##### ANNEXURE - 1

**CSMVS**

**Proposed Buddhist Art Gallery and Mumbai Gallery**

**Mumbai**

**TENDER**

##### FOR

**HVAC INSTALLATION**



***122-123, SAI COMMERCIAL BUILDING,***

***GOVANDI STATION ROAD,***

***DEONAR, MUMBAI – 400 088.***

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#

# **1201 TENDER DETAILS**

**1.0 SCOPE**

1.1 The scope under this section covers the general details and conditions applicable on this contract and listed below:

**2.0 PROJECT DETAILS**

2.1 The details of project and the contract are as indicated in the following sections.

 1) Project : Proposed Buddhist Art Gallery and

 Mumbai Gallery

 2) Site Location : Mumbai

 3) Client : CSMVS

**2.2 Scope of work**

1. Work : HVAC System

**2.3 Contract Details**

 1) Type : Works Contract

 2) Rate : Fixed Item Rate

 3) Quantity : Measurable as per BOQ

 4) Quantity Variation : +/- 20 % of Total Contract Value

 5) Rate Validity : Entire contract period

 6) Offer Validity : 30 days

 7) Offer Value : Based on tender quantity and

 rate offered

 8) Contract Value : Based on tender quantity and

 rate agreed up on

 9) Final Contract Value : Based on quantity executed and

 rates agreed upon

**3.0 Programme Schedule**

 1) Issue of tender : October 12, 2022

1. Submission of tender : October 18, 2022

 3) Award of work : October 21, 2022

 4) Commencement of work : October 24, 2022

 5) Completion of work : December 05, 2022

 6) Testing & Commissioning : December 06, 2022

 7) Liquidated Damage : 0.5% per week of delay

 Max. to 10% of contract value

**4.0 Material Delivery**

 1) Location : Site

 2) Freight & Insurance : Inclusive

 3) Loading and Unloading : Inclusive

**5.0 Insurance**

 1) Material : Inclusive

 2) Workmen : Inclusive

 3) Third Party : Rs.50,000 per occurrence

 subject to 3 such incidence.

**6.0 Guarantee**

 1) Validity : 24 months after handing over

 2) Servicing : Free of cost including spare

 parts during guarantee

 3) Downtime Period : 24 Hrs

 4) Penalty for delay : As per liquidated damage

**7.0 Terms of Payment**

 1) Advance : 20% contract value against

 Bank guarantee

1. Delivery : 50% - Prorata

 3) Erection : 20% - Prorata

 4) Commissioning : 5%

 5) Retention : 5% after defects liability of

 One year against BG

**8.0 Approvals**

 1) Statutory Approval : By contractor

 2) Liaison work with authorities : By contractor

 3) Compliance with local codes

 and Regulation : By contractor

**9.0 Site Facilities**

 1) Power Supply : Free at one point

 any extension by contractor

 2) Water Supply : Free at one point, any

 extension by contractor

 3) Storage : Covered Space by Client, Partition, doors & security by contractor

 4) Security : By contractor till the installation is taken over by clients

# **1202. DELIVERY AND COMPLETION**

**1.0 SCOPE**

1.1 The scope under this section shall cover the schedule of completion proposed for the entire installation.

1.2 The actual schedule shall be worked out in co-ordination with the civil construction activity and the programme schedule of the site in charge.

**2.0 SCHEDULE OF COMPLETION**

2.1 The proposed delivery and completion period shall be as shown in Tender Details. The contractor shall furnish detailed delivery and completion schedule within 7 days of LOI.

# **2101 GUIDE LINES**

**1.0** **SCOPE**

1.1 The scope of this section covers guidelines for the contractor on the specification and schedule of material and the general requirements.

**2.0** **SCOPE OF CONTRACT**

2.1 The scope of work under this contract covers of equipment, material, accessories and labour required for the specified works and to carry out the erection as specified and shown on the drawing and schedule of material.

2.2 Safety, good workmanship and quality are the prime requisites of the work covered under this contract. All the equipments, material and the workcarriedout shall meet the relevant codes, specification and the intents ofspecifications and the proper functioning of the systems and installationand shall be in correct lines, levels etc.

**3.0 MATERIAL**

3.1 The equipments and material shall meet the specifications and requirements indicated in the technical specifications covered under specific section and the relevant equipment data.

3.2 The Makes of material shall be one of the recommended makes covered under Section 2104 Makes of material.

**4.0 SPECIFICATION**

4.1 The technical specification attached herewith gives general guidelines and minimum standards for equipments material and workmanship. However it is the responsibility of the contractor to meet the statutory provision and local codes.

**5.0 SCHEDULE OF WORK**

5.1 The schedule of work shall be as indicates the items of work estimated at the time of preparation of this tender. The quantities have to be worked out by the contractor based on Good for Construction drawings issued with the tender.

**6.0 STANDARDS & REGULATIONS**

6.1 Each section indicates the Indian Standard Specification to be followed. It is the responsibility of the contractor to meet the statutory regulation local codes and other relevant standards and specifications connected to the work being carried out.

**7.0 INSPECTION & TESTING**

7.1 The Consultants/Clients have the right to inspect the plants, equipments and materials at manufacturer's work or at site at any stage and reject the materials that is substandard or does not meet the requirements of the specification and codes.

7.2 The contractor shall provide at his cost at site and elsewhere instruments and appliances for testing and equipments and installation at various stages of manufacturing/installation. These instruments shall be got tested and calibrated for their accuracy and performance from the approved institutions.

7.3 The inspection and testing carried out by the Consultants/Clients/Third party does not relieve the contractor of their responsibility of carrying out routine inspection during each stage of procurement, manufacture and installation and also meeting the intents and requirements of the specification and statutory requirements.

7.4 All equipments and the installation to be tested in the presence of the Consultants/Clients after carrying out necessary rectification, adjustments and balancing. Four sets of test readings should conform to the specification, equipment data, standards and codes.

**8.0 TRAINING**

8.1 The operating staff of the clients shall be trained free of cost for the operation, maintenance overhauling etc. of the equipments and installation.

**9.0 STATUTORY INSPECTION**

9.1 The contractor shall be fully responsible for meeting all the statutory obligations and local inspectorates pertaining to the works carried out by them. The contractor should prepare all working drawings and obtain approval of competent authorities and also have the equipment and installation inspected and got approved.

 All official fees will be paid by the clients directly against demand in writing from the appropriate authorities and all other expenses for submission and approval of the various relevant statutory bodies shall be embodied in the tender prices. You shall also do the necessary liaison work with the power supply company on client's behalf.

**10.0 REFERENCE DRAWINGS**

10.1 The drawings issued with the tender and shown in Section 2103 are Good for Construction (GFC) drawings and are part of the tender documents. Contractor shall preserve one set of this drawing in good condition incorporating all modifications carried out from time to time during the erection period at the site and shall return them to the Consultants/Clients after completion of the work.

**11.0 WORKING DRAWINGS**

11.1 Contractor shall prepare execution drawings and got approved by the Consultant before carrying out the execution, modify the drawings, if required, to suit the site conditions and get the approval. The execution drawings shall contain all details.

11.2 The approval of the drawings does not relieve the contractor of their responsibility of meeting the intents and requirements of the specification and statutory requirements.

11.3 The contractor shall submit the followings details within 15 days of award of the contract.

 a) List of equipments and the power output

 b) Foundation drawings and structural support details for equipment to be carried out by the civil contractor.

On completion of the installation, the contractor shall prepare and submit AS EXECUTED drawing incorporating all modification carried out during the execution.

**12.0 PAYMENTS**

12.1 The mode of payment shall be based on the Mile Stone billing schedule as mutually agreed.

**13.0 HANDING OVER**

13.1 The installation shall be handed over after a satisfactory testing along with the following documentation.

1. Two sets of prints of the as installed drawings along with CD.
2. Four sets of test reading and certificate of local authorities.
3. Four sets of detailed equipment data and operation and maintenance manuals.

 d) List of recommended spares.

 e) Performance guarantee in the prescribed form.

13.2 The final acceptance shall be effective only after the submission of the above documents. Final payment will be released only after the handing over and submission of documentation.

**14.0 PERFORMANCE GUARANTEE**

14.1 All equipment and the entire installation shall be guaranteed to yield the specified ratings and design conditions plus/minus 3% tolerance. Any equipment found short of the specified ratings by readings shall be rejected.

# **2102 REFERENCE DRAWING**

**1.0 SCOPE**

1.1 The scope under this section covers the basic drawings and details to understand.

 a) Scope of work

 b) Location of equipments

 c) General idea on the entire installation

 d) Material requirements and labour force required for the completion

 of work in the stipulated time schedule.

1.2 The detailed working drawings and the drawings required for the submission to statutory authorities shall be the responsibility of the contractor. Contractor shall submit the drawings to the Consultants for their scrutiny/approval before issuing to the statutory authorities and site for execution.

**2.0 LIST OF DRAWINGS**

2.1 The following are the list of reference drawings.

|  |  |  |
| --- | --- | --- |
| **NO** | **DRAWING NO.** | **LIST OF DRAWINGS** |
| 1. | 2406-00-51 | FL – 00 Buddhist Art Gallery Layout – HVAC |
| 2. | 2406-01-51 | FL – 01 Mumbai Gallery Layout - HVAC |

**3.0 EXECUTION DRAWINGS**

* 1. Contractor shall prepare shop drawings and equipment foundation drawings and submit for the approval of Consultants before taking up the work. Also they shall submit the panel fabrication drawings for Consultants approval before taking up the panel fabrication.

# **2103 MAKES OF MATERIAL**

1. **SCOPE**

1.1 The scope under this section shall cover the recommended makes of equipments, material components. The final choice of makes shall be indicated at the time of award of work.

1.2 The makes of material and model offered by the contractor shall be indicated at the space provided for proper evaluation of the offer.In the absence of such indication, the decision rests with the Consultants/Clients.

1.3 The client reserve the right to change the make and model of the materials even after awarding the work but before contractor plans order with

**2.0 MAKES RECOMMENDED**

2.1The makes of material recommended are as shown below.

|  |  |  |  |
| --- | --- | --- | --- |
| Sl.no. | Items | Makes Recommended | Makes offered |
| 1.0 | EQUIPMENTS |  |  |
| 1.1 | Refrigeration Equipments |  |  |
| 1.1.1 | VRF units | Daikin, Hitachi, Mitsubishi, Toshiba |  |
| 2.0 | Exhaust / Fresh Air fans | Caryaire, Comferi, Dynaire, Flakt |  |
| 3.0 | Copper pipes | IBP, Rajco, ABC, Champ, Mehta Tubes |  |
| 4.0 | GI sheets | Sail, Tata, Zenco, Jindal |  |
| 5.0 | Dampers | Cosmos, Caryaire,Dynacraft, Rolastar |  |
| 6.0 | Grilles & Diffusers | Caryaire,Dynacraft,Cosmos, Nutech |  |
| 7.0 | Thermal Insulations | Armaflex,Superion,Aeroflex,Polybond |  |
| 8.0 | Acoustic Insulation | Armaflex,Superion,Aeroflex,Polybond |  |
| 10.0 | ELECTRICAL |  |  |
| 10.1 | MCCB / RCCB | Schneider, Legrand, Hager |  |
| 10.2 | SF unit / HRC fuses | Schneider, L&T, ABB |  |
| 10.3 | MCCBs, Starters &Contactors | ABB, Schneider, L&T, Legrand |  |
| 10.4 | Panel fabrication byOEM approvedVendors as per | Marine Electricals, Sterling Generators, Arrow, Manshu Electricals |  |

|  |  |  |  |
| --- | --- | --- | --- |
| Sl.no. | Items | Makes Recommended | Makes offered |
| 11.0 | AUXILIARY EQUIPMENTS |  |  |
| 11.1 | Relays (OL & EF) | Microprocessor based |  |
| 11.2 | PF relay | Ducati, Epcos, Accuver |  |
| 11.3 | Digital programmableTimer | Legrand, Moeller,Schneider, L&T |  |
| 11.4 | Meters | Conserve, L&T, Elmeasure, Socomoc |  |
| 11.5 | Signal lamps | LED lamps |  |
| 11.6 | Push buttons | BCH, Teknic, Rass (L&T) |  |
| 11.7 | Connectors | Wago, Connect-well, Elmex |  |
| 11.8 | Capacitor | Epcos, Vishay, L&T |  |
| 12.0 | CABLING |  |  |
| 12.1 | Cables | Ravin, KEI, Polycab, RR Kable, Finolex |  |
| 12.2 | Glands | Comment, Braco, Dowels,Globex |  |
| 12.3 | Lugs | Dowel, Ismal, Jainson,Globex |  |
| 13.0 | WIRING |  |  |
| 13.1 | PVC conduits &Accessories | Precision |  |
| 13.2 | Wires | RR Kables, KEI, Polycab,Havells |  |
| 13.3 | Switches & Sockets(White) | Northwest Convex, Legrand Arteor, NorisysCube |  |
| 13.4 | GI / MS conduit &Accessories | BEC, Vimco, BI, NIC |  |

**2104 MEASUREMENTS & PAYMENTS**

**1.0 Scope**

1.1 The scope under this section covers the mode of measurements and payments for HVAC System.

1.2 The general requirements, break-up and mode of payment etc. shall be as specified under MEASUREMENTS AND PAYMENTS

**2.0** **Measurements**

|  |  |  |  |
| --- | --- | --- | --- |
| Sl.no | Item | Item Included | Item Excluded |
| **1.0** | **GENERAL FOR ENTIRE WORK** |
| 1.1 | In general the item rates shall include the following unless otherwise specifically indicated in the respective item.a) All supports, hangers, fixing accessories.b) PCC pedestalsc) Anti corrosive treatment for metallic surfaces.d) Anti vibration mounts / pads for required rating for electro mechanical Equipment.e) Electrical motor drive assembly, starters and isolators for electro Mechanical equipment.f) All fittings and accessories of all type suitable for the piping network.g) All fittings and accessories of all type suitable for air distributionNetwork.h) All opening and chasing in brick work including rough finishing. |
| 1.2 | The following items are excluded or measured and paid separately.a) RCC pedestal for heavy equipment and pumps.b) Opening in RCC work.c) Excavation and back filling. |
| **2.0** | **EQUIPMENTS** |  |  |
| 2.1 | General |  |  |
| 2.1.1 | Each equipment assembly shall be measured as one unit and classified based on the type and capacity | Complete factory assembled and tested equipment assembly with all components, accessories, motors, drive assembly, starter and isolator all safety and control instruments and control wiring |  Nil |

|  |  |  |  |
| --- | --- | --- | --- |
| Sl.no | Item | Item Included | Item Excluded |
| 2.2 | Refrigeration Equipment |  |  |
| 2.2.1 | VRF Units |  |  |
| a. | Each VRF condensing unit shall be measured as one unit and classified based on the type and capacity | VRF condensing unit, assembly control (panel ref. net kit etc.) |  Nil |
| b. | Each VRF evaporator shall be measured as one unit and classified based on type, cooling/ heating capacity and dehumidified air quality | Evaporator assembly, control system ref net kit, condensate drain pumps for ceiling and wall mounted units. Chorded control unit for ceiling mounted AHU. | Cordless remote control unit, power outlets for cassette and high wall units |
| c. | Cordless remote control unitEach RCU shall be measured as one unit and shall have, temperature, fan speed and deflector control | Evaporator assembly, control system ref net kit, condensate drain pumps for ceiling and wall mounted units. Remote sensor for ceiling concealed units |  Nil |
| 2.2.2 | Unitary Equipments |  |  |
|  | Each unitary equipment such as split unit, packaged unit, window unit shall be measured as one unit and classified based on the capacity and type of the evaporators | Entire unit including outdoor condensing unit, evaporator chordless remote control 7m length of refrigerant pipes, power and control cabling, excluding window unit | Power outlet  |
| 2.3 | Air Handling Equipment |  |  |
| 2.3.1 | Air Handling Units |  |  |
|  | Each air handling unit shall be measured as one unit and classified based on type cooling / heating capacity and DHA. | Entire AHU assembly with filter, cooling coil and heating coil / electrical heater, wherever, specified. Fan section with motor and drive assembly, power panel and cabling for motor and control system. | Power supply to control panel |
| 2.3.2 | Ventilation Units |  |  |
|  | Each ventilation unit shall be measured as one unit and shall be classified based on the type and air handling capacity | Entire ventilation unit assembly with filter section, fan section, motor and drive assembly, starter and isolator, power cabling | Power input to control panel |

|  |  |  |  |
| --- | --- | --- | --- |
| Sl.no | Item | Item Included | Item Excluded |
| 2.3.3 | Exhaust fans |  |  |
|  | Each exhaust fan shall be measured as one unit and classified based on type, air quantity and static pressure.The fans shall include the following :a) Centrifugal fanb) Axial fanc) Propeller fans with socket & chordd) Inline duct fans with socket  and chorde) Ceiling mounted fan with socket and chord | Fan, motor drive assembly, starter and isolator for (a) & (b) | Power input |
| **3.0** | **REFRIGERANT PIPING & CONTROL CABLING** |  |  |
| 3.1 | VRF System |  |  |
| 3.1.1 | The refrigerant piping shall be measured on the basis of unit length and classified based on size | Supply and return piping with all fittings and accessories, thermal insulation piping trough / tray.  | Ref. net kit |
| 3.1.2 | Ref net kit |  |  |
|  | The ref net kit in the piping main branches shall be measured as one unit. The ref net kit at ODU and individual evaporator shall be part of respective equipment. | Ref net kit | Nil |
| 3.1.3 | Control Cabling |  |  |
|  | The control cabling shall be measured on the basis of unit length. | Control cabling and interconnection and cable tray / trough | Nil |
| 3.2 | Unitary Equipment |  |  |
| 3.2.1 | The refrigerant piping shall be part of the equipment upto 7 m of distance (average) between ODU and evaporator. The excess length of piping shall be measured and paid on the basis of unit length | Supply and return piping with all fittings and accessories, thermal insulation, piping tray /trough | Nil |
| 3.2.2 | Control cabling |  |  |
|  | The control cabling shall be measured on the basis of unit length. | Control cabling and interconnection and cable tray / trough | Nil |

|  |  |  |  |
| --- | --- | --- | --- |
| Sl.no | Item | Item Included | Item Excluded |
| **4.0** | **THERMAL INSULATION** |  |  |
| 4.1 | DUCTS |  |  |
|  | The ducts insulation shall bemeasured on the basis of unit surface area (sq.m.) of the duct insulated and classified based on thicknessof insulation | Insulation,bonding,claddingand fixing material | Nil |
| 4.4 | WALL,FLOORS & CEILING |  |  |
|  | The wall, floors & ceiling thermal insulation shall bemeasured on the basis of the surface area in sq.m ofthe surface insulated andshall be classified on the basis of thickness ofinsulation | Insulation,bonding,cladingand fixing materials andwooden frame work | Nil |
| **5.0** | **AIR DISTRIBUTION** |  |  |
| 5.1 | Ducting work |  |  |
| 5.1.1 | Air distribution ducting shall be measured based on the surface area of the fabricated and erected duct. The ducting shall be classified based on the thickness of GI sheet and the shape of ducting – rectangular, circular, oval, spiral etc. | GI sheet, fabrication, stiffeners, flange connection, guide vanes, splitters, opening for mounting collars, grills and diffusers, dampers etc. supports and hangers  | Volume control dampers, fire damper, thermal and acoustic insulation. |
| 5.2 | Air outlet |  |  |
| 5.2.1 | Each air outlet shall be measured as one unit and shall be classified based on type and air quantity or on cross sectional area in indicated in the BOQ. The air outlet classification shall be modular/ linear grill diffusers, slot diffusers | Air outlet with flanges and collars, volume control damper for supply outlet |  |

|  |  |  |  |
| --- | --- | --- | --- |
| Sl.no | Item | Item Included | Item Excluded |
| 6.0 | ELECTRICAL WORK |  |  |
| 6.1 | POWER PANELS |  |  |
|  | Each power panel shall be measured as one unit | Incoming and outgoingfeeders busbars indicatingand control instrumentsinternal wiring |  Nil |
| 6.2 | CONTROL PANELS |  |  |
|  | The control panels along with the piping and cabling shall form part of the equipment and hence no extra payment shallbe made | Control panel with instruments and indicators,piping and cabling | Remotestart/pushbutton andconnectedcabling |
| 6.3 | POWER CABLING |  |  |
|  | The power cabling shall be measured based onthe basis of unit length ofcable between the lugs at each end termination | Cables, clamps | EndMeasured |
| 6.4 | CABLE END TERMINATION |  |  |
|  | Each cable end terminationshall be measured as one unit | Glands, lugs | Nil |
| 7.0 | MISCELLANEOUS |  |  |
| 7.1 | STRUCTURAL STEEL |  |  |
|  | The structural supports,hangersetc. shall form part of the itemsupported and hence no additional payments applicable | Structural supportsgrouting, red-oxide primer, final painting | Nil |
| 7.2 | CORROSION TREATMENT |  |  |
| 7.2.1 | EXPOSED PIPES |  |  |
|  | The anti-corrosion treatment ofexposed pipe by means of painting shall be part of thepipe cost and hence no additional payments applicable | 2 coats of red oxide primary 2 coats of synthetic enameled paintof approved colour | Nil |
| 7.2.2 | CONCEALED PIPES |  |  |
|  | The anti-corrosion treatment ofUnderground pipes by means ofspecial wrapping shall be measured on the basis of thelength of the pipe treated andshall be classified according tothe size of pipe | Bonding and wrappingMaterial | Nil |

