मिमी मोटी खांचेदार रेल	8
751 to 1500	2.4	40 x 3	10
1501 to 2250	2.0	50 x 3	12
2251 to above	2.0	50 x 3	12

1. 750 मिमी से अधिक चौड़े डक्ट को MS एंगल का सहारा प्रदान किया जाना है।
2. धुंआ/अग्निरोधी कनेक्शन के पास वाले डक्ट में अतिरिक्त हैंगर लगाए जाएंगे।
3. सभी डक्ट का निर्माण और स्थापना कारीगरी से किया जाएगा, जो IS 655 / SMACNA के नवीनतम मानकों के अनुरूप होगा।

### 1.1.8 मापन के लिए दस्तावेज़ीकरण:

1. प्रत्येक ड्राइंग के लिए, डक्ट कार्य की सभी आपूर्ति के साथ कंप्यूटर से बना सामग्री का विस्तृत बिल होगा जिसमें सभी प्रासंगिक डक्ट आकार, आयाम और मात्रा लिखी होगी। इसके

अतिरिक्त, सार पत्रक भी उपलब्ध कराए जाएंगे जिसमें गेज के हिसाब से डक्ट क्षेत्र और डक्ट आकार रेंज, यथा लागू, प्रदान किया जाएगा।

2. मापन शीट में प्रत्येक निर्मित डक्ट पीस को शामिल किया जाएगा जिसमें गेज-वार डक्ट के बाहरी सतह क्षेत्र के सार के साथ आयाम और बाहरी सतह क्षेत्र को दिखाया।

3. सभी डक्ट पीस पर पार्ट संख्या होगी, जो मापन शीट में उसे दिए गए सीरियल नंबर के अनुरूप होना चाहिए। उपरोक्त प्रणाली शीघ्र और उचित साइट मापन, सत्यापन और अनुमोदन सुनिश्चित करेगी।

### **1.1.9 परीक्षण:**

डक्ट की स्थापना के बाद, डक्ट खंड का एक हिस्सा (कुल डक्टवर्क का लगभग 20%) यादृच्छिक पर चुना जाए और रिसाव के लिए परीक्षण किया जाए। रिसाव परीक्षण की प्रक्रिया के लिए SMACNA- “HVAC एयर डक्ट रिसाव परीक्षण मैनुअल” का पालन किया जाना चाहिए।

विभिन्न क्षेत्रों में आवश्यक मात्रा के रूप में वायु आपूर्ति करने के लिए पूरी वायु वितरण प्रणाली को संतुलित किया जाएगा और प्रत्येक आउटलेट के माध्यम से वायु मात्रा के अंतिम शेष को मंजूरी के लिए प्रभारी अभियंता के पास भेज दिया जाएगा। पंखों की निर्मुक्ति और विभिन्न आउटलेट पर निर्धारित हवा की मात्रा निर्दिष्ट और उद्धृत के समान या 5% कम होगी। वायु संतुलन पूर्ण होने के बाद शाखा डक्ट समायोजन स्थायी रूप से चिह्नित किए जाएंगे ताकि इन्हें किसी भी समय विस्थापित होने पर उनकी सही स्थिति में बहाल किया जा सके।

### **1.2 GI / SS सर्पिल डक्टिंग:**

संवृत सेल इलास्टोमेरिक 9 मिमी मोटी नाइट्राइल रबड़ या समकक्ष की इन्सुलेट सामग्री के साथ फैक्ट्री निर्मित दोहरे आवरण सर्पिल डक्टिंग को SR 505 आसंजक या समकक्ष का उपयोग करके दीवारों के बीच चिपकाया जाएगा।

बाहरी आवरण GI/SS सर्पिल गोल डक्टिंग का होना चाहिए और अंदरूनी आवरण स्टेनलेस स्टील की सादा शीट का होना चाहिए, जिसमें नीचे दिए गए इन्सुलेशन के बाद डक्ट के आंतरिक आयाम होंगे।

डक्ट का बाहरी आवरण बाह्य रूप से पाउडर लेपित होगा और साइट की स्थितियों और ड्रॉइंग में दर्शाए अनुसार आवश्यक बैंड बनाये जाने चाहिए। डक्ट कनेक्शन दोहरी दीवार का होगा जिसमें साइट की दीवार के सहारे से आंतरिक इन्सुलेशन युग्मक/ MS या SS फ्लेंज होगा।

डक्ट के बाहरी आवरण के लिए बाह्य रंग प्रभारी अभियंता द्वारा अनुमोदित किया जाएगा। लागत में निविदा ड्रॉइंग में दर्शाए बैंड, रेड्यूसर, कॉलर आदि शामिल होंगे।

**नोट:** सर्पिल डक्ट के GI/SS बाहरी आवरण पर न्यूनतम 120 GSM की जस्ता कोटिंग होगी।

### 1.3 विद्युत-रोधी लचीली वाहिकाएं (डक्ट):

स्प्रिंग इस्पात तार हेलिक्स से लैमिनेट किया AI- पॉलिएस्टर की कई परतों के साथ इंसुलेट किये लचीले डक्ट को ISO श्रेणी 6, श्रेणी 7 और श्रेणी 8 क्लीन रूम के प्रत्येक फिल्टर मॉड्यूल के लिए GI आपूर्ति डक्ट कार्य से सहारा दिया जाएगा। 300 एमएम व्यास की लचीली डक्टिंग वायु दाब +2500 Pa और वेग के 30m/s लिए उपयुक्त होगी।

लचीले डक्ट कार्यों को प्रत्येक फिल्टर मॉड्यूल और शीट मेटल कॉलर पर स्टेनलेस स्टील के लचीले डक्ट बैंड और डक्ट बैंड लॉक का इस्तेमाल करके सील और सुरक्षित कर दिया जाएगा।

### 1.4 स्क्रबिंग प्रणाली के लिए PP FRP डक्टिंग:

पॉलीप्रोपीलेन फाइबर प्रबलित प्लास्टिक (PPFRP) डक्ट, गीले स्क्रबर, निकास यूनिट और चिमनी को जोड़ने वाली धुंआ भरी हवा को ले जाने के लिए। डक्ट को आवश्यक उपकरण के साथ स्क्रबर और ब्लोअर से जोड़ा जाएगा। धुंआ के आवधिक परीक्षण के लिए ब्लोअर आउटलेट डक्ट पर एक नमूना बिंदु प्रदान किया जाएगा। 120 डिग्री पर सभी तीनों तरफ स्ट्रिंग तारों के सहारे से चिमनियों को लगाया जाएगा और पर्याप्त सहारे, फ्लेंज, बैंड आदि के साथ डक्ट

प्रदान की जाएंगी। सभी डक्ट 3 मिमी पॉली प्रोपीलेन और 5 मिमी मोटी FRP लाइनिंग से बनाए जाएंगे और डक्ट फिटिंग सिस्टम में न्यूनतम दाब पात के लिए बनाए जाएंगे।

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## 2. मोटर चालित आग / धुआं डैम्पर

निम्नलिखित विनिर्देशों के समान या अधिक वाले मोटर चालित आग डैम्पर निविदा ड्रॉइंग/SOQ में दर्शाए गए स्थानों पर प्रस्तुत और स्थापित किये जाएंगे। डैम्पर को UL 555 के अनुसार 2 घंटे की आग प्रतिरोध रेटिंग को पूरा करना होगा और CBRI द्वारा परीक्षण और प्रमाणित किया जाएगा। फायर (आग) डैम्पर फ्रेम 1.6 मिमी मोटाई के जस्ती इस्पात से बना होगा, जो डक्ट कनेक्शन के लिए उपयुक्त फ्लेंज के साथ 4-भाग निर्माण में C चैनल में बनाया जाएगा। डैम्पर ब्लेड 1.6 मिमी मोटाई की एकल आवरण जस्ती स्टील की होंगी और प्रबलन और उचित बंद करने और ऑपरेशन के लिए सटीक रूप से अनुदैर्घ्य निर्मित 3 खांचे होंगे। सकारात्मक बंद करने के लिए ब्लेड को समानांतर व्यवस्थित किया जाएगा। प्रत्येक ब्लेड में दोनों तरफ सहारे के लिए एक्सल होंगे जिसके साथ फ्रेम में बाहर निकले छेद में निसादित कांस्य के स्व-स्नेहनकारी बेयरिंग टर्निंग होंगे। सभी ब्लेड फ्रेम सेक्शन में लिंकेज का उपयोग करके परस्पर जुड़े होंगे। जैम सील स्टेनलेस स्टील लचीला धातु संपीड़न प्रकार के होंगे।

निर्माण के समय निर्माता को प्रत्येक डैम्पर के साथ 24V एक्चुएटर (प्रेरक) की आपूर्ति की जाएगी। एक्चुएटर का चयन उसके आकार के अनुसार डैम्पर की बल आघूर्ण आवश्यकताओं को पूरा करने के लिए किया जाएगा। प्रत्येक मोटर चालित आग डैम्पर में डक्ट और HVAC घटक क्षति को रोकने के लिए नियंत्रित बंद तापमान संवेदक से लैस किया जाएगा। झटके से बंद करने वाला डैम्पर अस्वीकार्य है। हीट डिटेक्शन डिवाइस को 165 डिग्री F (74 डिग्री C) का होना चाहिए। हीट डिवाइस को अग्नि दुर्घटना की स्थिति में एक्चुएटर की विद्युत आपूर्ति काट देना चाहिए। फायर कंट्रोल पैनल या स्मोक डिटेक्शन कंट्रोल पैनल से सिग्नल प्राप्त करने पर आग व धुआं डैम्पर को बंद हो जाना चाहिए।

नियंत्रण कक्ष में निम्नलिखित विशेषताएं शामिल होंगी:

- 220 V/24 V स्टेप डाउन ट्रांसफार्मर
- चालू/बंद संकेत लाइट
- पावर ऑन संकेत लाइट
- टेस्ट बटन
- सहायक संपर्क बिंदु

### 3. पैन ह्यूमिडिफायर (आर्द्रिकारक)

मौसमी आपरेशन के लिए पर्याप्त क्षमता वाले स्टेनलेस स्टील पैन ह्यूमिडिफायर किट जिसमें इमर्सन हीटर, फ्लोट वाल्व असेंबली, इनलेट, मेकअप और जल निकासी कनेक्शन, केबल बिछाना और अर्थिंग आदि शामिल हैं, और जैसे ह्यूमिडिस्टेट, गीजरस्टेट आदि जैसे यथावश्यक नियंत्रण के साथ परिपूर्ण होंगे। पैन ह्यूमिडिफायर DDC के माध्यम से संचालन के लिए संगत होगा।

पैन टाइप ह्यूमिडिफायर SOQ में निर्दिष्ट अनुसार फर्श/दीवार पर लगाने वाले होंगे और जरूरत पड़ने पर वाष्प डालने के लिए आपूर्ति वायु नली से जुड़ी होती है। हीटर की क्षमता SOQ में बताए अनुसार होगी।

#### 3.1 निर्माण:

मुख्य बॉडी SS-304 की 2 मिमी मोटी स्टेनलेस स्टील शीट से बनी होगी, जिसमें त्वरित भरने, मेक अप, अति प्रवाह, निकास और स्टीम आउटलेट के कनेक्शन होंगे। जल स्तर देखने के लिए 75 मिमी व्यास x 12 मिमी मोटा साइट ग्लास प्रदान किया जाएगा। सर्विसिंग के लिए ह्यूमिडिफायर के अंदर पहुंचने के लिए एक शीर्ष कवर प्रदान किया जाएगा। ह्यूमिडिफायर 0.8 मिमी मोटी एल्यूमीनियम शीट से इंसुलेट और आच्छादित किया जाएगा। पैन ह्यूमिडिफायर के लिए उचित स्विचगियर/पैनल प्रदान किया जाएगा।

## 4. परिवर्ती वायु आयतन (VAV) प्रणाली

### 4.1 VAV स्टेशन - सामान्य:

सभी VAV (वैरिएबल एयर वॉल्यूम) स्टेशन प्रत्यक्ष डिजिटल नियंत्रण के साथ दाब स्वतंत्र प्रकार का होगा ताकि स्वीकार्य शोर मापदंड में निर्दिष्ट आराम स्तर और वेंटिलेशन दरों को प्राप्त करने के लिए निर्धारित न्यूनतम और अधिकतम मानों के बीच प्राथमिक वायु प्रवाह दर को नियंत्रित और मॉनिटर किया जा सके।

VAV स्टेशन वांछित क्षेत्र तापमान प्रदान करने के लिए हवा को नियंत्रित करेगा। नियंत्रक दाब, डैम्पर ब्लेड की स्थिति और डैम्पर से बहने वाली हवा के तापमान को मापेगा।

VAV स्टेशन में AMCA श्रेणी-I रिसाव के समान अल्ट्रा-लो लीक, उच्च निष्पादन नियंत्रण डैम्पर के साथ एक एयर मापन स्टेशन होगा। संपूर्ण असेम्बली प्रभावी निर्धारित बिंदु मॉनिटरिंग और समायोजन प्रदान करने के लिए फैक्टरी में असेम्बल की जाएगी और और परीक्षण किया जाएगा। यूनिट एक मानक दाब ट्रांसड्यूसर मानक के साथ आएगी, जिसके साथ वायु मात्रा (cfm) के आनुपातिक उत्पादन संकेत और कारखाना में फिट कि गया स्टैंडअलोन DDC नियंत्रक होगा।

### 4.2 VAV स्टेशन का अवलोकन:

इस अनुप्रयोग में, हवा मापन नियंत्रण डैम्पर सतत तापमान पर हवा की आपूर्ति करेगा, जबकि अलग-अलग क्षेत्र थर्मोस्टेट वांछित क्षेत्र के तापमान को बनाए रखने के प्रत्येक स्थान पर हवा के प्रवाह में भिन्नता रखेगा। एक विशिष्ट क्षेत्र के तापमान निर्धारित-बिन्दु को बनाए रखने के लिए हवा की विशिष्ट मात्रा की जगह स्थान के आकार और आंतरिक और बाह्य ताप भार से तय होती है, इसे प्रत्यक्ष डिजिटल नियंत्रणों द्वारा फैलाया जाएगा।

## 3. निर्माण:

केसिंग बाहर निकले एल्यूमिनियम से बने एकल आवरण की होगी। केसिंग रिसाव दर AMCA श्रेणी-I रिसाव के समान होगी। सभी VAV स्टेशन में स्टेशन के इनलेट और आउटलेट पर 25 मिमी फ्लैज कनेक्शन के साथ आयताकार डक्ट कनेक्शन होंगे।

VAV स्टेशन में मापन के लिए उपयुक्त आवश्यक लैमिना वायु प्रवाह प्रदान करने के लिए स्टेशन के इनलेट पर 75 मिमी गहरा हेक्सागोनल पैटर्न का वायु-प्रवाह स्ट्रेटनर होगा, एल्यूमीनियम के साथ एक बहु-पत्ती विपरीत ब्लेड टैंपर, एल्यूमीनियम, एरोफोइल ब्लेड निर्माण, चौड़ाई 100 मिमी, और खुले गियर संचालित होगा। स्पेशल डैम्पर स्पिंडल स्टील (10 मिमी व्यास) का बना होगा, जो स्वयं-स्नेहन नायलॉन बेयरिंग में घूमता है।

प्रत्येक VAV स्टेशन में फैक्ट्री में फिट किया गया टर्मिनल के इनलेट पर एक बहुबिंदु, औसत प्रवाह संवेदक होगा। यह वायु प्रवाह संवेदक कम से कम 3.0 के प्रवर्धन गुणक के साथ वायु दबाव संकेत को रैखिक रूप से बढ़ाएगा। वायु प्रवाह संवेदक में 2x8 सेंसिंग बिंदु से कम नहीं होंगे, जिन्हें लॉग-टैक्बैशेफ विधि के अनुसार व्यवस्थित किया जाएगा। संकेतों का औसत निकाला जाएगा और संवेदक के केंद्र से मापा जाएगा और अनियमित डकट अभिगम के साथ भी सटीकता 5% के भीतर होगी।

#### **4.4 नियंत्रण:**

##### **4.4.1 नियंत्रक:**

नियंत्रक DDC उन्नत अनुप्रयोग नियंत्रक होगा जो बिंदु से बिंदु तक एनालॉग नियंत्रण का उपयोग करके प्रत्यक्ष डिजिटल नियंत्रण पर अनयोन्यक्रिया करता है और वर्तमान या भावी BMS प्रणाली के साथ संगत होगा।

##### **4.4.2 एक्चुएटर:**

एक्चुएटर में एक दाब सेंसर, डिजिटल VAV नियंत्रक और डैम्पर एक्चुएटर होंगे सभी एक में, जो आराम क्षेत्र में दाब-स्वतंत्र VAV प्रणाली के लिए संचार क्षमता के साथ ठोस समाधान प्रदान करेगा।

ऑपरेटिंग डिवाइसों के लिए नैदानिक सॉकेट को चालू करने के लिए इसके पास एक कनेक्शन सुविधा भी होनी चाहिए।

##### **4.4.3 थर्मोस्टेट:**

थर्मोस्टेट में वोल्टेज आनुपातिक संकेत यानि 0-10V DC होगा।

एयर कंडीशनिंग और वेंटिलेशन  
कार्यों के लिए विनिर्देश

**खंड- XII**

**डक्ट इंसुलेशन (विद्युत-रोधन)**

## 1. डक्ट के लिए तापीय (थर्मल) इन्सुलेशन

### 1.1 सामान्य:

डक्ट थर्मल इन्सुलेशन के लिए सामग्री, आसंजक, और इन्सुलेशन की मोटाई निविदा अनुसूची में निर्दिष्ट के अनुसार होगी।

### 1.2 नाइट्राइल रबड़ (संवृत सेल):

#### 1.2.1 गुण:

1. इलास्टोमेरिक नाइट्राइल रबड़ की थर्मल चालकता  $0^{\circ}\text{C}$  के औसत तापमान पर  $0.033\text{W}/(\text{m}\cdot\text{K})$  से अधिक नहीं होगी।
2. इन्सुलेशन का अग्नि निष्पादन ऐसा होगा कि यह सतह पर आग के प्रसार के लिए BS 476 भाग 7 के अनुसार श्रेणी 1 पास करे, और श्रेणी 'O' अग्नि वर्ग को पूरा करने के लिए BS 476 भाग 6 की अग्नि प्रसार की आवश्यकता को भी पास करे।
3. अन्य साधारण सामग्रियों के विपरीत, यह स्व-शामक होना चाहिए, आग के गोले नहीं गिराए और आग नहीं फैलाए।
4. इन्सुलेशन सामग्री के लिए बिना किसी आवरण या वाष्प बाधा के नमी विसरण प्रतिरोध कारक या ' $\mu$ ' मान न्यूनतम 10,000 होगा।
5. इसमें माइक्रोबॉन, रोगाणुरोधी उत्पाद संरक्षण, EPA अनुमोदित होगा, रोगाणुरोधी व्यवहार: DIN EN ISO 846 पद्धति के अनुसार कवक नहीं होने की जांच की जाएगी, (कवक), बैक्टीरिया प्रतिरोध के लिए एक मानक: (बैक्टीरिया) के लिए DIN EN ISO 846 पद्धति C के अनुसार कोई बैक्टीरियल विकास नहीं और 99.9% की कमी का परीक्षण किया गया।
6. अस्थायी रेंज: न्यूनतम  $+ 7^{\circ}\text{C}$  लेकर अधिकतम  $105^{\circ}\text{C}$ ।
7. सामग्री रंग: हरा/काला
8. खुले इन्सुलेशन (आसमान की तरफ खुले) के लिए कुछ भी लगाने पर उसे ग्लास फाइबर क्लॉथ द्वारा और उपचारित किया जाएगा जिसके ऊपर UV प्रतिरोधी पेंट लगाया जाएगा।

9. विशेष टिप्पणी: तकनीकी परिणामों की गणना /परीक्षण प्रमाण पत्र के लिए - डक्ट थर्मल इन्सुलेशन के लिए Alu आबद्धता के बिना परीक्षण परिणामों को ध्यान में रखा जाना चाहिए।

### 1.2.2 अनुशंसित आसंजक:

1. आसंजक विशेष रूप से डक्ट इन्सुलेशन पर लगाने के लिए तैयार किया जाएगा और इन्सुलेशन की आपूर्ति निर्माता द्वारा की जाएगी।

2. आसंजक सॉल्वेंट आधारित/पानी आधारित रबड़ इन्सुलेशन आसंजक होगा जो बैजीन मुक्त होगा।

3. यह छिद्रिल और अछिद्रिल सतहों के लिए उत्कृष्ट आबंधक होना चाहिए।

4. आसंजक उष्णकटिबंधीय परिस्थितियों के लिए त्वरित सूखने के लक्षण वाला होगा और इसमें 5°C से 85°C तक सर्विस तापमान होगा

5. आसंजक सामग्री का गुण निम्नानुसार होगा:

- श्यानता @ 30°C : 700 - 1200 cps
- विशिष्ट गुरुत्व : 0.80 - 0.85 g/cc
- घनत्व : 0.083 kg/m<sup>3</sup>+  
0.01
- ज्वलनांक : > 10 °C
- व्याप्ति : आबद्ध सामग्री / लीटर से 6-8 वर्ग मीटर
- सूखने का समय : 4 - 5 मिनट
- कील अवधारण समय: 25 मिनट

### 1.2.3 अनुप्रयोग - बंद डक्ट:

1. इन्सुलेशन कार्य शुरू करने से पहले सभी तेल, ग्रीस, गंदगी, आदि को हटाने के लिए डक्ट सतहों को साफ किया जाएगा।

2. आयाम में पर्याप्त भत्ते के साथ वाले आकार के लिए संवृत सेल इलास्टोमेरिक रबड़ शीट्स काटने के लिए सतह आयामों का माप ठीक से लिया जाएगा।

3. सामग्री संपीड़न के द्वारा फिट किया जाएगा और सामग्री को खींचने नहीं दिया जाना चाहिए।
4. इन्सुलेट सामग्री शीट के पीछे की ओर आसंजक की पतली परत और फिर धातु की सतह पर लगाई जाएगी।
5. आसंजक टैक सूखा हो, तो इन्सुलेट सामग्री शीट को स्थिति में रखा जाएगा और अच्छा बंधन करने के लिए दृढ़ता से दबाया जाएगा।
6. निर्माता की अनुशंसाओं के अनुसार सभी अनुदैर्घ्य और अनुप्रस्थ जोड़ों को बंद कर दिया जाएगा।
7. आसंजक निर्माता द्वारा अनुशंसित ही होगा।

#### **1.2.4 अनुप्रयोग - खुली डक्ट:**

1. इन्सुलेशन कार्य शुरू करने से पहले सभी तेल, ग्रीस, गंदगी, आदि को हटाने के लिए डक्ट सतहों को साफ किया जाएगा।
2. आयाम में पर्याप्त भत्ते के साथ वाले आकार के लिए संवृत सेल इलास्टोमेरिक रबड़ शीट्स काटने के लिए सतह आयामों का माप ठीक से लिया जाएगा।
3. सामग्री संपीड़न के द्वारा फिट किया जाएगा और सामग्री को खींचने नहीं दिया जाना चाहिए।
4. इन्सुलेट सामग्री शीट के पीछे की ओर आसंजक की पतली परत और फिर धातु की सतह पर लगाई जाएगी।
5. आसंजक टैक सूखा हो, तो इन्सुलेट सामग्री शीट को स्थिति में रखा जाएगा और अच्छा बंधन करने के लिए दृढ़ता से दबाया जाएगा।
6. निर्माता की अनुशंसाओं के अनुसार सभी अनुदैर्घ्य और अनुप्रस्थ जोड़ों को बंद कर दिया जाएगा।
7. आसंजक निर्माता द्वारा अनुशंसित ही होगा।
8. नाइट्राइल रबड़ इन्सुलेशन पर UV प्रतिरोधी पेंट की 1 कोट लगाएं।
9. फिर 7 mm/mill मोटा फाइबर ग्लास कपड़ा लपेटें।



10. फाइबर ग्लास कपड़ा पर UV प्रतिरोधी पेंट की दूसरी कोट लगाएं।

### 1.3 आबंध उपचारित बुना ग्लास फाइबर:

1. तापमान रेंज: कुल मिलाकर 0°C से +105°C (बेस उत्पाद के बावजूद)

2. रंग: काला

3. उपचार: कपड़े को कड़कीला और इकट्टा नहीं होने का गुण देने के लिए, आसान स्थापना में मदद करने के लिए, फाइबर कटाव को कम करने, अच्छे सौंदर्य और घर्षण प्रतिरोध के लिए जल आधारित ऐक्रेलिक बाइंडर से उपचारित किया जाएगा। फाइबर स्पिंलेज/थ्रेड रेवलिंग न्यूनतम होना चाहिए।

4. घनत्व: 200 +/- 20 gsm

5. तन्य क्षमता: 275 +/- 25 kg / 50 mm (न्यूनतम)

6. मोटाई: 0.18 mm / 7 mill

7. प्रकार: सॉल्वेंट आधारित एक्रिलिक आसंजक

8. उखड़ने की क्षमता: 1000 ग्राम/25 मिमी (न्यूनतम) - (स्टील के लिए आसंजक)

### 1.4 भौतिक रूप से क्रॉस-लिंकड पॉलीओलेफिन फोम:

#### 1.4.1 भवन के अंदर (बंद डक्ट):

फैक्टरी लैमिनेट किए एल्यूमीनियम पन्नी फलक और स्व-आसंजक बैकिंग के साथ इलेक्ट्रॉन बीम (भौतिक रूप से) क्रॉस-लिंक पॉलीओलेफिन फोम इन्सुलेशन। फोम का घनत्व 25kg/m<sup>3</sup> होगा और अधिकतम थर्मल चालकता K 23<sup>0</sup> C पर 0.032W/mK होगी। पारगम्यता प्रतिरोध कारक 'μ' 80000 से अधिक होना चाहिए। BS 476 भाग 6 और BS 476 भाग 7 के अनुसार परीक्षण करने पर इन्सुलेशन सामग्री की न्यूनतम आग दर्जा गुण श्रेणी O होना चाहिए।

**स्थापना:** फोम इन्सुलेशन निर्माता के निर्देश के अनुसार स्थापित किया जाना चाहिए। सभी जोड़ों को एक दूसरे के खिलाफ मजबूती से लगाया जाना चाहिए, 75 मिमी चौड़े प्रबलित