**6.0** **Payments**

6.1 The payment shall be made on the basis of quantities measured and the unit rates accepted.

6.2 The payment shall made according to the stages/terms indicated in general condition of contract.

6.3 Surplus material after the inspection shall be taken back by the contractor. In case the owner intents to take over these material payments shall be made to the contractor at the supply rates/or rate mutually agreed upon.

**2105 CODES AND REGULATIONS**

**1.0 Scope**

1.1 The scope under this section shall cover the basic codes, regulations and standard specifications, but not limited to applicable for the scope of work covered under this tender.

1.2 However, this will not relieve the Contractor of their responsibilities in meeting the requirements of regulations and standards of local authorities.

1.3 The codes and standards indicated shall be latest with all amendments applicable as on date.

**2.0 Publications**

2.1 The codes and regulations applicable are as per the publications issued by the following authorities / institutions.

|  |  |  |
| --- | --- | --- |
| A | API | American Petroleum Institute |
|  | ANSI | American National Standard Institute |
|  | ASTM | American Society of Testing and Materials |
|  | ASHRAE | American Society of Heating, Refrigeration andAirconditioning Engineers |
| B | BSI | British Standard Institute |
|  | BIS | Bureau of Indian Standard |
| C | CIBSE | Chartered Institution of Building Services |
| D | DIN | Deutsches Institute fur Normung (German Standard) |
| E | EN | European National Standards |
| F | EEMUA | Engineering Equipment and Material users Association |
| I | IEC | International Electromechanical Commision |
|  | ISO | International Standard Organisation |
| M | MSS | Manufacturers Standardization Society |
| N | NEC | National Electric Code |
|  | NFPA | National Fire Protection Association |
|  | NEMA | National Electrical Manufacturers Association |
|  | NBCI 2016SP-7 | National Building Code of India |
|  | OSHA | Occupational Safety and Health Administration |
| S | SMACNA | Sheet Metal Airconditioning Contractors National Association |
| U | UBC | Uniform Building Code |
|  | UFC | Uniform Fire Code |
|  | UMC | Uniform Mechanical Code |
|  | UPC | Uniform Plumbing Code |
|  | UL | Underwriters Laboratories |

**3.0 Codes and Regulations**

3.1 The codes, regulations and the standard specification applicable for various equipment, materials, installation and testing and commissioning shall as per the following standards. The international standards shall be applicable wherever relevant Bureau of Indian Standards are not available.

|  |  |  |
| --- | --- | --- |
| a | NBCI | 2016 – SP7 |
| b | ASHRAE 2014 | Refrigerantion |
| c | ASHRAE 2015 | Application |
| d | ASHRAE 2016 | System and Equipments |
| e | ASHRAE 2017 | Fundamentals |

3.2 The relevant Bureau of Indian Standard Specification applicable, but not limited to are as under.

3.2.1 Refrigeration Equipments

|  |  |  |
| --- | --- | --- |
| **No.** | **Standard** | **Specification** |
| a. | BIS : 659 | Safety codes for air conditioning |
| b. | BIS : 660 | Safety codes of mechanical refrigeration |
| c. | BIS : 1391(1992) | Specification of room air condition Part 1 – Unitary Air Condition |
| d. | BIS : 1391(1992) | Specification of room air condition Part 2 – Split Air Condition |
| e. | BIS : 2825 | Code for unfired pressure vessel |
| f. | BIS : 3103 | COP for Industrial Ventilation |
| g. | BIS : 4503 | Shell and tube heat exchangers |
| h. | BIS : 5111 | COP and measurement procedure for testing refrigeration valves |
| i. | BIS : 7896 | Data for outside design condition for air conditioning for summer months |
| j. | BIS : 10123 | Data sheets for shell and tube exchangers |
| k. | BIS : 10594 | Thermostat expansion valves |
| l. | BIS : 10609 | Refrigerant Number Designation |
| m. | BIS : 10617 | Hermetic compressors |
| n. | BIS : 10470 | Air cooled Heat exchangers |
| o. | BIS : 11327 | Requirements for refrigerant condensing unit |
| p. | BIS : 11329 | Finned type heat exchanger for room air conditioner |
| q. | BIS : 11330 | Refrigeration oil separators |

**3.3.2 Air Handling Equipment**

|  |  |  |
| --- | --- | --- |
| **No.** | **Standard** | **Specification** |
| a. | BIS : 374 | Electrical ceiling fan type fan and regulator |
| b. | BIS : 1169 | Electrical pedestal type fans and regulator |
| c. | BIS : 2997 | Air circulator type electrical fan and regulators |
| d. | BIS : 4283 | Hot air fans |
| e. | BIS : 4894 | Centrifugal fans |
| f. | BIS : 8272 | Industrial cooling fans (man collars) |
| g. | BIS : 10470 | Air cooled heat exchanger |
| h. | BIS : EN 779 | Filters |

**3.3.3 Pipes**

**a) MS/GI Pipes**

|  |  |  |
| --- | --- | --- |
| **No.** | **Standard** | **Specification** |
| a. | BIS : 1239 | Mild steel tubes, tubulars and other wrought steel fittings (Part 1 & 2) |
| b. | BIS : 1839 | Malleable iron GI fittings |
| c. | BIS : 2629 | Recommended practice for Hot dip galvanising of iron and steel |
| d. | BIS : 3589 | Electrically welded steel pipes for water gas and sewage (150 mm to 2000 mm nominal size) |
| e. | BIS : 4736 | Hot dip zinc coatings for steel tubes |
| f. | BIS : 6392 | Steel pipe flange |

**b)** **Non Metallic pipes**

|  |  |  |
| --- | --- | --- |
| **No.** | **Standard** | **Specification** |
| a. | BIS : 1239 (part) | For UPVC threaded pipes |
| b. | BIS : 4984 | For HDPE pipes |
| c. | BIS : 4985 | For PVC /UPVC pipes |
| d. | BIS : 7384 | For PVC fittings |
| e. | ASTM-D-1785 | For PVC pipes |

**c)** **Copper pipes**

|  |  |  |
| --- | --- | --- |
| **No.** | **Standard** | **Specification** |
| a. | BS : 2871 | Copper tubes for water, gas and sanitation |
| b. | EN : 1057 | Seamless round copper tubes for water, gas, sanitation and heating application |
| c. | EN : 1971 | Electromagnetic (Eddy current) examination of copper and copper alloy tubes |
| d. | EN : 1254 | Copper and copper alloy plumbing fitting |
|  |  | P-1 Fittings with ends for capillary soldering or capillary brazing to copper tubes |
|  |  | P-2 Fittings with compression ends for use with copper tubes |
|  |  | P-5 Fittings with short ends for capillary brazing to copper tubes |
| e. | EN : 29453 | Soft solder alloys – Chemical composition and forms |

**d.** **Stainless Steel pipes (SS)**

|  |  |  |
| --- | --- | --- |
| **No.** | **Standard** | **Specification** |
| a. | ASTM-A-312 | Seamless and welded austenitic stainless steel pipes |
| b. | ASTM-A-530 | Testing of welded austenitic stainless steel pipes |

**e. Thermoplastic pipes**

|  |  |  |
| --- | --- | --- |
| **No.** | **Standard** | **Specification** |
| a. | BIS : 4984 | High density PE (HDPE) pipes for water supply |
| b. | BIS : 4985 | Unplasticised PVC (UPVC) pipes for potable water supply |
| c. | BIS : 10124 | Fabricated PVC fittings for portable water supply |

|  |  |  |
| --- | --- | --- |
| **No.** | **Standard** | **Specification** |
| d. | BIS : 5382 | Rubber sealings rings or gas mains, water mains and sewers |
| e. | ASTM-D1785 | Threaded UPVC pipes |
| f. | DIN : 8076 | Fittings with metal inserts |
| g. | DIN : 8077 | Polypropylene pipes |
| h. | DIN : 8078 | Polypropylene pipe type 3 quantity requirement test |
| i. | DIN : 16962 | Joints and fittings for PP pressure pipes |
| j. | ISO : R288 | Fittings with threaded metal inserts |
| k. | DVS : 2208 | Welding of thermoplastic materials |

**3.3.5 Piping work**

|  |  |  |
| --- | --- | --- |
| **No.** | **Standard** | **Specification** |
| a. | BIS : 554 | Dimension of pipe threads where pressure tight joints are required on the threads |
| b. | BIS : 634 | COP for plastic pipe work for potable water supply |
| c. | BIS : 822 | COP for inspection of weld |
| d.  | BIS : 5822 | COP for laying of welded steel pipe |

**3.3.6 Motive & Transmission Equipment**

|  |  |  |
| --- | --- | --- |
| **No.** | **Standard** | **Specification** |
| a. | BIS : 325 | 3 Ph. Induction motors |
| b. | BIS : 900 | COP for installation and maintenance of induction motors |
| c. | BIS : 996 | 1 Ph. small AC and universal electric motors  |
| d. | BIS : 1231 | Dimensions of foot mounted induction motors |
| e. | BIS : 2122 | COP for selection, storage, installation and maintenance of belts for power transmission |
| f. | BIS : 2223 | Dimensions of flange mounted induction motors |
| g. | BIS : 2253 | Type of construction and mounting of motors |
| h. | BIS : 2949 | V belts for industrial purpose |
| i. | BIS : 3003 | Carbon brushes for electrical machines |
| j. | BIS : 3142 | V-grooved pulleys for V belts give sectionsA,B,C,D and E |
| k. | BIS : 4029 | Guide for testing 3 Ph. induction motor |
| l. | BIS : 4691 | Degree of protection provided by enclosure for rotating electrical machinery |
| m. | BIS : 4722 | Rotating electrical machinery |
| n. | BIS : 4728 | Terminal marking for rotating electrical machines |
| o. | BIS : 6362 | Designation of the method of cooling of rotating electrical machines |

**3.3.7 Noise & Vibration Control**

|  |  |  |
| --- | --- | --- |
| **No.** | **Standard** | **Specification** |
| a. | BIS : 1950 | COP for sound insulation of non-industrial buildings |
| b. | BIS : 3483 | COP for noise reduction in industrial buildings |
| c. | BIS : 4954 | Recommendations for noise abetment in town planning |
| d. | BS : 2750 Part 1-9 | Laboratory and Field Measurement of Airborne Sound Insulation of Various Building Elements |
|  |  | Recommendations of Field Laboratory Measurement of Airborne and Impact Sound Transmission in Buildings |
| e. | BS : 3638 | Methods of Measurement of Sound Absorption in as Reverberation Room |
| f. | BS : 4773 Part 2 | Acoustic Testing |
| g. | BS : 4856 Part 2 | Acoustic performance without additional ducting of forced fan convection equipment |
| h. | BS : 4856 Part 5 | Acoustic performance without additional ducting of forced fan convection equipment |
| i. | BS : 4857 Part 2 | Acoustic testing and rating of high pressure terminal reheat units |
| j. | BS : 5643 | Glossary of Refrigeration, Heating, Ventilation and Air conditioning terms |

**3.3.8 Air Distribution**

|  |  |  |
| --- | --- | --- |
| **No.** | **Standard** | **Specification** |
| a. | BIS : 277 | Galvanised steel sheet |
| b. | BIS : 513 | Cold rolled low carbon steel sheets and strips |
| c. | BIS : 655 | Metal air ducts |
| d. | BIS : 659 | Safety code for air conditioning |
| e. | BIS : 737 | COP for wrought aluminium and aluminium alloy sheets and strip for general engineering purpose |
| f. | BIS : 1079 | Hot rolled carbon steel sheets and strips |
| g. | BIS : 2629 | Recommendation practice for hot dip galvanising of iron & steel |
| h. | CP : 352 | Mechanical ventilation and air conditioning in buildings |
| i. | SMACNA | Low pressure duct construction standard |

**3.3.9 Insulation**

|  |  |  |
| --- | --- | --- |
| **No.** | **Standard** | **Specification** |
| a. | BIS : 702 | Specification for industrial bitumen |
| b. | BIS : 3346 | Method of determination of thermal conductivity of thermal insulation material |
| c. | BIS : 3677 | Specification for unbonded rock and slag wool for thermal insulation |
| d. | BIS : 3690 | Specification for glass wool mats for thermal insulation |
| e. | BIS : 4671 | Specification for expanded polystyrene thermal insulation purposes |
| f. | BIS : 5688 | Methods of test for performance block – type and pipe covering type thermal insulation |
| g. | BIS : 5696 | Specification for loose mineral wool (rock wool and slag wool) |
| h. | BIS : 7240 | COP for application and finishing of thermal insulation material at temperature between -80 °C to – 40 °C |
| i. | BIS : 7413 | Application and finishing of thermal insulation material |
| j. | BIS : 8183 | Specification for bonded mineral wool |
| k. | BIS : 9743 | Specification for thermal insulation finishing cements |
| l. | BIS : 10556 | COP for storage and handling of insulation material |
| m. | BIS : 11239 | Method of test for cellular thermal insulation material (P1-P13) |
| n. | BIS : 11307 | Specification for cellular glass block and pipe thermal insulation |
| o. | BIS : 12436 | Specification for performed rigid polyurethane (PUR) and isocynaurate (PIR) foam for thermal insulation |
| p. | BIS : 13013 | COP for packing thermal insulation material |
| q. | BIS : 13204 | Specification for rigid phenolic foams for thermal insulation |
| r. | BIS : 14164 | Industrial application and finishing of thermal insulation material temperature above 80 °C and upto 700 °C |

**3.3.10 Electrical Installation**

|  |  |  |
| --- | --- | --- |
| **No.** | **Standard** | **Specification** |
| a. | BIS : 732 | COP for electrical wiring installation |
| b. | BIS : 1646 | COP for fire safety of buildings (General) electrical installation |
| c. | BIS : 5216 | Guide for safety procedure and practice in electrical work |
| d. |  | Indian Electricity Acts and Rules |

The electrical work associated with HVAC shall conform to relevant standard specification indicated under Book 5 Electrical Systems.

# **2201 REFRIGERATION UNITS**

1.0 SCOPE

1.1 The scope of this section shall cover refrigeration units such as condensing units, and water chilling units.

 a) Refrigeration

 b) Condensers

 c) Evaporators

 d) Motors

 e) Controls

 f) Refrigerant piping

2.0 STANDARDS

2.1 The following standards shall be applicable :

 a) IS:659 Safety codes for air conditioning

 b) IS:660 Safety codes for mechanical refrigeration

 c) IS: 5111 COP and measurement procedure for testing refrigeration valves

 d) IS:10594Thermostat expansion valves

 e) IS:10617Hermetic compressors

 f) IS:11327Requirements for refrigerant condensing units

 g) IS:11330Refrigeration oil separators

 h) IS: 2825 Code for unfired pressure vessels

 i) IS:10123Data sheets for shell and tube heat exchangers

 j) IS: 4503 Shell and tube heat exchangers

3.0 GENERAL REQUIREMENTS

3.1 The refrigeration equipments shall meet the requirements shown in equipment data and shall be complete with refrigeration compressors, motor drive assembly, condenser, refrigeration piping controls, first charge of refrigerant etc. including all accessories.The water chilling units shall include chiller, thermal insulation and anti freeze thermostat.

3.2 The refrigeration units shall ~~be vapour absorption~~ or vapour compression type and shall meet the requirements of the equipment data and relevant IS and BS specification.

4.0 COMPRESSORS

4.1 ROTARY SCREW COMPRESSORS

 The rotary screw compressors shall be positive displacement field serviceable semi hermetic /hermetic, single or twin helical rotary of precision machined cast iron housing of adequate pressure to suite the refrigerant, but not less than 21 bar.

 The compressors shall be provided with internal muffler, temperature activated off-cycle heater, discharge check valve, suction and discharge shut off service valve.

 The compressor and motor shall be designed for continuous operation at 2960 rpm and shall pressure lubricated roller bearing. The motors shall be single speed non reversing squirrel cage conduction pressure lubricated, liquid refrigerant injection cooled with inherentinternal thermal overload and external over current protection.

 The capacity control shall be stepssless 100% to 10% using continuous functions side valves operated through microprocessor controller and shall be suitable for string at unloaded condition.

 The lubricant system shall preferably through refrigerant system differential pressure and shall include service replaceable full flow cartridge filter of 0.5 micron.

 Each refrigerant circuit shall include liquid line shut off valve with charging port, lowside pressure relief device removable core filter drier, solenoid valve, sight glass with moisture indicator, expansion valve.