एल्यूमीनियम टेप के साथ सभी जोड़ों को सील करें। प्रत्येक डक्ट को अलग-अलग इन्सुलेट करें, फ्लैज को इन्सुलेशन सामग्री की 120 मिमी चौड़ी पट्टी से इन्सुलेट किया जाना चाहिए, जोड़ों को 75 मिमी प्रबलित एल्यूमीनियम पन्नी टेप के साथ सील करना सुनिश्चित करें। इन्सुलेशन के अतिरिक्त संपीड़न से बचने के लिए सभी सहायक हैंगर को उसी इन्सुलेशन सामग्री से अस्तर लगाना चाहिए। (निर्माता के निर्देश देखें)। यह सुनिश्चित करें डक्ट के इन्सुलेशन लगाने के दौरान कोई भी एयर पॉकेट नहीं रह जाए। कोई भी मामूली सतह कट को एल्यूमीनियम पन्नी टेप से कवर किया जाना चाहिए।

#### 1.4.2 भवन के अंदर (खुली डक्ट):

फैक्टरी लैमिनेट किए मजबूत और अति-कठोर बहु-परतित मिश्रित एल्यूमीनियम पन्नी फलक और स्व-आसंजक बैकिंग के साथ इलेक्ट्रॉन बीम (भौतिक रूप से) क्रॉस-लिंक पॉलिऑलेफिन फोम इन्सुलेशन। फोम का घनत्व 25kg/m<sup>3</sup> होगा और अधिकतम थर्मल चालकता K 23<sup>0</sup> C पर 0.032W/mK होगी। पारगम्यता प्रतिरोध कारक ' $\mu$ ' 40000 (25mm के आधार पर) से अधिक होना चाहिए। BS 476 भाग 6 और BS 476 भाग 7 के अनुसार परीक्षण करने पर इन्सुलेशन सामग्री का न्यूनतम आग दर्जा गुण श्रेणी O होना चाहिए। सामग्री का पंचर प्रतिरोध ASTM D4833 के मुताबिक 400N से अधिक होना चाहिए। सामग्री UV रोधक होगी और अपक्षय परीक्षित होगा।

**स्थापना:** फोम इन्सुलेशन निर्माता के निर्देश के अनुसार स्थापित किया जाना चाहिए। सभी जोड़ों को एक दूसरे के खिलाफ मजबूती से लगाया जाना चाहिए, UV रोधक और मौसम प्रतिरोधक गुणों वाले 75 मिमी चौड़े प्रबलित एल्यूमीनियम टेप के साथ सभी जोड़ों को सील करें। प्रत्येक डक्ट को अलग-अलग इन्सुलेट करें, फ्लैज को इन्सुलेशन सामग्री की 120 मिमी चौड़ी पट्टी से इन्सुलेट किया जाना चाहिए, जोड़ों को 75 मिमी प्रबलित एल्यूमीनियम पन्नी टेप के साथ सील करना सुनिश्चित करें। इन्सुलेशन के अतिरिक्त संपीड़न से बचने के लिए सभी सहायक हैंगर को उसी इन्सुलेशन सामग्री से अस्तर लगाना चाहिए। (निर्माता के निर्देश देखें)। यह सुनिश्चित करें डक्ट के इन्सुलेशन लगाने के दौरान कोई भी एयर पॉकेट नहीं रह जाए। कोई भी मामूली सतह कट को एल्यूमीनियम पन्नी टेप से कवर किया जाना चाहिए।

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## 2. डक्ट के लिए ध्वानिक रोधन (इन्सुलेशन)

### 2.1 सामान्य:

डक्ट के ध्वानिक इन्सुलेशन के लिए सामग्री, आसंजक और इन्सुलेशन की मोटाई निविदा अनुसूची में निर्दिष्ट के अनुसार होगी।

फंगसरोधी और रोगाणुरोधी गुणों के लिए माइक्रोबैन के साथ ओपन सेल नाइट्राइल रबड़ सामग्री:

### 2.2 ध्वानिक सामग्री गुण:

1. ध्वानिक सामग्री ओपन सेल नाइट्राइल रबड़ की होनी चाहिए।
2. इसकी सामग्री फाइबर मुक्त होगी।
3. इसका घनत्व 140-180 kg/m<sup>3</sup> के भीतर होगा।
4. इसमें माइक्रोबैन, रोगाणुरोधी उत्पाद संरक्षण, रोगाणुरोधी व्यवहार होगा: DIN EN ISO 846 पद्धति के अनुसार कवक नहीं होने की जांच की जाएगी, (कवक), बैक्टीरिया प्रतिरोध के लिए एक मानक: (बैक्टीरिया) के लिए DIN EN ISO 846 पद्धति C के अनुसार कोई बैक्टीरियल विकास नहीं और 99.9% की कमी का परीक्षण किया गया।
5. सामग्री की तापीय चालकता @ 20 डिग्री से. पर 0.047 W/m.K अधिक नहीं होगी।
6. सामग्री +850 डिग्री C के अधिकतम सतह तापमान और -20 डिग्री C के न्यूनतम तापमान को सहन करने वाली होगी। सामग्री BS 476 भाग 7 और UL 94 के अनुसार लौ की सतह के प्रसार के लिए श्रेणी 1 रेटिंग के अनुरूप होगी।
7. इन्सुलेशन को स्वतंत्र मान्यता प्राप्त परीक्षण एजेंसी से ASTM C1071-16 के अनुसार इन्सुलेशन, वायु क्षरण प्रतिरोध परीक्षण पास करना होगा।
8. सामग्री की मोटाई अलग-अलग अनुप्रयोग के लिए निर्दिष्ट के अनुसार होगी।
9. निर्माता की सिफारिश के अनुसार इन्सुलेशन लगाया जाएगा।

10. डक्ट वर्क में उपयोग के लिए EPA द्वारा स्वीकृत।

11. ISO 354 के अनुसार परीक्षित रैंडम आपतन ध्वनि अवशोषण गुणांक (RISAC) नीचे संलग्न तालिका के अनुसार न्यूनतम होगा।

आवृत्ति Hz	125	250	500	1000	2000	4000
10 मिमी	0	0.05	0.15	0.4	0.85	1
15 मिमी	0	0.1	0.3	0.75	1	0.9
20 मिमी	0.05	0.15	0.4	0.9	1	0.95
25 मिमी	0.05	0.25	0.85	1	0.9	0.95
30 मिमी	0.1	0.35	0.95	1	0.95	1
40 मिमी	0.15	0.5	1	0.9	0.95	0.95
50 मिमी	0.25	0.75	1	1	1	1

### 2.3 अनुप्रयोग:

डक्ट के अंदर की सतह को निर्माता द्वारा अनुशंसित आसंजक से कवर किया जाएगा। फोम शीट को आवश्यक आकारों में काटकर फोम पर आसंजक लगाएं और इसे डक्ट की सतह पर चिपकाएं।

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एयर कंडीशनिंग और वेंटिलेशन  
कार्यों के लिए विनिर्देश

**खंड- XIII**

**परिवर्ती आवृत्ति ड्राइव (VFD)**

## 1. परिवर्ती आवृत्ति ड्राइव (VFD)

### 1.1 कार्यक्षेत्र:

इस खंड में पंखा और पंप की गति नियंत्रण के लिए आपूर्ति किए जाने वाले परिवर्ती आवृत्ति ड्राइव (VFD) के प्रकार का वर्णन किया गया है।

### 1.2 सामान्य:

1. VFD को निर्माता द्वारा सहायता प्रदान की जाएगी जो अपनी सुविधा से पूर्ण तकनीकी सहायता, स्पेयर होल्डिंग और समस्या दूर करने की क्षमता प्रदान करेगा। निर्माता द्वारा संचालन और रखरखाव इंजीनियरों के लिए प्रशिक्षण पाठ्यक्रम आयोजित किया जाएगा।
2. आपूर्तिकर्ता प्रस्ताव के साथ उत्पाद की पूर्ण तकनीकी जानकारी प्रदान करेगा जिसमें कैटलॉग, संचालन पुस्तिका, आयामी ड्राइंग, वजन आदि शामिल हैं।
3. VFD IEC जैसे मान्यता प्राप्त अंतरराष्ट्रीय मानकों के अनुरूप होंगे और ISO 9001 के अनुसार निर्मित किए जाएंगे और UL सूचीबद्ध होंगे।
4. आपूर्तिकर्ता को एक सामान्य यूजर इंटरफेस, सामान्य सर्किट आवश्यकताओं और सामान्य स्पेयर पार्ट्स सुनिश्चित करने के लिए पूरी आवश्यक पावर रेंज पर नियंत्रक की श्रृंखला की पेशकश करेगा।
5. VFD "स्टैंड अलोन" मोड में ऑपरेशन के लिए उपयुक्त होंगे, मोटर की आवश्यक सुरक्षा के साथ या केंद्रीय नियंत्रित बिल्डिंग मैनेजमेंट सिस्टम (BMS)/डायरेक्ट डिजिटल कंट्रोल (DDC) के एक भाग के रूप में परिपूर्ण होंगे।

### 1.3 डिजाइन आवश्यकताएं:

1. VFD 3 फेज,  $415 \pm 10\%$  V, 50 Hz इनपुट पावर सप्लाई पर ऑपरेशन के लिए उपयुक्त होगा।

2. VFD निम्नलिखित परिस्थितियों में पूर्ण भार पर ऑपरेशन के लिए उपयुक्त होगा:

- इनपुट आपूर्ति वोल्टेज विविधता: + 10%
- इनपुट आपूर्ति आवृत्ति भिन्नताएं: + 6%
- परिवेशी तापमान: 0 - 50°C
- अधिकतम सापेक्ष आर्द्रता: 95% गैर संघनक
- कंपन: 3 दिशाओं में 0.7 g RMS
- पूर्ण भार पर न्यूनतम दक्षता: 96%

3. VFD निश्चित वोल्टेज और आवृत्ति को परिवर्ती वोल्टेज और आवृत्ति में बदलने के लिए उन्नत डिजिटल वेक्टर नियंत्रण प्रौद्योगिकी का उपयोग करेगा। यह सुनिश्चित किया जाना चाहिए कि पूर्ण मोटर शक्ति का उपयोग रेटेड गति पर किया जाए।

4. मोटर परिचालन के दौरान होने वाले टॉर्क और गति भिन्नता के नुकसान से बचने के लिए VFD स्वतः + 10% के मुख्य लाइन के बदलावों के दौरान आउटपुट वोल्टेज को सही कर देगा।

5. VFD में न्यूनतम IP 20 की सुरक्षा के साथ एक मेटल बाड़ा (घेरा) होगा और किसी भी डी-रेटिंग के बिना IP 54 कंट्रोल पैनल के अंदर स्थापित करने के लिए उपयुक्त होगा। नियंत्रण कक्ष के अंदर स्थापित करते समय VFD को पर्याप्त ठंडा करने के लिए आवश्यक निकासी और वायु प्रवाह बिल्कुल स्पष्ट रूप से कहा जाएगा।

6. VFD का उत्पादन तरंगरूप पंपों और पंखों द्वारा उत्पादित द्विघातीय लोड टॉर्क को नियंत्रित करने के लिए उपयुक्त होगा, ताकि सभी भारों और गतियों पर मोटर से अधिकतम कुल दक्षता प्राप्त करना सुनिश्चित किया जा सके।

7. VFD के उत्पादन का V/f अनुपात ऑपरेटिंग लोड परिस्थितियों के आधार पर गतिशील रूप से परिवर्ती होगा। जुड़े हुए उपकरण की क्षति को रोकने के लिए स्थिर V/f अनुपात सेट करना संभव नहीं होगा। यह ऊर्जा खपत को अनुकूलित करने के लिए है।
8. VFD को 0.5 सेकंड के लिए 160% टॉर्क प्रदान करने और शुरुआत पर 1 मिनट के लिए 110% टॉर्क प्रदान करने में सक्षम होगा। यह वास्तव में VFD से जुड़ी मोटर की परिचालन सीमा को प्रतिबिंबित करेगा।
9. VFD किसी भी IEC मानक डिजाइन मोटर के साथ मिलकर काम करेगा और मोटर को डीरेक्ट करने या सामान्य मुख्य लाइन ऑपरेशन पर अनुमानित सामान्य श्रेणी 'B' से ऊपर मोटर तापमान में वृद्धि करने की आवश्यकता नहीं होगी। धीमी गति से चलने वाली गति पर भी मोटर को बाहरी ब्लोअर की आवश्यकता नहीं होगी।
10. VFD को मोटर बेयरिंग की इलेक्ट्रो फ्लूटिंग और मोटर वाइंडिंग को नुकसान से सुरक्षा प्रदान की जाएगी। यह सुरक्षा निम्नलिखित में से किसी एक द्वारा प्रदान की जाएगी:
- VFD में लगे LC फिल्टर
  - VFD के IGBT की सॉफ्ट स्विचिंग
11. VFD में एक "स्वचालित ऊर्जा अनुकूलक" कार्य को समाहित करेगा जो किसी भी आंशिक लोड में अधिक से अधिक मोटर दक्षता देने के लिए लगातार स्तर तक आउटपुट वोल्टेज को समायोजित कर देता है।
12. मोटर की रेटेड गति पर  $\pm 0.5\%$  की स्थिर मोटर गति को बनाए रखने के लिए VFD स्वचालित रूप से आउटपुट आवृत्ति और वोल्टेज समायोजित करेगा। यह सटीकता 1% से 100% की गति सीमा पर संवृत प्रतिक्रिया लूप के उपयोग के बिना रखी जाएगी।
13. VFD मोटरों के कनेक्शन को सामान्य रेटिंग से एक फ्रेम आकार बड़ा और 4 आकारों तक छोटा करने देगा।
14. VFD को श्रेणी 1A (150 मीटर) और श्रेणी 1 B (50 मीटर) दोनों को पूरा करने के लिए RFI फिल्टर को शामिल करके सके डिजाइन के अभिन्न भाग के रूप में रेडियो आवृत्ति व्यतिकरण (RFI) नियंत्रण के लिए विद्युत चुंबकीय संगतता (EMC) दस्तावेज EN 55011/ EN 50270 का अनुपालन करेगा। VFD के निर्माता द्वारा ही RFI फिल्टर की आपूर्ति की जाएगी और उपरोक्त मानदंडों को पूरा करने के लिए उनका मानक डिजाइन होना



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15. VFD अन्य RFI उत्पादक उपकरणों के व्यतिकरण से प्रतिरक्षित होगा और वह नवीनतम संशोधन के साथ AS/NZS 4252.1 - 1994, IEC 61000-4-2, IEC 61000-4-3, IEC 61000-4-4, IEC 61000-4-5, IEC 61000-4-6 और VDE 0160 का अनुपालन करेगा।

16. VFD में मानक, निर्मित DC रिएक्टर शामिल होंगे, जिसमें मुख्य लाइन हार्मोनिकस नियंत्रित करने के लिए दोनों प्रेरक और कैपेसिटिव तत्व शामिल होंगे। नियंत्रकों द्वारा निर्मित हार्मोनिक करंट विरूपण करंट रेटिंग के अनुसार क्रमशः IEC 61000-3-2 और IEC 61000-3-4 का अनुपालन करेगा।

17. जिन VFD में हार्मोनिक नियंत्रण के लिए अंतर्निर्मित DC रिएक्टर शामिल नहीं होंगे, उन्हें मुख्य लाइनों की तरफ बाहरी 3-फेस AC रिएक्टरों के साथ 3% न्यूनतम प्रतिबाधा वाले साधनों के साथ आपूर्ति की जाएगी। ये AC रिएक्टर VFD वाली कंपनी के ही होंगे और निर्माता द्वारा ही VFD के एक अभिन्न हिस्से के रूप में प्रदान किया जाएगा।

18. VFD मुख्य लाइन ऑपरेशन पर न्यूनतम 1 आरंभ/मिनट देने में सक्षम होंगे। इलेक्ट्रॉनिक/स्वतः संचालन का उपयोग कर आरंभ/बंद ऑपरेशन असीमित होगा।

19. VFD इनवर्टर ट्रांजिस्टर या स्विचिंग डिवाइस को नुकसान किए बिना किसी कॉन्टैक्टर (संपर्कक) या पृथक्त्र के माध्यम से आउटपुट पर स्विच करने देने के लिए उपयुक्त रूप से संरक्षित किया जाएगा।

20. नियंत्रक में उन सुविधाओं को शामिल किया जाएगा जो समय के साथ आउटपुट वोल्टेज वृद्धि की दर (dV/dt) को सीमित करते हैं, और चरम वोल्टेज को होने से रोकते हैं। मोटर द्वारा सामना किया जाने वाला अधिकतम चरम वोल्टेज 0.1  $\mu$ sec बढ़ोतरी समय के साथ 950 V डिग्री होगा। विनिर्देशित से अधिक dV/dt वाले VFD को निर्माता द्वारा ही अभिन्न LC फिल्टर के साथ आपूर्ति की जाएगी।

21. मोटर से उत्पन्न ध्वानिक शोर को कम करने के लिए VFD की स्विचिंग आवृत्ति समायोज्य होगी। स्विचन आवृत्ति का समायोजन करते समय VFD पर कोई डी-रेटिंग नहीं लागू होगी। VFD ध्वानिक शोर पूरे भार पर 65 dB(A) से अधिक नहीं और 50% भार पर 60 dB(A) से अधिक नहीं होगा।

22. VFD और मोटर के बीच 150 मीटर तक कवचित केबलिंग करने देने में VFD सक्षम होगा। यदि प्रस्तुत VFD इस केबल की लंबाई की अनुमति नहीं दे सकता हो, तो सप्लायर को अनुमति दी जाने वाली अधिकतम केबल लंबाई, केबल की लंबाई 150 मीटर तक बढ़ाने के लिए आवश्यक मोटर कॉयल प्रतिबाधा मान, अतिरिक्त वोल्टेज ड्रॉप और मोटर डी-रेटिंग के बारे में बताना होगा।

23. VFD खुद को वास्तविक मोटर मापदंडों के अनुकूल करने के लिए स्वचालित मोटर ट्यूनिंग फंक्शन को शामिल करेगा। ट्यूनिंग मोटर के प्रेरण और प्रतिरोध के मापन के आधार पर किया जाएगा।

24. VFD स्वचालित रूप से स्पिनिंग पंखे को मुख्य लाइन बाधा या बाईपास रनिंग से अंतरण के बाद ट्रिपिंग के बिना अग्र या पश्च रनिंग फिर से कनेक्ट करने में सक्षम होगा।

25. VFD में DC इंजेक्शन ब्रेकिंग होनी चाहिए, यह सुनिश्चित करने के लिए कि पूर्व-घूर्णन उच्च जड़त्व लोड मोटर, यहां तक कि रिवर्स दिशा में भी, स्विच किया जा सके, शून्य पर ब्रेक लगाया जा सके, और फिर सही दिशा में प्रीसेट गति तक बढ़ाया जा सके।

26. VFD के साथ मोटर की ऑपरेटिंग आवृत्ति रेंज में होने वाले डक्ट कार्य और पाइप लाइनों में अनुनाद को समाप्त करने के लिए समायोज्य बैंड चौड़ाई वाले कम से कम 4 बाय-पास आवृत्तियां प्रदान की जाएंगी।

27. VFD में प्रक्रिया के संवृत लूप नियंत्रण को सक्षम करने के लिए एक अंतर्निहित प्रोग्रामयोग्य PID नियंत्रक को शामिल होगा। यह न्यूनतम और अधिकतम सीमाओं का ध्यान रखेगा और इसमें प्रति वाइंड-अप कार्य शामिल होगा। PID नियंत्रक सामान्य या व्युत्क्रम मोड में कार्य करने में सक्षम होगा। VFD से 0/4 - 20mA सिग्नल के माध्यम से फीड बैक सिग्नल की रिमोट मॉनिटरिंग आवश्यक है।

28. PID नियंत्रक 2 सेन्सर फीडबैक को स्वीकार करने में सक्षम होगा। यह 2 संकेतों के न्यूनतम, अधिकतम, योग, अंतर और औसत की गणना करने में सक्षम होगा। इसके अलावा, इसमें 2 ज़ोन न्यूनतम या अधिकतम चयन होगा जहां ज़ोन में स्वतंत्र निर्दिष्ट बिंदु होंगे।

29. प्रेशर ट्रांसमीटर को प्रवाह मापक उपकरण के रूप में इस्तेमाल करने देने के लिए, VFD फीडबैक सिग्नल पर वर्ग मूल रूपांतरण करने में सक्षम होगा।

30. VFD में एक इंटरलॉक फ़ंक्शन शामिल होना चाहिए जो डैंपर जैसे अन्य यांत्रिक उपकरणों के नियंत्रण और इंटरलॉकिंग करने देता है।

31. स्टेटर में संघनन निर्मित होने को रोकने के लिए VFD में एक पूर्व-ताप कार्य शामिल होगा। मोटर के बंद होने पर, तो यह नियंत्रक से कम DC वोल्टेज प्राप्त करेगी।

32. बिजली चले जाने के मामले में, VFD प्रोग्रामयोग्य समय देरी के बाद स्वचालित रूप से पुनः आरंभ करने में सक्षम होगा।

#### 1.4 नियंत्रण और निगरानी कार्य:

1. BMS इंटरफ़ेस को नुकसान से बचाने और ऑपरेटर सुरक्षा सुनिश्चित करने के लिए VDE 0160 PELV (सुरक्षात्मक अतिरिक्त कम वोल्टेज) का अनुपालन सुनिश्चित करने के लिए बिजली और नियंत्रण घटकों के बीच पूर्ण गैल्वनी पृथक्करण शामिल किया जाएगा। नियंत्रण टर्मिनलों का शॉर्ट सर्किट नियंत्रण कार्ड को नुकसान नहीं पहुंचायेगा।

2. कम से कम 6 डिजिटल इनपुट को स्वतंत्र रूप से प्रोग्राम किए जाने के साथ प्रदान किया जाएगा और 3ms से कम का स्कैन समय होगा। डिजिटल इनपुट पर अधिकतम शोर उन्मुक्ति के लिए प्रत्येक इनपुट के लिए सिंक करंट 24 V पर न्यूनतम 10 mA होगा।

3. VFD में वोल्टेज (अधिकतम 10V) और वर्तमान (अधिकतम 20mA) इनपुट को स्वीकार करने वाले दो एनालॉग इनपुट लगाए जाएंगे। ये इनपुट मुक्त रूप से प्रोग्राम योग्य और स्केलेबल होंगे।

4. VFD की रिमोट मॉनिटरिंग के लिए दो प्रोग्राम योग्य रिले प्रदान किए जाएंगे। प्रोग्राम योग्य विकल्पों में न्यूनतम तैयार, रन और अलार्म शामिल होगा। VFD से आवृत्ति उत्पादन 0.5 Hz से अधिक होने पर रन रिले फ़ंक्शन केवल एक रन सिग्नल आरंभ करेगा।

5. निगरानी के लिए 0/4-20 mA के दो प्रोग्राम योग्य अनुरूप एनालॉग आउटपुट दिए जाएंगे। प्रोग्राम योग्य विकल्प न्यूनतम गति, वर्तमान और टॉर्क के रूप में शामिल होंगे।

6. VFD थर्मिस्टर से इनपुट को स्वीकार करने में सक्षम होगा।

7. VFD स्पंद ट्रेन को स्वीकार कर सकेगा, जिसकी आवृत्ति प्रतिक्रिया का एनालॉग संदर्भ देती है।

8. डिजिटल इनपुट और किसी भी लूप पावर युक्त एनालॉग सेंसर के लिए सेंसर की आपूर्ति प्रदान करने के लिए VFD में आंतरिक पावर सप्लाई होगी। इस आंतरिक पावर सप्लाई में 24V DC पर 100 mA की न्यूनतम क्षमता होगी।

9. VFD स्पंद ट्रेन आउटपुट उत्पन्न करेगी, जिसकी आवृत्ति संचारित होने वाले सिग्नल की आनुपातिक है।

10. VFD के पास स्थानीय नियंत्रण पैनल होगा जिसमें बहु-लाइन चयन अल्फा-न्यूमेरिक डिस्प्ले होगा जो निम्न न्यूनतम सूचना प्रदर्शित करेगा:

- आउटपुट आवृत्ति Hz में
- फीडबैक सिग्नल यूनिट में
- करंट (विद्युत धारा) A में
- आउटपुट वोल्ट V में
- घंटे में चलने का समय
- इनपुट फ्रिक्वेंसी Hz में
- पावर kW में
- ऊर्जा kWh में
- इनपुट वोल्टेज V में

11. मानक LED डिस्प्ले वाले VFD स्वीकार्य नहीं हैं और अतिरिक्त अल्फान्यूमेरिक डिस्प्ले के साथ आपूर्ति की जाएगी। स्थानीय नियंत्रण पैनल का उपयोग पैरामीटर सेट करने और VFD ट्यूनिंग के लिए किया जाएगा।

12. VFD स्पष्ट अंग्रेजी पाठ में निम्नलिखित न्यूनतम खराबी प्रदर्शित करेगा न कि कोड द्वारा:

- मुख्य फेज क्षति
- अति वोल्टेज
- कम वोल्टेज
- इन्वर्टर अधिभार
- मोटर थर्मल अधिभार
- अधि करंट
- अर्थ (भूसंपर्क) खराबी
- स्विच मोड पावर सप्लाई खराबी
- आउटपुट शॉर्ट सर्किट
- RS 485 संचार टाइमआउट
- तापमान पर हीट सिंक
- मोटर फेज लुप्त
- इन्वर्टर खराबी

13. BMS द्वारा हाथ से या रिमोट ऑटो कंट्रोल द्वारा स्थानीय नियंत्रण करने देने के लिए VFD हाथ/ऑफ/ऑटो स्विच प्रदान करेगा। यह फ़ंक्शन स्थानीय नियंत्रण पैनल के माध्यम से या डिजिटल I/O के माध्यम से चयन किया जाएगा

14. VFD अतिरिक्त इंस्ट्रूमेंटेशन और रीसेट की सुविधा के बिना मोटर द्वारा "कुल खपत kWh" और "कुल चालन अवधि" को लॉग और प्रदर्शित करेगा।

15. BMS प्रणाली के साथ क्रमिक संचार के लिए VFD में खुले प्रोटोकॉल के साथ एक RS485 सीरियल पोर्ट फिट होगा।

16. VFD के स्थानीय डिस्प्ले पैनल पर निम्नलिखित इंगित करने वाली रोशनी लगाई जाएगी:

- VFD 'ऑन' रोशनी
- VFD 'चेतावनी' रोशनी
- VFD 'अलार्म' रोशनी

17. अनधिकृत पैरामीटर को रीसेट करने से रोकने के लिए VFD के स्थानीय डिस्प्ले पैनल में पैरामीटर लॉक उपलब्ध होगा।

### 1.5 संरक्षण विशेषताएं:

1. VFD निम्नलिखित स्थितियों में सुरक्षित रूप से बंद हो जाएगा और अलार्म रिले का संचालन करेगा। प्रदर्श स्पष्ट अंग्रेजी पाठ में खराबी की प्रकृति इंगित करेगा।