 The compressors shall have capacity control from 25% to 100%.The control panels shall be preferably solid state and shall include.

1. Pressure gauges for :

 Suction, discharge, lube oil

1. Safety cutout with indicators and reset

 Refrigerant high and low pressure

 Lube oil pressure differential

 Anti-freeze thermostat

 Motor high temperature

 Chilled water and condenser water flow switch

1. Operating switch, indicators & reset

 Power failure

 Thermostat controlling liquid line

 Solenoid valve in response to return water temperature

1. Starter with over load, protection, under voltage release and single phase prevention.

4.5 POWER AND CONTROL PANEL

The power and control panels shall be integral unit with IP55 enclosure suitable for outdoor installation.

 Power Panel

 The power panel shall include the following

1. Incoming and outgoing feeder circuit breakers
2. Starters and relays for compressors & fan motors
3. Safety ,control instruments and indicators
4. Single phase preventors
5. Interconnection and wiring

Control Panel

The control panel shall be microprocessor based and shall have the following features.

1. LCD display unit for minimum 75 character
2. Automatic capacity control
3. Automatic system protection
4. Remote monitoring and controlling capability through RM display terminal, IBM PC compatible computer terminal, interface for BMS and Energy Management.

The LCD display unit shall indicate the following

1. Compressor capacity in % of full load
2. Compressor status
3. Current drawn by each compressor motor
4. Demand current limit reset volume
5. Number of compressor start
6. Elapsed run time of each compressor
7. Fan ON-OFF status
8. External start-stop command status
9. Alarm status and history
10. Remote chilled water reset value
11. Water flow switch status

 l) Chilled water inlet & outlet temperature

1. Condenser & evaporator pressure
2. Calendar of events

The automatic capacity control shall be based on the return chilled water temperature through compressor loading cycle programmable.

The automatic system control shall ensure protection on the following.

1. High pressure cutout, manual reset
2. Low pressure cutout, manual reset
3. Compressor, solid state, thermal sensing overloads, manual reset
4. High refrigerant discharge temperature manual reset
5. Low water temperature freeze protection, manual reset
6. Phase failure protection against low voltage, phase imbalance, or reversal
7. Safety alarm contacts for high pressure or discharge temperature
8. Freeze protection
9. Compressor run error
10. Low oil level
11. Power loss
12. Chilled water flow loss
13. Sensor error
14. Anti-recycle time delay

5.0 CONDENSER

5.1 The condenser shall be water cooled shell and tube with minimum 19mmdia plain or integrally finned seamless copper tubes designed for workingpressure of 20 kg/sq.cm on refrigerantside and 7 kg/sq.cm on water sideconforming to IS : 4503 and IS : 2825.

5.2 The condensers shall include multi-pass water heads, surge cocks, detachable thermowells on inlet and outlet, drain vents with valve, refrigerant inlet, valved liquid outlet purged connections, safety valve etc.

5.3 The condensers shall ensure ample liquid storage and minimum 3 degree C liquid sub-cooling.

6.0 MOTOR

6.1 The compressor shall be belt driven or directly coupled to the motor of required capacity.The motor rating shall be as indicated under equipment data and conform to the specification covered under motive and transmission equipments.

7.0 INSTALLATION

7.1 The refrigeration unit shall be mounted on a structural frame work with a common base frame having adequate strength.The structural base frame shall be mounted into a suitable concrete sub-base or pad separated from the main floor by means of necessary vibration isolation pads.The concrete sub-base will be provided by the civil contractor on the basis of foundation details submitted by the equipment manufacturer.It shall be the responsibility of the HVAC contractor to inspect and check the adequacy and certification of the sub-base.

7.2 The contractor shall supply the required charge of refrigerant and lubricants for the commissioning and testing of the plant.The refrigerant systems shall be vacuumised to 7 mm of hg. absolute and maintained for 24 hours before charging.

7.3 Water drain connections on chiller and condenser shall be piped to a 50 mm drain header through a funnel type open sight drain.

7.4 Pressure switches, preferably differential pressure type or flow switches shall be provided in condenser and chiller lines and interlocked with the compressor starting without condenser and chilled water flow established.

7.5 Crank case heaters shall be **ON** when the compressor stops.

8.0 TESTING

8.1 Unit shall be tested for establishing the capacity and power consumption. Refrigeration capacity of the unit shall be computed from measurement of water flow and entering and leaving water temperature.Flow measurements shall be through flow meters.Tests shall be carried in accordance with IS : 5111 for reciprocating water chilling units.Computed results shall tally with the specified capacities and power consumption figures furnished with the tender offer.Tests shall be carried out on :

 a)The compressor and drive motor side

 b)Chiller side

 c)Condenser side

8.2 All meters, gauges thermometers, watt meters shall be furnished by the contractor and be duly calibrated.All necessary distance pieces etc. required in the piping shall be provided at the time the piping is installed.

8.3 All test readings shall be correlated with each other and with the design parameters before submission for approval.Atleast 4 test readings lasting over a period of 3 hours shall be recorded.Minimum 3 days continuous running and testing should be done without any break down.

# **2202 UNITARY EQUIPMENTS**

1.0 SCOPE

1.1 The scope under this section shall cover the general specification and requirements of unitary equipments such as

1. Modular packaged air-conditioning unit
2. Split air-conditioning units
3. Window air-conditioning units

2.0 GENERAL REQUIREMENTS

2.1 The unitary equipments shall consists of the following

1. Refrigeration compressors
2. Condensers
3. Evaporator
4. Refrigerant piping
5. Control panel and wiring

2.2 The units shall be air tooled or water cooled as specified in the equipment data and bill of materials.

2.3 The water cooled packaged unit and the window units shall be single modular type with compressor, condenser, evaporator and power and control unit mounted in single cabinet.

2.4 The air cooled package unit and the split air conditioners shall be modular type having separate outdoor air cooled condensing unit and indoor evaporator unit with interconnecting refrigerant piping, power and control wiring etc.

2.5 The unit shall be in sectionalized construction with fan section, coil section condenser section, compressor insulated drain pan etc.the enclosures shall be heavy gauge sheet steel with powder coating or synthetic enameled paint finish.

2.6 Necessary thermal and acoustic insulation shall be provided to avoid condensation and reduce noise.

2.7 The power and control equipments shall be selected for the following power supply.

a) Three phase 415V, 50 Hz

b) Single phase 240V, 50 Hz

The electrical and electronic equipments shall be suitable for voltage fluctuation of ± 15% and frequency ± 5%.

3.0 PACKAGED UNIT (If Required)

3.1 The water cooled packaged unit shall be modular type in 3 sections as shown below.

1. Compressor and condenser section
2. Filter and cooling coil section
3. Blower section
	1. The air cooled packaged units shall be with separate cabinets for evaporator and condenser. Theevaporator unit shall be of monitor type in two sections as shown below.
4. Compressor and condenser section
5. Filter and cooling coil section
6. Blower section

The condensing units shall be in single section with condenser and propeller fans

3.3 COMPRESSOR

Compressor shall be multi-cylinder reciprocating type.Compressor shall have spring loaded suction and discharge valve heads.Compressors shall be complete with required accessories such as pipe flanges, suction strainers, muffler, suction and discharge pressure gauges, oil heaters, oil pressure gauge.HP-LP cutout, OP cutout, overload for motor protection, unloader etc.Compressor shall be suitable to operate on 3 phase, 400/440 volts, 50 cycles A.C supply and shall be designed to withstand voltage fluctuation of 15%.

3.4 WATER COOLED CONDENSER

Water cooled condenser shall be of shell and tube type with multi-pass tubes of copper and shell of mild steel with removable heads.Condenser tubes shall be integrally finned copper tubes rolled into steel tube sheets.Condenser shall be complete with required accessories such as hot gas inlet and liquid outlet connections and necessary shut off valves, drain valve, air vent and test cock, water inlet and outlet connections as required together with thermometers and pressure gauges, fusible relief and purge valves.Condenser shall be sized to provide positive sub cooling of liquid refrigerant to the extent of 2.77 deg.C.

Condenser inlet and outlet connections shall be provided with thermometers and pressure gauges.

3.5 AIR COOLED CONDENSER

Condenser coil shall be of copper tube having aluminum fins firmly bonded to tubes. Tube dia shall be between 12.5 to 15 mm, min.24 g wall thickness and fin spacing deep. Each coil shall be factory tested and 21 Kg/sq.cm. test pressure.

The coil shall have integral sub cooling circuit.The air volume and coil face area shall be adequate for the capacity. Air velocity across the coil not exceed 150 m/min. Air volume of the condenser shall be minimum 25 cu./min per ton of refrigeration capacity.

Condenser casing shall be made of corrosion resistant heavy gauge steel finished with enamel paint.

Fans shall be propeller axial type. One or more fans shall be provided for the required capacity.

Fan motor shall be TEFC, squirrel cage, induction motor suitable to operate on 3 phase, 50 cycles, 400/440 volts, 50 cycles, A.C. supply and provided with pulley, v belt set or direct drive flexible coupling with guards.Motor shall have class “B” insulation and shall be provided with IP-55 protection.

3.6 COOLING COILS

Cooling coils shall be fin and tube type having aluminum fins firmly bonded to copper tubes assembles in G.I. frame.Face surface area of cooling

3.7 Each unit shall be HDP washable or metallic type and shall be 50 mm thick.Filter holding frame shall be designed such that by pass of air can be avoided.Velocity across filter shall not exceed 120 m/min.

3.8 INSTALLATION

Entire air cooled condenser assembly shall be installed on MS channel stand through vibration isolators and at the place as indicated in drawings.

The package unit shall be mounted ona suitable concrete base pads separated from the main floor by means of necessary neoprene serrated vibration isolation pads.Vibration isolators like neoprene serrated rubber base pads or Dunlop metallic cushy-foot mountings shall be used between packaged unit and concrete foundation.

All the equipment including base frame etc. shall be factory painted with two coats of a suitable enamel paint of approved colour over a rust resistant primer.Paint that have become marred during shipment or erection shall be cleaned off with mineral spirit, wire brushed and spot primed over the affected areas, then coated with enamel paint to match the colour shade of adjoining factory painted surface.

3.9 PERFORMANCE RATING

The unit shall be selected for the lowest operating noise level.Capacity ratings and power consumption at design conditions shall be verified at the time of testing and commissioning of installation.Cooling capacity of the unit shall be computed from the measurement of air flow and dry and wet bulb temperature of air entering and leaving the cooling coil.Computed results shall conform to the specified capacity and quoted ratings.

3.10 All safety controls like HP cut out, LP cut out, OP cut out, water line flow switches/differential pressure switches shall be checked for their functioning and setting and record of all the settings shall be submitted to Consultants/Clients.

4.0 SPLIT UNITS

4.1 The split air conditioning units shall be in two separate cabinets, one for outdoor condensing unit and another for indoor evaporator unit. The evaporator unit shall be floor/wall/ceiling suspended. Also the ceiling suspended unit shall be ductable or direct supply system.

4.2 The refrigerant piping, power and central cabling between the condensing unit and evaporator shall be properly protected to avoid damage.The refrigerant pipes shall beinsulated to avoid condensation, reduction in the rated capacity and performance.

4.3 CONDENSING UNITS

Compressor for small size units shall be hermetically sealed and internally sprung with rubber mountings.Thermal overload protection shall be provided Crank-case heaters are to be permanently wired to be ‘ON & Suction and liquid lines shall be adequately sized and shall terminate in back-seating valves.

Motors shall be permanent split capacitor type and fully weather-proofed. Voltage is 200/254 single phase or 380V 3 PH 50 HZ Optimum motor speed shall be 900 rpm but in no case exceeding 1500 4pm synchronous.Insulation shall be class B to BS 3979 and BS 2613.Built-in over load protection shall be incorporated.

Condenser fans shall be propeller type with aluminum blades riveted to a zinc plated steel hub having twin hardened grub screws.

Coil shall be of finned tubes with staggered tubes to give maximum heat transfer and be of proven capacities.

Casings shall be constructed from folded panels riveted together except where access is required self tapings screws being used. Casing material shall be pre galvanized sheet steel generally to BS 2689 electrostatically powder coated with textured epoxy stoved at 180 degree C (356  F).

Motors and compressors shall be wired into a weather proof electrical box situated behind the back panel of the unit.The control shall comprise the following.

Contactor (s) for compressors

High and low pressure switches which are factory preset.

A starting pressure switch to ensure that fans do not run before adequate systems pressure has built up, preventing cycling of compressors against the low pressure switch.

An electrical overload switch (giving a 5 second delay between starting of the first and second compressor wherever two compressors are used) with overload protected tap-off for the evaporator and condenser fans.

4.3 EVAPORATOR

For cooling duty DX coil shall be fitted.Electric heaters shall be fitted for heating duty.Coils shall be multi-fin copper tubes staggered to give maximum heat transfer, fins shall be formed from aluminum strip with fully collared holes to maintain a permanent mechanical bond with the tubes which are mechanically expanded into them.

Finsspacing shall be 2.5 mm (10/inch), tubes and bends are seamless solid-drawn copper are seamlesssolid-drawn copper DX coils shall be tested to a pressure of 20 bars (300 lbs/sq.in) & proof tested to a pressure of 20 bars (50 lbs/sq.in).Coil shall be cleaned, dehydrated and capped.

The fan shall be a DIDW centrifugal fan or fans having a corrosion protected steel impeller with forward curved blades.A steel hub with two hardened fixing screws shall be welded into the fan plate.The impeller is secured to a steel shaft with runs in ball bearing assemblies, whichare sealed and lubricated for life.Insulation Class B for all motor.Both fan and motor shall be mounted rigidly into a steel sub frame which is itself suspended in the cabinet on rubber anti-vibration mountings.Safety bolts shall be fitted to constrain the sub-frame in transit and to facilitate replacement of the mountings if necessary.Drive from the motor to the fan shall be direct.

Cabinets and plenum shall be constructed from folded panels riveted together.Material is pre-galvanized sheet steel generally to BS 2989.Condensate drain connections shall be 20 mm.A supply and return grilled shall be provided along with the unit.

Air filters shall be cleanable type having a minimum 90% efficiency using Test Dust No. 2 in accordance with BS : 2831.Sheathed heating elements shall be fitted with necessary high temperature cut-out switch, isolator, contactorsand thermostats.

Motors shall be wired into an electrical control box by means of a flexible harness.The box shall contain necessary terminal blocks for connection of mains supply and control circuits, with necessary contactors.A room thermostat with 3-speed fan switch shall be provided for the automatic control of the unit.All wirings to and from the thermostat shall be included in the scope of supply.

4.4 INSTALLATION

The condensing units shall be mounted on terrace, chajja or M.S. fabricated platform as per the drawing and site conditions.The unit mounted onRCC slab shall be with M.S. base frame with minimum heights of 300 mm from the finished floor.

Where the unit is mounted on to the wall the same shall be by means of M.S. platform of adequate size to facilitate easy maintenance and repairs.The platform shall be supported by means of M.S. brackets grouted on to the wall.Also the platform shall be provided with safety railing.All structural steel work shall be provided with anti corrosive treatment.

The wall mounted evaporators shall be fixed to the wall using anchor bolts and screws of adequate capacity.The ceiling units shall be suspended from fixed to the ceiling using anchor bolts and suspension rod of adequate capacity.

The condensing units and evaporators shall be leveled properly to avoid stress and strains on bearings as well as to allow free flow of condenser.

4.5 TESTING

All compressors shall be factory run and the system leak tested before dispatch.A test certificate to this effect shall be furnished for each unit.

The condenser and evaporator unit after commissioning shall be tested for its capacity and power consumption.

# **2203 AIR HANDLING EQUIPMENTS**

1.0 SCOPE

1.1 The scope under this section shall cover supply installation, testing and commissioning of Air Handling Equipment consisting of :

 a) Fan coil units

 b) Centrifugal fans

 c) Propeller fans

 d) Vane axial fans

2.0 STANDARDS

2.1 The following standards shall be applicable

 a) IS : 4283 Hot air fans

 b) IS : 8272 Industrial cooling fans (man collars)

 c) IS : 4894 Centrifugal fans

 d) IS : 10470 Air cooled heat exchangers

 e) IS : 2997 Air circulator type electrical fan and regulator

 f) IS : 1169 Electrical pedestal type fans and regulators

 g) IS : 374 Electrical ceiling type fan and regulator

3.0 GENERAL REQUIREMENTS

3.1 The air handling equipments shall meet the requirements indicated in the Equipment Data and shall be complete with fan, casing, motor mounting frame, vibration isolators.

3.2 The ventilation units, AHU's and FCU's shall be provided with air filters.Equipment used for heating/cooling system shall be provided with air cooled heat exchangers.

3.3 The equipment data indicated is a guide line for selection of the equipment based on various parameters which may vary from manufacturer to manufacturer.Hence the contractors should verify the adequacy of the equipment offered considering the basic requirement and parameters indicated in the equipment data.

3.4 All fans shall be double ball or roller bearings and selected for low noise level.

3.5 All air handling equipment shall be connected to the fire alarm system and shall be automatically switched off in case of fire in the zone served by that equipment.The supply and return air intakes shall be provided with fire dampers.

4.0 FAN COIL UNITS

4.1 The fan coil units shall be horizontal ceiling suspended meeting the requirements indicated in the equipment data, and complete with filter, R.A. plenum, fan and cooling/heating coils.

4.2 The enclosure shall be 1.2 mm galvanized sheet steel with supporting frame work suitable for 4 point suspension.

4.3 Fans shall be slow-speed direct driven centrifugal forward curve type, statically and dynamically balanced.Fansshall have three speed (100%, 70% and 50%) and quite in operation.The maximum sound power level of the unit shall not exceed NC 40.Acoustically treated duct collars of minimum 500 mm length shall be provided at the FCU outlet.

4.4 Fan motors shall be single phase 220V 50 CPS with built in thermal overload protection and shall be capable of reliable starting and vibration free operation up to 90% of the rated voltage.Motor shall be mounted on a 14 SWG motor board and capable of being removed easily.The motors shall be suitable for round the clock operation.

4.5 The cooling coils shall be as specified in air cooled heat exchangers.

5.0 FAN SECTION

5.1 The fan sections shall be sectionalized construction and consisting of casing, fan, filters, dampers etc.The casing shall be fabricated out of GI sheets of minimum 1.2 mm thick welded construction with 2mm thick MS angle frame work and cross brazing.

5.2 The fans shall be forward curved centrifugal double inlet mounted ona common shaft.The fans shall be of GI, house in streamlined scroll cases and statically and dynamically balanced.The fans sections shall be provided with detachable filter section and damper section.

5.3 The drive assembly shall consist of motor, multi vee grooved adjustable pitch pulleys and multiple vee belts.The motor mounted on adjustable base frame shall be erected over the fan section through mounting shoes or structural members.The belts shall rotate in self aligning ball bearings.