- मुख्य फेज क्षति
- अति वोल्टेज
- कम वोल्टेज
- इन्वर्टर अधिभार
- मोटर थर्मल अधिभार
- अधि करंट
- अर्थ (भूसंपर्क) खराबी
- स्विच मोड पावर सप्लाइ खराबी
- आउटपुट शॉर्ट सर्किट
- RS 485 संचार टाइमआउट
- तापमान पर हीट सिंक
- मोटर फेज लुप्त
- इन्वर्टर खराबी

2. VFD में स्वतः और मैनुअल रीसेट ऑपरेशन दोनों की व्यवस्था होगी। इससे पहले कि नियंत्रक सिस्टम को पुनरारंभ करने के लिए मैनुअल रीसेट आवश्यक करने के लिए बंद करे स्वतः मोड में प्रति खराबी के लिए 10 रीसेट प्रयासों तक का प्रोग्राम योग्य विकल्प होगा। स्वतः मोड में ट्रिप के बाद पुनरारंभ समय समायोज्य होगा। मैनुअल रीसेट मोड में रीसेट को नियंत्रक पर कीपैड और रिमोट सिग्नल दोनों से पूरा किया जाएगा।

3. VFD को डेटा लॉग मेनू से लैस किया जाएगा जो कम से कम 10 नवीनतम खराबियों को स्टोर करने देगा। बिजली चले जाने की स्थिति में अंतिम खराबी मेमोरी की आवश्यकता होगी।

4. VFD के पास किसी भी ड्राइव घटकों को नुकसान किए बिना आउटपुट टर्मिनलों पर निरंतर शॉर्ट सर्किट से बचने के लिए पर्याप्त तेज़ करंट सीमा सुविधा होगी।

5. VFD को हाई स्पीड सेमी कंडक्टर फ़्यूज़ जैसे विशेष प्रकार के इनपुट सुरक्षा उपकरणों की आवश्यकता नहीं होगी। यदि, VFD के संरक्षण के लिए ये आवश्यक हों, तो उसे VFD सप्लायर की आपूर्ति के दायरे में शामिल किया जाना चाहिए।

6. VFD खराबी स्थितियों में यथासंभव लंबे समय तक ऑपरेशन को चालू रखेगा। उदाहरण के लिए, नियंत्रक स्वतः ही अपने आप को डी-रेट करेगा और उच्च मोटर तापमान या फेज क्षति पर गति को सुरक्षित स्तर तक कम कर देगा ताकि ट्रिप के कारण बंद करने की बजाय प्रक्रिया पर कुछ नियंत्रण बनाए रखा जा सके।

7. नियंत्रक में इलेक्ट्रॉनिक मोटर थर्मल अधिभार संरक्षण शामिल होगा, जहां ट्रिप का समय मोटर चालन आवृत्ति, वास्तविक मोटर करंट, संचालन का समय और मोटर के निर्धारित करंट पर आधारित हो। कम गति पर संचालन को ध्यान में रखते हुए डिवाइस अपने आप ट्रिप समय को संशोधित करेगा। ट्रिप होने पर, नियंत्रक इंगित करेगा कि खराबी मोटर थर्मल ट्रिप है।

8. सामान्य सर्विस कार्य के दौरान कोई रियर एक्सेस आवश्यक नहीं होगा।

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एयर कंडीशनिंग और वेंटिलेशन  
कार्यों के लिए विनिर्देश

खंड - XIV

प्रत्यक्ष डिजिटल नियंत्रण

## 1. प्रत्यक्ष डिजिटल नियंत्रण (DDC) प्रणाली

### 1.1 A/C प्रणाली विवरण और सामान्य विवरण:

DDC प्रणाली को शुरू करने का उद्देश्य मुख्य रूप से मापदंडों के सटीक नियंत्रण और निगरानी करना है और साथ ही A/C सिस्टम के लिए ऊर्जा बचत सुनिश्चित करना है। जहां तक क्लीन रूम के अंदर सकारात्मक दाब बनाए रखने का संबंध है, उसमें अपकेन्द्री ब्लोअर के लिए अत्याधुनिक, परिवर्ती गति ड्राइव निर्दिष्ट किये गये हैं।

उच्च श्रेणी वाले एयर कंडीशनिंग सिस्टम में जल शीतित और एयरकूल्ड चिलर पैकेज शामिल हैं जिसके साथ शीतित जल और कंडेन्सर जल पंप, कूलिंग टावर, एयर कूल्ड कंडेंसर पंखे जैसे अन्यत्र निर्दिष्ट संबंधित उपकरण शामिल हैं। एयर कंडीशनिंग के लिए ठंडे पानी की संचलन प्रणाली के माध्यम से क्लीन रूम/सामान्य AC क्षेत्रों के लिए चिलर बड़े ब्लोअर/AHU से जुड़े हैं। AHU विभिन्न इमारतों और मंजिलों में फैले हुए हैं। ऊर्जा प्रबंधन, उपकरण निगरानी और नियंत्रण के लिए डिजाइन DDC भवन उपयोग के लिए उपयुक्त होगा। नियंत्रण रणनीतियों को यह सुनिश्चित करने के लिए विकसित किया जाएगा कि निर्दिष्ट पर्यावरणीय परिस्थितियों को बनाए रखा जाए, जबकि उपकरण संचालन के दिन से ही सिस्टम पैरामीटर की त्वरित वापसी, विश्वसनीयता और अनुमापन सुनिश्चित करने के लिए ऊर्जा खपत को कम करने को उचित महत्व देना चाहिए। प्रभावी एयर कंडीशनिंग (वातानुकूलन) के लिए, तापमान, दाब, पानी और वायु प्रवाह दरों, वोल्टेज, वर्तमान, आदि को नियंत्रित करने और मॉनिटर करने के लिए आवश्यक है, जैसा कि नियमित आधार पर हस्ताक्षर व्याख्या के लिए प्रदान किया जाता है और किया जाता है। इस उद्देश्य के लिए, DDC प्रणाली आवश्यक है। लोड प्रबंधन की संभावना के कारण यह ठीक से A/C सिस्टम के लिए ऊर्जा बचत में वृद्धि करेगा। DDC उपकरणों के संचालन के दिन से सिस्टम पैरामीटर की त्वरित वापसी, विश्वसनीयता और खोजक्षमता सुनिश्चित करेगा। DDC प्रणाली में ऊर्जा प्रबंधन, एल्गोरिथ्म होगा जो ठंडे पानी के तापमान को संचालित AHU की संख्या के आधार पर कमीशनिंग के दौरान निर्धारित 5.0 और 10.0 डिग्री C के बीच निरंतर बनाए रखेगा, यह सुनिश्चित करते हुए कि तापमान, आर्द्रता, ओस बिंदु निर्धारित बिंदु के बारे कोई समझौता नहीं किया जाए। इसके अलावा "चिलर मैनेजमेंट सॉफ्टवेयर/लॉजिक के लिए दिशानिर्देश" देखें।



## 1.2 महत्वपूर्ण विचारणीय बिंदु:

1. DDC प्रणाली केवल चिलर मापदंडों/घटनाओं की दूरस्थ निगरानी करती है जिन्हें चिलर के माइक्रोप्रोसेसर पैनल से एक्सेस किया जा सकता है। DDC सिस्टम द्वारा निर्दिष्ट के अलावा चिलर पर कोई समग्र प्लान्ट मॉनिटरिंग और नियंत्रण कार्य नहीं किया जाएगा। निर्दिष्ट DDC प्रणाली बाहरी हार्डवेयर/सॉफ्टवेयर पर निर्भर नहीं होगी। इसे ध्यान में रखते हुए, DDC प्रणाली में ठंडे पानी और कंडेन्सर पानी को मापने के लिए सेंसर भी शामिल किया गया है, ताकि यह सही रूप में स्टैंडअलोन प्रकार का बन जाए।
2. DDC सिस्टम एकसमान होगा, ताकि सभी स्तरों पर 16 या 32 बिट या बाद के प्रोसेसर से मेल खा सके। निर्दिष्ट प्रणाली अत्याधुनिक, मापनीय, मॉड्यूलर, भावी, उच्च गति और वास्तव में पीयर-टू-पीयर संचार प्रकार की होगी। तगड़े और गैर-विफल प्रवण प्रकार के डिजाइन के लिए पृथक क्षेत्र नियंत्रकों में भी ऐतिहासिक डेटा संग्रहण प्रदान किये जाएंगे। इसका मतलब यह होगा कि अकेले केन्द्रीकृत ऐतिहासिक डेटा संग्रहण को यह अनुमति नहीं होगी कि DDC प्रणाली को सही रूप में स्टैंडअलोन प्रकार का बनने दिया जाए।
3. DDC प्रणाली में ओपन/यूनिवर्सल प्रोटोकॉल और ऊर्जा प्रबंधन, सटीक AHU सिस्टम, रोशनी नियंत्रण/लिफ्ट प्रबंधन/फायर अलार्म/एक्सेस कंट्रोल/CCTV/ट्रांसपोर्ट और अन्य PLC आधारित नियंत्रण प्रणाली जैसे अन्य बाहरी प्रणालियों के एकीकरण की जरूरत होती है, जिन्हें बाद में इस DDC प्रणाली के आसपास निर्माण किया जा सकता है। इसलिए, 8 सीरियल पोर्ट/ईथरनेट कनवर्टर/सीरियल से मॉडबस कन्वर्टर/अन्य इंटरफेस विस्तार और अन्य सिस्टम के एकीकरण के लिए आवश्यक हैं। हालांकि, यह स्पष्ट किया जाता है DDC सिस्टम के साथ चिलरों के एकीकरण के अलावा कि कम से कम 4 सीरियल पोर्ट संचालित डिवाइस को इंटरफेस किया जाएगा।
4. विक्रेता I/O समरी में आवश्यक प्रत्येक उपकरण या उपकरण के एक समूह के लिए नेटवर्कयोग्य नियंत्रकों का उपयोग करने के लिए स्वतंत्र हैं, जो सीधे DDC क्षेत्र बस से जुड़े होंगे, डेटा अर्जन के लिए मुख्य PDM (मुख्य PC) के साथ संचार करेंगे।
5. DDC प्रणाली ऊर्जा की खपत के बारे में उपयोगकर्ता परिभाषित नियतकालिक रिपोर्ट/ग्राफ प्रदान करने में सक्षम होगी।
6. DDC प्रणाली में लैन के माध्यम से पहुंचने के लिए उपयोगकर्ता टर्मिनलों की आवश्यक संख्या शामिल होगी। आदेश के अनुसार आपूर्ति किया जाने वाला सॉफ्टवेयर लाइसेंस वाला

होगा और मूल उपयोगकर्ता पुस्तिका/लाइसेंस/मीडिया और ऑपरेशन मैनुअल आपूर्ति के साथ प्रदान की जाएगी। ऑटो क्युयिंग की सुविधा के साथ मीडिया और प्रीलोडेड के साथ आवश्यक संख्या में सॉफ्टवेयर का फ्लोटिंग लाइसेंस प्रदान किया जाएगा। नोड लॉक लाइसेंस स्वीकार नहीं किया जाएगा।

7. DDC प्रणाली को इंटरनेट के माध्यम से भी एक्सेस किया जाएगा। इसके लिए आवश्यक फ़ायरवॉल सॉफ्टवेयर में शामिल की जाएगी।

### 1.3 निगरानी की जाने वाली उप-प्रणालियां:

पृथक-पृथक परियोजना की जरूरतों के आधार पर, DDC निम्नलिखित उप-प्रणालियों के डेटा अधिग्रहण, निगरानी और नियंत्रण करने में सक्षम होगी:

चिलर पैकेज, कंडेन्सर वाटर पंप, शीतित जल पंप, कूलिंग टॉवर पंखा मोटर, एयर कूल्ड पंखे, AHU/ब्लोअर स्थान, पैक यूनिट, डक्टेबल यूनिट, VRF सिस्टम, पंखा कॉइल यूनिट और अन्य संयंत्रों के उपकरणों से संबंधित विवरण अन्यत्र वर्णित और I/O सार में वर्णित जैसा होगा।

DDC प्रणाली इनहम बुश, जॉनसन कंट्रोल्स, मैक क्वे, ट्रेन और कैरियर या अन्य प्रतिष्ठित कंपनी जैसे चिलरों के निर्माण के प्रोटोकॉल के लिए संगत होगी। इसलिए, यह आवश्यक है कि इसमें एक खुला या सार्वभौमिक प्रोटोकॉल हो। गैर-संगतता के मामले में गेटवे का उपयोग किया जा सकता है। प्रणाली का डिजाइन "खुली" नेटवर्क आर्किटेक्चर, वितरण और प्रसंस्करण में नवीनतम तकनीक का उपयोग करेगा। प्रस्तावित प्रणाली नवीनतम रूप में होनी चाहिए और आज के भवन निर्माण सेवाओं के पूर्ण स्पेक्ट्रम के लिए स्वतंत्र रूप से प्रोग्राम योग्य प्रबंधन और स्वचालन स्टेशनों का होना चाहिए।

निविदा अनुसूची के अनुसार I/O सारिणी की एक सूची दिशानिर्देश के रूप में संलग्न की गई है जहां फ़ील्ड सेंसर/उपकरण स्थापित किए जाएंगे। सभी सहायक उपकरण जैसे सेंसर, दाब स्विच, नियंत्रण वाल्व और एकचुएटर डायरेक्ट डिजिटल कंट्रोल मॉड्यूल और आउटस्टेशन निर्माता के ही होंगे।

प्रस्तुत की गई प्रणाली की संरचना पूरी तरह से मॉड्यूलर होगी और छोटी प्रणाली से बड़ी वितरण प्रणाली तक किसी भी स्तर पर स्वतंत्र रूप से विस्तार योग्य होगी। प्रणाली का प्रत्येक स्तर अगले स्तर तक स्वतंत्र रूप से काम करेगा।

यह सिस्टम पूरी तरह से नवीनतम उद्योग मानकों, माइक्रोसॉफ्ट विंडोज -10 या नवीनतम ऑपरेटिंग सिस्टम के अनुरूप होगा, जिससे उपयोगकर्ता इन ऑपरेटिंग सिस्टम के साथ प्रदान की जाने वाली सुविधाओं का पूर्ण उपयोग कर सके।

अधिकतम लचीलापन प्रदान करने के लिए और भवन उपयोग में परिवर्तनों के अनुकूल होने के लिए, प्रस्तावित प्रणाली BACNET, प्रोफिबस और ईथरनेट TCP/IP संचार प्रौद्योगिकियों के उपयोग में सहायक होंगी।

ठेकेदार ड्राइंग/अनुसूची/विनिर्देशों से BMS द्वारा नियंत्रित/मॉनिटर किए जाने वाले उपकरणों की संख्या निर्धारित करेगा। यह जानकारी BMS आपूर्तिकर्ता को दी जाएगी। नियंत्रण और/या निगरानी कार्यों के लिए आवश्यक सभी संयंत्र और उपकरण BMS नेटवर्क द्वारा पठनीय सभी आवश्यक इंटरफेसिंग उपकरण के साथ फिट होंगे। ठेकेदार समन्वय करेंगे और यह सुनिश्चित करेंगे कि यह उपकरण BMS को आवश्यक संकेत प्रदान करेगा।

#### **1.4 सामान्य प्रणाली आर्किटेक्चर:**

सिस्टम तार्किक रूप से तीन विशिष्ट स्तरों में संरचित होगा, जो प्रबंधन, संचार और प्रक्रिया स्तर हैं। प्रत्येक स्तर दूसरे से स्वायत्त होगा। इन स्तरों के लिए एक्सेस सुरक्षा प्रदान की जाएगी। सभी सिस्टम स्तरों पर पीयर-टू-पीयर कम्युनिकेशन संभव होगा और सिस्टम डिज़ाइन संरचना मॉड्यूलर होगी ताकि सीधा विस्तार किया जा सके।

##### **1.4.1 प्रबंधन स्तर:**

संयंत्र के शीर्ष प्रबंधन और संचालन में प्रक्रिया दृश्य, डेटा विश्लेषण और तीसरे पक्ष के साथ डेटा के आदान-प्रदान शामिल होंगे। प्रबंधन स्तर पर, संचार को सभी दिशाओं में, नेटवर्क भर में और सीधे कनेक्शन के माध्यम से होना संभव होगा।

संयंत्र पर्यवेक्षण और संचालन, अलार्म प्रबंधन, सूचना और डेटाबेस प्रबंधन फ़ंक्शन के लिए व्यक्तिगत कंप्यूटर आधारित ऑपरेटर प्रबंधन स्टेशन प्रदान किए जाएंगे। सभी वास्तविक-समय नियंत्रण कार्य DDC नियंत्रकों में स्थित होंगे ताकि अधिक त्रुटि सहिष्णुता और विश्वसनीयता सुनिश्चित हो सके।

ऑपरेटर मैनेजमेंट स्टेशन माइक्रोसॉफ्ट विंडोज -10 या बाद के ऑपरेटिंग सिस्टम के उपयोग के अनुसार बहु-कार्य 32-बिट/64 बिट प्रोग्राम करने में सक्षम होना चाहिए।

प्रणाली का प्रबंधन स्तर एक से मिलकर होगा और अधिक प्रबंधन स्टेशन PC और संबंधित सॉफ्टवेयर मॉड्यूल को संभालने में सक्षम होगा।

**प्रबंधन स्टेशन निम्न में सक्षम होगा:**

- लाइव के साथ संयंत्र अधिचित्रित डेटा की ग्राफिकल प्रस्तुतियों का प्रदर्शन।
- सभी सक्रिय पेज के असली मल्टीटास्किंग के साथ उच्च गुणवत्ता वाले गतिशील ग्राफिक्स।
- प्रोसेस डिवाइसेस को मॉनिटर और परिचालन/प्रभावित करना।
- प्रक्रिया स्तर से अलार्म संदेशों को प्राप्त करना और प्रिंटर, मोबाइल, फ़ैक्स, ई-मेल जैसे उचित रिपोर्टिंग डिवाइस पर उन्हें निर्देशित करना।
- संचार समस्याओं और अन्य डिवाइस खराबियों के लिए मॉनिटर प्रोसेस डिवाइस।
- अलार्म संचालन - अलार्म का त्वरित और आसानी से पता करने के लिए सभी अलार्म ग्राफिकल ट्री संरचना में प्रदर्शित किए जाएंगे।
- प्रक्रिया स्तर में समय रणनीतियों को समायोजित करना।
- प्रोसेस डिवाइस से लॉग इन किए गए डेटा का दीर्घकालिक भंडारण।
- साइटों, एप्लिकेशन, फ़ंक्शंस और ऑब्जेक्ट्स पर अलग-अलग पहुंच के लिए बहु-स्तरीय उपयोगकर्ता अभिगम नियंत्रण।
- ग्राफिक रूप से लॉग इन डेटा प्रदर्शन।
- कस्टम एप्लिकेशन प्रोग्रामिंग
- डेटा प्रकलन के लिए ग्राफिकल जेनिस का उपयोग।
- उपयोगकर्ता इंटरफ़ेस मूल टास्कबार पर आधारित होगा, जो हमेशा दिखाई देता है।
- अलार्म, उपयोगकर्ता क्रियाएं, सिस्टम इवेंट्स और संदेशों के लिए पूर्ववृत्त लॉगिंग।
- अलार्म संचालन - अलार्म का त्वरित और आसानी से पता करने के लिए सभी अलार्म ग्राफिकल ट्री संरचना में प्रदर्शित किए जाएंगे।

- भौगोलिक रूप से वितरित परियोजनाओं पर एक व्यापक सिंहावलोकन के लिए LAN/WAN कनेक्शन के माध्यम से सीरियल कनेक्शन/50 साइटों के माध्यम से कम से कम 4 साइटों का एक साथ कनेक्शन।
- ट्रिप के पहले कारण की पहचान के लिए उपकरण/सिस्टम की ट्रिप और सभी ट्रिप का कारण समयबद्ध किया जाएगा।

अधिकतम खराबी सहिष्णुता के लिए, प्रबंधन स्टेशन बिंदु-से-बिंदु संचार के माध्यम से प्रक्रिया स्तर से जुड़े रहते हैं। यह RS232, ईथरनेट/ TCP/IP LAN / WAN या ऑटोडायल लिंक के माध्यम से होगा।

#### 1.4.2 संचार स्तर:

सामान्य प्रयोजन नियंत्रकों का उपयोग निगरानी/नियंत्रण उपकरणों के लिए किया जाएगा, जिन्हें AHU, चिलर, ठंडा पानी पंप, शीतन टॉवर, लिफ्ट, फायर अलार्म पैनल, जनरेटर, ट्रांसफॉर्मर इत्यादि से अनुकूलित तर्कों के आधार पर निष्पादन करना होगा।

DDC प्रणाली के मध्य में माइक्रोप्रोसेसर आधारित मॉड्यूल होंगे, जिन्हें कार्यात्मक आवश्यकताओं के अनुसार अलग-अलग प्रोग्राम किया जा सके।

स्वचालन स्तर DDC नियंत्रक इमारत में मुख्य संयंत्र की निगरानी और नियंत्रण करेंगे। DDC नियंत्रक आउटस्टेशन स्वतंत्र रूप से प्रोग्राम किये जाएंगे और सभी निम्नलिखित दैनिक कार्य निष्पादन करने की क्षमता होगी:

ए) प्रक्रिया नियंत्रण और इंटरलॉक कार्य

- ज्ञात पैरामीटर के सामने मापित मानों की तुलना के आधार पर अलार्म/ईवेंट उत्पन्न करें।

बी) समय नियंत्रण रणनीतियां

सी) रनटाइम समग्रता

- लॉग किए गए मानों के संचरण के साथ प्रबंधन स्तर तक विशिष्ट डेटा-बिंदुओं के रुझान में लॉगिंग।

डी) ऊर्जा गणना

ई) डेटा/प्रोग्राम का बैकअप (> = 5 वर्ष)

DDC नियंत्रकों को निर्दिष्ट सभी डेटा बिंदुओं के सबसे आर्थिक समावेशन के अनुरूप मॉड्यूलर या कॉम्पैक्ट प्रकार के यूनिट से चुना जाएगा। प्रत्येक नियंत्रण मॉड्यूल एक केंद्रीय कंप्यूटर से नियंत्रण के बिना एक स्टैंड-अलोन आधार पर काम करने में सक्षम होगा।

मॉड्यूलर नियंत्रकों के लिए इनपुट/आउटपुट कनेक्शन, विशेष बाह्य उपकरणों के लिए उपयुक्त प्लग-इन मॉड्यूल के माध्यम से होगा। डिजिटल मॉड्यूल में इनपुट/आउटपुट की स्थिति का दृश्य संकेत होगा। डिजिटल इनपुट मॉड्यूल 230 V AC तक नियंत्रण वोल्टेज स्वीकार करने में सक्षम होगा और इसमें अभिन्न स्थिति संकेत होगा।

दोनों प्रकार के नियंत्रण मॉड्यूल को उसी BACNET संचार नेटवर्क पर एकीकृत करना संभव होगा। प्रत्येक नियंत्रक निष्पादन एक से कम सेकेंड की नमूना दरों के साथ 0.5% नियंत्रण सटीकता के लिए होगा।

मुख्य संयंत्र DDC नियंत्रक 32/64 बिट या बाद में स्वतंत्र रूप से प्रोग्राम वाले होंगे। DDC नियंत्रकों के रूप में VAV नियंत्रणों के लिए इस्तेमाल किए जाने वाले नियंत्रकों का इस्तेमाल नहीं किया जा सकता

सभी DDC को UL अनुमोदित होना चाहिए, इसमें एक वास्तविक समय घड़ी बनी होनी चाहिए और PID नियंत्रण के लिए उपयुक्त होना चाहिए।

BMS प्रबंधन और स्वचालन स्तर के निर्माण में उपयोग किए जाने वाले उत्पाद, स्वचालन और नियंत्रण नेटवर्क बनाने के लिए BACNET प्रोटोकॉल के अनुसार होंगे। सभी नियंत्रकों को BACNET परीक्षण प्रयोगशाला (BTL) लिस्टिंग प्राप्त करनी होगी और BTL लोगो प्रदर्शित करना होगा।

कक्ष यूनिट सामान्य तापमान और स्थानीय निर्धारित बिंदु अर्जित करने के लिए प्रत्येक नियंत्रक पर दो-तार संचार लिंक का उपयोग करेगी। ये एक अभिन्न तापमान/ निर्धारित बिंदु डिजिटल डिस्प्ले भी प्रदान करेंगे। 5 कमरे यूनिट तक के लिए एक ही दो तार संचार लिंक का उपयोग करने में सक्षम होंगे।

एक मानक पतले क्लाइंट/वेब ब्राउज़र के माध्यम से लोन टॉक BACNET नेटवर्क से जुड़े सभी स्वचालन स्टेशन नियंत्रण मॉड्यूल के पूर्ण संचालन की अनुमति के लिए सिस्टम में वेब सर्वर के लिए सुविधा होगी। इन कार्यों में शामिल होंगे:

- लाइव के साथ संयंत्र अधिचित्रित डेटा की ग्राफिकल प्रस्तुतियों का प्रदर्शन।
- सभी मापित मानों, निर्धारित बिंदुओं, संयंत्र अवस्थाओं, संचालन अवस्थाओं और पैरामीटरों के डेटा बिंदु प्रदर्शन और संचालन।
- स्वीकृति के साथ अलार्म मॉनिटरिंग और दृश्य और श्रव्य अलार्म संकेत।
- अलार्म और इवेंट पूर्ववृत्त।
- SMS और ई-मेल के माध्यम से अलार्म संचार
- सर्वकालिक अनुसूची, अपवाद कैलेंडर और तापन वक्रों का संचालन
- माइक्रोसॉफ्ट एक्सेल के लिए डेटा निर्यात करने की सुविधा के साथ रूझान डेटा को पढ़ना।
- मल्टी उपयोगकर्ता स्तर एक्सेस सुरक्षा
- ईथरनेट या मोडेम कनेक्शन।

#### 1.4.2.1 DDC नियंत्रक विशिष्टता:

स्टैंडअलोन नियंत्रक अर्थात अन्य DDC या कंट्रोल स्टेशन के साथ संचार भंग होने की स्थिति में, वे अपने दम पर कार्य करने में सक्षम होंगे। प्रत्येक एयर हैंडलिंग यूनिट/ब्लोअर सिस्टम के लिए इनबिल्ट साइकोमेट्रिक गणना के साथ आवश्यक क्षमता की EPROM चिप होगी, जो पूरी तरह से प्रीवायर्ड पाउडर लेपित घेरे में होगी। सभी आवश्यक डेटा अर्जन, प्रसंस्करण क्षमता, RAM, ऐतिहासिक डेटाबेस प्रदान करेगा। नियंत्रक प्रदर्शन और कीपैड, 'रिट्रल' या समकक्ष पैनल और रिले के साथ परिपूर्ण होना चाहिए। DDC नियंत्रकों को निर्दिष्ट में निर्दिष्ट सभी डेटा बिंदुओं के सर्वाधिक किफायती समावेशन के अनुरूप होने के लिए मॉड्यूलर या कॉम्पैक्ट प्रकार की यूनिट से चुना जाएगा।