The fan section having 2 motors (one working and one standby) shall have the shaft extended on both sides with drive pulleys.

6.0 CENTRIFUGAL FANS

6.1 The centrifugal fans shall be heavy duty single or double suction conforming to IS : 4894.The casing shall be of heavy gauge steel sheet/plate seam welded with necessary stiffened with angle or channel side bracings and with fixed suction and discharge flanges, manually operated suction vanes, access doors etc.

6.2 The impellers shall be backward curved hollow heavy section aerofoil construction with internal re-enforcement with non-overloading characteristic.The wheels hubs shall be machine cast or fabricated.

6.3 The shafts shall be of hot rolled steel or alloy steel liberally sized to achieve the critical speed at least 30% above the normal speed.The bearing shall be heavy duty self-aligningregressable ball or roller type capable of absorbing radial and thrust loads.

7.0 PROPELLER FANS

7.1 The propeller fans shall be ring or diaphragm mounted and meeting the requirements indicated in the equipment data.

7.2 Mounting plate shall be of steel construction, squares with streamlined venturi inlet (reversed for supply applications) coated with baked enamel finish.The mounting plate shall be of standard size, constructed of 12 to 16 gauge sheet steel depending upon the fan size.Orifice ring shall be correctly formed by spinning or stamping to provide easy passage of air without turbulence and to direct the air stream.

7.3 Fan blades shall be constructed of aluminium or steel fan hub shall be of heavy welded steel construction with blades bolted to the hub.Fan blades shall be quite in operation and shall be statically and dynamically balanced at the factory.

7.4 Shaft shall be of steel, accurately ground and shall be ample size for the load transmitted, and shall not pass through first critical speed thru. and full range of specified fan speeds.

7.5 Motor shall be standard (easily replaceable) permanent split capacitor or shaded pole for small sizes, totally enclosed with pre-lubricated sleeve or ball bearings, designed for quite operation with a maximum speed of 1000 rpm for fans 38 cm dia or larger and 1400 rpm for fans 31 cm dia and smaller.Motors for fans 60 cm dia and larger shall be suitable for 415 +5% volts, 50 cycles, single phase power supply.Motors shall be suitable for either horizontal or vertical services.

7.6 The following accessories shall be provided with propeller fans as indicated in schedule of quantities.

a) Wire guard on inlet side and birdscreen at the outlet.

b) Gravity operated aluminium louver shutters built into a steel frame.

c) Regulators for controlling fan speeds for single phase fan motors.

8.0 FILTERS

8.1 The filters shall be metallic, PVC or fabric as specified in equipment data.Air handling units for special application shall be provided with Microvee or HEPA.

8.2 Metallic filter shall consist of V fold galvanized wire mesh inter speed with a flat layer of galvanized wire mesh.The density of the filter medium shall increase in the direction of air flow.Wire mesh edges shall be suitable hemmed to eliminate the danger of abrasion during handling.Filter medium shall be supported on either side by galvanized expanded metal casing.Filter frame shall be constructed of galvanized sheet of thickness not less than 18 gauge.Filter shall be either dry or oil melted type.Oil shall be suitable mineral oil of approved type.

 Alternatively the filter frames shall be fabricated for aluminium alloy conforming to IS : 737 and medium shall be aluminium alloy. All filters must be capable of being completely cleaned of their accumulated dust by flushing with tap water.

8.3 Fabric filters shall be flat filter fabric or suitable material recommended by the manufacturer stitched by inforce wire gauge support and crimped to form deep folts. Suitable aluminium spacers shall be provided to ensure uniform distribution of air flow through the filter.Filter casing shall be provided with neoprene sponge rubber sealing,the filter shall be either dry type or oil wetted type, with element of three ply or five ply construction a specified in data sheet.

8.4 Nylon filters shall be made of repellanting nylon fabric with continuous water spraying on it from a header for keeping it clean.Efficiencyof this filter should be 85% down to 10 microns.

8.5 Microvee filters shall be constructed by plating acculinuous sheet of filter medium into closely spaced plates separated by heavy corrugated aluminium spacers.The microvee filter shall have an efficiency of 98.9% down to five micron.The clean filter static pressure drop shall not be greater than 25mm WG when operating at the rated capacity.A neoprene sponge rubber sealing shall be provided on either face of the filter frame.

8.6 The HEPA filters shall consist of aluminium frame with media of 100% submicronic glass fibres.The glass fibres shall be suitably for the condition of use and shall have high resistance to corrosion vapours.The filter shall have filtration efficiency of 98.97% down to 0.3 microns.When tested with hot DDP test, the filter capacity specified shall be taken as rated capacity at 25mm WG pressure drop and offer shall be made accordingly.It should be possible to use HEPA filter upto 75mm WG pressure drop.

9.0 HEAT EXCHANGERS

9.1 The heat exchangers/cooling coils for the air handling equipment shall be aircooled with meeting the requirements shown in the equipment data.Theface area and the chilled water quantity are based on the proper bonding of the tubes and fins and efficiency of heat transfer.Hence coil area indicated is only a guideline and while selecting and offering the coils the contractor should ensure the coil leavingconditions and the room conditions for the specified cooling load.

9.2 The coil section for AHU shall consist of single coil for cooling and heating or two separate coils for cooling and heating as specified.The coils shall consist of staggered copper coils with bonded aluminium fins.There shall be 300 to 500 fins per meter spaced by means of integral collars.The face area shall be sufficient to meet the cooling/heating load at the same not less than the area indicated in the equipment data and the air velocity across the coil is not exceeding 3 meter per second.

9.3 The number of rows of coils for cooling and heating coils shall be as indicated on the equipment data at the same time not less than 4 rows for coolingcoil and 2 rows for heating coils.The coils shall be tested to 20 Kg/sq.cm air pressure.

9.4 The coil connection shall be on one side and shall have the following.

a) Control valve on return line

b) Shut off valve on supply & return lines

c) Thermowells on supply & return header

d) Pressure gauge code on supply & return header

9.5 The coil section shall be insulated and shall be with drain tray and insulated drain pipe to the nearest floor drain.

9.6 Multi-blade face and by pass dampers with brass, bronze bush bearing shall be provided wherever required.The blades shall be of 1.2 mm thick with rubber sealing edges.The dampers shall be provided with modulating motors for automatic operation.

9.7 The AH units wherever specified shall be provided with a spray/pan humidifier with circulating pumps, spray nozzles, eliminator heater and float valves etc.

9.8 Coils for FCU shall be plate-tin designed and tested to 20 kg/sq. cm working pressure.Supply and return connections shall be 16mm O.D copper arranged either right or left handed as required.Manual air vents shall be provided on the return headers with a flexible pipe discharging into the drain-pan.End connections shall have supply, return and control solenoid valves (on return side).

9.9 Coil drain pans shall be fabricated of 1.25 mm galvanized sheet or aluminium with sandwiched insulation.Pan shall be large enough to contain the unit and the coil connections shut off valves, solenoid valves etc.Units shall be mounted on the pan with rubber bushes.Inside of pan shall be finished with 6 mm thick plastic and slopped towards the drain.Interior of the pan shall be finished smooth and pitch towards 25 mm drain connection located on the same side as the coil connections.Coil drain pan shall have no metal to metal contact and units covering the tune ends shut-off and control valves.

9.10 Unit control package shall consists of three way valve and two shut-off valves.A wall mounted control panel shall consist of :

 a) ON-OFF room thermostat with adjustable set point.

 b) Control switch with OFF and high, medium and low speeds.

 A sample of the entire unit and control panel shall be got approved by the Consultant before manufacturer.

10.0 Axial Flow Fan

10.1 Fan shall be complete with motor, motor mount belt driven (or direct driven) and vibration isolation.

10.2 Casing : shall be constructed of heavy gauge sheet steel. Fan casing, motor mount and straightening vane shall be of welded steel construction. Motor mounting plate shall be minimum 15mm thick and machined to receive motor flange.

10.3 An inspection door with handle and neoprene gasket shall be provided. Casing shall have flanged connection on both ends for ducted applications. Support brackets for ceiling suspension shall be welded to the casing for connection to hanger bolts. Straightening vanes shall be aerodynamically designed for maximum efficiency by converting velocity pressure to static pressure potential and minimizing turbulence. Casing shall be bonderized, primed and finish coating with enamel paint.

10.4 Rotor :hub and blades shall be cast aluminum or cast steel construction. Blades shall be die-formed aerofoils shaped for maximum efficiency and shall vary in twist and width from hub to tip to effect equal air distributionalong the blade length. Fan blades mounting on the hub shall be statically and dynamically balanced. Extended grease leads for external lubrication shall be provided. The fan pitch control may be manually re-adjusted at site upon installation, for obtaining actual air flow values, as specified and quoted.

10.5 Motor : shall be energy efficient squirrel cage, totally enclosed, fan cooled standard frame, constant speed, continuous duty, single winding, suitable for 415 ± 10% volts, 50 cycles, 3 phase AC power supply, provided with Class F insulation. Motor shall be specially designed for quite operation. The speed of fans shall not exceed 1000 RPM for fans with impeller diameter above 450 mm, and 1440 RPM for fans with impeller diameter 450 mm and less. For lowest sound level fan shall be selected for maximum efficiency or minimum horse power. 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.

10.6 Fans used for smoke extraction duty shall be Class H and rated for minimum 300 deg.C

10.7 Drive : to fan shall be provided through belt drive with adjustable motor sheave and standard sheet steel belt guard with vented front for heat dissipation. Belts shall be of oil resistant type.

10.8 Vibration isolation:The assembly of fan and motor shall be suspended from the slab by vibration isolation suspension of rubber in shear type.

10.9 Accessories :The following accessories shall be provided with all fans.

1. Outlet cone for static pressure regain.
2. Inlet cone
3. Fan silencers may be provided where required. Fans shall be factory

assembled and shipped with all accessories factory mounted.

# **2204 WATER DISTRIBUTION**

1. **SCOPE**

**1.1** Scope under this section shall cover water distribution piping complete with :

i) Specification for materials

ii) Method of fabrication, assembling and installation

iii) Testing and commissioning.

**2.0 CODES AND REGULATIONS**

2.1 The materials and the piping work shall conform to the relevant codes, regulations and standard specifications covered under Section 2102.

**3.0 GENERAL REQUIREMENT**

3.1 Materials

3.1.1 The pipes, fittings and valves shall be suitable for the medium transported, system pressure and temperature and shall be non corrosive to the medium transported and the ambient.

3.1.2 All materials shall be free from any defects viz., blow holes / flaw, pinholes, cracks, skin defects etc. The wall thickness shall be as shown in the schedule of materials and shall be based on the system pressure, velocity and temperature of the medium transported with necessary allowance for erosion.

3.1.3 All materials shall be new and one of the recommended make.The pipes, fittings and valves shall bear brand and valves name and certification by Local Bureau of Standards.

3.1.4 The fittings shall include coupling, tees, bends, reducers, nipples and plugs.The flanges shall be as per the pressure class indicated in the schedule of material.

3.1.5 The threading on fittings shall conform to the Standard specifications unless otherwise specified with horizontal threading for female ends and tapered for male ends.

3.1.6 Valves shall be incorporated in the system as shown in the drawing and shall be suitable for the medium handled and the duty specified.

3.2 Piping Work

3.2.1 The piping work shall follow the details set out on the tender drawings making due allowance for diagrammatic nature of the drawings and taking account and intension of the specific requirements of systems and requirements.

3..2.2 The pipe runs shall be installed in accordance with best acceptable practice and shall be arranged to present a neat appearance and shall be parallel with each other and with building structure except where falls / drops are required for draining and venting. All vertical riser / drops shall be in Plumb.

3.2.3 The pipe assembly shall be suitable for the materials of piping material used and recommended by the manufacturer.The assembly shall generally be as indicated below unless otherwise indicated.

1. Cast Iron S&S - Synthetic caulking
2. Cast Iron hubless - Grooved DI couplings
3. Carbon steel / Mild steel - Welding
4. Galvanised Iron - Threading
5. Stainless steel - Welding
6. Copper - Soldering / Brazing
7. UPVC - Synthetic solvent coating
8. CPVC - Synthetic solvent coating
9. Polypropylene - Fusion
10. Polybutyene - Fusion

3.2.4 The pipes shall be accurately cut to the required length using proper tools and the ends smoothened and cleaned thoroughly before assembling.The inside and outside of pipes and fittings shall be cleaned thoroughly before and after the fabrication work.

3.2.5 The pipes shall be laid in lines and levels indicted on the drawings.The vertical risers shall be properly secured to the building structure with necessary clamps. The horizontal runners shall be hung from the ceiling using pipe hangers or laid on structural steel racks, duly clamped.

3.2.6 Additional supports shall be provided at the assembly of valves and control accessories, change in direction of pipes etc.

3.2.7 Necessary unions, flanged joints and isolation valves shall be incorporated in pipe line for easy maintenance, replacement and isolation of section of pipes. The flanged joins shall be with 3 mm neoprene gasket for normal and temperature system. CAF gasket shall be used for higher temperature installation.

3.2.8 All fabricated piping shall conform to the fabrication dimensional tolerance specified in the code for pressure piping. ANSI B 31.3 and shall in no case be more than the following ;

1. Individual tolerance : ± 1.5 mm
2. Overall tolerance : ± 3.0 mm

3.2.9 All piping work shall be provided with protective coating to suit the ambient condition surrounding the piping work and duly colour coded.

3.2.10 The steam, fuel oil piping etc. falling under regulation of local authorities shall meet the requirements laid down in such regulation and the fabricators should hold necessary valid certificate / license.

3.2.11The hot water and steam piping shall be provided with expansion loops / flexible pipe and roller shoes as per good engineering practice to avoid stress on the pipe due to expansion and contraction

3.2.12 In general, permanently welded-in rings shall not be used.If back-up rings should be necessary or desirable, they may be used only upon specific approval of the Consultants / Engineer-in-charge. If used, they shall be streamlines to minimize turbulence and resistance to flow through the pipe.

3.2.13 Copper and thermoplastic pipe assembly shall be composite fittings having threaded gunmetal ends at one side of jointing valves/flanges, equipments and sanitary fittings.

3.2.14 The pipe bending shall be carried out carefully using proper tools of appropriate size to avoid cracks or any other damage to the internal and external surface of the pipe. Filling of sand or inserting of spiral ring as recommended by the manufacturer shall be followed.

3.2.15 The cost of piping work shall include all supports, brackets, suspendors, fixing materials, clamps and all accessories unless otherwise specifically indicated in the bill of materials.

3.2.16 Proper cutting tools suitable for the piping material shall be used for cutting the pipes as recommended by the manufacturer. The cut ends shall be reamed to removeburrs before making the joints.

4.0 PIPING MATERIAL

4.1 General

4.1.1 The piping materials for various services shall be as indicated in system design and bill of materials.

4.1.2 The pipe fittings shall be suitable for the medium transported, system pressure and temperature and shall be non-corrosive to the medium transported and the ambient.

4.1.3 The pipes and fittings shall be truly cylindrical having uniform thickness and smooth surface both internal and external.

4.1.4 The pipes and fittings shall be free from any defects viz., blow holes / flaw, pinholes, cracks, skin defects etc. The wall thickness shall be shown in the schedule of materialsad shall be based on the system pressure, velocity and temperature of the medium transported with necessary allowance for erosion.

4.1.5 The pipes and fittings shall be new certified by Bureau of Indian Standards and one of the recommended make. The pipes and fittings shall bear brand name and BSI certification.

4.1.6 The fittings shall include couplings, tees, bends, reducers, nibbles and plugs. The flanges shall be as per the pressure class indication in the schedule of material.

4.1.7 The threading on fittings shall conform to IS : 534 unless otherwise specified with horizontal threading for female ends and tapered threads for male ends.

4.2.1 The mild steel pipes and fittings shall conform to the following standards and codes.

1. IS : 1239 Mild Steel tubes, tubular and other wrought iron steel

fittings (Part 1 & 2)

1. IS : 3589 Seamless or electrically welded steel pipes for water,

gas and sewage.

1. IS : 1879 Malleable cast iron pipe fittings.
2. IS : 2108 Black hart malleable iron casting
3. IS : 554 Dimension for pipe threads where pressure tight joints

are required on threads.

4.2.2 The wall thickness of the pipes shall be based on the system pressure and the medium to be transported. For normal working pressure the pipe shall be as indicated below unless otherwise indicated in the schedule of work.

1. ERW pipes Below 150 mm Heavy class
2. ERW pipes Above 150 mm rolled out of 5 mm plate
3. Seamless pipes Below 300 mm Schedule 40
4. Seamless pipes Above 300 mm Schedule 20

4.2.3 The fittings shall be forged steel conforming to IS : 1879 /2108.

4.2.4 The GI pipes and fittings shall conform to the following standards and codes in addition to that of Carbon Steel Pipes.

1. IS : 2629 Recommended practice for hot tip galvanizing of iron and steel.
2. IS :4736 Hot dip Zinc coatings on structural steel and allied products.
3. IS :4759 Hot dip Zinc coatings on structural steel and allied products.

4.3 Pipe Fittings

4.3.1 General requirements

4.3.1.1 The pipe fittings shall include :

1. Reducers, sweeps, elbows etc for change in direction.
2. Bends, sweeps, elbows etc. for change in direction.
3. Tees, oblique branches, swept branches etc. for junctions and branch offs.
4. Flanges, expansion bellows and loops, anchors etc.

4.3.1.2 The following general particulars shall be applicable for such fittings, irrespective of materials and grades, unless otherwise specifically indicated.

1. **All fittings upto 150 mm shall be factory fabricated.**
2. Reduction and enlargement

The reduction and enlargement of pipe bore shall preferably be eccentric type where venting and drawing is required. The included angle shall be 10 deg. where space permits, but not exceeding 30 deg.

1. Change in direction

All changes in directions shall be carried out in such a way that the ratio of inner diameter to the radius of the center line of bend shall be not less than 1: 1.5 . Shorter radius shall be accepted only in case of space restriction at site.

1. Junctions

All junctions and branch off shall be of swept in with radius or oblique to achieve a lead in the direction of flow.

1. Expansion loops

The expansion loops shall be square or rectangular ‘U’ fabricated out of single length pipe forge bent to the required dimension. Where loops are too large to be fabricated in one piece they may be fabricated in sections and flange joints at site.

4.3.2 Steel Tubular Fittings

4.3.2.1 The tubular fitting shall conform to to the following :

1. IS : 1239 For dimensions
2. IS : 1387 For material

4.3.2.2 Bends

 The bends and springs shall be of the same material and grade of the main piping system. The end of the fittings shall be plain, bi-veiled or screwed taper thread depending on the type of assembly specified.

 The bends and springs may be provided from manufacturer’s work or manipulated at site. The site fabrication shall be through cold bend using hydraulically operated machines. Care shall be taken in manipulation to avoid formation of notches, corrugation, excessive thinning of pipe wall at the throat. All bends shall be normalized by heat treatment after manipulation.

4.3.2.3 Junctions

 The site fabricated steel junctions shall be carried out precisely to take the form of pulled bend and shall be not less than 60 deg. The opening in the main pipe shall be accurate and having the profile suitable to receive the branch off line and welded together. Care shall be taken to avoid prolusion of the branch into the main pipe and excessive flux.

4.3.2.4 **The flanges shall be slip-on welded type of PN 10 rating to BS : 4504.**

4.3.3 Malleable Pipe Fittings

4.3.3.1 The malleable pipe fittings shall conform to the following :

1. IS : 1879 For dimensions
2. IS : 14329 For material

4.3.3.2 Malleable cast iron fittings shall be manufactured by the White hart process to Grade – 1, suitable for 10.0 bar. The fittings shall be with threaded socket for bores upto 50 mm and welded socket for bores above 50 mm.

4.3.3.3 The screwed end of the fitting shall be with parallel female and tapered male threads, the axis of threads being coincident with true axis of the fitting and conforming to IS : 554.

4.3.3.4 The fittings shall be of long sweep where standard fittings are not available for the duty, reductions shall be made with reducing sockets of eccentric pattern.

4.3.3.5 The flanges shall be of welding neck for welded pipe assembly and threaded neck for threaded pipe assembly.

4.3.6 Forged Steel fittings

4.3.6.1 The forged steel fitting shall be manufactured from seamless mild steel tubes. The fittings shall be with bi-veiled ends, suitable for butt welding and shall have the same bore and thickness of the pipe.

4.3.7 Galvanised fittings

4.3.7.1 All tubular and malleable fittings shall be hot dip galvanized after the fabrication, but before threading or tapping, conforming to IS : 4736.

4.3.6 Mechanical Grooved fittings

4.3.6.1 Mechanical grooved fittings shall be of malleable iron, ductile iron or carbon steel with an elastomeric gasket stretched over on both sides. The gasket shall be suitable for the system pressure and temperature.

4.3.6.2 The joints shall prevent pipe separating under the operating pressure and allow limited angular movement, expansion and contraction. Rigid connection shall be used where flexibility is not allowed.

4.3.6.3 The manufacturer’s recommendation shall be strictly followed for the piping work.

4.3.7 Unions

4.3.7.1 The unions shall be malleable iron with internal threading and external hexagon nut finish.

4.3.7.2 The unions on special application shall be of bronze or stainless steel.

4.4 Cast Iron Pipes

4.4.1 The cast iron pipes shall conform to the following standards and codes.

1. IS : 210 Grey iron casting
2. IS : 1536 Centrifugally CI (Spun) pressure pipes for water, gas and sewage.
3. IS : 1537 Vertically CI pressure pipes for water gas and sewage.
4. IS : 1538 Centrifugally CI fittings for pressure pipes for water gas & sewage.

4.4.2 The CI pipes shall be spigot and socket pipes of LA class conforming to IS : 1536 unless otherwise indicated. The fittings shall conform to IS : 1538.

4.4.3 The pipes and fittings shall be suitable for lead joints.

4.5 Stainless Steel Pipes

4.5.1 The stainless steel pipes shall conform to the following standards and codes.

1. ASTM – A 312 Seamless and Welded Austenitic Stainless Steel Pipes.
2. ASTM – A 530 Testing of Welded Austenitic Stainless Steel Pipes.

4.5.2 The stainless steel pipes shall be seamless or welded annealed tubing with plain ends conforming to ASTM 312 – TP 304/316 as indicated in the bill of materials. The pipes shall be internally electro polished with 300 grade finish.

4.5.3 The fittings shall be butt /socket welded conforming to ASTM A – 182 or with integral solder ring capillary.

4.5.4 The pipe thickness shall be as per Schedule 10 for pipes upto 50 mm dia and schedules for pipes above 50 mm dia.

4.5.5 Stainless steel pipe fittings may be made on site from the pipe, using bending springs and not damaging the wall. Flattening rippling, scoring of tube will not be accepted

4.6 Copper Pipes

4.6.1 The copper pipes and fittings shall conform to the following standard specification.

1. BS :2871 Copper tubes for water, gas and sanitation.
2. EN :1057 Seamless round copper tubes for water gas, sanitation and heating application.
3. EN :1971 Electromagnetic (Eddy Current) examination of Copper and copper alloy tubes.
4. EN : 1254 Copper and copper alloy plumbing fittings.

P-1, fittings with ends for capillary soldering or capillary brazing to copper tubes.

P-2, fittings with compression ends for use with copper tubes.

P-5, fittings with short ends for capillary brazing to copper tubes.

1. EN : 29453 Soft solder alloys – Chemical composition and forms.

4.6.2 In case of light gauge copper tubes, bends, springs, cranks and affects can be site fabricated from the same tubes. Cold bending is permitted upto 28 mm dia. Larger pipes upto 40 mm dia shall be annealed before manipulation.

 Tubes shall be loaded with springs prior to manipulation, where bending machines are used, the same shall have smooth clean guides and formers.

4.6.3 The fittings shall be manufactured from copper or corrosion resistant copper alloy casting, drawing or hot pressing.

4.6.4 Compression fittings may be used only where specified and shall be manipulative Type B.

4.6.5 The compression fitting shall have profiled ends with :

1. Internal conical seating
2. External lugs or threads
3. Machined central ferrules having double tape in cross section.
4. Machined conical friction ring and coupling nut or flanges.

4.7 Thermoplastic Pipes

4.7.1 The thermoplastic pipes shall be of Polyvinyl chloride (PVC), Polypropylene (PP) or Polyethylene (PE) as indicated on the drawing and schedule of materials.

4.7.2 The thermoplastic pipes and fittings shall conform to the following standards and codes.

1. IS : 4984 High Density PE (HDPE) pipes for water supply.
2. IS : 4985 Un-plasticized PVC (UPVC) pipes for potable water supply.
3. IS : 10124 Fabricated PVC fittings for portable water supply.
4. IS : 5382 Rubber sealing rings or gas mains, water mains & sewers.
5. ASTM-D-1785 Threaded UPVC pipes
6. DIN : 8076 Fittings with metal inserts
7. DIN : 8077 Polypropylene pipes
8. DIN : 8078 Polypropylene pipe type 3 quantity requirement test
9. DIN : 16962 Joints and fittings for PP pressure pipes
10. ISO : R288 Fittings with threaded metal inserts
11. DVS : 2208 Welding of thermoplastic materials

4.7.3 The PVC pipes shall be unplasticised (UPVC) or chlorinated (CPVC) suitable for solvent joints conforming to IS : 4985. The fittings shall be injection moulded. Composite fittings conforming to ISO : R288 having combination of PVC and gunmetal ends shall be provided at connection to equipments valves and outlets, PVC pipes with threaded joints wherever required shall conform to ASTM-D-1785.

4.7.4 UPVC push fit injunction moulded fittings shall be of socketed end with the rubber ring seated firmly into a groove in such a way that the ring is not dislocated during push fit jointing.

4.7.5 The polyethylene pipes shall be of HDPE suitable for fusion welding. The connection to equipments, valves and outlets shall be through combination flanged joints having flanges of HDPE and metal.

4.7.6 The polypropylene pipes shall be of Random Copolymer (PP-R) conforming to DIN 8077 suitable for fusion joints. The fittings shall conform to DIN : 16962 for fusion welding. Fittings for connections to equipments, valves and outlets shall be with composite fittings conforming to ISO R288.

5.0 Fabrication and assembly

5.1 General requirement

5.1.1 The pipe assembly shall be suitable for the materials of piping material used and recommended by the manufacturer. The assembly shall generally be as indicated below unless otherwise indicated.

1. Carbon steel /Mild steel - Welded
2. Galvanised Iron - Threaded
3. Stainless Steel - Welded
4. UPVC - Solvent
5. CPVC - Solvent
6. Polypropylene - Fusion
7. Polybutyene - Fusion

5.1.2 The pipe assembly shall be suitable for the medium transported, its pressure and temperature leak proof assembly with good workmanship, neat appearance and easy access for maintenance shall be prime requisites of the piping work.

5.1.3 The pipes shall be accurately cut to the required length using proper tools and the ends smoothened and cleaned thoroughly before assembling. The inside and outside of pipes and fittings shall be cleaned thoroughly before and after the fabrication work.

5.1.4 The pipes shall be laid in lines and levels indicated on the drawings. The vertical risers shall be properly secured to the building structure with necessary clamps. The horizontal runners shall be hung from the ceiling using pipe hangers or laid on structural steel racks., duly clamped.

5.1.5 Pipe supports shall be of steel with a prime coat of red oxide and two finish coats of matt black paint after installation. Supports shall be space as follows.

|  |  |  |
| --- | --- | --- |
| Size | Horizontal | Vertical |
| Upto 15 mm | 1.25 m | 1.8 m |
| 20 to 25 mm | 2.00 m | 2.5 m |
| 32 to 125 mm | 2.50 m | 3.0 m |
| 150 & over | 3.00 m | 3.0 m |

5.1.6 Additional supports shall be provided at the assembly of valves and control accessories, change in direction of pipes etc.

5.1.7 All supports shall be from structural steel, steel inserts in concrete, adequate shear fasteners wall brackets or floor supports as decided by the engineer-in-charge depending upon the location of the support.Hangers shall be secured to light weight roof, wall false ceiling or any other member which is not structurally meant for such loading.Hangers from structural steel shall be from suitably designed clamps or attachments and in no case should drilling or punching of such steel members be allowed.All pipe supports shall becapable of being adjusted in height to the tune of 50 mm.

5.1.8 Pipe clamps shall be specially fabricated fittings for pipes.All clamps shall be of mild steel prime coated with red oxide and finish coated with matt black paint.Clamps shall take into account pipe movement owing to temperature variations & anchors, and in no case shall the clamping arrangement induce stresses beyond the safe load limits of the pipe under fully filled conditions.Where pipes are insulated, the clamping shall interpose a hard insulation material or shall be designed so that the insulation is not compressed for more than 60% of its compression strength.

5.1.9 Auto air vents shall be provided at all high points in the piping systems for air purging.Vent size shall be as follows and suitable for specified test pressure.

Upto 152 mm : 12 mm size globe type gun metal valves

 With hose connections

Over 152 mm : 20 mm size globe type gun metal valves

 with hose connection.

5.1.10 Drains shall be provided at all low points and all drain valves shall be gun metal globe type with hose connections.

5.1.11 Pipes passing through the walls and floors shall be provided with GI light duty passage sleeves with puddle flanges.The sleeves shall be ofadequate size with clearance on minimum 25 mm all around pipe / insulated pipe.The sleeves provided in the internal partitions shall be flush with the wall surface whereas the same in floor slabs and external wall shall have minimum 50 mm projection.

All openings after the passage of the pipe shall be filled with fire barrier materials.Additional water proofing sealants are to be provided at the sleeves facing the external side.

5.1.12 All piping shall be laid and tack welded in position with flanges, valves etc. for the inspection and approval of the site in charge and only after the approvalthe piping shall be fully welded.Slip-on flanges shall be demented for welding.Piping may be presented to the Engineer for such approval in section.Random samples of valves shall be tested for leaks and seating.Necessary hand pump and blank flange facilities with pressure guage, valves etc. should be provided at site.

5.1.13 Necessary unions, flanged joints and isolation valves shall be incorporated in pipe line for easy maintenance, replacement and isolation of section of pipes.The flanged joints shall be with 3 mm neoprene gasket for normal and temperature system.CAF gasket shall be used for higher temperature installation.

5.1.14 All fabricated piping shall conform to the fabrication dimensional tolerance specified in the code for pressure piping, ANSI B 31.3 and shall in no case be more than the following.

a) Individual tolerance :±1.5 mm

b) Overall tolerance :± 3.0 mm

5.1.15 All piping work shall be provided with protective coating as specified separately in this section and duly colour coded.

5.1.16 The steam, fuel oil piping etc. falling under IBR or regulation of local authorities shall meet the requirements laid down in such regulation and the fabricators should hold necessary valid certificate/license.

5.1.17 The hot water and steam piping shall be provided with expansion loops / flexible pipe and roller shoes as per good engineering practice to avoid stress on the pipe due to expansion and contraction.

5.1.18 In general, permanently welded-in rings shall not be used.If back-up rings should be necessary or desirable, they may be used only upon specific approval of the Consultants /Engineer-in-Charge.If used, they shall be streamlined to minimize turbulence and resistance to flow through the pipe.

5.1.19 Copper and thermoplastic pipe assembly shall have composite fittings having threaded gunmetal ends at one side for jointing valves/flanges, equipments.

5.1.20 The pipe bending shall be carried out carefully using proper tools of appropriate size to avoid cracks or any other damage to the internal and external surface of the pipe.Filling of sand or inserting of spiral ring as recommended by the manufacturer shall be followed.

**5.2** **Mild Steel Piping-Welded Assembly**

5.2.1 The pipe assembly shall be carried out by electrical are welding.

5.2.2 The welding electrodes with suitable coating shall be of **Advani Orlicon make** and shall be got approved by the Owner/Consultants.

5.2.3 Machine cut levels to form the welding groove are preferred, but smooth, clean slag free flame cut and ground levels are acceptable.

5.2.4 The pipes to be aligned and tack welded, leaving a gap of 1.5 mm for pipes upto 150 mm dia and 3.0 mm for pipes above 150 mm dia for fuse penetration are not acceptable.

5.2.5 In the case of multiple pass welding the slag shall be cleaned from the previous layer before lacking up the neat layer, the weld shall be cleaned free from scale slag flux etc.

5.2.6 The finished weld shall be uniform and shall be project not less than 1.5 mm or more than 3 mm from the outlet surface of the pipe.

5.2.7 Pipe bends fabricated out by hot bending of pipes are acceptable upto 50 mm dia. The minimum radius of the bend shall be not less than 6 times the diameter and the bends shall be free of budges, cracks, airlinks, buckles etc. hot bends shall be done with the pipe filled with tamped sand.Following the bending operation, the bend shall be allowed to cool slowly in still air before the sands is removed.

5.2.8 Cold bends to a radius of six (6) the normal pipe diameter or greater may be made without subsequent stress relieving.No cold bending is allowed on pipe larger than 50 mm nominal diameter.

5.2.9 All welding shall have full thickness penetration and shall be done when the electrical are in process.Gas welding may be sued with Consultant’s approval.The initial root run of all but weld shall be carried out with electrodes not exceeding 12 SWG.

5.2.10 In multiple pass welding the slag shall be cleaned from each layer and any serious defects chipped and before the next layer is applied.Pining shall be done if necessary to prepare a bead for the next to pass.

5.2.11 No under cutting of pipe adjacent to the complete weld will be permitted.

**5.3** **Copper Piping – Soldered Assembly**

5.3.1 The copper pipe assembly shall be through soldered joints as recommended by the manufacturer.Proper tools shall be used for bending, cutting, cleaning and jointing.

5.3.2 The jointing shall be through integral solder ring fittings unless otherwise specifiedThe pipes to be cut using tube cutter or fine bladed hacksaw and cleaned thoroughlyusing fine file and scotch brite pads.

5.3.3 The pipe end to be inserted inside the fitting fully after applying water soluble flex on the outer surface of pipe and internal surface of the fitting.Apply heat using blow lamps till the solder ring is molten and uniformly appears around the mouth of the fitting.

5.3.4 The refrigerant copper piping shall be as shown on the drawing on based on the following criteria

a) Suction line :Pressure drop not exceeding 1.1 °C equivalent

b) Liquid lines : Pressure drop not exceeding 0.5 °C equivalent

c) Discharge line : Pressure drop not exceeding 0.5 °C equivalent

**5.4** **PVC Piping Solvent - Adhesive Assembly**

5.4.1 The PVC pipe assembly shall be carried out by means of solvent cement and rubber ring. The pipe assembly and fabrication shall be generally as per the recommendation of the manufacturer. The cur end of the pipe shall made smooth by filling before the carrying out of the assembly. Space provision of minimum 10 mm shall be kept inside the socket for expansion.

5.4.2 PVC piping with threaded assembly shall generally be as indicated in GI pipe assembly.

5.4.3 The pipe shall be supported as per the recommendations of the manufacturer to avoid sagging and stress on the joints. The support interval shall, at any case, not exceed 1500 mm.

**5.5** **Polypropelene /Polybutylene Piping – Fusion Assembly**

5.5.1 The PP-R and PB piping shall be through fusion welding as recommended by the manufacturer. The pipe ends are to be smothened and cleaned thoroughly before making the joint.

5.5.2 The pipes end to be welded shall be heated to the adequate temperature and duration to achieve proper joint. The polyfusion welding duration shall be as per DVS 2207 norms furnished below.

|  |  |  |  |
| --- | --- | --- | --- |
| Pipe size(mm) | Heating time(Sec.) | Working time(Sec.) | Cooling time(Sec.). |
| 16 | 4 | 3 | 2 |
| 20 | 5 | 4 | 2 |
| 25 | 7 | 4 | 2 |
| 32 | 8 | 6 | 4 |
| 40 | 12 | 6 | 4 |
| Pipe size(mm) | Heating time(Sec.) | Working time(Sec.) | Cooling time(Sec.). |
| 50 | 18 | 6 | 4 |
| 63 | 24 | 8 | 6 |
| 75 | 30 | 8 | 6 |
| 90 | 40 | 8 | 6 |
| 110 | 50 | 10 | 8 |

**6.0** **Cleaning**

6.1 The pipe shall be thoroughly cleaned internally and externally during the fabrication, assembling and completion, of the entire piping work using compressed air, clean water etc.

6.2 Necessary detergents shall be used while cleaning and flushing the piping system and in-line instruments, traps etc. shall be isolated.

6.3 All field fabricated piping shall be cleaned at the completion of fabrication. Care shall be taken to see that all burrs, welding icicles and weld spatter are removed by reaming, chipping, filling sandering or other suitable means.

 All foreign material such as cement, motor sand, heavy oil lid and loose scale shall be removed from the interior of pipe by thoroughly flushing with water. To avoid large size foreign material being washed into smaller diameter branch blind from a larger diameter header line, special precautions should be taken to disconnect at branched or to selectively blank them off.

6.4 A record shall be kept of cleaning of each line or section of erected piping. Cleaned lines shall be tagged.

6.5 Proper temporary drainage for flushing water shall be provided so that no damage is done to permanent facilities.

6.6 Valves shall be cleaned when received. All possible precautions shall be taken to prevent contamination and valves shall be inspected immediately prior to installation. If a valve is found to be contaminated in any way, it shall be cleaned as follows :

i) Removed all foreign particulars by wiping with clean lint less cloth.

1. Wipe interior of valve with a clean lint less clothes moistened with cleantrychlorethylene

6.7 If contamination is excessive in metallic valves, suspends the valve in a degreasing tank with hand wheel uppermost. Direct stream of liquid trichloroethylene into the rim of the valve, though both ends and against all inside surfaces. Flush thoroughly to remove all foreign matter

**7.0** **Above Grade Piping**

7.1 All piping shall be erected as shown on the drawing and in accordance with this specifications so as to confirm with the applicable codes and engineering design.