#### 1.4.2.2 प्रत्यक्ष डिजिटल नियंत्रक क्षमताएं:

1. नियंत्रकों में स्व-विश्लेषण/नैदानिक सुविधा होगी और वह नियंत्रण केंद्र को हर तरह की खराबी संदेश प्रसारित करेगा। नैदानिक परीक्षण में विफल रही हर चिप के प्रिंटआउट में बोर्ड पर लगी हर चिप की पहचान और चिप संख्या/स्थान शामिल होगा और इसके साथ यह भी शामिल होगा कि नैदानिक परीक्षण में चिप "सफल" हुई थी या "विफल"। यह एक वांछित

आवश्यकता है क्योंकि इससे समस्या दूर होगी और किसी भी विफल नियंत्रक के कम से कम संभावित डाउन समय सुनिश्चित करेगी। जिन नियंत्रकों में ऐसी सुरक्षा सुविधा नहीं है उनमें EPROM में कस्टम सॉफ्टवेयर नैदानिक रेजिडेंट प्रदान किया जाएगा। निविदाकर्ता लिखित रूप में पुष्टि करेगा कि सभी नियंत्रकों में इस स्व-नैदानिक आवश्यकता को पूरा किया गया है।

2. नियंत्रकों के लिए ऑपरेटिंग सिस्टम (OS) सॉफ्टवेयर EPROM रेजिडेंट होगा। नियंत्रकों की मेमोरी में रेजिडेंट होगा और प्रोग्राम, नियंत्रण अनुक्रमों के कार्यान्वयन के लिए एल्गोरिदम की एक प्रासंगिक लाइब्रेरी, आंतरिक नियंत्रण ऑपरेटर, गणित, तर्क और संबंधपरक ऑपरेटर के लिए उपलब्ध होगा।

3. नियंत्रकों और/या नियंत्रण स्टेशन टर्मिनल के बीच संचार की विफलता की स्थिति में, अलार्म, रिपोर्ट और लॉग नियंत्रकों पर संग्रहीत किया जाएगा और संचार बहाली पर टर्मिनल को प्रेषित किया जाएगा।

4. नियंत्रक की मेमोरी लॉस, या बैकअप पॉवर की समाप्ति की स्थिति में, यूनिट के शुरू होने पर बिना ऑपरेटर अनुदेश के आवश्यक डेटा-बेस स्वचालित रूप से डाउनलोड किया जाएगा। सॉफ्टवेयर के रीबूट के लिए मैनुअल हस्तक्षेप की आवश्यकता वाले नियंत्रक नहीं चाहिए।

5. नियंत्रकों के बीच बाहरी हवा के तापमान जैसे डेटा साझा करने के लिए जहां जानकारी की आवश्यकता होती है, वहां वैश्विक बिंदुओं को आवंटित करने के लिए यह संभव होगा कि जानकारी या तो वृद्धिशील मान के परिवर्तन या विशिष्ट समय अंतराल पर प्रसारित हो।

6. प्रत्येक DDC नियंत्रक के पास न्यूनतम 5 साल के लिए बैटरी बैकअप वाली वास्तविक समय घड़ी होगी। बिजली बहाली पर सभी घड़ियों को नेटवर्क में स्वचालित रूप से सिंक्रोनाइज़ किया जाएगा। नियंत्रक कम से कम निम्न ऊर्जा प्रबंधन कार्य करने में सक्षम होंगे: -

ए) समय और घटना प्रोग्राम

बी) छुट्टी की समय-सूची

सी) बिजली की अधिकतम और वितरित मांग

डी) इष्टतम शुरू और बंद प्रोग्राम

ई) रात्रि मार्जन

एफ) लोड रीसेट

जी) शून्य ऊर्जा बैंड

एच) ड्यूटी चक्र



- आई) एन्थैल्पी विश्लेषण और नियंत्रण
- जे) रन टाइम का योग
- के) अनुक्रमण और अनुकूलन
- एल) अपवाद समय-सूची

7. सभी उपलब्ध ऊर्जा प्रबंधन सॉफ्टवेयर की सॉफ्टवेयर सुविधाओं और ऑपरेटिंग अनुक्रमों का विस्तृत विवरण मूल्यांकन के लिए निविदा के साथ प्रस्तुत किया जाएगा।

8. सभी DDC नियंत्रक के साथ टर्मिनल पट्टी पर सहायक उपकरणों का समुचित समापन दिया जाएगा ना कि सीधे नियंत्रक तक।

9. DDC नियंत्रकों में अनुकूली नियंत्रण क्षमता होगी, जिससे नियंत्रण सॉफ्टवेयर प्रतिक्रिया समय को मापता है और अधिकतम नियंत्रण के लिए नियंत्रण मानकों को समायोजित करता है। सॉफ्टवेयर AHU और चिलर सिस्टम के परिवर्ती नियंत्रण लूपों (सभी P, P+I, P+I+D या कोई एक) के स्व-ट्यूनिंग करने देगा ताकि विभिन्न लोड परिस्थितियों में सबसे कुशल और अनुकूलित नियंत्रण प्रदान किया जा सके।

10. ऊर्जा प्रबंधन प्रोग्राम पिछले अनुभव और वर्तमान परिचालन स्थितियों के आधार पर अपने पैरामीटर अपडेट करेंगे।

11. एक डिजिटल इनपुट बिंदु की स्थिति के आधार पर रन टाइम संचित किया जाएगा। इससे शुरूआती समय या बंद समय का योग करना संभव होगा। रन टाइम की गणना गैर-वाष्पशील मेमोरी में रहेगी।

### 1.5 नियंत्रकों और विद्युत पैनलों के लिए घेरे:

नियंत्रकों को लॉकेबल वंडल प्रूफ बक्सों में रखा जाएगा जिन्हें किसी भी अनधिकृत व्यक्ति द्वारा छेड़छाड़ से बचाने के लिए फर्श पर या दीवार पर लगाया जाएगा। संयंत्र कक्ष स्थानों और बाह्य अनुप्रयोग में उपयोग किए जाने वाले सभी DDC नियंत्रकों को IP 54 रेटिंग एन्क्लोज़र (घेरे) में ही रखा जाएगा। पैनल 14 SWG CRCA शीट स्टील कक्ष से संवृत धातु का होगा जिसमें सभी निकटवर्ती यूनितों के बीच और सभी कवर के नीचे गैस्केट लगी होगी ताकि जोड़ धूलरोधी हो जाएं। सभी दरवाजे और आवरण को कब्जे और लैच लगाए जाएंगे और सख्त आधार प्रदान करने के लिए यथावश्यक रूप से मोड़ा और बांधा जाएगा। शीट धातु में किसी भी प्रकार के जोड़ों को वेल्डिंग स्लेग (धातुमल) के साथ सीम वेल्ड किया जाएगा और

वेल्डिंग पिट्स को प्लंबर धातु से चिकनाया जाएगा। सभी पैनल और कवर ठीक से लगाए जाएंगे और पैनलों में फ्रेम और छेद से सही ढंग से फिट हो जाएंगे। फिक्सिंग स्क्रू धातु की पर्याप्त मोटाई में छिद्र में प्रवेश करें या नट लगाए जाएं। स्व-चूड़ी स्क्रू का इस्तेमाल नियंत्रण कक्षों के निर्माण में नहीं किया जाएगा। पैनल में इनकमिंग और आउटगोइंग कंड्यूट/केबल के स्थान के अनुरूप अनुमोदित आकार और संख्या के नॉकआउट छेद प्रदान किए जाएंगे। केबल के भार को सहारा देने के लिए उपयुक्त क्लैप लगाए जाएंगे। बक्से का आयाम आवश्यकता पर निर्भर करेगा, जिसका रंग प्रभारी-अभियंता के परामर्श से निर्धारित किया जाएगा। उपयोग किए जा रहे DDC नियंत्रक को न्यूनतम निम्न की पुष्टि करनी चाहिए:

- ANSI/ASHRAE मानक 135-2001 (BACNET) के आधार पर, ENV13321-1, UL 916 सूचीबद्ध और CE (यूरो मानदंड) के अनुरूप।
- संचालन स्टैंडअलोन, BACNET इंटरफेस या ईथरनेट / ETHERNET / IP में निर्मित के साथ 78k बिट।
- ठेकेदार द्वारा प्रदान किए गए नियंत्रक फंक्शन कार्ड प्रकार में कॉन्फिगर करने योग्य प्लग के नहीं होंगे।
- भावी विस्तार के लिए नियंत्रकों के पास 20% अतिरिक्त क्षमता (डिजिटल/एनालॉग इनपुट/आउटपुट) होगी।
- ऑपरेटर टर्मिनल, प्रबंधन स्टेशन और वेब सर्वर डिवाइस के साथ वेब ब्राउज़र के लिए वैकल्पिक कनेक्शन।
- स्वतंत्र रूप से प्रोग्राम योग्य
- फ्लैश ROM, वास्तविक समय प्रसंस्करण और बहु-कार्य
- 16/32-बिट प्रोसेसर सिस्टम, 1.5 MB प्रोग्राम मेमोरी
- आपूर्ति वोल्टेज AC 24V +/-20% 50/60 Hz
- इवेंट चालित डेटा ट्रांसमिशन।
- स्वचालित मुख्य लाइन रिकवरी
- PPS2 कनेक्शन

- डिजिटल आउटपुट 250V 2A रेटेड बदलाव संपर्क होगा
- ऐतिहासिक डेटा मेमोरी भंडारण। नियंत्रक में ऑपरेटिंग सिस्टम सॉफ्टवेयर और डेटा फ़ाइलों के भंडारण के लिए काम करने की जगह के रूप में उपलब्ध मेमोरी को नियंत्रक के पूर्ण अंक के लिए तय किया जाएगा।
- गैर-वाष्पशील स्मृति में संग्रहीत सॉफ्टवेयर अनुप्रयोग
- RAM के पूर्ण संचालन का साथ देने के लिए निकेल-कैडमियम/लिथियम बैटरी वाले नियंत्रकों में, स्थानीय बिजली के चले जाने पर बैटरी में 12 घंटे तक का बैक अप होगा। बैटरी से एक्चुएटर, वाल्व, डैम्पर इत्यादि को बिजली की आपूर्ति नहीं की जाएगी। इसके बाद के संस्करण उपरोक्त बैटरी रिजर्व के अलावा, मानक बैटरी की समाप्ति के बाद कम से कम 2 दिनों के लिए RAM को बनाए रखने के लिए एक और बैटरी प्रदान की जाएगी। प्रत्येक नियंत्रक के साथ लो-बैटरी अलार्म प्रदान किया जाएगा और नियंत्रण स्टेशन पर एक संकेत दिया जाएगा। यहां तक कि अगर मेमोरी EPROM पर संग्रहीत है, तो भी बैटरी बैकअप की आवश्यकता होगी। बैटरी बैकअप > 5 साल।

अनुप्रयोग प्रोग्राम तैयार करने के लिए, निम्नलिखित न्यूनतम फ़ंक्शन तत्वों की आवश्यकता है:

- फ़ंक्शन रीसेट करें
- निर्धारित बिन्दु जंप
- पोजिशनिंग टाइम
- P-नियंत्रक (रिवर्स या सीधे लागू)
- P1-नियंत्रक (रिवर्स या सीधी लागू)
- I-हटाने के साथ PI-नियंत्रक (रिवर्स या सीधे लागू)
- PID नियंत्रक (रिवर्स या सीधे लागू)
- 2-बिंदु नियंत्रक (रिवर्स या सीधे लागू)
- आनुपातिक अतिरिक्त अनुक्रम (रिवर्स या सीधे लागू)
- डेटा ट्रांसमीटर (डिजिटल या एनालॉग)
- डेटा कन्वर्टर (एनालॉग-डिजिटल या डिजिटल-एनालॉग)

- रिंग काउंटर
- टाइमर (स्विच ऑन या स्विच ऑफ)
- लॉजिक ऑपरेशंस:
  - i. लॉजिक "AND"
  - ii. लॉजिक "OR"
  - iii. लॉजिक "EXOR"
  - iv. लॉजिक "NOT"
- तुलनात्मक संचालन:
  - i. अधिकतम मान
  - ii. न्यूनतम मान
  - iii. औसत मान
- एन्थलापी गणना
- अनुकूलक
- माध्य मान गणना
- हिस्टेरेसिस
- आउटपुट चरण (डिजिटल या एनालॉग)

डिजिटल आउटपुट संभावित मुक्त आउटपुट होंगे। एनालॉग आउटपुट सही एनालॉग आउटपुट (0-10 V DC, 0-20 mA & 4-20 mA) होंगे। प्रतिरोध सिग्नल PTC या NTC) (PT 100, PT 1000, PT 3000, Balco 500, NI 1000).

समर्थित डिजिटल इनपुट/आउटपुट प्रकार निम्न होंगे, लेकिन इन तक सीमित नहीं होंगे:

ए) आम तौर पर खुला संपर्क

बी) आम तौर पर बंद संपर्क

सी) मॉड्युलेटिंग आउटपुट सही आनुपातिक आउटपुट होंगे ना कि फ्लोटिंग कंट्रोल प्रकार के।

उपरोक्त ब्लॉक DDC नियंत्रकों में रहेंगे और किसी भी उच्च स्तरीय इंटरफेस/नियंत्रक से स्वतंत्र होंगे। समस्या-हल, मरम्मत और बदलने की सुविधा के लिए प्लग-इन कनेक्टर के माध्यम से सभी बोर्ड का समापन किया जाएगा। कनेक्शन के टांका नहीं लगाने दिया जाएगा। नियंत्रकों को प्राथमिक रूप से निदान LED संकेतक से सुसज्जित किया जाएगा जिसमें कम से कम पावर अप टेस्ट ओके, और बस त्रुटि संकेत होगा। पैनल के दरवाजे खोले बिना सभी LED दिखाई देंगी। स्थानीय बिजली चले जाने की स्थिति में नियंत्रक कार्यों (नियंत्रण, लॉगिंग, मॉनिटरिंग और संचार) के पूर्ण संचालन को बनाए रखने के लिए नियंत्रकों को नियामक निर्बाध विद्युत आपूर्ति स्वीकार करना संभव होगा। पंखा कूलिंग की आवश्यकता वाले नियंत्रक स्वीकार्य नहीं हैं। पोर्टेबल प्लग-इन कीपैड डिस्प्ले के माध्यम से, स्थानीय स्तर पर नियंत्रक डेटा जानकारी तक पहुंचने की सुविधा होगी, जो सभी नियंत्रकों के लिए सामान्य हो सकती है और आमतौर पर अनधिकृत छेड़छाड़ को रोकने के लिए हटाया जा सकता है। अन्यथा, स्थानीय पूछताछ और समायोजन के लिए उसके आवरण के साथ प्रत्येक नियंत्रक की एक कीपैड होगा और अभिन्न प्रदर्श होगा। दोनों मामलों में ही, इस प्रकार प्रणाली तक पहुंच मुख्य ऑपरेटर टर्मिनल के समान ही का पासवर्ड के द्वारा सीमित होगी। यदि पोर्टेबल ऑपरेटर टर्मिनल (POT) नियंत्रकों को प्रोग्राम करने के लिए जरूरी हैं, तो इसके लिए सॉकेट प्रदान किए जाएंगे। POT का अनुलग्नक किसी भी तरह से सामान्य पैनल ऑपरेशन या बस कनेक्शन को बाधित या अक्षम नहीं करेगा। सिस्टम के किसी भी भाग को ऑफ-लाइन किए बिना सिस्टम में नए नियंत्रक जोड़ना संभव होगा।

इसके अलावा, DDC यूनिट सॉफ्टवेयर में निम्नलिखित अतिरिक्त कार्य होने चाहिए:

सभी संकेतों की सीमा और यूनिट (आयाम) का मुक्त चयन (मापित मान, संचित मान, गणना मान, आदि)

ऑपरेटिंग प्राथमिकताओं के अनुसार पहुंच सुरक्षा का मुक्त आवंटन

ऑपरेटर टर्मिनल और/या प्रबंधन स्टेशन से मैन्युअल ओवरराइड प्राथमिकताओं (सॉफ्टवेयर) की मुक्त परिभाषा

AHU जैसे उपकरणों के लिए जहां भी नियंत्रण लॉजिक आवश्यक है, प्रस्तावित DDC नियंत्रक प्रावरणी पर एक डिजिटल डिस्प्ले होगा। यह डिस्प्ले प्रत्येक 3-3 पैरामीटर के 2 श्रेणियों को

प्रदर्शित करने में सक्षम होगा। अलार्म की स्थिति में, डिस्प्ले 'अलार्म' संकेत पर स्विच हो जाएगा। कुल मिलाकर, नियंत्रक के पास 8 अलग-अलग अलार्म को इंगित करने की क्षमता होगी। एक ही समय में एक से अधिक अलार्म सक्रिय होने पर, नियंत्रक एक कोडित वर्णाक्षर प्रदर्शित करेगा, यह सूचित करने के लिए कि नियंत्रक में एक से अधिक अलार्म हैं।

### 1.4.3 प्रक्रिया स्तर:

निम्न न्यूनतम महत्वपूर्ण कार्यों को सुनिश्चित करने के लिए एक नियंत्रण प्रणाली की आवश्यकता है:

- सभी क्षेत्र नियंत्रित स्थानों की स्थितियों की निगरानी
- आंकड़ा अर्जन
- परिभाषित नियंत्रण कार्यों के लिए सुविधा
- अलार्म संकेत

ब्लोअर रूम/AHU में आर्द्रता के नियंत्रण और मॉनिटरिंग के लिए पट्टी हीटर के द्वारा रीहीट (पुनःतापन) सुविधा का प्रस्ताव किया गया है। चरणों में केवल सीमित मान आधारित चालू/बंद स्विचन का अनुमान करना है।

#### 1.4.3.1 नियंत्रण फ़ंक्शन:

AHU/पंखा काँइल यूनिट/पैक यूनिट/ब्लोअर सिस्टम के लिए कमांडिंग स्विचिंग के निम्नलिखित तरीके होंगे।

- ऑटो चालू/बंद (स्थानीय बंद संभव)
- मैनुअल मोड (स्थानीय चालू/बंद संभव)
- अनुसूची मोड (स्वतः समय आधारित/घटना आधारित कार्यक्रम के अनुसार स्वतः 'ON' आने के लिए उच्च और निम्न साइड उपकरण)।

- उपकरणों का सही अनुक्रमण सुनिश्चित किया जाएगा ताकि सिस्टम की मांग के बिना कोई उपकरण नहीं चले। एयर कंडीशनिंग सिस्टम के TR के अनुसार किलोवाट को कम करने के लिए उपकरणों का लोड, टाइम शेयरिंग और अनुक्रमण सुनिश्चित किया जाएगा।
- डिस्प्ले पर डायनामिक डेटा नियमित आधार पर अपडेट किया जाएगा।
- क्षेत्र उपकरण और ट्रिप आदेशों के लिए कीबोर्ड कमांड निष्पादित किया जाएगा।
- कीबोर्ड और डिस्प्ले से ऑपरेटर के अनुरोध की प्रतिक्रिया न्यूनतम अवधि में पूरी की जाएगी।

उपरोक्त नियंत्रण के अलावा निर्धारित बिंदु बदलना संभव होगा:

- कॉइल छोड़ने वाला तापमान
- R.H
- तापमान
- क्लीन रूम के अंदर सकारात्मक दाब।

नियंत्रण नवीनतम माइक्रोप्रोसेसर आधारित नियंत्रक के साथ उपलब्ध कराया जाएगा जिसके साथ इनबिल्ट रीयल-टाइम घड़ी, ट्रांसफार्मर, टर्मिनल आदि के लिए न्यूनतम 5 वर्षों के लिए बैटरी बैकअप, I/O संलग्न I/O सूची के अनुसार होगी। DDC प्रणाली प्राथमिकता के अनुसार प्रत्येक घटना का प्रबंधन करेगी, स्थिति अद्यतनों, रखरखाव मुद्दों, व्यक्तिगत फ़ाइलों में महत्वपूर्ण घटनाओं का संग्रह करना। उपयुक्त प्रदर्श भी उपलब्ध होगा। PC खराब होने के मामले में डेटा की हानि से बचा जायेगा। स्टैंडबाय PC, राउटर, सभी आवश्यक हार्डवेयर और सॉफ्टवेयर सहित हॉट स्टैंडबाय सुविधा को शामिल किया जाना है। DDC प्रणाली के लिए PC और नियंत्रकों आदि के लिए आवश्यक UPS आपूर्ति की क्षमता को निर्दिष्ट किया जाएगा। सभी आवश्यक डेटा केबल और सहायक उपकरण शामिल किए जाएंगे जिसमें आवश्यकतानुसार एक्सेसरीज़, बिछाने और समाप्ति शुल्क इत्यादि शामिल होंगे।

नियंत्रकों पर लिखे गए अनुप्रयोग विशिष्ट लॉजिक के आधार पर स्वायत्त कक्षवार आराम नियंत्रण के लिए व्यक्तिगत टर्मिनल यूनिट कंट्रोलर होंगे। सभी टर्मिनल यूनिट कंट्रोलर निम्न सामान्य आवश्यकताओं को पूरा करेंगे:

- लोन मार्क और BACNET TCP/IP
- AC 230 V बिजली की आपूर्ति या DC बिजली आवश्यक एडेप्टर के साथ संचालित।
- स्क्रू या DIN रेल के साथ लगाने योग्य।
- कैबिनेट के बिना स्थानीय स्थापना के लिए वैकल्पिक टर्मिनल कवर।
- डाउनलोड करने योग्य एप्लिकेशन सॉफ्टवेयर/समायोज्य पैरामीटर सेट, उपयोग के प्रकार को डाउनलोड करने योग्य पूर्व-परीक्षण एप्लिकेशन सॉफ्टवेयर द्वारा परिभाषित किया जाएगा।

समूहन, शेड्यूलिंग इत्यादि जैसे सामान्य कार्यों को स्वचालन स्तर पर मास्टर नियंत्रक के भीतर हासिल किया जाएगा।

परियोजना पर उपलब्ध कराए गए सभी टर्मिनल यूनिट कंट्रोलर में कक्ष यूनिट के माध्यम से स्थानीय निर्धारित बिंदु समायोजन की सुविधा होगी।

अनुप्रयोग विशिष्ट नियंत्रकों का उपयोग पंखा कोइल यूनिट आदि जैसे टर्मिनल उपकरणों के लिए किया जाएगा। ये नियंत्रक लोन मार्क संगत बस संचार के साथ होंगे। संचार बस में कोई विफलता समस्या FCU नियंत्रक के काम को प्रभावित नहीं करनी चाहिए। प्रत्येक FCU के लिए एक समर्पित स्टैंड-अलोन नियंत्रक प्रदान किया जाएगा। विभिन्न क्षेत्रों की सेवा करने वाले FCU के लिए एक आम नियंत्रक स्वीकार्य नहीं होगा। इन नियंत्रकों को बस केबल के साथ खोला जाएगा और BMS से जुड़े होंगे।

सामान्य तौर पर, वे निम्नलिखित विनिर्देशों का पालन करेंगे:

- परिवर्तन के साथ या बिना 2 या 4 पाइप FCU के लिए
- PID नियंत्रण



- BUS केबल पर डाउनलोड करने योग्य एप्लिकेशन सॉफ्टवेयर।
- लोनमार्क और BACNET संगत बस संचार।
- प्रबंधन स्टेशन सॉफ्टवेयर में एकीकृत होना।
- AC 24 V PWM वाल्व एक्चुएटर, AC 24 V वाल्व और डैंपर एक्चुएटर, या इलेक्ट्रिक हीटिंग कॉयल का नियंत्रण।
- पंखा नियंत्रण के लिए वोल्ट-फ्री रिले
- ऑपरेटिंग वोल्टेज 230 V
- आंतरिक फ्यूज, थर्मल, स्वचालित रीसेट
- 4.8 kbps या अधिक पर स्थानीय बस, खुले मुड़े युग्म के 2/4 तार के माध्यम से 1 कमरे के यूनिट के साथ जोड़ने योग्य।

अनुप्रयोग विशिष्ट नियंत्रक निम्न प्रकार के कक्ष नियंत्रकों के साथ संयोजन में कार्य करने में सक्षम होंगे। विशिष्ट अनुप्रयोगों में उपयोग किए जाने वाले विशिष्ट प्रकार के कक्ष नियंत्रक का चयन आपरेशन के क्रम में लिखे गए वर्णन को पूरा करने के लिए निम्न प्रकारों में से किसी एक से किया जाएगा।

#### 1. टाइप 1

- एकीकृत कक्ष तापमान संवेदक

#### 2. टाइप 2

- एकीकृत कक्ष तापमान संवेदक
- तापमान निर्धारित बिंदु के लिए डायल

#### 3. टाइप 3

- एकीकृत कक्ष तापमान संवेदक

- तापमान निर्धारित बिंदु के लिए डायल
- बंद/ऑटो 1 मोड के लिए रॉकर स्विच (एकल गति पंखा)

#### 4. टाइप 4

- एकीकृत कक्ष तापमान संवेदक
- तापमान निर्धारित बिंदु के लिए डायल
- बंद/ऑटो 1 मोड और पंखा गति (3 गति पंखा) के लिए रॉकर स्विच।

#### 5. टाइप 5

- एकीकृत कक्ष तापमान संवेदक
- तापमान निर्धारित बिंदु के लिए डायल
- बंद/ऑटो 1 मोड और पंखा गति (3 गति पंखा) के लिए रॉकर स्विच।
- मापित तापमान का LCD डिस्प्ले

#### 6. टाइप 6

- एकीकृत कक्ष तापमान संवेदक
- तापमान निर्धारित बिंदु के लिए रॉकर स्विच (बढ़ाना/घटाना)
- बंद/ऑटो 1 मोड और पंखा गति के लिए रॉकर स्विच।
- मापित तापमान का LCD डिस्प्ले
- लॉन बस के माध्यम से नियंत्रकों के साथ संचार।
- रोशनी और ब्लाइंड के लिए एक्सचेंजबल रॉकर स्विच।
- रोशनी और ब्लाइंड के संचालन के लिए डाउनलोड करने योग्य सॉफ्टवेयर अनुप्रयोगों का चयन
- आपरेटिंग मोड 'ऑटो' - कम्फर्ट, 'ऑफ' - स्टैंडबाय या अर्थव्यवस्था

#### 7. मुद्रण

- प्रिंटर को सीधे प्रबंधन स्टेशन या फ़ाइल सर्वर से कनेक्ट करना संभव होगा।

#### 8. रिमोट मॉनिटरिंग एवं नियंत्रण

यदि आवश्यक हो तो अतिरिक्त हार्डवेयर के साथ, निम्न संभव विधियों के माध्यम से

सिस्टम से पूछताछ करना संभव होगा:

- टेलीफोन कनेक्शन
- भवन IT नेटवर्क

स्वचालन नियंत्रक नेटवर्क पर स्थापित समर्पित एम्बेडेड वेब सर्वर डिवाइस पर संग्रहीत जानकारी तक पहुंचने के लिए IT नेटवर्क के माध्यम से पासवर्ड तक पहुंच के साथ वेब ब्राउज़र प्रौद्योगिकी।

- मोबाइल पेजर्स/फोन/ई-मेल आदि को अलार्म रिपोर्टिंग
- भवन प्रबंधन प्रणालियों के माध्यम से ऊर्जा उपयोग की निगरानी और नियंत्रण।

## 9. BMS - रिकॉर्ड

### 1.5 सामान्य:

DDC प्रणाली के विवरण में सभी निर्माता तकनीकी डेटा शीट्स और यूजर मैनुअल शामिल होंगे। नियंत्रण वाल्व अनुसूची प्रवाह दर, वाल्व दाब ड्रॉप और सिस्टम डिज़ाइन आधार पर प्रदान किया जाएगा, जिस पर विशेष वाल्व प्रकार का चयन किया जाएगा।

DDC नियंत्रण प्रणाली सॉफ्टवेयर रणनीतियाँ

ऑपरेटिंग और रखरखाव नियमावली में शामिल करने के लिए नियंत्रक रणनीतियों को हार्ड कॉपी और CD-ROM दोनों में प्रदान किया जाएगा।

सिस्टम लगाना शुरू करने से पहले प्रभारी-अभियंता को सभी शुरुआती रणनीतियों की प्रतियां हार्ड कॉपी और CD-ROM दोनों में दी जाएंगी।

नियंत्रण प्रणालियों की सुपुर्दगी के तीन महीने के भीतर सभी 'यथा स्थापित' रणनीतियों की प्रतियां इंजीनियर को हार्ड कॉपी में और CD-ROM दोनों में दी जाएंगी।

## 1.6 BMS सॉफ्टवेयर और लाइसेंस:

BMS सॉफ्टवेयर रिडंडंसी विकल्प के साथ क्लाइंट/सर्वर सॉफ्टवेयर होगा।

BMS सॉफ्टवेयर में 10,000 I/O बिंदु या उससे अधिक के लिए लाइसेंस होना चाहिए।

क्लाइंट की संख्या: 5 या अधिक

DDC प्रणाली में LAN के माध्यम से पहुंचने वाले उपयोगकर्ता टर्मिनलों की आवश्यक संख्या शामिल होगी। आदेश के अनुसार आपूर्ति किया जाने वाला सॉफ्टवेयर लाइसेंसी होगा और मूल उपयोगकर्ता पुस्तिका/लाइसेंस/मीडिया और ऑपरेशन मैनुअल आपूर्ति के साथ प्रदान किया जाएगा। ऑटो क्युयिंग की सुविधा के साथ सॉफ्टवेयर के फ्लोटिंग लाइसेंस, मीडिया और प्रीलोडेड के साथ प्रदान किया जाएगा। नोड लॉक लाइसेंस स्वीकार नहीं किया जाएगा। नियंत्रण प्रणालियों के सभी लाइसेंस अधिकार, निर्माता के सॉफ्टवेयर पैकेज को सुपुर्दगी के समय पर ग्राहक को हस्तांतरित किया जाएगा। क्लाइंट की ओर से उपयोगकर्ता पंजीकरण, विशेषज्ञ सिस्टम हाउस पार्टनर द्वारा नियंत्रण प्रणाली निर्माता के सीधे किया जाना चाहिए।

सभी नियंत्रण प्रणाली निर्माता मॉनिटरिंग या BMS सॉफ्टवेयर की प्रतियां CD-ROM या अन्य बड़े पैमाने पर भंडारण डिवाइस पर उपलब्ध कराई जाएंगी, इसके साथ में किसी भी ग्राफिक्स और डेटाबेस की प्रतिलिपियां उपलब्ध कराई जाएंगी जिनकी घातक कंप्यूटर विफलता के बाद सिस्टम को पुनः इंस्टॉल करने की आवश्यकता हो सकती है।

## 1.7 माध्यमिक प्रणालियों का एकीकरण:

DDC प्रणाली में निम्नलिखित अतिरिक्त सुविधाएं भी होंगी। स्टैंडअलोन नियंत्रकों के बीच पीयर-टू-पीयर संचार आवश्यक है। अगर कोई नियंत्रक विफल हो जाता है, तो प्रणाली को निर्बाध रूप से उपलब्ध कराने के लिए आइडलिंग नियंत्रक उसके बचाव में आगे आएगा। MAC या नेटवर्क-CSMA/CD जिन्हें आमतौर पर ईथरनेट सर्वर और OFC नेटवर्क कहा जाता है, पूरे स्थान पर उपलब्ध होने पर, डेटा अर्जन, स्थानांतरण, नियंत्रण और निगरानी के लिए उपयोग किया जाएगा। DDC प्रणाली इस नेटवर्क के साथ एक बस नेटवर्क बनायेगी। ईथरनेट सर्वर का विनिर्देश सामान्यतः प्रोटोकॉल - TCP / IP किसी भी नेटवर्क के लिए परिवहनीय है।

प्रत्येक ब्लॉक/भवन/मंजिल/स्कंध में ऑप्टिकल फाइबर केबल (OFC) के साथ ईथरनेट स्विच उपलब्ध हैं। सेंसर, अंतर सिग्नल, आदि के लिए व्यावर्तित युग्म केबल का इस्तेमाल किया जाएगा; शोर वाले वातावरण के लिए परिरक्षित व्यावर्तित युग्म या परिरक्षित बहु कंडक्टर केबलिंग का इस्तेमाल किया जाएगा।

इसके अतिरिक्त, कार्यों और अन्योन्यक्रिया की आवश्यकता के आधार पर एक प्रणाली के भीतर सबसे उपयुक्त स्तर पर एकीकरण भी किया जाएगा (यदि आवश्यक हो)। निम्नलिखित एकीकरण संभव होना चाहिए।

- लोन वर्क
- लोन मार्क
- BACNET /लोन वर्क
- BACNET/IP और / TCP/IP
- OPC
- मानक मालिकाना बसों का एकीकरण: मोडबस, M बस, KNX.

मूल BACNET के साथ एक खुले सिस्टम डिवाइस की आवश्यकताओं के भाग के रूप में, लोन मार्क प्रोटोकॉल किसी सामान्य गेटवे / प्रोटोकॉल कनवर्टर डिवाइस के बिना सामान्य क्षेत्र बस बैकबोन नेटवर्क पर कनेक्ट किया जाएगा। यदि विभिन्न उप-प्रणालियों के बीच संपर्क की आवश्यकता है, तो एकीकरण स्वचालन या क्षेत्र स्तर पर किया जाएगा। एकीकरण प्रबंधन स्तर पर नहीं होना नियोजित निवारक रखरखाव पैकेज या ऊर्जा मॉनिटरिंग पैकेज जैसे तृतीय पक्ष सॉफ्टवेयर पैकेज से लिंक प्रबंधन स्तर पर किया जाएगा। रखरखाव प्रबंधन और ऊर्जा प्रबंधन पैकेज के साथ अलार्म और ऐतिहासिक जानकारी साझा करते समय, प्रबंधन प्रणाली एक मानक व्यावसायिक रूप से उपलब्ध प्रारूप में जानकारी प्रदान करेगी उदा. MS एक्सेस और मानक तंत्र उदा. ODBC का उपयोग करेगा। प्रबंधन प्रणाली से वास्तविक समय "लाइव" सूचना किसी तीसरे पक्ष के पैकेज में स्थानांतरित कर दी जाएगी उदा. MS एक्सेल, मानक इंटर-एप्लीकेशन तंत्र द्वारा उदा. DDE या OPC या प्रबंधन प्रणाली के लिए एक दस्तावेज API का उपयोग करके एक कनेक्शन विकसित करके किया जाएगा। जहां तृतीय पक्ष डिवाइस और प्रबंधन प्रणाली के बीच भौतिक कनेक्शन की आवश्यकता हो, वहां उप-सिस्टम आपूर्तिकर्ता डिवाइस में कनेक्शन बनाने

के लिए आवश्यक लाइन ड्राइवर और केबल, दस्तावेजीकरण और सहयोग प्रदान करेगा जो प्रोटोकॉल रूपांतरण प्रदान करेगा।

### 1.8 सॉफ्टवेयर मॉड्यूल:

प्रबंधन स्टेशन सॉफ्टवेयर मॉड्यूलर, लक्ष्योन्मुखी, स्पष्ट रूप से संरचित होगा और यह विंडोज -10 (या बाद के) मानक 32/64 बिट या बाद की तकनीक पर आधारित होगा।

मुख्य सॉफ्टवेयर ऐप्लीकेशन में न्यूनतम रूप में निम्न शामिल होंगे

- प्लॉट व्यूअर: संयंत्र का ग्राफ़िक्स आधारित संचालन
- ट्रेड (रुझान) व्यूअर: मापित मानों का लॉगिंग और निष्पादन
- अलार्म व्यूअर: अलार्म संदेशों का निष्पादन
- अलार्म राउटर: अलार्म का स्वचालित रूटिंग
- लॉग व्यूअर: अलार्म, सिस्टम इवेंट्स और उपयोगकर्ता गतिविधियों की लॉगिंग

निम्नलिखित के मामले में अलार्म संदेश को मोबाइल/फ़ैक्स/ई-मेल (जिसके लिए आवश्यक सॉफ्टवेयर/हार्डवेयर शामिल किया जाएगा) पर सूचित किया जाएगा: -

- बिजली की आपूर्ति बंद
- नियंत्रणों पर चिलर ट्रिपिंग
- महत्वपूर्ण यूनिट बंद
- महत्वपूर्ण क्षेत्रों में तापमान और R.H की असामान्यता
- सॉफ्टवेयर द्वारा तैयार की गई रिपोर्ट उपयोगकर्ता परिभाषित/मानक रिपोर्ट होगी
- केबलिंग और कंड्यूट के लिए आधार विभाग द्वारा निर्दिष्ट के अनुसार होगा।

कार्यालय शुरू होने/बंद होने से 15 से 75 मिनट के बीच प्रणाली के चालू/बंद होने के समय में परिवेश के तापमान और समय कार्यों को अलग किया जा सकता है, यह इस पर निर्भर करता है कि परिवर्ती 15 से 30 डिग्री सेल्सियस पर है।

#### 1.8.1 टास्क बार:

उपयोगकर्ता और सिस्टम के बीच सभी अन्योन्यक्रिया के लिए टास्क बार संपर्क का पहला और अंतिम बिंदु होगा।

महत्वपूर्ण प्रणाली की जानकारी का त्वरित अवलोकन प्राप्त करने के अलावा, उपयोगकर्ता टास्क बार में विभिन्न आइकनों पर क्लिक करके एक कार्यक्रम से दूसरे कार्यक्रम को दूसरे ऑपरेटिंग सिस्टम में स्विच कर सकेंगे। जिन सिस्टम में रिमोट साइट्स शामिल हैं उनमें टास्क बार का उपयोग उन साइटों के बीच स्विच करने के लिए किया जाएगा (उपयोगकर्ता के एक्सेस विशेषाधिकारों के तहत)।

सिस्टम को नए उपयोगकर्ताओं के लिए आसान बनाने के लिए, सिस्टम चयनित कार्यक्रमों तक पहुंच के साथ उपयोगकर्ता-विशिष्ट प्रारंभ-अनुक्रमों का सपोर्ट करेगा।

### 1.8.2 टास्क बार की विशेषताएं:

- लॉग-इन और लॉग-आउट पर प्रोग्राम मॉड्यूल और तृतीय पार्टी सॉफ्टवेयर तक पहुंच के लिए एक्सेस विशेषाधिकार और सुरक्षा तंत्र का नियंत्रण।
- सिस्टम और उप-प्रणालियों के लिए उपयोगकर्ता-और-पासवर्ड आधारित पहुँच
- स्वचालित उपयोगकर्ता-विशिष्ट प्रारंभिक अनुक्रम
- अलार्म और सिस्टम संदेश स्थिति, साइट कनेक्शन स्थिति, समय और दिनांक का प्रदर्शन।
- विभिन्न साइटों पर कनेक्शन करने और समाप्त करने की सुविधा।
- अधिकतम 4 साइटों के साथ एक-साथ कनेक्शन।

### 1.8.3 संयंत्र व्यूअर:

प्लॉट व्यूअर निम्न सुविधाओं का समर्थन करेगा:

- श्रेणीबद्ध रूप से जुड़े, एनिमेटेड उच्च-रिज़ॉल्यूशन बिट-मैप रंग ग्राफिक्स (XGA 1024 x 768 पिक्सल)।
- स्थिति के आधार पर एनीमेशन के साथ 2 D और 3 D प्रतीक का विकल्प।
- निर्धारित बिंदुओं, मापदंडों, ऑपरेटिंग मोड, अलार्म, टाइमपरॉग, ऑन-लाइन और ऑफ-लाइन रुझान डेटा सुविधाओं के लिए सीधी पहुंच।
- सभी सक्रिय पेजों के साथ गतिशील बहु-कार्य।
- कई स्तरों पर संयंत्र की निगरानी और संचालन।
- विंडोज के मानक संचालन के साथ मिलकर प्लॉट व्यूअर नेविगेशन बार का उपयोग करते हुए कई पेजों का लचीला संचालन।
- अन्य सभी प्रबंधन स्टेशन सॉफ्टवेयर अनुप्रयोगों के लिए नेविगेशन।

- उपयोगकर्ता-निश्चित पेज आकार।
- एक ही स्तर पर या स्तरों के बीच जंप के लिए जंप टैग
- सभी गतिशील वस्तुओं के लिए टूलटिप्स, 'उपयोगकर्ता', 'तकनीकी' या 'सिस्टम' सूचना के विकल्प के साथ।
- संदर्भ-विशिष्ट जानकारी (जैसे डेटा शीट) किसी भी गतिशील ऑब्जेक्ट से जोड़ी जा सकती है।
- ग्राफिक्स को रंगीन या मोनोक्रोम में मुद्रित करने के लिए सक्षम।
- सभी 32/64-बिट ग्राफिक फ़ाइल स्वरूपों को विंडोज द्वारा संगत को इंपोर्ट किया जा सकता है (जैसे AutoCAD, PCX आदि)।
- साइकोमेट्रिक चार्ट का डायनेमिक डिस्प्ले, एयर कंडीशनिंग प्रक्रियाओं के आसान सिमुलेशन को सक्षम करना।
- डिवाइस की स्थिति, त्रुटियों और विसंगति के संकेत के साथ प्रदर्शन का ग्राहक डिजाइन
- डायनेमिक सूचना हर सेकंड पर अपडेट की जाएगी। हालांकि, डेटा का संग्रह हर घंटे पर किया जाएगा।
- अनुरूपित आरेखों के एक हिस्से के रूप में बार चार्ट और रुझानों को शामिल करना या केवल चित्र बार चार्ट और रुझान तैयार बनाना।
- अलार्म में परिवर्ती का मान लाल रंग में प्रदर्शित किया जाना चाहिए।
- अलार्म/ट्रिप और कुछ पूर्वनिर्धारित संचालन स्थितियों को इंगित करने के लिए रंगों को बदलें और परिवर्ती और उपकरण प्रतीकों को फ्लैश करें।

#### 1.8.4 अलार्म हैंडलिंग और अलार्म व्यूअर:

यह प्रणाली (सिस्टम) न्यूनतम निम्न सुविधाओं से संगत होगी:

- अलार्म का संचालन और परिचालन (उपयोगकर्ता की सुविधाओं के आधार पर)।
- अलार्म संदेश मुद्रण।
- अलार्म प्रबंधन स्टेशन से स्वतंत्र रूप से मुद्रित (स्वचालन स्तर पर सीधे कनेक्शन)।
- अलार्म के तत्काल प्रदर्शन और संचालन के लिए स्वचालित पॉप-अप विंडो (तृतीय पार्टी प्रोग्राम में पॉप-अप सहित)।
- श्रव्य या बहु-मीडिया अलार्म संकेत।



- साइट से सभी सक्रिय अलार्म का निरंतर अवलोकन (स्वचालित रूप से अपडेट किया गया, प्राथमिकता के अनुसार प्रदर्शित किया गया, व्यक्तिगत दृश्य का विकल्प)।
- अलार्म के ग्राफिक्स आधारित सांस्थितिक दृश्य।
- कालानुक्रमिक अलार्म दृश्य।
- विस्तृत जानकारी प्रदर्शित करने का विकल्प।
- संबद्ध संयंत्र ग्राफिक्स तक सीधी पहुंच।
- व्यापक फिल्टर और खोज मानदंड (समय, तिथि, प्राथमिकता, शाखा, अलार्म स्थिति आदि)।
- अलार्म प्राथमिकता/अलार्म स्थिति (स्क्रीन और प्रिंटर) के आधार पर रंग कोडिंग।
- सीमा मान (उच्च, निम्न), स्थिति में बदलाव, समय सीमा समाप्त आदि के लिए अलार्म आदि।
- नियमित अंतराल पर अनुत्तरित अलार्म को दोहराए जाने का विकल्प।
- आगे के विश्लेषण के लिए 3री पार्टी प्रोग्राम को अलार्म डेटा प्रिंट करने या एक्सपोर्ट करने की सुविधा के साथ रिपोर्ट तैयार करना।
- प्रयोक्ता परिभाषित फिल्टर मापदंडों को सेव करने की सुविधा।
- ऑन-लाइन विन्यास सहित अलार्म दृश्य का उपयोगकर्ता-विशिष्ट विन्यास।
- ISA सिफारिश के साथ लाइन में अलार्म अनुक्रम।
- यदि अलार्म को समूहित किया गया है, तो ISA के साथ लाइन में पुनः-फ्लैश सुविधा प्रदान करें।
- अलार्म के लिए पर्याप्त भंडारण क्षमता।
- मांग पर बैकलॉग पेज प्रदर्शित करें।
- स्वयं-नैदानिक जांच द्वारा पता लगाए गए कोई सॉफ्टवेयर और हार्डवेयर गलती प्रदर्शित करें।
- मौजूदा अलार्म, खराब पॉइंट अलार्म, लॉक आउट अलार्म आदि जैसे विभिन्न अलार्म का प्रदर्शन सार।

### 1.8.5 अलार्म रूटिंग:

चौबीसों घंटे अलार्म को मॉनिटर करने के लिए, अलार्म रूटिंग BMS की एक महत्वपूर्ण विशेषता है। BMS में निम्नलिखित विशेषताएं हैं:

- अलार्म प्रिंटर, फ़ैक्स, पेजर या मोबाइल फोन के लिए अलार्म का रूटिंग।
- प्रत्येक संदेश प्राप्तकर्ता के लिए समय सारणी।
- प्राथमिकता के आधार पर अलार्म रूटिंग।
- शाखा (HVAC, सुरक्षा इत्यादि) पर आधारित अलार्म रूटिंग।
- साइट पर जिम्मेदार व्यक्ति को अलार्म रूटिंग।

- टेक्स्ट पर आधारित अलार्म रूटिंग।
- विशिष्ट उपकरणों या प्रणालियों के लिए जिम्मेदार व्यक्ति (यों) को अलार्म रूटिंग।
- प्रबंधन प्रणाली से संदेश के मैनुअल ट्रांसमिशन का विकल्प।

### 1.8.6 टाइम शेड्यूलिंग:

टाइम-शेड्यूलर में निम्नलिखित विशेषताएं होंगी:

- 7 दिन का प्रोग्राम
- अपवाद प्रोग्राम (स्थानीय, बिल्डिंग-वार या सिस्टम-वार)
- प्लॉट व्यूअर ग्राफिक्स के भीतर समय प्रोग्राम का सीधा डिस्प्ले।
- स्विच टाइम की सरल ग्राफिक्स प्रोग्रामिंग
- सिस्टम में सभी समय प्रोग्राम के ग्राफिक्स आधारित अवलोकन।
- सभी अपवाद प्रोग्राम सहित 7 दिन के प्रोग्राम के ग्राफिक्स आधारित अवलोकन।
- समय प्रोग्राम से प्रभावित सभी संयंत्र बिंदुओं के ग्राफिक्स आधारित अवलोकन।
- विभिन्न ऑपरेटिंग मोड (आराम, स्टैंड-बाय, एनर्जी होल्ड-ऑफ) की सीधी प्रविष्टि
- सभी समय के प्रोग्राम का आसान निर्माण, संशोधन और विलोपन।
- विशिष्ट सप्ताह या दिनों तक तेजी से पहुंच के लिए सुविधाओं को स्कॉल।
- प्रबंधन स्टेशन से स्वतंत्र भंडारण और प्रसंस्करण
- सिस्टम में सभी समय प्रोग्राम का स्वचालित सिंक्रनाइज़ेशन
- विभिन्न समय क्षेत्रों (दूरस्थ प्रबंधित साइट्स) का समर्थन
- रेडियो घड़ी के माध्यम से तुल्यकालन का विकल्प।

- विभिन्न डिस्प्ले फॉर्मों में मुद्रित रिपोर्ट

### 1.8.7 ट्रेंड (रुझान) व्यूअर:

रुझान व्यूअर में निम्नलिखित विशेषताएं होंगी:

- ऑनलाइन या ऑफ-लाइन वास्तविक-समय डेटा।
- प्रति विंडो तक दस संकेतों का एक साथ प्रदर्शन।
- निरपेक्ष या सापेक्ष समय अंतराल।
- तेज डेटा विश्लेषण के लिए ज़ूम, स्क्रॉल और कर्सर सुविधाएँ।
- 2 D या 3 D में प्रदर्शित चार्ट के साथ लचीले, आसानी से उपयोग वाली स्केलिंग सुविधा।
- स्वचालित स्केलिंग और डेटा निर्यात के साथ प्रवृत्ति के दृश्यों के लिए ड्रेग और ड्रॉप सुविधा।
- ऑफ-लाइन डेटा लॉगिंग मैनुअल रूप से, स्वचालित रूप से या किसी समय या ईवेंट के आधार पर ट्रिगर।
- ऑफ लाइन ट्रेंड डेटा के लॉगिंग और इंटरमीडिएट स्टोरेज प्रबंधन से स्वतंत्र रूप से संचालित।
- स्वचालन स्तर से स्थानीय या दूरस्थ प्रबंधन स्टेशनों पर स्वचालित अपलोड।
- ऑन-लाइन और ऑफ-लाइन प्रवृत्ति डेटा के प्रबंधन स्टेशन का निष्पादन और संग्रह
- प्रवृत्ति डेटा का प्रिंट-आउट
- 3री पार्टी सॉफ्टवेयर के लिए डेटा का आसान एक्सपोर्ट
- रुझान डेटा को सीधे ADP (एडवांस्ड डेटा प्रोसेसिंग) जैसे सहायक प्रोग्राम में या 3री पार्टी सॉफ्टवेयर जैसे एमएस एक्सेल को एक्सपोर्ट करने की सुविधा

- ट्रेड व्यूअर टाइम बेस को लॉग व्यूअर में एक फिल्टर सृजन के रूप में सीधे इस्तेमाल किया जा सकता है।
- चयनित समय के लिए एक समूह में चयनित मानकों का रुझान और आवश्यक (चयनित) पैमाने पर।

### 1.8.8 लॉग व्यूअर:

लॉग व्यूअर को निम्न खंडों में वर्गीकृत किया जाएगा:

- अलार्म लॉग: इसमें सभी इनकमिंग अलार्म को कालानुक्रमिक क्रम में शामिल किया गया है।
- सिस्टम लॉग: किसी सिस्टम में कहीं पर प्रिंटर में कागज खत्म हो गया है, या हार्ड डिस्क भर गई है तो एक नज़र में दिखाता है। यहां संचार की घटनाएं भी यहां दर्ज की गई हैं, उदाहरण के लिए दिखाता है कि कब संचार स्थापित हुआ था या समाप्त हुआ था।
- उपयोगकर्ता लॉग: उपयोगकर्ता द्वारा प्रबंधन स्टेशन पर की गई गतिविधियों, अनधिकृत प्रयासों, मापदंडों के संशोधन, निर्धारित बिन्दु आदि को सूचीबद्ध करता है।
- स्थिति लॉग: सभी आने वाले संदेशों की स्थिति की जांच करने के लिए।

लॉग व्यूअर में निम्नलिखित विशेषताएं होंगी:

- प्रबंधन स्टेशन को भेजे गए अलार्मों का संग्रहण।
- सभी सिस्टम संदेशों का संग्रहण (प्रिंटर, संचार, प्रबंधन स्टेशन, मॉडेम इत्यादि से)।
- प्रबंधन स्टेशन पर की गई सभी उपयोगकर्ता गतिविधियों का संग्रहण।
- घटनाओं और गतिविधियों पर उपयोगकर्ता टिप्पणियां दर्ज करने और संग्रहित करने की सुविधा।
- प्रत्येक प्रविष्टि पर विस्तृत जानकारी की एक की-स्ट्रोक पर प्रदर्शित करने की सुविधा।

- प्रदर्शित जानकारी की मात्रा को कम करने और कम करने के लिए व्यापक फिल्टर विकल्प।
- जानकारी तक तेजी से पहुंच के लिए व्यापक खोज सुविधाएं।
- किसी दिन या सप्ताह के लिए डेटा का अवलोकन प्रदर्शित करने की सुविधा।
- एक बार परिभाषित, फिल्टर और खोज मापदंड भविष्य में पुनः उपयोग के लिए सेव किया जा सकता है।
- लगभग असीमित प्रविष्टियों (हार्ड डिस्क क्षमता के आधार पर) का संक्षिप्त संग्रह।
- स्वचालित डेटा प्रबंधन और संग्रह कार्य।
- लॉग सार बनाने और मुद्रित करने की सुविधा।
- 3री पार्टी सॉफ्टवेयर के साथ आगे के विश्लेषण के लिए लॉग प्रविष्टियों का एक्सपोर्ट (जैसे- MS एक्सेस)।
- लॉग दृश्य की उपयोगकर्ता विशिष्ट विन्यास लाइन पर सीधे अनुकूलित किया जा सकता है।
- प्री और पोस्ट ट्रिप लॉग।
- ऑपरेशन इंजीनियर्स एक्शन लॉग।
- सिस्टम/उपकरण खराबी लॉग।