 Arrangement drawing shall show general location and will indicate special dimensions, location of valves, fittings etc. whenever critical.

7.2 Piping shall be grouped in banks wherever possible but most at the same time have dimensions, locations of valves, fittings etc,. wherever critical.

7.3 Due provision shall be made for thermal expansion of pipes and equipments preferably by flexible arrangement, expansion etc.

 Special attention shall be given in the handling and erection of piping to prevent damage and ensure the continued cleanliness of such piping.

7.4 Piping carrying corrosive liquids shall not be positioned above mild steam line or electric cables.

7.5 All flanged joints shall be fitted up so that the gasket contact faces uniformly on the gasket, and then made up with relatively uniform bolt stress. The gasket shall be properly compressed in accordance with the design principles applicable to the type of gasket used. All bolts shall extend completely through their nuts.

7.6 Piping connections to equipments shall be made in conformity with details shown on the drawings.Large size piping attached to upper flanges of vessels shall be installed after final setting shimming and grouting of the vessel supports.

7.7 Mill weighting and grouting of all rotary equipments shall be done before theconnected piping has been installed and properly anchored or supported.

7.8 Slopes of piping specified on drawings shall be maintained.Where no slopes required or where a required slow approaches the horizontal, piping shall be checked for sag with a level not less than 1 meter long equipped with a graduated bubble vial.All low points where liquid may be entrapped shall be removed.

7.9 Valved drains shall be provided at all low points where the liquid may be trapped.All high points shall have valved cents or plugged connections prior approval of theSite in-charge /Consultants shall be required for making these provisions.

7.10 After piping is erected in final position, it shall be cleaned, tested for tightness and dried out where required as already described in this specification.

**8.0** **Underground Piping**

8.1 Pipe buried underground shall have minimumcover of 600 mm and shall be laid over compacted soil with a sand cushion of 150mm below as well as above the pipe.

8.2 Necessary brick or PCC pedestal shall be provided to avoid stress on pipe lines, where the soil strata is poor.

8.3 Insulated pipes shall be laid only on PCC pedestals and shall have adequate coating and wrapping to prevent entry of moisture and damage to the insulation.

8.4 All pipes crossing roads and pavements shall be taken through hume pipes of minimum diameter of 3 times the finished pipe size.

9.0 **Anticorrosion Treatment**

9.1 The exposed pipe assembly shall be provided with outer coating to prevent corrosion.

9.2 Pipe laid above ground shall be provided with the following anti corrosive coating.

1. Two coats of paint of approved colour over two coats of red-oxide primer for M.S pipe.
2. Two coats of paint of approved colour for G.I piping.

9.3 Pipe laid underground or concealed in building structure shall be provided with two coats of bituminastic paint and wrapped with 4 mm thick polymeric composit tape of multiple layered bitumen and polyethylene or glass fiber tissue.Insulated pipes laid underground shall be wrapped with 3 layers of glass fiber tissue fabric with solvent adhesive coating.

9.4 All mild steel pipes and pipe fittings shall be thoroughly cleaned of oil and grease, using a solvent degreaser, which must be allowed to dry.All rust soil and other unwanted matter must be removed prior to solvent degreasing by chipping, manual scrapping and/or wire brushing.

9.5 Three coats of cold coal tar (Shalimastic H.D. or equal) shall be applied resulting in a final film thickness of 0.79 mm and simultaneously inner wrap of fibre glass reinforced or equal shall be pulled into it.Manufacturers’ recommendation shall be followed for the coal tar application.

9.6 Immediately following the application of the inner wrap a layer of outer-wrap (glass fibre) based outer wrap impregnated with coal tar or equal shall be applied to the external surface of the coating.

9.7 The coating shall be then allowed to dry and shall be protected from burrs, scratches and sharp edges.

**10.0 Testing**

10.1All piping shall be pressure tested by filling water, removing air locks and applying pressure using hand or hydraulic test pump unless otherwise specified.

10.2 The test pressure shall be equivalent to the higher value of the following :

 Minimum 1000 kPA

1. Twice the dynamic head of the pump gravity head due to expansion tank,Cooling tower etc.

ii) 2.5 times the no delivery head of the pump.

10.3 The pressure shall be maintained for a minimum period of **24 Hrs**. and achieve pressure drop with in 50 kPA

10.4 The testing shall be carried in section by blocking both ends or closing the valves, if provided.After completion, the entire installation shall be once again defective material and workmanship.

10.5 After commissioning the system, each valve shall be tested for effective working closing and opening a number of times.

10.6 The piping coming under IBR or any local authorities regulator shall be tested according to the clause laid under each regulations.

10.7 All testing shall be carried our in presence of the owner / consultants and test register shall be maintained water, labour, equipments and register required for the testing shall be the responsibility of the contractor.

10.8 The contractor shall make all arrangements for testing and removal after testing of all water, connections, if any without causing damage to the property of the employer or any other contractor.

10.9 After the entire piping has been tested and equipment connected, the system of water piping shall be filled and drained till all the dirt, miscal and any other foreign matter is flushed out to the satisfaction of the Engineer-in-charge.At any rate, the system shall be flushed out to the satisfaction of the Engineer-in-charge.At any rate, the system shall be flushed at least 3 times before commissioning.All strainers shall be cleaned of all accumulated dirt before the system is charged.

# **2205MOTIVE & TRANSMISSION EQUIPMENTS**

1.0 SCOPE

1.1 The scope of this section covers motive equipments such as :

 a) Motors

 b) Pulleys

 c) Drive belts

2.0 STANDARDS

2.1 The following standards shall be applicable :

 a) IS : 325 3 Ph. Induction Motors

 b) IS : 996 1 Ph. small AC and universal electric motors

 c) IS : 900 COP for installation and maintenance of

 induction motors

 d) IS : 1231 Dimensions of foot mounted induction motors

 e) IS : 2223 Dimensions of flange mounted induction

 motors

 f) IS : 2253 Type of construction and mounting of motors

 g) IS : 4029 Guide for testing 3 Ph. induction motor

 h) IS : 4722 Rotating electrical machinery

 I) IS : 4691 Degree of protection provided by enclosure for

 rotating electrical machinery

 J) IS : 4728 Terminal marking for rotating electrical machines

 K) IS : 3003 Carbon brushes for electrical machines

 L) IS : 6362 Designation of the method of cooling of rotating

 electrical machines

 M) IS : 3142 V-grooved pulleys for V belts give sections

 A,B,C,D and E

 N) IS : 2949 V belts for industrial purpose

 O) IS : 2122 COP for selection, storage, installation and

 maintenance of belts for power transmission

3.0 GENERAL REQUIREMENTS

3.1 The motors and transmission equipments shall be suitable for the motive power required and the speed of the equipment to be driven.

3.2 For air handling equipments desired to run for 24 hrs. shall be provided with 2 nos. motive and transmission equipment.

4.0 MOTORS

4.1 The motor shall conform to the details shown on the equipment data of the equipment driven and shall be designed for an average ambient of 45 degree C with a peak of 50 degree C.

4.2 The motors shall be squirrel cage induction upto and including 200 hp unless otherwise indicated. The motors shall be suitable for continuous operation round the clock and statically and dynamically balanced to achieve smooth operation and low noise level.

4.3 The enclosure shall be of cast iron having a minimum degree of protection as shown below.

 a) Refrigeration units

 b) Air handling equipment

 c) Pumps

 d) Air washer equipments

4.4 The stator and rotor cores shall be made out of high quality magnetic steel stapings of high permeability and low loss. The stator winding shall be with synthetic enameled copper wire with slot insulation of minimum class B insulation. The rotor winding shall be of caged construction with copper or copper alloy bars brazed to end ring of same material. The motors shall be with shaft mounted fans for cooling the windings.

4.5 The shaft shall be of high grade tensile steel suitable for heavy duty. The bearing at the free end shall be ball type at free end and roller type at the load end.

5.0 PULLEYS

5.1 The pulleys shall be of heavy duty M.S or Cast Iron with V groves. The pulleys shall be with suitable bearing to achieve low friction less.

6.0 DRIVE BELTS

6.1 The drive belts shall be V-belts suitable for industrial purpose. The size and number of belts shall be according to the power to be transmitted. The belt safety factor shall be not less than 2.5

7.0 INSTALLATION

7.1 The motors shall be directly coupled to the equipment. However, indirect driven equipments are acceptable provided it is essential for the proper performance of the equipment and owing to the space restrictions.

7.2 The motor and the equipment shall be mounted on a common base frame. The direct driven equipments shall be provided with flexible couplings. The couplings and the belt and pulley assembly shall be provided with suitable safety guards.

8.0 TESTING

8.1 The motors shall be meggered to record a IR value of not less than 1 megohm. The direction of rotation of the equipment to be checked before putting the equipment to operation. The no load and full load currents to be recorded.

# **2206 NOISE AND VIBRATION CONTROL**

1.0 SCOPE

1.1 The scope under this section covers control of noise and vibration for the equipments and installation.

2.0 STANDARDS

2.1 The following standards shall be applicable:

 a) IS :1950COP for sound insulation of non-industrial buildings

 b) IS :3483COP for noise reduction in industrial buildings

 c) IS :4954Recommendations for noise abatement in townplanning.

2.2 In addition to the above standards any other standards prevailing and the general construction and installation practices shall be applicable for the control of noise and vibration.

3.0 GENERAL REQUIREMENTS

3.1 The equipments and the installation shall be selected, designed and erected such a way that the noise and vibration is minimum where the noise level is high necessary precaution to be taken in the selection of the equipments and necessary acoustic treatment to be provided.Similarly where the vibration is high necessary isolator shall be provided to minimise the transmission of the vibration to the structure or other areas.

4.0 NOISE CONTROL

4.1 The equipments shall be selected for low noise level especially on handling equipments.Fan and drive motors shall be statically and dynamically balanced and provided with proper bearings.The sound pressure level should not exceed NC 60.

4.2 The fan coil and air handling unit R.A plenum shall be acoustically insulated.The supply and return air ducts shall be acoustically insulated for a minimum length of 3m or as shown on the drawing. The duct lining shall be carried out with 50 kg/cu.m open cellular nitrile rubber of 15 mm thick. The inner surface of the duct shall be cleaned and stick pin fixed to the sheet metal. The insulation material to be pressed against the sheet till the bonding is achieved.The sheet metal duct shall be increased accordingly to accommodate the insulation and get a clear ducts size indicated on the drawings.

4.3 The acoustic treatment of equipment rooms shall be by providing acoustic

 insulation of walls and ceiling as shown on the drawing. The material for insulationshall be of 30 mm thick open cellular Nitrile rubber of 56 kg/cu.m. The wall / ceiling surface shall be cleaned thoroughly and the stick pins fixed at 500 mm centers on both direction. The bonding material shall be applied uniformly on the surface and the rear side of insulation. The insulation shall be pressed on the surface till the bonding is achieved. Necessary GI cleats shall be fixed over the insulation and GI cross binding wires tied over the insulation for additional protection.

4.4 The velocity of air inside the ducts shall be limited to 9 m/sec. for main ducts and 7.5 m/sec. for branch ducts.The grilles shall be selected such that the noise pressure level should not exceed NC 25 for conference and guest rooms, NC 30 for public areas and NC 35 for mechanical areas.

5.0 AIR TIGHT DOORS

5.1 The air handling equipment room shall be provided with air tight doors.The doors shall be made of 14 SWG MS frame and 50 mm hollow door panels of 16 SWG MS filled with normal density resin bonded glass wool.There shall be double acoustic seal at the hinged side of the door and single seal at the other sides.The latche shall be positive pressure with adjustable strike and push rod release.The leakage shall not exceed 0.2 cmh/sq.m

6.0 VIBRATION CONTROLS

6.1 The equipments shall be statically and dynamically balanced and shall be provided with necessary concrete foundation.The equipments shall be fixed to the foundation/floor through vibration isolators.

6.2 The pipe connection to the pumps and other vibrating equipments shall be through flexible connection and necessary flexible hangers shall be provided for the pipe support near the equipments.

6.3 The duct connection to the air handling equipments shall be through double canvas connection or other flexible connection.

6.4 The equipment foundation shall be provided by other agencies based on the foundation drawing furnished by the air conditioning contractor.Necessary supervision during the construction of foundation and grouting of anchor/foundation bolts etc. shall be the responsibility of the air conditioning contractor.

# **2207AIR DISTRIBUTION**

1.0 SCOPE

1.1. The scope under this section covers air distribution system consisting of :

 a) Sheet metal ducting

 b) Grilles and diffusers

2.0 STANDARDS

The following standards shall be applicable.

a) IS : 277 Galvanised steel sheet

b) IS : 513 Cold rolled low carbon steel sheets and strips

c) IS : 655 Metal air ducts

d) IS : 659 Safety code for airconditioning

e) IS : 737 COP for wrought aluminium and aluminium alloy sheets and strips for

 general engineering purposes.

f) IS : 1079 Hot rolled carbon steel sheets and strips

g) IS : 2629 Recommended practic for hot-dip galvanising of iron & steel

h) CP : 352 Mechanical ventilation and air-conditioning in buildings

i) SMACNA Low pressure duct construction standard

3.0 GENERAL REQUIREMENT

3.1 The material and fabrication shall meet the requirement of the relevant standard specifications and codes. The materials and fabrication shall be suitable for the system pressure. All upstream ducting for VAC units shall be of minimum 500 Pa pressure clause.

3.2 The duct shall be preferrably factory fabricated to SMACNA standards.

3.3 The contractor shall prepare detailed shop/working drawings and get it approved by the Consultants before taking up the fabrication work. The drawing shall indicate the size and thickness of duct, air flow rate, air discharge at each outlet, size of discharge, grilled diffuser, location and size of guide vanes, dampers, access door etc.

3.4 Ducts shall be straight, smooth, air tight and neatly finished. The system leakage shall not exceed 5% .

* + 1. The sheet metal ducting shall be done for the proper distribution of air in airconditioned/ventilated space. The ducting shall be designed on the basis of equal pressure drop and shall incorporate necessary accessories like reducers, bends, splitters, dampers and guide vanes for proper control and smooth air flow.

3.6 The selection of air diffusing attachments and their location shall be done to achieve uniform air distribution. The grilles and diffusers shall be pained M.S or aluminium as specified and shown on the drawing.

3.7 The ducting shall be supported by means of hangers from the ceiling slab using anchor bolts and shall not rest on the false ceiling. Chipping of concrete slab and exposing reinforcement is prohibited.

3.8 Duct crossing walls and slabs shall be treated for anticorrosion and the openings shall be closed properly unless indicated on the drawing for the purpose of return air. There shall be no traverse joint in the section of duct concealed in brick wall. All longitudinal seams shall be sealed with mastic sealents.

3.9 Volume control dampers of splitter or louvred type shall be provided as shown on the drawings. Additional dampers if required shall be provided for proper balancing of the air distribution system.

3.10 Fire dampers shall be provided at the AHU outlet and return air inlet to the Air Handling Equipment/room Additional fire dampers shall be provided as per the codes of local fire authorities.

3.11 Access door shall be provided adjacent to the fire, splitter and louvered dampers.

3.12 Air outlets shall be selected based on the air quantity, throw and aerodynamic noise power not exceeding NC 30.The location size and shape of the air outlets shall be co-ordinated with interior and false ceiling scheme.

3.13 The ducting material and fabrication shall meet the requirements of local authorities, especially the fire authorities and shall incorporate necessary fire dampers to stop/curtail the propagation of fire through the duct.

4.0 MATERIAL

4.1 The ducting material shall be of aluminium or GI as specified. The GI shall be of lock forming quality sheets or coils conforming to standards ASTM A 653 and A 924 or conforming to grade D of IS : 1079 or IS : 513 as specified in IS : 272 coils are preferred to reduce the number of longitudinal joints.

4.2 The zinc coating of the sheets shall be hot dip G60 grade having minimum 180 gms/sq.m.

4.3 The yield strength of sheet and reinforcement shall be 200 Mpa.

4.4 The gaskets shall be self adhesive 3mm formed rubber or expanded polyethylene. The filters shall be heavy mastic sealants having excellant adhesion and elasticity.

4.5 The duct flanges and supporting materials shall be mild structural steel sections. The duct hangers shall be MS rod with threaded end and adjustable nuts.

4.6 All galvanised plain sheets shall be reasonably flat and free from twist. The zinc coating shall be clean, even and free from ungalvanised spots. Sheets shall not crack or peel during bending or fabrication. All sheets shall be procured from approved manufacturers.

5.0 DUCT FABRICATION

5.1 The duct shall be rectangular or circular as indicated on the drawings. The minimum thickness of the sheets shall be as per the pressure class and specified in SMACNA standards reproduced below, at the end of this Section.

5.2 The longitudinal joints shall preferrably be restricted to two diagonally opposite edges and shall be machine formed Pittsburgh lock type or button punch snap lock type.

5.3 The joints and seams should be able to withstand 1.5 times maximum operating pressure without deformation or failure. The traverse joints and reinforcement shall be as per SMACNA standards furnished above. The maximum deflection on traverse reinforcement joint shall be 6mm for ducts upto 1200 mm width and W/200 for greater width.

5.4 Cross breaking or beading shall be provided to tackle natural sag.

5.5 The companion flanges and girth angles shall be metered and welded at corners and rivetted to the duct at 75mm centres. The longitudinal seams shall be inside groove or pitsburg type. The flanged joints shall be made air tight with 3mm rubber or 6mm felt gasket and secured with 10mm GI bolts at 150mm centres. Ducts shall not be cross broken, if insulated. The seams and joints shall be rendered air tight with mastic sealant.

5.6 The elbows shall have a minimum R/D ratio of 1:3. The elbows of R/D rate of less than 1:3 and square elbows wherever provided due to site condition, shall be with equally spaced guide vanes for smooth flow. Splitter dampers shall be provided for all branch splits. All branches, feeding more than two outlets, shall be provided with control dampers.

5.7 Capped air flow connections shall be provided, wherever shown, for testing and balancing of air distribution.

5.8 The joints shall be sealed as indicated below.

|  |  |  |  |
| --- | --- | --- | --- |
| Sl.no. | Pressure Class | Sealing Class | Sealing details |
| 1. | 500 Pa | C | All travers joints only |
| 2 | 750 Pa | B | All travers joints and longitudinal seams only |
| 3 | 1000 Pa and above | A | All travers joints, longitudinal seamsand duct walls penetration |

 The upstream ducting for the VAV shall be considered as 1000 Pa class.

6.0 DAMPERS & GUIDE VANES

6.1 The GUIDE VANES shall be provided as shown below :

 a) At every non-split branch take off

 b) At every bend/elbow of less than 1.3 R/D ratio

 c) At first 4 collers after the fans and first two collar after every bends.

 The vanes shall be double walled and properly curved for smooth air flow and change in direction of flow and shall be fabricated out of 0.8 mm GI sheets. The vanes shall be fixed to the side runners at equidistant and riveted/bolted to the ducts.