### 1.8.9 इंटरनेट लॉग व्यूअर:

यह एक **वैकल्पिक** अनुप्रयोग है, जो उपयोगकर्ताओं को किसी साइट के प्रबंधन में अधिक स्वतंत्रता प्रदान करता है। उदाहरण के लिए, माइक्रोसॉफ्ट इंटरनेट एक्सप्लोरर या मोज़िला फ़ायरफ़ॉक्स जैसे ब्राउज़र उपयोगकर्ता को इंटरनेट कनेक्शन वाल किसी भी PC से लॉग डेटाबेस तक पहुंच प्रदान करता है। मानक लॉग दर्शक की ही तरह, उपयोगकर्ता फिर सभी संयंत्र और सिस्टम द्वारा संग्रहीत या मॉनीटर किए गए ईवेंट का एक संपूर्ण दृष्टिकोण प्राप्त कर सकता है।

इंटरनेट लॉग व्यूअर किसी भी विशेष प्रबंधन स्टेशन सॉफ्टवेयर के बिना उपयोगकर्ता के PC पर शुरू किया जाएगा। लॉग व्यूअर तक पहुंच पासवर्ड से सुरक्षित हो सकती है।

#### 1.8.10 वेब नियंत्रण:

वेब नियंत्रण मॉड्यूल के माध्यम से सिस्टम के पास दूरस्थ साइटों से कनेक्ट करने की क्षमता होगी। पृथक DDC सामान्य प्रयोजन संचार ट्रंक (अन्यत्र वर्णित) में इस वेब नियंत्रण मॉड्यूल से जुड़ने की सुविधा होगी। इसे दूरसंचार PC /लैपटॉप के माध्यम से DDC सामान्य प्रयोजन नियंत्रक के ट्रंक को देखने और नियंत्रित करने में मदद करनी चाहिए। पोर्टेबल ऑपरेटर टर्मिनल (अन्यत्र वर्णित) में दिखने वाले सभी पैरामीटर इस रिमोट PC /लैपटॉप से उपलब्ध होंगे। इस पेशकश की गई व्यवस्था में इन संचार ट्रंक से जुड़ा संयंत्र और उपकरण को नियंत्रित करने/निगरानी करने की सुविधा होगी जो पासवर्ड सुरक्षा के माध्यम से होनी चाहिए।

#### 1.8.11 तृतीय पार्टी सॉफ्टवेयर का एकीकरण और डेटा विनिमय:

प्रणाली मानक इंटरफेस और ड्राइवों के उपयोग की सहायता करेगी जो प्रबंधन स्टेशन स्तर पर सीधे तृतीय पार्टी सॉफ्टवेयर में एकीकृत करने या सिस्टम से डेटा का सामान्य उपयोग करना आसान बनाते हैं, उदा. ODBC (ओपन डेटाबेस कनेक्टिविटी) के माध्यम से। DDE (डायनेमिक डेटा एक्सचेंज) मौजूदा डेटा को MS एक्सेल जैसे स्प्रेडशीट प्रोग्राम में लगातार लोड करने में सक्षम बनाता है, ताकि आगे की प्रक्रिया के लिए लगातार अद्यतन ग्राफ तैयार किए जा सकें।

#### 1.8.12 ऑब्जेक्ट व्यूअर:

संचालन को आसान बनाने के लिए, सॉफ्टवेयर में दो दृश्य मोड होंगे।

- सिस्टम व्यू: सिस्टम नेटवर्क का पदानुक्रमिक दृश्य प्रदान करता है।
- उपयोगकर्ता पदनाम व्यू: सिस्टम डेटाबेस के आधार पर उपयोगकर्ता पते का पदानुक्रमित विश्लेषण देता है।

आम तौर पर, सिस्टम निम्न सुविधाओं का समर्थन करेगा

- सिस्टम के माध्यम से तीव्र नेविगेशन

- वस्तुओं और अलार्म का तेज़ी से पता करना
- सभी वस्तुओं की विस्तृत जानकारी
- प्रक्रिया स्तर से मौजूदा मानों का प्रदर्शन
- निर्धारित बिंदुओं और मापदंडों का संशोधन
- उपयुक्त एक्सेस स्तर वाले उपयोगकर्ता मैनुअल रूप से आउटपुट को ओवरराइड भी कर सकते हैं।
- दो प्रदर्शन मोड - सिस्टम व्यू और उपयोगकर्ता पदनाम व्यू।
- खोज सुविधाएं
- विभिन्न इंटरनेट ब्राउज़रों की ही तरह जम्प सुविधाएं और बुकमार्क्स सुविधाएं।
- उपयोगकर्ता पदनाम और अलार्म टैक्स्ट का संशोधन
- अधिकतम 10 पदानुक्रमित स्तर और अधिकतम 40 अक्षरों वाले पते का प्रयोक्ताओं के लिए अनुकूलन।
- सिस्टम ऑब्जेक्ट्स को ढूंढने के लिए "ढूंढना" फ़ंक्शन

### 1.8.13 रिपोर्ट:

रिपोर्ट उपयोगकर्ता को विशिष्ट समय या विशिष्ट घटनाओं के होने पर पर सिस्टम से नवीनतम जानकारी प्रदान करेगी। निम्नलिखित सुविधाओं का समर्थन किया जाएगा:

- समय और/या प्राथमिकता के आधार पर भेजी गई रिपोर्ट।
- मैनुअल या स्वचालित ट्रिगरिंग
- उपयोगकर्ता-परिभाषित या मानक रिपोर्ट
- प्रबंधन स्टेशन सॉफ्टवेयर में तृतीय पार्टी रिपोर्ट प्रोग्राम को एकीकृत करने की सुविधा।

### 1.8.14 पहुंच (एक्सेस) सुरक्षा:

प्रबंधन स्टेशन केवल अधिकृत उपयोगकर्ताओं को सिस्टम तक पहुंच प्रदान करेगा। सिस्टम प्रशासक हर उपयोगकर्ता की व्यक्तिगत जरूरतों को पूरा करने के लिए एक वातावरण तैयार करेगा। एक्सेस सुरक्षा सुविधा उन इमारतों (साइट्स) और उपकरणों को परिभाषित करेगी जिस तक किसी उपयोगकर्ता को पहुंच दी जाएगी, साइट के भीतर उस उपयोगकर्ता के लिए उपलब्ध सॉफ्टवेयर मॉड्यूल और फंक्शन। सिस्टम निम्न सुविधाओं का समर्थन करेगा:

- प्रयोक्ता नाम पासवर्ड
- अलग-अलग सुविधा तक पहुंच जिसमें प्लान्ट व्यूअर में अलग-अलग ऑब्जेक्ट के लिए साइटों, सबसिस्टम, प्रोग्राम फंक्शंस तक पहुंच को कवर करने वाले।
- 1000 तक उपयोगकर्ताओं को 100 उपयोगकर्ता समूहों में समूहित।
- स्वचालित लॉग आउट (निष्क्रियता की अवधि के बाद)
- एन्क्रिप्टेड पासवर्ड
- विंडोज द्वारा प्रदान की गई नेटवर्क सुरक्षा।

### 1.9 हार्डवेयर आवश्यकताएं:

#### 1.9.1 BMS मुख्य और गौण सर्वर विनिर्देश:

निम्न विनिर्देशों के अनुसार नवीनतम विंडोज सर्वर के साथ मुख्य और गौण सर्वर के लिए दो सर्वर ग्रेड सिस्टम।

कंप्यूटर का प्रकार: सर्वर रैक माउंट

प्रोसेसर: इंटेल जिऑन (6 कोर) 2.2GHz (E5-2420 v2 या समकक्ष) या उच्चतर

रैम: 16 GB या उच्चतर

हार्ड डिस्क: क्षमता 1 TB या उच्चतर

DVD राइटर: DVD राइटर या ब्लू-रे ड्राइव



पोर्ट: 4 USB पोर्ट

ईथरनेट पोर्ट: 2 पोर्ट, प्रत्येक 1 Gbps

डिस्प्ले: 20 "LED या बड़ा रंगीन डिस्प्ले

माउस: ऑप्टिकल स्क्रॉल माउस

ऑपरेटिंग सिस्टम: Windows Server 2012 R2 मानक 64 बिट या नवीनतम

कंपनी: DELL / HP

### 1.9.2 क्लाइंट PC विनिर्देश:

कंप्यूटर का प्रकार: डेस्कटॉप

प्रोसेसर: इंटेल ® कोर ™ i5 (6ठी जेनरेशन) या उच्चतर

रैम: 8 GB (4 GB X 2 को प्राथमिकता)

हार्ड डिस्क: क्षमता 500 GB या उच्चतर

DVD राइटर: DVD राइटर या ब्लू-रे ड्राइव

पोर्ट: 4 USB पोर्ट

ईथरनेट पोर्ट: 2 पोर्ट, प्रत्येक 1 Gbps

डिस्प्ले: 20 "LED या बड़ा रंगीन डिस्प्ले

माउस: ऑप्टिकल स्क्रॉल माउस

ऑपरेटिंग सिस्टम: विंडोज 10 प्रोफेशनल 64 बिट

कंपनी: DELL / HP

प्रिंटर विनिर्देश: HP लेजर जेट pro M 403 dn या नवीनतम रंगीन ग्राफिक प्रिंटर।

### 1.9.3 BACNET राउटर:

एक ही नेटवर्क में प्रबंधन स्टेशन और अन्य नियंत्रकों के साथ डेटा का आदान-प्रदान करने के अलावा, विभिन्न समूहों में DDC मॉड्यूल के बीच वैश्विक डेटा (यानी विभिन्न बसों पर) के हस्तांतरण की अन्य क्षमता।

प्रस्तावित BMS को BACNET प्रोटोकॉल, मोडबस, 485 और लोन बस पर नियंत्रकों के साथ विस्तारित करने में सक्षम होना चाहिए।

BMS को BACNET डिवाइस, मोडबस डिवाइस, RS485 डिवाइस को ईथरनेट TCP/IP के माध्यम से प्रोसेस लेवल पर और प्रबंधन स्तर के एकीकरण करने देना चाहिए।

BMS को प्रक्रिया स्तर पर भावी BACNET नियंत्रकों को एकीकृत करने और मौजूदा नियंत्रकों के साथ अंतर-प्रक्रिया संचार प्रदान करने देना चाहिए।

#### **1.9.4 DDC नेटवर्क:**

यह नेटवर्क DDC मॉड्यूल को एक-दूसरे के साथ संवाद करने देगा और उपयोगकर्ता को सभी जुड़े DDC नियंत्रकों के लिए ऑपरेटर टर्मिनल के माध्यम से पहुंच प्रदान करेगा।

एक ही बाड़े (घेरे) के भीतर जहां भी DDC नियंत्रकों इस्तेमाल किया गया है, उन्हें एक दूसरे के साथ BACNET IP / LON के जरिए जुड़ा होना चाहिए।

बिजली चले जाने पर भी डेटा रखा जाना चाहिए। बिजली चले जाने और चरम लोड के कारण डेटा हानि नहीं होनी चाहिए।

एकीकृत परीक्षण और सर्विस फंक्शन के द्वारा सिस्टम की स्थायी स्व-निगरानी सुनिश्चित की जानी चाहिए।

उपयुक्त इंटरफेस और उपयुक्त इन/आउटपुट में सभी विद्युत और यांत्रिक संयंत्रों को एकीकरण करने देने होगा।

#### **1.9.5 पैरामीटर/संरचना और प्रोग्रामिंग के केंद्रीय सेटिंग:**

सभी पैरामीटरों (निर्धारित बिंदु, नियंत्रण एल्गोरिदम, समय, इत्यादि) और संरचना आरेखों (नियंत्रण और इंटरलॉक प्रोग्राम) को डाउनलोड फंक्शन के साथ सिस्टम नियंत्रक से प्रबंधन केंद्र से और/या ऑपरेटर टर्मिनल से निचले स्तर के सिस्टम नियंत्रकों और DDC यूनिटों में दर्ज करने और/या संशोधित करना संभव होना चाहिए। सिस्टम मैनेजर सभी डेटा को केंद्रीकृत रूप से पढ़ने और लिखने में सक्षम होना चाहिए। ग्राफिक और तत्व उन्मुख प्रोग्रामिंग भाषा का उपयोग करके पैरामीटर सेट करना और एप्लिकेशन प्रोग्राम को व्यवस्थित करना संभव होना चाहिए। इस प्रयोजन के लिए ऑपरेशन अभियंता के लिए विशेष रूप से एक अलग PC /सर्वर प्रदान किया जाएगा। इसका किसी भी परिस्थिति में, ऑपरेशन के लिए उपयोग नहीं किया जाएगा।

### 1.9.6 पोर्टेबल ऑपरेटर टर्मिनल (POT):

प्रत्येक DDC नियंत्रक के पास पोर्टेबल ऑपरेटर टर्मिनल (POT) में प्लग करने के लिए एक समर्पित सर्विस पोर्ट होगा। संचार ट्रंक पर किसी एक नियंत्रक को POT को प्लग करके बस पर किसी भी पैरामीटर को पढ़ना, लिखना और परिवर्तित करना संभव होगा। इसके प्रावरों पर म्यूट सुविधा के साथ दृश्य और श्रव्य अलार्म होगा। POT में अन्यत्र उल्लेखित न्यूनतम तीन पासवर्ड स्तर होंगे। POT को जोड़ने के लिए पृथक केबलिंग स्वीकार्य नहीं होगी। किसी भी आउटस्टेशन से स्थानीय रूप से पैरामीटर बदलना POT द्वारा किया जाएगा, जो वास्तव में पोर्टेबल, हैंड हैल्ड होगा ना कि लैपटॉप के माध्यम से।

POT लोनटाक/ BACNET नेटवर्क से जुड़े सभी DDC नियंत्रण मॉड्यूल के पूर्ण संचालन करने देगा। इनमें शामिल कार्य हैं:

- स्वीकृति के साथ अलार्म मॉनिटरिंग और दृश्य और श्रव्य अलार्म संकेत।
- अलार्म और इवेंट के लिए विस्तृत संदेश के साथ पॉप अप विंडो
- अलार्म और इवेंट पूर्ववृत्त
- डेटा बिंदु प्रदर्शन और सभी मापित मान, निर्धारित बिंदु, संयंत्र अवस्थाओं का परिचालन।
- ऑपरेटिंग अवस्थाएं और पैरामीटर
- ग्राफिक आधारित प्रदर्शन और सभी समय सूचियों, अपवाद कैलेंडर का परिचालन।
- ऑनलाइन ट्रेडिंग और हीटिंग वक्र
- संयंत्र में मुख्य मानों के उपयोगकर्ता विशिष्ट विन्यास अवलोकन
- बहु उपयोगकर्ता स्तर पहुंच सुरक्षा

POT में ग्राफिक्स और टैक्स्ट के लिए एक उच्च रिज़ोल्यूशन छह लाइन प्रकाशित डिस्प्ले, ऑपरेशन के लिए कीज़ (चाबियाँ) और एक दृश्य और श्रव्य सामान्य अलार्म संकेत होगा। प्रदर्शित टैक्स्ट जानकारी को 40 अक्षरों तक स्पष्ट पाठ के अंग्रेजी वर्णन के साथ भवन और संयंत्र के लेआउट को प्रतिबिंबित करना चाहिए।

### 1.10 प्रलेखन (दस्तावेज़ीकरण):

इस प्रणावी के स्पष्ट दस्तावेज़ीकरण के लिए, निम्नलिखित दस्तावेज प्रदान किए जाने हैं:

- सिस्टम आरेख
- वायरिंग आरेख
- मापदंडों की सूची

सभी दस्तावेज अंग्रेजी में होंगे। उसी पेज पर अंग्रेजी सहित बहुभाषी दस्तावेज स्वीकार्य नहीं हैं। विक्रेता सिस्टम की सुविधाओं और कार्यों को संचालित, रखरखाव, बढ़ाने या समझने के लिए आवश्यक सभी दस्तावेजों की दस (10) समान प्रतियां प्रदान करेगा। इसमें न्यूनतम शामिल हैं लेकिन इन तक सीमित नहीं हैं:

- हार्डवेयर स्थापना पुस्तिका जिसमें बाह्यरेखा आयाम, उपकरण विनिर्देश, लगाने का विवरण, विद्युत और सिग्नल कनेक्शन के विवरण, वजन, गर्मी भार और सभी उपकरणों के लिए बिजली की आवश्यकताएं शामिल होंगी।
- प्रमुख सिस्टम घटकों, सबसिस्टम, बिजली की आपूर्ति और मुद्रित सर्किट बोर्ड, कार्ड, और खरीदी गई वस्तुओं सहित मॉड्यूल के लिए सभी उपकरणों की कीमतों के साथ पार्ट्स की सूची।

रखरखाव मैनुअल जिसमें शामिल हैं:

- परिचालन सिद्धांत
- सभी इनपुट/आउटपुट मॉड्यूल के ब्लॉक स्कीमैटिक्स सहित सभी आवश्यक योजनाएं।
- समस्या हल के लिए रखरखाव निर्देश, नियमित समायोजन और निवारक रखरखाव प्रक्रिया, असेम्बली और डिसेम्बली निर्देश, ऑन और ऑफ लाइन परीक्षण प्रक्रियाओं और सिस्टम की स्थापना के लिए अन्य सभी जानकारी।
- सभी घटकों, वर्कस्टेशन, प्रिंटर, नियंत्रक, डेटा अधिग्रहण उपकरणों आदि के लिए ऑपरेटिंग निर्देश और उपकरण उपयोगकर्ता मैनुअल।

- इस विनिर्देश द्वारा आवश्यक सभी I/O, नियंत्रण, तर्क और निष्पादन के मानक विन्यास कार्यों को कवर करने वाले विन्यास निर्देश।
- हार्डवेयर तकनीकी विवरण नियमावली
- सिस्टम विन्यास डायग्राम, ब्लॉक आरेख में नाम और (वर्ग) मॉडल संख्याओं के साथ सभी उप-प्रणालियों की पहचान करते हुए।
  - रिक्त प्रकार प्रोग्रामिंग शीट भरें।
  - प्रोग्राम डिस्क
  - प्रोग्राम लिस्टिंग
  - निम्न के लिए निर्मित ड्रॉइंग
    - कैबिनेट की समग्र आम असेम्बली
    - आंतरिक लेआउट
    - आंतरिक वायरिंग योजनाएं
    - कार्ड असाइनमेंट के साथ I/O लिस्टिंग।
    - केबल और समापन सहित सभी क्षेत्र संशोधन।
  - ग्राफिक्स, ओवरव्यू आदि जैसे सभी ऑपरेटर इंटरफेस स्क्रीन की हार्ड कॉपी।
  - अलार्म असाइनमेंट।
  - एन्कोडिंग जानकारी के साथ सीरियल डेटा लिंक लिस्टिंग।
  - उचित अनुक्रमण के साथ सॉफ्ट कॉपी में सभी अनुप्रयोग इंजीनियरिंग दस्तावेज।

- रिले और अलार्म के लिए विभिन्न सेटिंग्स सहित सभी विन्यास (प्रदर्श) और अलार्म प्रदर्श की हार्ड और सॉफ्ट प्रतियां।

सौंपते समय, सभी दस्तावेजों को अद्यतन होना चाहिए और चालू होने की तिथि के साथ प्रदान किये जाने चाहिए।

### 1.11 सेवाएं:

आवश्यक सेवाओं का प्रकार और दायरा नीचे वर्णित है।

इंजीनियरिंग, कमीशनिंग और समायोजन की दरों में सभी संयंत्रों के इष्टतम संचालन को सुनिश्चित करने के लिए आवश्यक सभी सेवाएं शामिल होनी चाहिए।

### 1.12 इंजीनियरिंग/योजना:

आवश्यक, पूर्ण प्रलेखन के अलावा, सेवा में शामिल होना चाहिए:

- ठेकेदार के साथ सभी कार्यों का विश्लेषण
- उपकरणों के कनेक्शन की शर्तों के बारे में बाध्यकारी जानकारी
- ठेकेदार और डिजाइन इंजीनियर के साथ समयबद्धता और समन्वय

### 1.13 कमीशनिंग/समायोजन:

फंक्शन-उन्मुख कमीशन में निम्नलिखित सेवाएं शामिल हैं, जिन्हें BMS विशेषज्ञ द्वारा प्रदान किया जाना है:

- उपकरणों के बाहरी कनेक्शन का सत्यापन
- सिस्टम के डेटा ट्रांसफर चैनलों का सत्यापन।
- उपकरणों से जुड़े सभी बुनियादी और उपयोगकर्ता प्रोग्राम की लोडिंग और परीक्षण

- नियंत्रण मानकों का अनुकूलन।

## 1.14 विद्युत और विद्युत संबंधित उपकरण:

### 1.14.1 परिवेश स्थितियां:

सभी नियंत्रण 0-40 डिग्री सेल्सियस और 90% RH गैर-संघनक के बीच परिवेशी स्थितियों में कार्य करने में सक्षम होंगे।

### 1.14.2 परिरक्षण और वायरिंग:

कंड्यूट (20 या 25 मिमी व्यास) को बिछाने और फिक्सिंग से पहले, ठेकेदार सावधानीपूर्वक लेआउट को इंगित करने वाली ड्रॉइंग की जांच करेगा, कंड्यूट की संख्या और आकार की पर्याप्तता कंड्यूट के आकार और स्थान और अन्य प्रासंगिक विवरणों के बारे में खुद को संतुष्ट करेगा। ड्रॉइंग में कोई भी विसंगति पाए जाने पर, उसे प्रभारी-अभियंता के ध्यान में लाया जाएगा। कंड्यूट को वास्तविक रूप से बिछाना शुरू करने से पहले ठेकेदार द्वारा सुझाए गए संशोधनों को प्रभारी-अभियंता द्वारा अनुमोदित किया जाएगा।

### 1.14.3 कंड्यूट/ट्रंकर:

कंड्यूट और अन्य सामान प्रासंगिक भारतीय मानक के अनुरूप होंगे।

मात्रा अनुसूची में निर्दिष्ट के अनुसार आवश्यक व्यास के PVC कंड्यूट का उपयोग किया जाएगा। कंड्यूट और सहायक उपकरण के बीच जोड़ों को आसंजक की मदद से अच्छी तरह से चिपकाया जाएगा। कंड्यूट को मूल बंडलों में निर्माण स्थल पर लाया जाएगा और कंड्यूट की प्रत्येक लंबाई पर निर्माता का लेबल होगा।

### 1.14.4 कनेक्शन:

सभी जॉइंटिंग पद्धतियां प्रभारी-अभियंता द्वारा अनुमोदित की जाएंगी। सभी विद्युत तारों के लिए अलग-अलग कंड्यूट चलेगा। चूड़ियों और सॉकेट में तेल और ग्रीस नहीं होगा। कंड्यूट और नियंत्रक धातु के बक्से के बीच कनेक्शन बॉक्स के अंदर लगे पीतल के षट्भुज चिकने बोअर बुश के माध्यम से होगा, और कंड्यूट के लिए एक युग्मक के माध्यम से जुड़ा होगा। कंड्यूट

में जोड़ चिकने रहेंगे ताकि कंड्यूट में से खींचते समय कंडक्टर के इन्सुलेशन को नुकसान नहीं हो।

#### 1.14.5 कंड्यूट में बैंड:

जहां आवश्यक हो, पर्याप्त और उपयुक्त इनलेट और आउटलेट स्कू ज्वाइंट से बैंड और/या वृत्ताकार निरीक्षण बक्से के माध्यम से बैंड या मोड़ हासिल किया जाएगा। रिसेस प्रणाली के मामले में प्रत्येक जंक्शन बॉक्स के अच्छी तरह से कवर लगाया जाएगा और फिनिश दीवार की सतह के साथ फ्लश किया जाएगा। किसी भी बैंड की त्रिज्या कंड्यूट के बाहरी व्यास की 2-1/2 गुणा से कम नहीं होगी।

#### 1.14.6 संकेत सह संचार केबलिंग:

संकेत केबल निम्नलिखित विनिर्देशों का होगा:

ए. तार: अनीलित टिन्ड तांबा

बी. आकार: 1.5 वर्ग मिमी, 7 लड़

सी. कंडक्टर की संख्या: दो (एक जोड़ी)

डी. परिरक्षण: समग्र ब्लेड फॉइल एल्यूमिनियम पॉलिएस्टर शील्ड

ई. जैकेट: क्रोम PVC

एफ. अंकित DCR: कंडक्टर के लिए 17.6 ohm/km और शील्ड के लिए 57.0 ohm/km

जी. अंकित OD: 8.5 मिमी

एच. अंकित धारिता: 1 KHz पर कंडक्टर के बीच 130 pF/m. एक कंडक्टर और शील्ड से जुड़े अन्य कंडक्टर के बीच 180 pF/m.

आई. रंग: काला और लाल



#### 1.14.7 संचार केबलिंग:

संचार केबल निम्नलिखित विनिर्देशों का होगा:

ए) तार: अनीलित टिन्ड तांबा

बी) आकार: न्यूनतम 24 AWG लड़

सी) कंडक्टर की संख्या: एक जोड़ी (2 कंडक्टर)

डी) परिरक्षण: समग्र ब्लेड फॉइल एल्यूमिनियम पॉलिएस्टर शील्ड

ई) जैकेट: क्रोम PVC

एफ) अंकित DC प्रतिरोध: कंडक्टर के लिए 78.7 ohm/km और शील्ड के लिए 55.8ohm/km

जी) अंकित OD: 5.64 मिमी

एच) अंकित धारिता: 1 KHz पर कंडक्टर के बीच 131 pF/m. एक कंडक्टर और शील्ड से जुड़े अन्य कंडक्टर के बीच 243 pF/m.