6.2 The SPLITTER DAMPERS shall be double walled aerofoil blade fabricated out 1.6mm (16 SWG) GI sheet. The damper shall be complete with flanged sheet metal enclosure to suit the upstream and down stream duct connections, hinge at the down stream and operating road at the upstream end. The GI enclosure shall be one size thicker than the up stream duct.

6.3 The LOUVRED DAMPERS shall be multi blade aerofoil construction with opposed/parallel blades of maximum 250 x 1200 mm size . The blades shall be mounted on 50mm channel with suitable gang operated linkage and operating rod. The operation rod shall be terminated in a locking quadrant with position indicator.

6.4 The FIRE DAMPERS shall be rated for 2 hrs. fire resistance conforming to BS : 476-1 and CP-413 and shall be housed in a GI sheet enclosure flanged at both ends and shall include the damper blades, fusible link, holding spring, manual adjustable handle etc.

 The material for fabrication of fire dampers shall be as shown below :

 a) Damper blades - 3mm (GI SWG) Galvanised sheet steel

 b) Casing - 2mm (GI SWG)

 c) Bearing - Sintered

 d) Spring - SS 304

 e) Fusible link - Set for 7 deg C fusing temperature

6.5 All dampers larger than 1200 mm width shall be fabricated in multiple sections. The damper rods shall be MS epoxy coated with bronze bushes at one end and locking quadrant with damper position indicator at the other end. The damper rods shall extend beyond the enclosure frame and insulation.

6.6 The access doors for dampers shall be 400 x 400mm steel bolted with rubber gasket.

7.0 AIR OUTLETS

7.1 The air outlets shall be grille or diffuser type as indicated on the drawing. The grilles and diffusers shall be MS painted, aluminum or aluminum powder coated as shown on the drawing and schedule of material.

7.2 Supply air grilles shall be double deflection type with horizontal face bars and vertical rear bars placed in a rigid marginal frame. Bars shall be shaped and spaced at 18mm centres with swaged pivot pins positively holding the defections setting under all conditions of velocity and pressure. All grilles shall be provided with integral opposed blade, grille face kept-operated dampers.

7.3 Return grilles shall have fixed face bars shaped and set at 18mm centres. Bars shall be set at 5 degree deflection for vision proof installation. The grilles shall be complete with rigid marginal frames and shall be mateching with the supply grilles.

7.4 Ceiling diffusers shall be round/square/rectangular face flush type horizontal air diffusion pattern. Diffusers shall have ample margins to minimise ceiling smudge. Half diffusers shall be provided with face operated volume control dampers. Half diffusers shall be similar to full diffusers.

7.5 All MS grilles and diffusers shall be fabricated out of 1.0mm mild steel and painted with two coats of red oxide. All duct collars terminating on to a grille or diffuser shall be given two coats of black paint for a length of 300mm.

7.6 Aluminium grilles and diffusers wherever specified shall be of extruded aluminium with margins & GSS butterfly dampers. Grilles shall have horizontal face bars only.

7.7 Linear diffusers/grilles shall be die formed, flush mounted type with single or double directional air flow. The diffuser/grille shall be in a frame with minimum 20mm margin. All linear air diffusing equipment shall be fitted with a distribution sheet metal plenum as shown on the drawings.

8.0 AIR INTAKES & EXHAUST OUTLETS

8.1 The outside air intakes and exhaust air outlets shall consists of louvres, bird screen and enclosure, the total assembly fitted into wall with clear opening and the edges sealed with mastic sealent.

8.2 The sheet metal enclosure shall be made out of 1.25mm GI sheets flanged at both ends and with minimum 4 hold fast. The enclosure shall be minimum 250mm long or 100mm more than the width of the wall.

8.3 The louvers shall be 100mm wide mounted at 45 deg. and spaced at 100mm centres and shall be fabricated out of 1.25mm GI sheets.

8.4 The bird screen shall be made out of 15 x 15mm 1.0 mm GI wire mesh inset with 0.8mm GI frame and bolted to the enclosure flange at 150mm centres using 12mm MS brass bolts and nuts.

9.0 SUPPORTS & HANGERS

9.1 The ducts shall be supported at the traverse joints as indicated below :

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Duct Size(mm) | SupportSpacing (mm) | SupportingMember(Angle) | Cleat(Angle) | HangerRod(mm) dia | Anchor FastnerNo. &dia |
| Upto 500 | 3000 | ISA 2525/3 | 50 mm ISA4040/6 | 6 | 2 x 10 |
| 501-1500 | 3000 | ISA 4040/6 | 50 mm ISA4040/6 | 10 | 2 x 10 |
| 1501-2000 | 2500 | ISA 5050/6 | 200 mm ISA5050/6 | 10 | 4 x 10 |
| 2000 & Above | 2000 | ISA 5050/6 | 200 mm ISA5050/6 | 10 | 4 x 10 |

9.2 Additional supports wherever considered necessary by the Engineer - in-charge shall be provided. Supports shall be taken from steel members grouted in the RCC work and fixing of steel members shall involve minimum damage. The entire supporting system shall be meet with the approval of the Engineer-in-charge.

9.3 All duct supports, flanges, hanger shall be given two coats of red-oxide before installation and one coat of aluminium paint after erection.

9.4 Where ducts are connected to the wall, such connections shall be made through mild steel frame fixed to the wall through suitable shear fasteners.

10.0 INSTALLATION

10.1 The ducts shall be routed as shown on the drawing or as instructed. Working drawing shall be got approved before taking up the fabrication and erection.

10.2 Ducts connecting to air moving apparatus shall be through 15 OZ mildew resistant double canvas securely bonded and bolted at both ends as directed by the Engineer. On all circular spigots the flexible material is to be screwed with adjustable screw 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. The flexible connection shall not be less than 75mm and not more than 200mm.

10.3 The ducting work and the air outlets shall be properly co-ordinated with other building services and necessary modifications, if required to be incorporated at site. Similarly modifications and re-routings are to be carried out at site in case of obstruction/non-availability of space for ducting due to structural members, other equipment and services.

10.4 Uninsulated ducting in corrosion atmosphere shall be painted in black epoxy paint.

11.0 TESTING & BALANCING

11.0 The entire air distribution shall be adjusted and balanced for delivery of design air quantities or as required for achieving design space conditions. After all adjustments are made, the air readings shall be recorded on the drawings vis-a-vis the space conditions. All dampers after adjustment shall be set and locked in position. All air and static pressure measurements shall be done through probe type meters. Vane type meter readings are not considered reliable.

# **2208INSULATION**

1.0 SCOPE

* 1. The scope under this section covers thermal insulation of pipes, ducting, roof

and walls.

2.0 STANDARDS

2.1 The following standards shall be applicable.

 a) IS : 702 Specification for industrial bitumen

 b) IS : 3346 Method of determination of thermal conductivity of

 thermal insulation material

 c) IS : 3677 Specification for unbonded rock and slag wool for

 thermal insulation

 d) IS : 3690 Specification for glass wool mats for thermal insulation

 e) IS : 4671 Specification for expanded polystyrene thermal

 insulation purposes

 f) IS : 5688 Methods of test for preformed block – type and pipe

 covering type thermal insulation

g) IS : 5696 Specification for loose mineral wool (rock wool and

 slag wool)

 h) IS : 7240 COP for application and finishing of thermal insulation

 material at temperature between -80ºC to -40 ºC.

 i) IS : 7413 Application and finishing of thermal insulation material

 j) IS : 8183 Specification for bonded mineral wool

 k) IS : 9743 Specification for thermal insulation finishing cements

 l) IS : 10556 COP for storage and handling of insulation materials

m) IS : 11239 Method of test for cellular thermal insulation material

 (P1- P13)

n) IS : 11307 Specification for cellular glass block and pipe thermal

 insulation

 o) IS : 12436 Specification for performed rigid polyurethane (PUR)

 and isocynaurate (PIR) foam for thermal insulation

 p) IS : 13013 COP for packing thermal insulation material

 q) IS : 13204 Specification for rigid phenolic foams for thermal

 insulation

 r) IS : 14164 Industrial application and finsihing of thermal insulation

 material temperatures above 80 ºC and upto 700 ºC.

3.0 GENERAL REQUIREMENTS

3.1 The basic requirements of the thermal insulation are as shown below.

 a) Restrict the heat gain/heat loss

 b) Prevent condensation

 c) Prevent exposure of high temperature surface for personal protection

3.2 The insulation, bonding and clading material shall be suitable for the system/service specified.

3.3 The bonding the clading material shall be suitable for the insulation material used and recommended by the insulation manufacturer.

3.4 The application of insulation shall be as specified.However, necessary improvement, if required as per the recommendation of the manufacturer, shall be incorporated.

3.5 The material for insulation shall be nitrile rubber.

3.6 Exposure of glass wool and mineral wools in any form is unacceptable.

3.7 Pipe insulation shall be carried out only by preformed circular/semi-circular pipe sections of internal diameter exactly matching the outer diameter of the pipe to be insulated.Air pockets due to unmatching pipe sections or any other reason is not acceptable.Pipe insulation with slabs/sheets are acceptable for larger diameter pipe where preformed pipe section are not available.

3.8 All jointing both longitudinal and cross shall be staggered and the joints shall be sealed properly to avoid entry of moisture.Minimum 50 mm overlaping shall be provided at joints on vapour barrier and clading.

3.9 All surfaces to be insulated shall be thoroughly cleaned and dusted before applying the bonding and insulating materials.The bonding material shall be applied on both surfaces to be bonded.

3.10 All wooden plugs and batten used shall be treated for anti-termite with 3 coats of Shalimar clear liquid.Anchor bolts and screws shall be brass GI or powder coated.

3.11 All clading/vapour barrier provided shall be fire resistant.

3.12 All rigid form insulation shall be pre-inhibited, closed cellular structured solvent resistant having vapour permeability not excluding the figures indicated.

3.13 The bonded and unbonded glass wool/mineral wool shall be non-corroding short-free, non-hygroscopic specifically formed with a minimum fibredia of 7 micrometer. The unbonded glass/mineral wools shall be held in position using GI wire mesh.

3.14 The insulation shall be vermin proof, resistant to micro-organism and should not settle due to vibration.The insulation together with bonding resin shall have Class I/Class O as per BS : 476.The choice and thickness of insulation shall be as indicated in relevant sections and BOQ.

4.0 MATERIALS

4.1 The material for insulation shall be as shown below.

|  |  |
| --- | --- |
|  MATERIAL |  SPECIFICATION TEMPERATURE RANGE deg C |
|  | Densitykg/cu.m | K Valuew/m K | Water Vapour PermeabilityPerm-in | Cold insulation | Hot insulation |
| Closed cellular nitrile rubber | 40-70 | 0.035 | 0.060 | -40 to 20 | 20 to 85 |
| Fire inhibiting expanedpolystyrene | 18 | 0.0326 | 0.625 | -150 to + 20 | 20 to 60 |
| Expanded polyurethene | 32 | 0.025 | 0.500 | -150 to + 20 | 20 to 100 |
| Rigid phenolic foam | 32 | 0.022 | 0.250 | -150 to + 20 | 20 to 100 |
| Resin bonded glass wool | 34 | 0.037 | 13.550 | + 5 to + 20 | 20 to 150 |
| Resin bonded mineral wool/Rockwool | 48 | 0.041 | 13.550 |  ----- | 85 to 150 |
| Unbonded mineral wool | 48 | 0.041 |  ----- |  ----- | 85 to 230 |

4.2 The bonding and binding materials shall be as shown below.

a) Chemical adhesive/solvents manufactured and recommended by the

 manufacturer.

 b) Industrial bitumen 85/40 and 85/25.

 c) CPRX compound

 d) 20 mm GI chicken wire mesh of 24 G.

 e) 18 G, GI binding wire.

 f) GI anchor bolt and screw.

4.3 The vapour barrier/cladding material shall be as shown below.

 a) 50 micron reinforced aluminum foil facing

 b) 28G and 6 G aluminum sheet cladding.

 c) Foster seal fast coating 30-36

 d) 2 mm polymeric composite tape of polyethylene and bitumen film.

4.4 The bonding and cladding materials for different insulating materials shall be as shown below for indoor application.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Sl. |  Material |  Cold Insulation |  Hot Insulation | Additional Clading forExternal Application |
|  |  | Bonding | Clading | Bonding | Clading |  |
| 1. | Closed cellular nitirile rubber | Chemicaladhesive |  Nil | Chemicaladhesive |  Nil | Composite tape |
| 2. | Fire inhibiting expanded polystyrene | Bitumen | Alu. Foil | Bitumen | Alu.foil | Composite tape |
| 3. | Expanded polyurethene | Bitumen | Alu. Foil | Bitumen | Alu. foil | Composite tape |
| 4. | Rigid phenolic foam | Bitumen | Alu. Foil | Bitumen | Alu. foil | Composite tape |
|  |  |  |  |  |
|  |  |  |  |  |
| Sl. |  Material |  Cold Insulation |  Hot Insulation | Additional Clading forExternal Application |
|  |  | Bonding | Clading | Bonding | Clading |
| 5. | Resin bonded glass wool | Bitumen | Alu. Foil | Bitumen | Alu. foil | Alu. sheet |
| 6. | Resin bonded mineral wool/Rockwool |  ---- |  ---- |  Nil | Alu. sheet | Alu. sheet |
| 7. | Unbonded mineral wool |  ----- |  ----- |  Nil | Alu. sheet | Alu. sheet |

4.5 Additional cladding materials shall be provided for the insulation exposed to the atmosphere to prevent.

 a) Attack by birds, rodents and insects.

 b) Avoid ingress of water vapour.

 c) Reduce the heat input/loss.

 d) Weathering/faster aging of the insulation material

4.6 The thickness of insulation for various applications shall be as shown below.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Sl.no. |  ITEM | NitrileRubber | ExpandedPolystyrene |  PUF | PhenolicFoam | Glass wool/Mineral wool |
| A. | PIPING WORK |  |  |  |  |  |
| 1.0 | COLD INSULATION |  |  |  |  |  |
| 1.1 | Refrigerant Suction |  |  |  |  |  |
| 1.1.1 | + 3C suction | 50 | 100 | 75 | 75 | ----- |
|  |  |  |  |  |  |  |
| 1.1.2 | - 5C suction | 75 | 150 | 100 | 100 | ----- |
|  |  |  |  |  |  |  |
| 1.1.3 | - 20C suction | 100 | 200 | 150 | 150 | ----- |
|  |  |  |  |  |  |  |
| 1.2 | Chilled water |  |  |  |  |  |
|  |  |  |  |  |  |  |
| 1.2.1 | Upto 25 mm | 19 | 50 | 40 | 40 | ----- |
|  |  |  |  |  |  |  |
| 1.2.2 | 25 to 100 mm | 25 | 50 | 40 | 40 | ----- |
|  |  |  |  |  |  |  |
| 1.2.3 | Above 100 mm | 28 | 50 | 40 | 40 | ----- |
|  |  |  |  |  |  |  |
| 1.3 | Cooling coil drain |  |  |  |  |  |
|  |  |  |  |  |  |  |
| 1.3.1 | + 10C | 19 | 25 | 20 | 20 | ----- |
|  |  |  |  |  |  |  |
| 1.3.2 | + 3C to +5C | 28 | 50 | 50 | 50 | ----- |
|  |  |  |  |  |  |  |
| 1.3.3 | +10C to -20C | 50 | 100 | 100 | 100 | ----- |
|  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |
| Sl.no. |  ITEM | NitrileRubber | ExpandedPolystyrene |  PUF | PhenolicFoam | Glass wool/Mineral wool |
| 2.0 | HOT INSULATION |  |  |  |  |  |
|  |  |  |  |  |  |  |
| 2.1 | Hot water upto 85C |  |  |  |  |  |
|  |  |  |  |  |  |  |
| 2.1.1 | 15 - 40 mm dia | 9 | ----- | 25 | 25 | 40 |
|  |  |  |  |  |  |  |
| 2.1.2 | 50 - 150 mm dia | 13 | ----- | 40 | 40 | 50 |
|  |  |  |  |  |  |  |
| 2.1.3 | 200 and above | 19 | ----- | 50 | 50 | 75 |
|  |  |  |  |  |  |  |
| 2.2 | Saturated steam |  |  |  |  |  |
|  |  |  |  |  |  |  |
| 2.2.1 | Condensate |  |  |  |  |  |
|  | 15 - 40 mm | 13 | ----- | ----- | 25 | 25 |
|  | 50 - 150 mm | 19 | ----- | ----- | 25 | 40 |

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| 2.2.2 | Steam 1 bar - 100C |  |  |  |  |  |
|  | 15 - 40 mm | ----- | ----- | ----- | ----- | 25 |
|  | 50 - 150 mm | ----- | ----- | ----- | ----- | 40 |
|  |  |  |  |  |  |  |
| 2.2.3 | Steam 3 bar - 133C |  |  |  |  |  |
|  | 15 - 40 mm | ----- | ----- | ----- | ----- | 50 |
|  | 50 - 150 mm | ----- | ----- | ----- | ----- | 75 |
|  |  |  |  |  |  |  |
| 2.2.4 | Steam 10 bar - 179C |  |  |  |  |  |
|  | 15 - 150 mm | ----- | ----- | ----- | ----- | 75 |
|  | 200 and above | ----- | ----- | ----- | ----- | 100 |
|  |  |  |  |  |  |  |
| 2.2.5 | Thermic fluid 250C |  |  |  |  |  |
|  | 15 - 150 mm | ----- | ----- | ----- | ----- | 75 |
|  | 200 and above | ----- | ----- | ----- | ----- | 100 |
|  |  |  |  |  |  |  |
| B. | DUCTING WORK |  |  |  |  |  |
| 1.0 | Cold Insulation |  |  |  |  |  |
| 1.1 | Supply duct in A/C area | 10 | 25 | 20 | 20 | 25 |
|  |  |  |  |  |  |  |
| 1.2 | Return duct in A/C area | ----- | ----- | ----- | ----- | ----- |
|  |  |  |  |  |  |  |
| 1.3 | Supply duct in non A/C area | 19 | 50 | 30 | 30 | 50 |
|  |  |  |  |  |  |  |
| 1.4 | Return duct in non A/C area | 10 | 25 | 20 | 20 | 20 |
|  |  |  |  |  |  |  |
| 2.0 | HOT INSULATION |  |  |  |  |  |
| 2.1 | Air temp. 60 C | 10 | 25 | 20 | 20 | 25 |
|  |  |  |  |  |  |  |
| Sl.no. |  ITEM | NitrileRubber | ExpandedPolystyrene |  PUF | PhenolicFoam | Glass wool/Mineral wool |
| 2.2 | Air temp. 100 C | ----- | ----- |  |  | 50 |
|  |  |  |  |  |  |  |
| 2.3 | Air temp. 200 C | ----- | ----- | ----- | ----- | 75 |
|  |  |  |  |  |  |  |
| 2.4 | Air temp. 300 C | ----- | ----- | ----- | ----- | 100 |
|  |  |  |  |  |  |  |
| C | WALLS & CEILING |  |  |  |  |  |
|  |  |  |  |  |  |  |
| 1.0 | Exposed roof |  |  |  |  |  |
|  |  |  |  |  |  |  |
| 1.1 | Over RCC roof | 38 | 75 | 50 | ----- | ----- |
|  |  |  |  |  |  |  |
| 1.2 | Under RCC roof | 28 | 50 | 30 | 30 | 75 |
|  |  |  |  |  |  |  |
| 1.3 | Under GI roof | 38 | 75 | 50 | 50 | 75 |
|  |  |  |  |  |  |  |
| 1.4 | Under AC roof | 38 | 75 | 50 | 50 | 75 |
|  |  |  |  |  |  |  |

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| 2.0 | EXPOSED WALL |  |  |  |  |  |
|  |  |  |  |  |  |  |
| 2.1 | RCC wall | 28 | 40 | 30 | 30 | ----- |
|  |  |  |  |  |  |  |
| 2.2 | Brick wall | 28 | 25 | 20 | 20 | ----- |
|  |  |  |  |  |  |  |
| 3.0 | FALSE CEILING | 19 | 25 | 20 | 20 | 50 |
| D | COLD STORAGES |  |  |  |  |  |
| 1.0 | Cold Store (-5C) |  |  |  |  |  |
|  |  |  |  |  |  |  |
| 1.1 | Wall & ceiling | 50 | 100 | 75 | 75 | ----- |
|  |  |  |  |  |  |  |
| 1.2 | Floor | 50 | 100 | 75 | 75 | ----- |
|  |  |  |  |  |  |  |
| 1.3 | Door | 50 | 100 | 75 | 75 | ----- |
|  |  |  |  |  |  |  |
| 2.0 | Deep Freezers |  |  |  |  |  |
|  |  |  |  |  |  |  |
| 2.1 | Wall & ceiling | 75 | 150 | 100 | 100 | ----- |
|  |  |  |  |  |  |  |
| 2.2 | Floor | 75 | 150 | 100 | 100 | ----- |
|  |  |  |  |  |  |  |
| 2.3 | Door | 75 | 150 | 100 | 100 | ----- |

5.0 PIPE INSULATION WORK

5.1 Pipe insulation work shall be carried out only after the pressure testing of the pipe is completed.

5.2 The surface to be insulated shall be thoroughly cleaned and dusted before applying the bonding material.

5.3 The application of various insulation materials on piping and ducting work shall be as shown in the following sections.