आई) रंग: काला और लाल, काला और सफेद

#### 1.15 सहायक आइटम:

नीचे सूचीबद्ध स्थितियों में उपकरण के आइटमों को लगाया जाए तो BMS /कंट्रोल विशेषज्ञ द्वारा निम्नलिखित अनुषंगी वस्तुओं को शामिल किया जाएगा:

### 1.15.1 मौसम संरक्षण:

खुले वातावरण में लगे सभी उपकरणों को मौसमरोधी होना चाहिए। सभी नियंत्रण, बाह्य उपकरणों और चिलर से संबंधित सामान, छत पर लगी एयर हैंडलिंग यूनिट और अन्य उपकरण जो खुले में हैं, उन्हें धूल, वर्षा और सौर विकिरण से संरक्षित किया जाएगा। MEP ठेकेदार द्वारा पर्याप्त सुरक्षा शेड आदि प्रदान किये जाएंगे।

### 1.15.2 पाइप कार्य का निमज्जन:

डिवाइस की पूरी सक्रिय लंबाई के लिए उपयुक्त लंबाई के जंगरोधी पॉकेट, तापमान, दाब और मध्यम के लिए उपयुक्त 12 मिमी या 18 मिमी ब्रिटिश मानक पाइप थ्रेड (BSPT)।

### 1.15.3 डक्ट माउंटिंग (धातु या बिल्डर कार्य):

डिवाइस के लिए जरूरी माउंटिंग फ्लैज, क्लैपिंग बुश, कपलिंग, लॉक नट, गॉस्केट, ब्रेकट, सीलिंग ग्लैंड और कोई विशेष फिटिंग ठेकेदार द्वारा प्रदान की जाएगी।

### 1.15.4 नमूने:

सभी प्रकार के कमरे में लगे उपकरण के नमूने (यानी डिटेक्टर, थर्मोस्टेट आदि) BMS /नियंत्रण विशेषज्ञ द्वारा सलाहकार/अभियंता द्वारा अनुमोदन के लिए प्रदान किए जाएंगे।

### 1.15.5 शुद्धता:

नियंत्रण और मापन उपकरणों की सटीकता की निम्नलिखित सीमाएं होंगी:

तापमान:  $0^{\circ}\text{C}$  से  $50^{\circ}\text{C}$  की रेंज पर  $\pm 0.5^{\circ}\text{C}$

दाब: मापित मान का  $\pm 1.5\%$

आर्द्रता: 10 से 90% RH की रेंज पर  $\pm 2$  से 5% RH

### 1.16 औसत तत्व:

औसतन तत्वों का इस्तेमाल  $1.6\text{m}^2$  से अधिक के अनुप्रस्थ-काट क्षेत्र वाले वायु आपूर्ति डक्ट पर किया जाएगा और इसमें केशिका की न्यूनतम लंबाई 8.2 मीटर होगी।

केशिका ऐलीमेंट (तत्व) पूरे नलिका में सपाट हो जाएगा।

जहां तत्व की विस्तृति 1 m से कम है, वहां उसे इस उद्देश्य के लिए बनाए गए क्लिप से लगाया जाएगा और डक्ट में बेसहारा हो सकता है।

जहां तत्व की विस्तृति 1 m से अधिक है, वहां उसे यूनिस्ट्रूट या समान कठोर आधार पर आधारित किया जाना चाहिए। तत्व पर प्रत्येक 200 मीटर पर क्लिप लगाया जाएगा और तत्व के कंपन को रोकने के लिए आधार और हैंगर पर्याप्त होंगे।

#### **1.16.1 एयर सिस्टम के लिए दाब स्विच:**

एयर सिस्टम के लिए दाब स्विच डायफ्राम संचालित होंगे। स्विच की आपूर्ति वायु कनेक्शन के साथ की जाएगी ताकि उनका उपयोग स्थैतिक या अंतर दाब स्विच के रूप में किया जा सके।

डक्ट के कनेक्शन के लिए स्विच ट्यूब और धातु बैंड को जोड़ने के साथ अंतर दाब प्रकार के साथ परिपूर्ण होगा। हाउसिंग की रेटिंग IP54 होगी। दाब स्विच एयरफ्लो प्रूविंग, गंदे फिल्टर, आदि जैसे अनुप्रयोगों के लिए उपयुक्त न्यूनतम 3 श्रेणियों में उपलब्ध होंगे। निर्धारित बिंदु छुपा हुआ प्रकार होगा। संपर्क 250 V AC, 1A रेटिंग के साथ SPDT प्रकार होगा।

ये दीवारों पर लगाने या किसी भी समतल में डक्ट पर लगाने लायक होंगे। इसे इस तरह से माउंट किया जाना चाहिए ताकि संघनन सेंसिंग टिप्स से बाहर बह सके। केबल के लिए उचित अनुकूलक प्रदान किया जाएगा।

निर्धारित बिंदु को पैमाना सीमा के 40% -70% के भीतर आना होगा।

10% -30% से अधिक की पैमाना सीमा पर विभेदी समायोज्य हो सकते हैं।

#### **1.16.2 वायु प्रवाह स्विच:**

एयरफ्लो स्विच का चयन सही वायु वेग, डक्ट के आकार और माउंटिंग ऊंचाई के लिए किया जाएगा।

मोटर कंट्रोल पैनल उपकरण अनुसूची में विशेष वायुमंडलीय स्थितियों का विवरण दिया गया हो, वहां स्विच के कुछ हिस्सों को उपयुक्त तरीके से लेपित किया जाएगा या ऐसी स्थिति का

सामना करने लायक बनाया जाएगा। मानक से कोई भिन्नता होने पर उसका विवरण निविदा में दिया जाएगा।

किसी भी समतल में माउंट करने के लिए उपयुक्त होगा।

### **1.16.3 जल प्रवाह स्विच:**

जल प्रवाह स्विच का चयन सही जल वेग और पाइप आकार और माउंटिंग ऊंचाई के लिए किया जाएगा।

### **1.16.4 सामान्य तापमान/आर्द्रता डिटेक्टर:**

तापमान संवेदक में इस तरह की संवेदनशीलताएं होंगी कि स्थिर अवस्था से 0.2 deg C के डिटेक्टर (संसूचक) पर बदलाव सुधारात्मक तत्व को मापने के लिए पर्याप्त होगा।

तापमान सेंसर सकारात्मक तापमान गुणांक वाले सिलिकॉन सेंसर के साथ होगा। खुले केबल का उपयोग करके आधार प्लेट तक संवेदक के क्षेत्र वायरिंग की जाएगी। संवेदक हाउसिंग को आधार में प्लग किया जाएगा ताकि उन्हें वायरिंग कनेक्शनों को बाधित किए बिना आसानी से निकाल सकें। सुरक्षा मानक IEC 144, DIN 40050 के अनुसार IP30 होगा। इन्हें आम तौर पर फर्श स्तर से 1.5 मीटर ऊपर रखा जाना चाहिए। उन्हें ताप स्रोतों जैसे खिड़कियां, बिजली के उपकरण आदि के पास नहीं लगाया जाना चाहिए। अंतिम स्थान परामर्श इंजीनियरों की स्वीकृति के अनुसार होगा। सेंसर 0°C से 50°C तक रैखिक होगा।

यह अतिरिक्त-कम वोल्टेज पर काम करेगा और ब्रिटिश मानक कंड्यूट बक्से पर माउन्ट करने के लिए उपयुक्त होगा।

नमी संवेदक एक स्वतंत्र हाउसिंग में होगा या आम हाउसिंग में कक्ष/डक्ट प्रकार के तापमान संवेदक के साथ जोड़ा जाएगा। सेंसर को कैपेसिटिव सेंसिंग तत्व के साथ इलेक्ट्रॉनिक प्रकार का होना चाहिए। इसकी न्यूनतम रेंज 10 से 90% RH होगी।

### 1.16.5 निमज्जन/तापमान डिटेक्टर और डक्ट माउन्ट तापमान/आर्द्रता डिटेक्टर:

तापमान संवेदक में इस तरह की संवेदनशीलताएं होंगी वे स्थिर स्थितियों से क्रमशः 0.3°C और 0.2°C के लिए डिटेक्टर पर बदल जाती हैं, जो सुधारात्मक तत्व का मिलान शुरू करने के लिए पर्याप्त हैं।

नमी संवेदक एक स्वतंत्र हाउसिंग में होगा या आम हाउसिंग में कक्ष/डक्ट प्रकार के तापमान संवेदक के साथ जोड़ा जाएगा। सेंसर को कैपेसिटिव सेंसिंग तत्व के साथ इलेक्ट्रॉनिक प्रकार होना चाहिए। इसकी न्यूनतम रेंज 10 से 90% RH होगी।

तापमान सेंसर सकारात्मक तापमान गुणांक वाले सिलिकॉन सेंसर के साथ होगा। खुले केबल का उपयोग करके आधार प्लेट तक संवेदक के क्षेत्र वायरिंग की जाएगी। संवेदक हाउसिंग को आधार में प्लग किया जाएगा ताकि उन्हें वायरिंग कनेक्शनों को बाधित किए बिना आसानी से निकाल सकें। सुरक्षा मानक IEC 144, DIN 40050 के अनुसार IP43 होगा।

आसान स्थापना और रखरखाव के लिए वायरिंग टर्मिनल प्लग-इन प्रकार के होंगे। विशेषज्ञ नियंत्रण आपूर्तिकर्ता द्वारा दिए गए दिशानिर्देशों के आधार पर संवेदक को डक्ट में रखा जाएगा। सेंसर 0°C से 50°C तक पर रैखिक होगा।

### 1.16.6 दाब डिटेक्टर (तरल पदार्थ और गैसीय मीडिया के लिए):

दाब डिटेक्टर मध्यम और कार्य तापमान और दाब के लिए उपयुक्त होंगे। दाब डिटेक्टर कार्य दाब से 2 गुना हाइड्रोलिक परीक्षण दाब को बर्दाश्त करने में सक्षम होगा। कनेक्शन 12mm to 3mm o.d. तांबे की नली के लिए उपयुक्त होंगे।

डक्टवर्क वर्जनों को उनके कनेक्शन को स्थिर या विभेदक दाब डिटेक्टरों के रूप में उपयोग करने के लिए एयर कनेक्शन प्रदान किया जाएगा।

निर्धारित बिंदु को डिटेक्टर की संवेदनशीलता सीमा के 40% -70% के भीतर आना होगा।

तापमान संवेदक में इस तरह की संवेदनशीलता होगी कि स्थिर अवस्था में 1.5% के परिवर्तन से सुधारात्मक तत्व का माडुलन हो जाए।

स्थिर दाब संवेदक की रेटिंग IP 65 होगी और विभेदी दाब संवेदक न्यूनतम IP 54 होगा।

संचालन सिद्धांत हॉल-इफेक्ट ट्रांसड्यूसर पर आधारित होना चाहिए। डायफ्राम तांबा बेनिलियम प्रकार का होना चाहिए।

सेंसर को  $-10$  से  $70^{\circ}\text{C}$  के मध्यम तापमान के लिए प्रतिपूर्ति की जानी चाहिए, जिसमें परिवेशी  $25$  से  $60^{\circ}\text{C}$  के बीच हो।

#### **1.16.7 वायु दाब सेंसर:**

दाब संवेदक विभेदी प्रकार का होगा। निर्माण स्प्रिंग भरा डायफ्राम प्रकार का होगा। दाब के संबंध में झिल्ली के संचालन को प्रेरक युग्मन के द्वारा परिवर्तित किया जाना चाहिए, जो विद्युत्चुंबकीय रूप से नियंत्रक के लिए उपयुक्त आउटपुट देगा। दाब संवेदक IEC 529 के अनुसार IP 54 रेटिंग वाली हाउसिंग में होगा। सेंसर पर उपयुक्त माउन्टिंग व्यवस्था उपलब्ध होगी। संवेदक PVC ट्यूब, प्रोब, आदि के साथ परिपूर्ण होगा।

#### **1.16.8 एकचुएटर:**

निर्माताओं की सिफारिशों के अनुसार स्थापित किया जाएगा।

उनके पास संतुलन दाब के अधिकतम से बाहर निकलने के लिए वाल्व और डैम्पर को खोलने और बंद करने के लिए पर्याप्त टॉर्क होगा।

#### **ए. नियंत्रण डैम्पर एकचुएटर:**

कंट्रोल डैम्पर एकचुएटर उस प्रकार का होगा जहां स्पैन्डेपल एकचुएटर से गुजरता है और U क्लैप द्वारा गाड़ा जाएगा।

परियोजना पर रोटरी टाइप डैम्पर एकचुएटर का इस्तेमाल किया जाएगा। एकचुएटर को किसी रखरखाव की आवश्यकता नहीं होगी। विभिन्न आकारों के डैम्पर को संचालित करने के लिए एकचुएटर में पर्याप्त टॉर्क रेटिंग होगी।

यह दस्तावेज में कहीं और निर्दिष्ट जैसे स्प्रिंग रिटर्न संस्करणों में उपलब्ध होना चाहिए। यदि आवश्यक/विनिर्दिष्ट है तो सीमा स्विच प्रदान किए जाएंगे।

एकचुएटर ऑन/ऑफ के लिए और आपरेशन व्यवस्थित करने के लिए उपयुक्त होंगे।

## बी. एकचुएटर की अतिरिक्त सुविधाएं:

एकचुएटर की अतिरिक्त सुविधाओं की आवश्यकता तब होती है, जब मोटर कंट्रोल पैनल उपकरण अनुसूचियों या विशिष्टता के निष्पादन खंड में विवरण दिया गया हो।

## सी. सहायक स्विच:

ऑन/ऑफ अनुप्रयोगों के लिए, एकचुएटर में 220 V AC, 2 Amp रेटिंग के लिए उपयुक्त परिवर्तन संपर्क होंगे।

सहायक स्विच पैक में कम से कम एक होगा, यदि दो निर्दिष्ट किया गया हो, तो मोटर चालन के प्रत्येक छोर के लिए विद्युत स्वतंत्र रूप से एक-एक स्विच, कम-से-कम आधा मोटर चालन से ऑपरेशन के लिए समायोज्य होगा।

## डी. प्रतिक्रिया संकेत:

समानांतर ऑपरेशन के लिए या फीडबैक के रूप में मॉड्यूलन डैम्पर एकचुएटर से 0 से 10 V DC या 4-20 mA संकेत उपलब्ध होने चाहिए। कृपया जहां भी कहा गया हो, इस सुविधा को शामिल करने के लिए डेटा बिंदु अनुसूची/संचालन अनुक्रम /ड्रॉइंग को देखें।

### 1.16.9 नियंत्रण वाल्व (मॉड्यूलन):

#### ए. सामान्य:

4 से कम या उसके बराबर Kv वाले सभी नियंत्रण वाल्व में RG5 गनमेटल/लाल कांसे की बॉडी होगी। एकचुएटर PWM या 0-10v dc या 4-20 mA मॉड्युलेटिंग मोटर प्रकार या 3 बिंदु प्रतिवर्ती मोटर टाइप होंगे। PWM एकचुएटर का उपयोग इन-बिल्ट PID एल्गोरिदम वाले नियंत्रकों के साथ संयोजन में किया जाएगा।

Kv = 6.3 के साथ नियंत्रण वाल्व में RG5 गनमेटल/लाल कांसे की बॉडी होगी। एकचुएटर 3 बिंदु प्रतिवर्ती मोटर टाइप या 0-10v dc या 4-20 mA मॉड्युलेटिंग मोटर प्रकार के होंगे। एकचुएटर में मैनुअल ओवरराइड हाथ-पहिया होगा।

Kv >6.3 के साथ नियंत्रण वाल्व RG5 गनमेटल/ CI के होंगे। एकचुएटर 3 प्वाइंट चुंबकीय/या 0-10v dc मॉड्युलेटिंग मोटर प्रकार के होंगे। एकचुएटर में मैनुअल ओवरराइड हाथ-पहिया होगा।

40 मिमी तक के वाल्व 16 bar के अंकित दाब रेटिंग वाले होंगे। 50 मिमी और उससे अधिक वाले वाल्व को 10 bar के अंकित दाब के लिए रेट किया जाएगा, बशर्ते सिस्टम का ऑपरेटिंग दाब 6 bar से अधिक न हो। 100 मिमी के ऊपर वाल्व को 16 bar के अंकित दाब के लिए रेट किया जाएगा और इन वाल्वों के लिए एकचुएटर 0-10v DC or 4-20 mA मॉड्यूलेटिंग सिग्नल पर काम करने वाले चुंबकीय/इलेक्ट्रो-हाइड्रोलिक/मोटर वाले होंगे। 100 मिमी व्यास और ऊपर वाले वाल्वों के लिए एकचुएटर में स्प्रिंग रिटर्न फीचर और मैनुअल ओवरराइड हैंड-व्हील होगा।

15 मिमी और उससे ऊपर के सभी वाल्वों में रेंजक्षमता > 100 होगी।

#### **बी. प्राधिकरण:**

सभी 3 पोर्ट मॉडुलन वाल्वों को 0.4 और 0.68 के बीच एक प्राधिकरण बनाने के लिए चुना जाएगा।

2 पोर्ट मॉडुलन वाल्वों का इस्तेमाल करने वाले सिस्टम के लिए, MEP ठेकेदार नियंत्रण सप्लायर को सूचकांक सर्किट में दाब पात, जिस पर पंप शीर्ष की गणना की गई थी, पंप शीर्ष की गणना, परियोजना के लिए आदेशित पंप का डिजाइन शीर्ष, प्रणाली पर उपलब्ध दाब और प्रत्येक AHU / FCU के प्रत्येक शाखा सर्किट पर नोडल दाब जैसे विवरण प्रस्तुत करेगा।

इन आंकड़ों के आधार पर, नियंत्रण आपूर्तिकर्ता वाल्व चयन के लिए कार्य सिद्धांत प्रस्तुत करेगा।

#### **सी. तितली वाल्व:**

तितली वाल्व नियंत्रण निर्माता द्वारा या कंसल्टेंट/इंजीनियर द्वारा अनुमोदित विकल्प के द्वारा निर्मित किया जाएगा।

#### **1.16.10 अधिवास डिटेक्टर:**

कमरे में प्रकाश उपकरण और VAV बॉक्स के नियंत्रण के लिए अधिवास डिटेक्टर को माइक्रोप्रोसेसर आधारित निष्क्रिय इन्फ्रारेड डिटेक्टर होना चाहिए। डिटेक्टर 230 V AC पर काम करेगा और अधिकतम ऊर्जा बचत और मांग आधारित नियंत्रण के लिए प्रकाश और VAV बॉक्स के नियंत्रण के लिए 230 V AC पर 2 amps के न्यूनतम रेटिंग के विभव मुक्त उत्पादन देगा। इसमें न्यूनतम 0 से 300 सेकंड के विलंब पर एक समायोज्य स्विच होना



चाहिए और एक समायोज्य स्विच को न्यूनतम 0.5 से 30 मिनट की देरी पर होना चाहिए। डिटेक्टर को 6 X 12 मीटर का न्यूनतम क्षेत्र कवर करना चाहिए। डिटेक्टर को चल अवरक्त स्रोत का पता लगाने में सक्षम होना चाहिए। इसे सुस्त श्रमिकों के निम्न स्तर का पता लगाने के लिए अनुकूलित किया जाना चाहिए। डिटेक्टर में 50 सेंटीमीटर भौतिक संचालन की न्यूनतम संवेदनशीलता होनी चाहिए। डिटेक्टर CE अनुरूपता के साथ न्यूनतम IP50 होना चाहिए।

#### 1.16.11 BTU मीटर:

उपरोक्त मीटर में प्रयुक्त फ्लो मीटर अल्ट्रासोनिक सिद्धांत के आधार पर होना चाहिए, जिसमें कोई चल पुर्जे नहीं होने चाहिए। उपरोक्त मीटर में उपयोग किए जाने वाले तापमान सेंसर में 0.1 डिग्री सेल्सियस के विभेदन के साथ 0 से 130 डिग्री सेल्सियस की माप सीमा होती है। BTU मीटर में पैरामीटर, मान और खराबी के प्रदर्शन के लिए न्यूनतम 8-अंकीय LCD डिस्प्ले निर्मित होना चाहिए। मीटर BMS प्रणाली के साथ संगत होना चाहिए। BTU मीटर द्वारा प्रदान किए जाने वाले न्यूनतम कार्य निम्नानुसार हैं:

- अधिकतम मानों की गणना और संग्रहण
- बिलिंग डेटा का संग्रहण
- टैरिफ आश्रित डेटा का मापन
- EPROM में 13 मासिक संचयी ऊर्जा/वॉल्यूम मानों का संग्रहण।
- खराबियों का पता लगाना
- मानों, मानकों और खराबियों का प्रदर्शन
- डिस्प्ले का चयन योग्य दायरा
- टेस्ट और सर्विस फंक्शन

BTU मीटर में प्रत्येक 3 सेकंड के प्रवाह और तापमान 24 सेकंड के लिए न्यूनतम नमूना समय होना चाहिए। संभावित डिस्प्ले में kWh, MWh, GJ, MJ, kW, m<sup>3</sup>, m<sup>3</sup>/hr, h और deg C दर्शाना चाहिए। ताप मीटर में CE अनुरूपता के साथ क्लास 2 की न्यूनतम सटीकता होनी चाहिए।

### 1.17 DDC पैनल:

DDC नियंत्रकों को रखने वाले आउट-स्टेशन पैनल वातानुकूलित क्षेत्र के अंदर स्थित होंगे। यह सुनिश्चित करने के लिए उचित देखभाल की जाएगी कि नियंत्रण और बिजली के केबल के बीच कोई प्रेरण समस्या नहीं है। ये पैनल IP54 होंगे और विशेषज्ञ नियंत्रण आपूर्तिकर्ता द्वारा इनकी आपूर्ति की जाएगी।

इन आउट-स्टेशन पैनलों के अंदर स्थित DDC नियंत्रक इन DDC नियंत्रकों से जुड़े विभिन्न उपकरणों के लिए आवश्यक संकेत प्रदान करेंगे। DDC नियंत्रक मोटर नियंत्रण केंद्रों से वाल्ट मुक्त संपर्कों के रूप में डिजिटल इनपुट संकेतों को स्वीकार करने में सक्षम होंगे। ठेकेदार इस गतिविधि का समन्वय करेगा।

इन सभी आउटस्टेशनों को संचार बस केबल से जोड़ा जाएगा और BMS सेंट्रल स्टेशन पर समाप्त कर दिया जाएगा। BMS आपूर्तिकर्ता इन बस केबल की आपूर्ति करेगा।

इन पैनलों में से किसी से कनेक्ट होने के लिए पोर्टेबल हैंड हैल्ड टर्मिनल को कनेक्ट करना संभव होना चाहिए और उसी बस के किसी भी अन्य DDC नियंत्रकों से बात करना संभव होना चाहिए।

### 1.18 प्रशिक्षण:

सभी प्रशिक्षण BMS ठेकेदार द्वारा दिए जाएंगे और निर्दिष्ट मैनुअल और यथासंभव दस्तावेज का उपयोग करेंगे।

ऑपरेटर प्रशिक्षण में शामिल होंगे

- कुल टैक्स्ट और ग्राफिक्स को संशोधित करना
- कुल संचालन समीक्षा का अनुक्रम
- सभी डिस्प्ले और रिपोर्ट का कुल चयन
- सभी विशिष्ट OS फ़ंक्शंस का कुल उपयोग
- पोर्टेबल ऑपरेटर के टर्मिनलों का कुल उपयोग
- सेंसर की कुल समस्या का हल (खराब सेंसर का निर्धारण)

- कुल पासवर्ड असाइनमेंट और संशोधन
- 10 इंजीनियरों/तकनीशियनों/ऑपरेटर इंजीनियरों को DDC के संचालन, संरचना और रखरखाव से संबंधित प्रशिक्षण लेने की आवश्यकता है।
- हार्डवेयर और सॉफ्टवेयर बग दोनों को हल करने के लिए प्रशिक्षण की आवश्यकता है।

प्रशिक्षण दो या अधिक चरणों में दिया जाएगा। एक प्रशिक्षण सत्र सिस्टम पूरा होने पर आयोजित किया जाएगा, और दूसरा उपयोगकर्ता की सुविधा के अनुसार सिस्टम पूरा होने के पैंतालीस दिनों के भीतर आयोजित किया जाएगा। उपयोगकर्ता प्रोग्रामिंग और रखरखाव सहित उपरोक्त सभी कार्यों का पूरा ज्ञान होना चाहिए।

### 1.19 वारंटी:

BMS ठेकेदार द्वारा आपूर्ति किए गए सभी घटक, सिस्टम सॉफ्टवेयर, पार्ट्स और असेंबलियों को स्वीकृति की तिथि से दो साल तक सामग्री और कारीगरी में खराबियों के प्रति गारंटी दी जाएगी।

BMS ठेकेदार द्वारा वारंटी अवधि के दौरान विभाग को निशुल्क समस्या निवारण, मरम्मत, रिप्रोग्राम किया जाएगा या सिस्टम घटकों को बदला जाएगा।

वारंटी सेवा अवधि के दौरान किए गए सभी सुधारात्मक सॉफ्टवेयर संशोधनों को सभी उपयोगकर्ता दस्तावेज और उपयोगकर्ता और निर्माता संग्रहित सॉफ्टवेयर डिस्क पर अद्यतन किया जाएगा।

चिलर संयोजन के लिए चिलर प्रबंधन सॉफ्टवेयर/लॉजिक के लिए दिशानिर्देश:

1. सॉफ्टवेयर पृथक या चिलर पैकेज के संयोजन को तय करेगा जिसमें एयर कंडीशनिंग सिस्टम के लिए न्यूनतम किलोवाट प्रति TR की आवश्यकता होगी। इस उद्देश्य के लिए चिलर निर्माता का डेटा इस्तेमाल किया जाएगा। चिलर, पंपों, कूलिंग टावर, AHU, पैक यूनिट और पंखा कॉइल यूनिट का डेटा स्क्रीन पर निर्दिष्ट करने के लिए ऑपरेटर द्वारा की जाने वाली मरम्मत/समस्या हल/रखरखाव कार्य के लिए उपयोग किया जाएगा।

2. एसी प्लांट को 'चालू' करते समय, चिलर पैकेज को पहले 'चालू' होना होगा जो कम देर तक चलता है (कई कंप्रेसर चिलर पैकेज के मामले में, कंप्रेसर जो कम से कम घंटे चला हो

वह पहले 'चालू' हो)। अन्य चिलर पैकेज/कंप्रेसर को चलने के घंटों के आरोहण क्रम में 'चालू' होंगे, भले ही यह एकल या एकाधिक कंप्रेसर प्रकार के चिलर पैकेज हों।

3. चिलर के बीच लोड साझा करना संभव होना चाहिए। यदि यह बहु कंप्रेसर प्रकार का है, यदि एक कंप्रेसर में 80% से अधिक लोड ले रहा है, तो चिलर पैकेज अगले कम घंटे चले कंप्रेसर को कॉल करेगा और ये दोनों कंप्रेसर लोड को मिलकर साझा करेंगे, जो 80% से अधिक है। यदि कुल भार दो कंप्रेसर द्वारा संभाले जाने से अधिक है (यानी, पूरी स्थिति में प्रत्येक कंप्रेसर पर 80% भार फैक्टर है), तो चिलर पैकेज के तीसरे कंप्रेसर को 'चालू' होना चाहिए और सभी तीन कंप्रेसर मिलकर भार साझा करेंगे। लोड साझा करते समय, प्रत्येक कंप्रेसर को शुरू में 80% तक लोड किया जाएगा, फिर कुल मांग के आधार पर, अलग-अलग कंप्रेसर पर समान लोडिंग कारक का निर्णय लिया जाएगा और चरण में नीचे लाया जाएगा।

**नोट:** उपरोक्त को प्राप्त करने के लिए, DDC प्रणाली को पूरे चिलर सिस्टम के लिए रन टाइम समकारी करने का अनुमान किया जा सकता है, लेकिन बहु-कंप्रेसर चिलर पैकेज के मामले में, ऐसी प्रणाली के भीतर DDC द्वारा एक से अधिक कंप्रेसर चिलर पैकेज को चालू होने के लिए आदेश देने पर चिलर में निर्मित नियंत्रण कंप्रेसर के बीच रन टाइम समकारी के लिए प्रावधान होना चाहिए। वैकल्पिक रूप से, कई चिलर पैकेजों को DDC से अलग-अलग कंप्रेसर चालू करने के लिए एक्सेस होना चाहिए (अलग-अलग कंप्रेसर के लिए स्विचिंग कमांड स्वीकार करने और DDC को काम करने वाले कंप्यूटरों की संख्या के बारे में फ़ीडबैक देने के लिए)।

4. कम उपयोग अवधि के दौरान, यानि शाम 7 और सुबह 7 (12 घंटों) के बीच और सर्दियों के मौसम के दौरान, सॉफ्टवेयर में लोड किए प्रोफाइल के अनुसार न्यूनतम kW प्रति TR की खपत करने वाले चिलर पैकेज को प्राथमिकता दी जाएगी। किसी भी कारण से, अगर किसी खास प्रकार के चिलर पैकेज को संचालित नहीं किया जा सकता हो, तो किसी भी अन्य काम करने वाले चिलर पैकेज को चालू रखने के लिए ओवरराइड होना चाहिए।

5. रन टाइम समकारी, लोड साझा करने, अनुक्रमण और स्थानीय बिजली बोर्ड या DG स्रोत के माध्यम से दिन, माह और वर्ष भर उपलब्ध बिजली की आपूर्ति का उपयोग करने के लिए के चलाने के समय, समानांतर, के लिए पृथक चिलर पैकेज या संयोजन स्वचालित रूप से सॉफ्टवेयर द्वारा निर्णय लिया जाएगा। ओवरराइड/उपयोगकर्ता परिभाषित ऑपरेशन मोड हमेशा

किसी भी परिस्थिति से उबरने के लिए और संयंत्र प्रभारी के विवेक को सक्षम करने के लिए उपलब्ध होगा।

6. केंद्रीय चिलर प्रणाली सॉफ्टवेयर के साथ-साथ DDC में लगे सॉफ्टवेयर को किसी भी चिलर पैकेज के रूप में स्टैन्डबाय के रूप में नामांकित करने की सुविधा प्रदान करनी होगी उपरोक्त पैराग्राफ में वर्णित लोड साझा करने, अनुक्रमण और रन टाइम समकारी की सुविधा प्रदान करने के अलावा चिलर स्क्रीन पर उपयुक्त चयन या पोर्टेबल ऑपरेटर टर्मिनल (POT) के माध्यम से प्रदान करनी होगी।

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एयर कंडीशनिंग और वेंटिलेशन  
कार्यों के लिए विनिर्देश

खंड - **XV**

संपीड़ित वायु प्रणाली

## 1. संपीड़ित वायु सुविधा

### 1.1 एयर कंप्रेसर:

कंप्रेसर का प्रकार: एकल चरण रोटरी स्कू एयर कंप्रेसर- उच्च कुशल धुरी हवा सिरे  $\eta-v$  प्रोफाइल रोटर के साथ एयर कूल्ड टाइप।

मुक्त वायु प्रदाय और संचालन दाब: निविदा अनुसूची में निर्दिष्ट के अनुसार।

मोटर - F-श्रेणी इन्सुलेशन के साथ पिंजरी मोटर जिसके साथ स्टार-डेल्टा स्टार्टर और 415 V, +/- 10% और 50 Hz +/- 6% पर परिचालन के लिए उपयुक्त सुरक्षा और +/- 10% की संयुक्त विविधताएं, 3 फेज AC आपूर्ति और पावर फैक्टरी संवर्धन कैपेसिटर के साथ प्रदान की जाएगी।

वायु की गुणवत्ता: - सूखी हवा, तेल मुक्त

एयर कंप्रेसर साइलेंसर के साथ सूखे प्रकार के सक्शन एयर इनलेट फ़िल्टर के साथ परिपूर्ण होगा जिसमें रखरखाव और बदलने के लिए प्रावधान, एकीकृत विनियमन वाल्व के साथ लोड/अनलोड नियंत्रण प्रणाली के लिए यथावश्यक अन-लोडर और थ्री-वे सोलनॉइड वाल्व के साथ परिपूर्ण होगा।

वायु/तेल तापमान सेंसर आउटलेट तापमान को भांप लेता है और सुरक्षा सुविधा के रूप में शट डाउन कंप्रेसर को शामिल किया जाएगा।

### 1.2 वायु/तेल पृथकन प्रणाली:

1. बेस फ्रेम पर लगे osbic सिद्धांत को प्राप्त करने वाला टैंक।
2. तेल भरने वाला पोर्ट
3. वाल्व के साथ तेल निकास

4. दाब निर्मुक्ति वाल्व
5. तेल साइट ग्लास
6. स्पिन-ऑन वायु-तेल पृथकन तत्व
7. दीर्घ काल के लिए हवा के सिरे से रिसीवर टैंक तक गैर अनमनीय संबंध।
8. न्यूनतम दाब वाल्व
9. तीन-चरण वायु तेल पृथकन प्रणाली
  - पहला चक्रवाती क्रिया से (अपकेन्द्री)
  - दूसरा गुरुत्वाकर्षण द्वारा (भारी कण नीचे बैठ जाते हैं)
  - तीसरा संलयक फिल्टर के माध्यम से गुजारकर।

### 1.3 एयर इनलेट सिस्टम:

1. पूर्व-फिल्टर इनलेट सिस्टम को साफ हवा प्रदान करेगा।
2. एयर-फिल्टर हाउसिंग में निम्नलिखित विशेषताएं हैं:
3. 99% दक्षता के साथ 5-5 माइक्रोन के ट्विन पेपर तत्व
4. प्लास्टिक अवरोधक
5. सर्विस सूचक- फिल्टर सेवा की आवश्यकता का संकेत
6. एयर फिल्टर को इनटेक वाल्व को जोड़ने के लिए रबड़ कपलिंग।

### 1.4 शीतन प्रणाली:

1. एयर और तेल कूलर स्वतंत्र हैं और निम्न के लिए कॉम्पैक्ट ब्लॉक कूलर हैं:



- अधिकतम ताप अंतरण

- निम्न दाब पात

- कम वजन

2. कम अभिगम तापमान के लिए उच्च दक्षता पश्च कूलर।

3. चिकनाई वाले तेल को छानने के लिए हवा तेल मैनिफोल्ड ब्लॉक पर लगा तेल फिल्टर।

4. सिस्टम के भीतर तेल तापमान को नियंत्रित करने के लिए थर्मोस्टाटिक वाल्व।

5. प्रभावी शीतन के लिए पंखा मोटर के साथ शीतक पंखा।

### 1.5 स्नेहन प्रणाली:

1. 10-माइक्रोन रेटिंग के साथ उच्च क्षमता स्पिन-ऑन फिल्टर एलिमेंट।

2. पृथकन टैंक से हवा के सिरे तक तेल वापसी लाइन।

3. स्थायित्व के लिए कठोर पाइप कनेक्शन।

### 1.6 विद्युत और नियंत्रण पैनल:

इसमें निम्नलिखित शामिल होना चाहिए:

- कनेक्टर, रिले, एकल फेज निवारक आदि के साथ उपयुक्त स्टार डेल्टा स्टार्टर आवश्यकतानुसार परिपूर्ण।

- आपातकालीन सटॉप बटन

नियंत्रण पैनल में एयर-लॉजिक शामिल है, जो निम्नलिखित कार्य करता है:

- लोड-अनलोड कंट्रोल
- सटीक दाब नियंत्रण
- प्रोग्राम शुरू करना रोकना
- दोहरी दाब बैंड सेटिंग
- बहु-तर्क नियंत्रण
- मल्टी मोड नियंत्रण (स्थानीय/रिमोट/लैन)
- इंटेलिजेंट शटडाउन संरक्षण
- रखरखाव काउंटडाउन फ़ंक्शंस

की (कुंजी):

- प्रारंभ
- रुकें
- रद्द करें
- मान्य करें
- 4 कुंजी के साथ नेविगेशन

प्रकाशित संकेत:

- बिजली की आपूर्ति संकेत
- स्वचालित फ़ंक्शन मोड
- त्रुटि

कंप्रेसर चेतावनी और बंद होने के संकेत:

- आपातकालीन बंद
- एलिमेंट आउटलेट तापमान
- मुख्य मोटर अधिभार
- चरण अनुक्रम

- रिवर्स रोटेशन
- सामान्य खराबी संकेत

### 1.7 ध्वानिक चंदवा और ड्राइव व्यवस्था:

- एयर कंप्रेसर के लिए घेरे को रखरखाव के लिए लैच के साथ सर्विस दरवाजे के साथ पाउडर कोटिंग के साथ फिनिश किया जाएगा। शोर स्तर को सीमित करने के लिए चंदवा को ध्वानिक अवशोषित सामग्री के साथ उपचार किया जाएगा।
- चंदवा को दबाया जाता है ताकि यह सुनिश्चित किया जा सके कि चूषण फिल्टर पर कोई दाब नहीं है और एलीमेंट को धूल कणों के प्रवेश से बचाता है।
- विद्युत मोटर और कंप्रेसर यूनिट के लिए सहारे के लिए प्रतिकंपन माउंट किया जाता है और बाकी संरचना से चल घटक को अलग किया जाता है जिससे ध्वनि और कंपन अंतरण कम किया जाता है।

### 1.8 एयर रिसीवर:

निविदा अनुसूची में दर्शायी क्षमता का क्षैतिज या ऊर्ध्वाधर प्रकार का एयर रिसीवर जो 10 kg/cm<sup>2</sup> कार्यकारी दाब को झेलने के लिए उपयुक्त हो और उसके साथ इन/आउट फ्लैज कनेक्शन, दाब गेज, सुरक्षा वाल्व, मैनुअल निकासी कोक जैसी सभी सहायक उपकरण हो। एयर रिसीवर IS:2825 के अनुरूप होगा जिसके साथ वेल्डेड आधार स्टैंड के साथ IS:2062 सामग्री का होगा।

### 1.9 फिल्टर सेट:

फिल्टर सेट परियोजना आवश्यकता के अनुसार निविदा अनुसूची में बताए अनुसार होंगे। आवश्यकता के आधार पर, फिल्टर निम्न विनिर्देशों के अनुरूप होंगे:

1. ग्रेड PF फिल्टर तरल पानी और तेल में मिले 1 माइक्रोन (1 ppm) तक के कणों को निकालने के लिए उच्च दक्षता सामान्य प्रयोजन संरक्षण फिल्टर होंगे, जिन्हें 21 ° C पर 0.5 mg/m<sup>3</sup> की अधिकतम शेष ऐरोसोल मात्रा प्रदान करने होंगे।

2. ग्रेड PF फिल्टर पानी और तेल ऐरोसोल सहित 0.01 माइक्रोन (0.01 ppm) तक के कणों को निकालने के लिए उच्च दक्षता के तेल हटाने वाले फिल्टर होंगे, जिन्हें 21 ° C पर 0.01 mg/m<sup>3</sup> की अधिकतम शेष तेल ऐरोसोल मात्रा प्रदान करने होंगे।

3. ग्रेड CF फिल्टर तेल वाष्प और हाइड्रोकार्बन गंध को हटाने के लिए उच्च दक्षता वाले तेल हटाने वाले फिल्टर होंगे जिन्हें 21 ° C पर < 0.003 mg/m<sup>3</sup> की अधिकतम तेल मात्रा प्रदान करनी होगी।

### 1.10 स्टेनलेस स्टील पाइपिंग:

अल्ट्रा फिल्टर सेट बिंदु से विभिन्न उपयोगकर्ता के बिंदुओं तक संपीड़ित वायु की अनुप्रयोग पाइपिंग के लिए स्टेनलेस स्टील पाइपिंग ड्राइंग में दर्शाए अनुसार होगी। संपीड़ित हवा के अनुप्रयोग के लिए उपयुक्त स्टेनलेस स्टील पाइपिंग की आपूर्ति, निर्माण, स्थापना और बिछाना है। पाइप लाइन का 16 kg/cm का कार्य दाब झेलना होगा।

पाइप लाइन को आवश्यक विशेष चीजों जैसे फ्लैज, बेंड, टी, कनेक्टर के साथ प्रदान करना होगा और लैब के अंदर यूजर पॉइंट पर नियंत्रण वाल्व के साथ समाप्त करने के लिए उपयुक्त होना चाहिए। संपीड़ित हवा लाइन को आवश्यक क्लैम्प और सपोर्ट दीवार के साथ/फाल्स सीलिंग के ऊपर / फाल्स फर्श के नीचे /खाइयों से होते हुए जाना होगा। पाइपिंग को मौजूदा संपीड़ित हवा लाइन से जोड़ा जाएगा और सभी कार्य निष्पादित होंगे और प्रभारी- अभियंता के निर्देशन के अनुसार किए जाएंगे। लाइनें स्टेनलेस स्टील 304, Sch 40 ग्रेड की होंगी जिसके साथ आवश्यक विशेष चीजें जैसे एल्बो, बेंड, टी, फ्लैज, पृथकन वाल्व, क्लैम्प आदि होंगे। लाइन को ड्राइंग में दिखे अनुसार दीवार के साथ/फाल्स सीलिंग के ऊपर / फाल्स फर्श के नीचे /खाइयों से होते हुए जाना होगा।

पाइप लाइन पर प्राइमर कोट पर नीले रंग के दो कोट लगाने होंगे जिस पर काले रंग में तीर संकेतों के साथ चित्रित किया जाएगा और प्रभारी- अभियंता के निर्देशन के अनुसार परिपूर्ण किया जाएगा।

### 1.11 अल्ट्रा फिल्टर सेट:

आवश्यक क्षमता और रेटेड दाब के संपीड़ित हवा अनुप्रयोग के लिए अल्ट्रा फिल्टर सेट, जैसा

SOQ में दर्शाया गया है। फ़िल्टर सेट में सभी आवश्यक कनेक्शन के साथ कार्बन फिल्टर, पूर्व फिल्टर, फाइन फिल्टर और माइक्रो फिल्टर शामिल होंगे और आवश्यकतानुसार परिपूर्ण होंगे।

अंत कनेक्शन बाईपास व्यवस्था के साथ उपयुक्त व्यास वाली SS304 पाइपिंग का होगा। 16bar कार्याकारी दाब के साथ अनुमोदित कंपनी के उपयुक्त तितली वाल्वों को इनलेट, आउटलेट और फिल्टर बाईपास सर्किट में आपूर्ति और स्थापित किया जाएगा। दरों में SS एल्बो, SS टेबल E फ़्लैज, सपोर्ट, क्लैंप, रेड ऑक्साइड प्राइमर पर सिंथेटिक इनेमल पेंटिंग आदि जैसे विशेष चीजों की लागत शामिल होगी।

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एयर कंडीशनिंग और वेंटिलेशन  
कार्य के लिए विनिर्देश

खंड - XVI

IS कोड एवं ASHRAE मानक

## प्रशीतन और एयर कंडीशनिंग के लिए IS कोड

1. IS 655: 2006 (पुनः पुष्टि 2017): एयर डक्ट-विनिर्देश।
2. IS 659: 1964 (पुनः पुष्टि 2017): वातानुकूलन के लिए सुरक्षा कोड।
3. IS 660: 1963 (पुनः पुष्टि 2017): यांत्रिक प्रशीतन के लिए सुरक्षा कोड।
4. IS/ISO 817: 2005 (पुनः पुष्टि 2013): रेफ्रिजरेट - पदनाम प्रणाली।
5. IS 1391: भाग 1: 1992 (पुनः पुष्टि 2009): कमरे में एयर कंडीशनर - विनिर्देश - भाग 1: ऐकिक एयर कंडीशनर
6. IS 1391: भाग 2: 1992 (पुनः पुष्टि 2013): कक्ष एयर कंडीशनर: भाग 2 स्प्लिट एयर कंडीशनर।
7. IS 1474: 1959 (पुनः पुष्टि 2009): वाणिज्यिक रेफ्रिजरेटर।
8. IS 1475: भाग 1: 2001 (पुनः पुष्टि 2017): स्व-निहित पेयजल कूलर - विनिर्देश - भाग 1: ऊर्जा की खपत और निष्पादन।
9. IS 1476: भाग 1: 2000 (पुनः पुष्टि 2016): घरेलू रेफ्रिजरेटिंग उपकरण का निष्पादन - कम या बिना तापमान खाने वाले रेफ्रिजरेटर - भाग 1: ऊर्जा की खपत और निष्पादन।
10. IS 1869: 1961 (पुनः पुष्टि 2017): बर्फ के डिब्बे के लिए विनिर्देश।
11. IS 2167: 1983 (पुनः पुष्टि 2017): बोतल कूलर के लिए विनिर्देशन।
12. IS 2370: 2014: वॉक-इन ठंडे कमरे - विनिर्देश।
13. IS 2374: 1963 (पुनः पुष्टि 2017): आइस टैंक के लिए विनिर्देश।
14. IS 3315: 1994 (पुनः पुष्टि 2009): वाष्पीकरण वायु कूलर (डेजर्ट कूलर) - विनिर्देश।
15. IS 3615: 2007: रेफ्रिजरेशन और एयर कंडीशनिंग में इस्तेमाल किए जाने वाले शब्दों की शब्दावली।
16. IS 4831: 1968 (पुनः पुष्टि 2017): प्रशीतन के लिए यूनिट और प्रतीकों की सिफारिश।
17. IS 5038: 1969 (पुनः पुष्टि 2017): घरेलू रेफ्रिजरेटर के लिए आइस क्यूब ट्रे के लिए विनिर्देश।
18. IS 5111: 1993 (पुनः पुष्टि 2009): प्रशीतक कंप्रेसर का परीक्षण।
19. IS 7613: 1975 (पुनः पुष्टि 2017): एयर कंडीशनिंग और वेंटिलेशन प्रयोजनों के लिए पैनलवाले एयर फिल्टर परीक्षण करने की विधि।
20. IS 7872: 1975 (पुनः पुष्टि 2017): फ्रीजर के लिए विनिर्देश।

21. IS 7896: 2001 (पुनः पुष्टि 2017): भारतीय शहरों के लिए एयर कंडीशनिंग के लिए बाहरी डिजाइन की स्थितियां।
22. IS 8148: 2003 (पुनः पुष्टि 2009): पैक एयर कंडीशनर - विनिर्देश।
23. IS 9210: 1979 (पुनः पुष्टि 2017): प्रदर्श कैबिनेट के लिए विनिर्देश।
24. IS 10594: 1983 (पुनः पुष्टि 2017): थर्मोस्टैटिक एक्सपेंसन वाल्व के लिए विनिर्देश।
25. IS 10617: 2013: हर्मेटिक कंप्रेसर।
26. IS 11327: 2007: रेफ्रिजरेट संघनन यूनिट के लिए आवश्यकताएं।
27. IS 11328: 1985 (पुनः पुष्टि 2017): स्व-निहित स्वचालित आइस मेकर के लिए विनिर्देश।
28. IS 11329: 1985 (पुनः पुष्टि 2017): कक्ष एयर कंडीशनर के लिए पंख प्रकार के हीट एक्सचेंजर के लिए विनिर्देश।
29. IS 11330: 1985 (पुनः पुष्टि 2017): प्रशीतन तेल विभाजक के लिए विनिर्देश।
30. IS 11338: 1985 (पुनः पुष्टि 2009): रेफ्रिजरेटर, एयर कंडीशनर, वॉटर कूलर और बेवरेज कूलर में उपयोग के लिए थर्मोस्टेट के लिए विनिर्देश।
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32. IS 11951: 2009: डेज़र्ट कूलर के लिए पंप सेट।
33. IS 12249: 1987 (पुनः पुष्टि 2017): डेसीकेंट ड्रायर के लिए विनिर्देश।
34. IS/ISO 13261: भाग 1: 1998 (पुनः पुष्टि 2017): एयरकंडिशनिंग और वायु-स्रोत हीट पंप ध्वनि पावर रेटिंग। भाग 1 गैर-डक्ट वाले आउटडोर उपकरण।
35. IS 15750: 2006 (पुनः पुष्टि 2017): घरेलू फ्रॉस्ट-फ्री रेफ्रिजरिंग उपकरण - आंतरिक प्रबलित हवा परिसंचरण द्वारा शीतित रेफ्रिजरेटर - विशेषताएं और परीक्षण विधियां - विनिर्देश।



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1. मानक 15-2013, प्रशीतन प्रणालियों के लिए सुरक्षा मानक (पैकेज w/मानक 34-2013, रेफ्रिजरेंट के नाम और वर्गीकरण)
2. मानक 16-1983 (RA 2014), कक्ष एयर कंडीशनर और पैकेज टर्मिनल एयर कंडीशनर के लिए रेटिंग की परीक्षण की विधि
3. मानक 17-2015, तापस्थैतिक प्रशीतक विस्तार वाल्वों की परीक्षण क्षमता की विधि
4. मानक 18-2008 (RA 2013), स्व-निहित मैकेनिकल प्रशीतन के साथ पेयजल कूलर के लिए रेटिंग परीक्षण के तरीके
5. मानक 20-1997 (RA 2006), रिमोट मैकेनिकल - ड्राफ्ट एयर कूल्ड प्रशीतक कंडेंसर की रेटिंग के लिए परीक्षण की विधि
6. मानक 22-2014, वॉटर कूल्ड प्रशीतक कंडेंसर की रेटिंग के लिए परीक्षण की विधि
7. मानक 23.1-2010, सकारात्मक विस्थापन रेफ्रिजरेंट कंप्रेसर और कंडेन्सिंग यूनिट के निष्पादन की रेटिंग के लिए परीक्षण की विधि जो उप-क्रांतिक तापमान पर काम करते हैं
8. मानक 23.2-2014, सकारात्मक विस्थापन कंप्रेसर के निष्पादन की रेटिंग के लिए परीक्षण विधि जो रेफ्रिजरेंट के अति-क्रांतिक दाब पर काम करते हैं
9. मानक 24-2013, रेटिंग तरल कूलर की रेटिंग के लिए परीक्षण विधि
10. मानक 25-2001 (RA 2006), प्रशीतन के लिए कृत्रिम संवहन और प्राकृतिक संवहन एयर कूलर परीक्षण विधि
11. मानक 26-2010, जहाज पर यांत्रिक प्रशीतन और एयर कंडीशनिंग स्थापना
12. मानक 28-1996 (RA 2010), रेफ्रिजरेंट केशिका ट्यूब की प्रवाह क्षमता की परीक्षण विधि

13. मानक 29-2015, स्वचालित आइस मेकर की परीक्षण की विधि
14. मानक 30-1995, तरल-चिलिंग पैकेजिंग की परीक्षण की विधि
15. मानक 32.1-2010, बोटलबंद, डिब्बाबंद और अन्य सीलबंद पेय पदार्थ के लिए वेंडिंग मशीनों की रेटिंग के लिए परीक्षण विधि
16. मानक 32.2 2003 (RA 2011), टेस्टिंग प्री-मिक्स और पोस्ट-मिक्स पेय डिस्पेंसिंग उपकरण की रेटिंग के लिए परीक्षण विधि
17. मानक 33-2000, जबरन परिसंचरण एयर कूलिंग और वायु तापन कोइल की परीक्षण विधि
18. मानक 34-2013, रेफ्रिजरेट के पदनाम और सुरक्षा वर्गीकरण (पैक w /मानक 15-2013, रेफ्रिजेशन सिस्टम के लिए सुरक्षा मानक)
19. मानक 35-2014, रेफ्रिजरेट सुखाने के लिए शुष्ककों की परीक्षण विधि
20. मानक 37-2009, इलेक्ट्रॉनिक चालित ऐकिक एयर कंडीशनिंग और हीट पम्प उपकरण की रेटिंग के लिए परीक्षण विधि
21. मानक 40-2014, ताप-संचालित ऐकिक की रेटिंग के लिए परीक्षण विधि
22. एयर कंडीशनिंग और हीट-पम्प उपकरण
23. मानक 41.1-2013, फ्लो मीटर का उपयोग करते हुए वाष्पशील रेफ्रिजेंट द्रव्यमान मापन के लिए मानक विधि
24. मानक 41.2-1987 (RA 1992), प्रयोगशाला वायुप्रवाह मापन के लिए मानक विधि
25. मानक 41.3-2014, दाब मापन के लिए मानक विधि
26. मानक 41.4-2015, तरल प्रशीतक में स्नेहक के अनुपात को मापने के लिए मानक विधि
27. मानक 41.6-2014, नम हवा के गुणों के मापन के लिए मानक विधि
28. मानक 41.7-2015, गैस के प्रवाह के मापन के लिए परीक्षण विधि
29. मानक 41.8-1989, छिद्रित फ्लोमीटर का उपयोग करके पाइपों में तरल प्रवाह के मापन की मानक विधि

30. मानक 41.9-2011, वाष्पशील रेफ्रिजरेट के द्रव्यमान प्रवाह मापन के लिए कैलोरीमीटर परीक्षण विधि
31. मानक 41.10-2013, फ्लोमीटर का उपयोग करके वाष्पशील रेफ्रिजेंट द्रव्यमान प्रवाह मापन के लिए मानक विधि
32. मानक 41.11-2014, फ्लोमीटर का उपयोग करके वाष्पशील रेफ्रिजेंट द्रव्यमान प्रवाह मापन के लिए मानक विधि
33. मानक 51-2007, एरोडायनमिक निष्पादन रेटिंग के लिए पंखों के परीक्षण के लिए प्रयोगशाला विधि
34. मानक 52.2-2012, सामान्य वेंटिलेशन के परीक्षण की विधि कण आकार द्वारा निकालना क्षमता के लिए वायु-शोधन उपकरण
35. मानक 55-2013, मानव अधिवास के लिए ताप पर्यावरण स्थितियां
36. मानक 58-1986 (RA 2014), रूम एयर कंडीशनर और पैकेज टर्मिनल एयर कंडीशनर ताप क्षमता के लिए की रेटिंग की परीक्षण विधि
37. मानक 62.1-2010, स्वीकार्य इंडोर वायु गुणवत्ता के लिए वेंटिलेशन
38. मानक 90.1-2013 परिशिष्ट G: निष्पादन रेटिंग विधि (ANSI/ASHRAE/IES मानक 90.1-2013 I-P से अंश)
39. मानक 62.1-2013, स्वीकार्य इंडोर वायु गुणवत्ता के लिए वेंटिलेशन
40. मानक 62.2-2013, लो-राइज़ आवासीय भवनों में वेंटिलेशन और स्वीकार्य इंडोर वायु गुणवत्ता
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42. मानक 63.2-1996 (RA 2010), तरल लाइन फिल्टर शुष्कक निस्स्यंदन क्षमता की परीक्षण विधि
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