5.4 NITRILE RUBBER

a) The application of insulation shall be by means of slap-on methods.

However, sleeve-on/push through method shall be acceptable for open ended pipes upto 25 mm dia.

b) Cut the insulation to the required length neatly and perpendicular to the axis.

c) For sleeve on system push the insulation through open ended pipe, apply adhesive on the cut edges of both sections at the joints and allow to dry.Press the edges together firmly till the bonding is achieved.

d) For slap-on system, slit the insulation straight along the axis using slitting knife, or usepre-slitmaterial.Openout the insulation and slip on the pipe.

 Apply adhesive uniformly over both edges of the slit and allow to dry.

Press the surfaces together firmly from the ends and proceed to the centre.

e) Applyadhesive on both ends of butt joints uniformly and allow to dry and press the ends together firmly till the bonding is achieved.

f) For larger diameter piping insulation where preformed pipe sections are not available sheets shall be used with adequate care to avoid air pockets. The sheets are to be cut accurately and the adhesive applied uniformly to the edges and allowed to dry wrap the insulation tightly over the pipe and press the edges together till bonding is achieved.

g) All joints to be inspected thoroughly and sealed properly. Additional layer of insulation of minimum 100 mm shall be provided at the butt joints.

h) Insulation over fitting flanges and valves shall be carried out using the sheets. Insulation of suitable section and shape shall be fabricated using the sheets before fixingthesameoverthefittingsandvalves.

Manufacturers instruction shall be followed for the fabrication.

1. Insulation carried out indoor need not have any cladding.The insulation work carried outdoor and underground piping shall have cladding to protect the physical properties of the insulation, and mechanical injuries. The coating/cladding shall be as per the recommendations of the manufacturer.
2. The protective coating shall be in two layers. The first layer of coating shall be applied uniformly over the insulation and allowed to dry. The second layer of coating shall be carried out after a time gap of 8-12 hrs the underground pipe insulation shall be wrapped with 4 mm thick composite tape of polyethylene and bitumen film.

6.0 DUCT INSULATION WORK

6.1 The duct insulation shall be carried out after cleaning and dusting of the exterior surface of duct.

6.2 The application of various insulations on ducting shall be as shown in the following scheme.

6.3 NITRILE RUBBER

1. Cut the insulation sheet to the required length and width. Apply the chemical adhesive on the surface of the duct and insulation uniformly and allow to dry.
2. Press the insulation over the duct and hold it till the bonding is achieved.
3. Wrap the insulation around the duct and hold tightly till the bonding is achieved.
4. Apply the adhesive on the edges and press together till the bonding is over.
5. Seal the joints with 50 mm wide sheets.

7.0 WALL/CEILING INSULATION WORK

7.1 The insulation of wall and ceiling shall be carried out after thoroughly cleaning and dusting of the surface.

7.2 The application of various insulation shall be as shown in the following sections.

7.3 NITRILE RUBBER

1. Apply adhesive uniformly on the bonding surface of the insulation and press it against cleaned surface to be insulated till bonding is achieved.
2. Fix 18 G 50x50 mm GI washer over the insulation at 600 mm centres using wooden screws and selfexpanding nylon timbles. Make GI netting in cross binding pattern to hold insulation.

8.0 HOT FLUE DUCT INSULATION

1. The insulation shall be carried out with100 mm unbounded glass/mineral wool of 48 kg/cu.m.
2. Wool blanket shall be wrapped around the duct and held in position using GI wiremesh and lacing wire.
3. Clad the insulationwith24 gauge aluminium sheets with 50 mm over lap

and fixed with self lapping sheet metal screws.

Insulation and cladding at the flanged joints shall be carried out separately and shall be easily removable.

#

# **2209 ELECTRICAL INSTALLATION**

1.0 SCOPE

1.1 The scope of this section covers electrical installation connected with the air conditioning work.

2.0 STANDARDS

2.1 The following standards shall be applicable in addition to the relevant standards indicated in the sub-section.

 a) IS : 732 COP for electrical wiring installation

 b) IS : 1646 COP for fire safety of buildings, (General)

 electrical installation

 c) IS : 5216 Guide for safety procedure and practice in

 electrical work

 d) Indian Electricity Act and Rules

3.0 GENERAL REQUIREMENTS

3.1 The electrical work pertaining to the airconditioning installation shall be the responsibility of HVAC contractor unless otherwise indicated. The electrical work shall conform to the relevant Indian Standards and the codes and regulation of local authorities.

4.0 ELECTRICAL PANELS

4.1 The panels shall be cubicle, flush front free standing with individual feeders housed in separate enclosure and shall conform to IS : 8623, IS : 3072, IS : 2147, IS : 4047, IS : 2516, IS : 2529, IS : 3914 and IS : 5124. The ratings of feeders and accessories shall be selected for the fill load current of the equipment or the feeder load. The indicating and measuring instruments shall be 144 x 144 square. All incoming and outgoing feeders shall be with phase indicating lamps and ammeters. The panel fabrication drawings shall be got approved before taking up the fabrication work.

5.0 CABLING

5.1 All cables shall be PVC insulated, sheathed and armoured cables with copper conductor upto 100sq.mm and aluminium conductor of 16 sq.mm and above. The cables and the laying shall conform to IS:4288/IS:1255.

6.0 STARTERS

6.1 The starter selection shall be as indicated in the equipment data. The starters shall be totally enclosed air insulated metal clad conforming to IS : 5124, IS : 3914 and IS : 2959 and shall include adjustable thermal OL relays, single phase preventers, under voltage protection and additional contactors for inter-locking arrangement, indicators and remote controls.

7.0 EARTHING

7.1 All electrical equipments, panels, starters, cabling and conduiting shall be earthened conforming to IS : 732 and IS : 3043. The main earth grid shall be provided by others. The earthing conductors shall be as shown below :

 Load Earth conductor-GI

 Conduit & load upto 1 kw 2 nos. 10 SWG

 2 to 10 kw 2 nos. 4 SWG

 11 to 25 kw 2 nos. 12 x 2 mm

 26 to 50 kw 2 nos. 20 x 3 mm

 51 to 75 kw 2 nos. 25 x 3 mm

 76 to 100 kw 2 nos. 20 x 6 mm

 100 kw and above 2 nos. 25 x 6 mm

8.0 INSTALLATION & TESTING

8.1 The panels shall be provided with ISMC 75 base frame work and grounted to the floor or the pedestal provided. Individual starters, control station etc. shall be provided with ISA 25 frame support and grouted properly. Cables and earthing shall be laid in rents indicated and shall be supported on cable trays and clamped. Cables and earthing laid on floor shall be through PVC pipe sleeves buried in the floor or in cable trench.

8.2 The electrical installation shall be tested as indicated is IS : 732 and IS : 3043. The IR valves of panels and cables and the earth resistance shall be measured and Recorded. The test reports shall be signed and submitted by the licenced electrical supervisor.



**AIR DISTRIBUTION**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  **REINFORCEMENT CODE AND DUCT THICKNESS (mm)**  | NON REINFO-RCED | DUCT SIZE  | NON REINFO-RCED |  **REINFORCEMENT CODE AND DUCT THICKNESS (mm)**  |  |
|  **REINFORCEMENT SPACING OPTIONS (m)**  |  |  |  **REINFORCEMENT SPACING OPTIONS (m)**  |  |  |
| 0.60 | 0.75 | 0.90 | 1.2 | 1.5 | 1.8 | 2.4 | 3.0 | 3.0 | 2.4 | 1.8 | 1.5 | 1.2 | 0.90 | 0.75 | 0.60 |
| **3. RECTANGULAR DUCT REINFORCEMENT FOR +/- 1000 Pa**  |  |   |   |  **RECTANGULAR DUCT REINFORCEMENT FOR +/- 1500 Pa**  |  |  |   |
| B-0.55 | B-0.55 | B-0.55 | B-0.55 | B-0.55 | B-0.55 | REINFORCEMENT | 0.70 | 200 dn | 24 ga | REINFORCEMENT  |  | C-0.55 | C-0.55 | B-0.55 | B-0.55 | B-0.55 |
| B-0.55 | B-0.55 | B-0.55 | B-0.55 | B-0.55 | B-0.70 |  NOT REQUIRED | 0.85 | 230, 250 | 20 ga | NOT REQUIRED | B-0.85 | C-0.70 | C-0.70 | B-0.55 | B-0.55 | B-0.55 |
| B-0.55 | B-0.55 | C-0.55 | C-0.55 | C-0.55 | C-0.70 | B-0.85 | B-0.85 | 1.00 | 251,300 | 18 ga | C-1.00 | C-1.00 | C-0.85 | C-0.70 | C-0.70 | C-0.55 | C-0.55 | C-0.55 |
| C-0.55 | C-0.55 | C-0.55 | C-0.55 | C-0.70 | C-0.85 | C-0.85 | C-1.00 | 1.31 | 301, 350 | 18 ga | C-1.00 | C-1.00 | D-1.00 | D-0.85 | C-0.70 | C-0.55 | C-0.55 | C-0.55 |
| C-0.55 | C-0.55 | C-0.55 | D-0.55 | D-0.70 | D-0.85 | D-1.00 | C-1.31 | 1.31 | 351, 400 | 16 ga | D-1.31 | D-1.31 | D-1.00 | D-0.85 | D-0.70 | D-0.55 | C-0.55 | C-0.55 |
| C-0.55 | C-0.55 | C-0.55 | D-0.55 | D-0.70 | D-0.85 | D-1.00 | D-1.31 | 1.61 | 401, 450 |  | E-1.31 | E-1.31 | E-1.00 | E-0.85 | E-0.70 | D-0.55 | D-0.55 | C-0.55 |
| C-0.55 | C-0.55 | D-0.55 | D-0.70 | E-0.70 | E-0.85 | E-1.00 | E-1.31 |  | 451, 500 |  | F-1.61 | F-1.31 | F-1.00 | E-0.85 | E-0.70 | D-0.70 | D-0.55 | D-0.55 |
| C-0.55 | D-0.55 | D-0.55 | E-0.70 | E-0.70 | E-1.00 | E-1.31 | E-1.31 |  | 501, 550 |  | F-1.61 | F-1.31 | F-1.00 | F-0.85 | F-0.70 | E-0.70 | E-0.55 | D-0.55 |
| D-0.55 | D-0.55 | E-0.55 | E-0.70 | E-0.85 | F-1.00 | F-1.31 | F-1.13 |  | 551, 600 |  |  | G-1.31 | G-1.00 | F-0.85 | F-0.85 | E-0.70 | E-0.70 | E-0.70 |
| D-0.55 | E-0.55 | E-0.55 | E-70 | F-0.85 | F-1.00 | G-1.31 | G-1.31 |  | 601, 650 |  |  | H-1.61G | G-1.31 | G-1.00 | F-0.85 | F-0.70 | E-0.70 | E-0.55 |
| D-0.55 | E-0.55 | E-0.55 | F-0.70 | F-0.85 | F-1.00 | G-1.31 | H-1.61 |  | 651, 700 |  |  | H-1.61G | H-1.31G | H-1.00G | G-0.85 | F-0.70 | F-0.70 | E-0.70 |
| E-0.55 | E-0.55 | E-0.55 | F-0.70 | G-0.85 | G-1.31 | G-1.31 | H-1.61 |  | 701, 750 |  |  |  | H-1.31G | H-1.31G | G-0.85 | F-0.70 | F-0.70 | E-0.70 |
| E-0.55 | F-0.55 | F-0.70 | G-0.85 | H-1.00 | H-1.31G |  |  |  | 751, 900 |  |  |  | I-1.61H | I-1.31H | H-1.00G | H-0.85G | G-0.70 | F-0.70 |
| F-0.55 | G-0.70 | G-0.85 | H-1.00G | I-1.31G | I-1.61G |  |  |  | 901, 1000 |  |  |  |  | I-1.61H | I-1.31G | H-1.00G | H-0.85G | G-0.85 |
| G-0.704 | H-0.70G | H-0.85 | I-1.31G | I-1.31G |  |  |  |  | 1001, 1200 |  |  |  |  |  | I-1.31H | I-1.31H | I-0.85G | H-0.85G |
| H-0.70G | H-0.85G | I-1.00G | I-1.31G | I-1.61H |  |  |  |  | 1201, 1300 |  |  |  |  |  | J-1.61H | I-1.31H | I-1.00G | I-0.85G |
| H-0.70G | I-0.85G | I-1.00G | I-1.61H | J-1.61I |  |  | NOT |  | 1301, 1500 |  | NOT |  |  |  |  | J-1.31H | I-1.00H | I-0.85G |
| I-0.85G | I-1.00H | J-1.31H |  |  |  |  RECOMMENDED |  | 1501, 1800 |  RECOMMENDED |  |  |  |  | K-1.61I | J-1.31I | J-1.00H |
| I-1.00H | J-1.31I | K-1.61I |  |  |  |  |  |  | 1801, 2100 |  |  |  |  |  |  |  | L-1.61J | K-1.31I |
| J-1.00I | K-1.31I |  |  |  |  |  |  |  | 2101, 2400 |  |  |  |  |  |  |  | It-1.61 | L-1.31J |
| L-1.31I | L-1.31I |  |  |  |  |  |  |  | 2401, 2700 |  |  |  |  |  |  |  | Jt-1.61 | L-1.31J |
| L-1.31J | L-1.31J |   |   |   |   |   |   |   | 2701, 3000 |   |   |   |   |   |   |   | Kt-1.61 | K-1.31 |

|  |  |  |  |
| --- | --- | --- | --- |
| **4. RECTANGULAR DUCT REINFORCEMENT FOR +/- 2500 Pa**  |  |   |   |
| C-0.55 | C-0.55 | C-0.55 | C-0.70 | C-0.70 |  | REINFORCEMENT | 22 ga | 200 dn |
| C-0.55 | C-0.55 | C-0.55 | C-0.70 | C-0.85 | C-1.00 | NOT REQUIRED | 18 ga | 230, 250 |
| C-0.55 | C-0.55 | C-0.55 | D-0.70 | D-0.85 | D-1.00 | C-1.31 |  | 16 ga | 251,300 |
| C-0.55 | D-0.55 | D-0.70 | D-0.85 | E-1.00 | E-1.31 | D-1.31 |   |   | 301, 350 |
| D-0.55 | D-0.70 | E-0.70 | E-0.85 | E-1.00 | E-1.31 | E-1.61 |  |  | 351, 400 |
| D-0.55 | E-0.70 | E-0.70 | F-1.00 | F-1.00 | F-1.31 | F-1.61 |  |  | 401, 450 |
| E-0.70 | E-0.70 | F-0.85 | F-1.00 | G-1.31 | G-1.31 | G-1.61 |  |  | 451, 500 |
| E-0.70 | F-0.70 | F-0.85 | G-1.00 | G-1.31 | H-1.31G |  |  |  | 501, 550 |
| F-0.70 | F-0.70 | G-0.85 | H-1.00G | H-1.31G | H-1.31G |  |  |  | 551, 600 |
| F-0.70 | F-0.70 | G-0.85 | H-1.00G | H-1.31G | I-1.61G |  |  |  | 601, 650 |
| F-0.70 | G-0.70 | H-0.85G | H-1.31G | I-1.31G | I-1.61G |  |  |  | 651, 700 |
| G-0.70 | H-0.70G | H-0.85G | I-1.31G | 1-1.61G |  |  |  |  | 701, 750 |
| H-0.70G | H-0.85G | I-1.00G | I-1.31H | J-1.61H |  |  |  |  | 751, 900 |
| I-0.85G | I-1.00H | I-1.31G | J-1.61I |  |  |  | NOT |  | 901, 1000 |
| I-0.85H | I-1.31H | J-1.31I |  |  |  |  RECOMMENDED |  | 1001, 1200 |
| I-1.00H | J-1.31H | K-1.61I |  |  |  |  |  |  | 1201, 1300 |
| J-1.00I | K-1.31I | L-1.61I |  |  |  |  |  |  | 1301, 1500 |
| L-1.00I | L-1.61J |  |  |  |  |  |  |  | 1501, 1800 |
| Lt-1.61 |  |  |  |  |  |  |  |  | 1801, 2100 |
| Lt-1.61 |  |  |  |  |  |  |  |  | 2101, 2400 |
| Lt-1.61 |  |  |  |  |  |  |  |  | 2401, 2700 |
| Lt-1.61 |   |   |   |   |   |   |   |   | 2701, 3000 |