

बैंक ऑफ बड़ौदा, मुंबई में एयर हैंडलिंग यूनिट्स कि
आपूर्ति, स्थापना, परीक्षण और कमीशन

के लिए

निविदा आमंत्रित की जाती है।

Tender

for

*Supply, Installation, Testing & Commissioning of Air
Handling Units at Bank of Baroda, Mumbai.*



बैंक ऑफ बड़ौदा

सुविधाएं प्रबंधन विभाग, पहला मंजिल,

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FACILITIES MANAGEMENT DEPARTMENT

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RFP/TENDER REFERENCE NUMBER: BOB/BCC/FM/VB/111/HVAC/1/ AHU.

SECTION F

**TECHNICAL SPECIFICATIONS
(With list of Approved Makes)**

Technical Specification & Conditions

SPECIAL CONDITIONS OF THE CONTRACT

1. PRICES

The prices to be quoted by the intending tenderer shall include the supply and installation, at the site, of all equipment, ancillary material and other items whatsoever required for carrying out the job to fulfill the intent and purposes as laid down in the specifications and/or the drawings.

The Tenderer's price shall be deemed to include all nuts, bolts, shims, clamps, supports etc, as required for proper fixing and/or grouting of equipment, ancillary items etc. Whether specifically mentioned or not the Contractor shall also include, in his price, all taxes duties or other levies (viz. Excise duty, customs duty, sales tax, octroi, works contract tax etc.) which are legally livable on the air-conditioning equipment and installation. Failure to include all livable taxes and duties will not entitle the Contractor to any extra claims from the employer.

2. ASSEMBLY AND INSPECTION:

Shop assembly of all parts shall be made to ensure that all parts are properly fitted to minimize erection problems.

The Engineer-In-Charge reserves the right to inspect any machinery, material and equipment (hereinafter collectively called "Apparatus") finished or used by the Contractor under this Contract and may reject which is defective in workmanship or design or otherwise unsuitable for the use and purpose intended or which is not in accordance with the intent of this Contract. The Contractor shall on demand by the Engineer-In-Charge, remedy/replace at the Contractor's expenses any such defective or unsuitable apparatus. The Contractor shall advise the Engineer-In-Charge in advance when apparatus is ready for inspection in the Contractor's workshop and/or in his sub supplier's workshop.

The Engineer-In-Charge shall at all times have access to all parts of shop where apparatus is being manufactured and also shall be provided with all reasonable inspection facilities by the Contractor and his sub supplier.

None of the apparatus to be furnished or used in connection with this Contract will be supplied until shop inspection and performance testing, wherever possible, satisfactory to the Engineer-In-Charge's inspector has been made. Such shop inspection of the apparatus shall not however, relieve the Contractor from full responsibility for furnishing the apparatus conforming to the requirements of this Contract not prejudice any claim, right or privilege which the Engineer-In-Charge may have because of the supply of defective or unsatisfactory apparatus. Should the Engineer-In-Charge waive the right to inspect any apparatus, such waiver shall not relieve the Contractor from his obligation under this Contract.

3. WORKING DRAWINGS, MAINTENANCE MANUALS ETC:

On the award of the work, the Contractor shall immediately proceed with the preparation of detailed working drawings detailing the equipment that are to be installed and the ancillary works that are to be carried out. Three sets of all such working drawings shall be submitted to the engineer-in-charge, for his approval to ensure that the works will be carried out in accordance with the specifications and drawings, including such changes as may have been mutually agreed upon. All the drawings shall be received by the engineer-in-charge for his approval within three

weeks of the award of work. The approval of the drawings by the engineer-in-charge shall in no way relieve the Contractor from his obligations to provide a complete and satisfactory plant and installation as per intent. Omissions and/or errors shall be made good or rectified whether or not the drawings are approved. Prior to the completion of the work the Contractor shall furnish (4) four sets of comprehensive manuals, describing all components, furnishing a list of instructions for the operations and maintenance of the plant.

Any special tools required for the operation or the maintenance shall be supplied free with the plant.

4. ERECTION AND COMMISSIONING:

The Contractor shall carry out the complete erection and commissioning. All work shall commence on previously prepared foundation. The Contractor shall move all the materials from their place of storage into the plant. The Contractor shall make his own arrangement to off load equipment/material received at respective rail/road transport terminal points, dispatched to site and to store all material received at site. The Engineer-In-Charge shall provide clear storage and erection space only. The Contractor shall provide all erection programmes.

All consumables required for erection such as cotton waste, kerosene oil, emery paper, coil string, bamboos and planks for scaffolding etc as well as necessary welding rods, gases etc shall be provided by the Contractor. The Contractor shall carry out protective and finish painting. Carbon steel surface shall be thoroughly cleaned before painting. The Contractor shall indicate the water and electricity requirements during erection. The Contractor shall remove all the waste material or rubbish from and about the work site and leave the job thoroughly cleaned up and ready to use

1. TESTING: Items required to be tested at Factory before dispatch to site:

All AHUs, Cooling Coils, Factory fabricated ducts, pre- insulated pipes, electrical panels shall be tested in the factory before dispatch.

Other materials will be received against approved samples/test certificates/dimensional checking/ compliance with approved drawings etc.

All types of routine and type tests shall be carried out at the works of the Contractor or the manufacturers of the components. The Engineer-in-Charge / Consultant shall be free to witness any or all tests if he so desires.

On the completion of the installation, the Contractor shall arrange to carry out various initial tests as detailed below in the presence of and to the complete satisfaction of the engineer-in-charge, and their consultant or their representatives. Any defects or shortcomings found during the tests shall be speedily rectified or made good by the Contractor at his own expense.

The initial tests shall include but not be limited to the following:

To operate and check the proper functioning of all electrically operated components viz., blowers, air handling units as well as other electrical motors.

To check the air distribution in the system and to provide design air flow in all areas specifically shown on the drawings by adjusting the grills, diffusers and dampers,

which should be provided by the Contractor wherever required whether they are specifically shown on the drawings or not.

To check the system against leaks in different circuits, alignment of motor, 'V' belt adjustments, vibration and noise, power consumption etc. Control setting and all such other tests, which are essential for smooth functioning of the plant.

On the satisfactory completion of all 'Initial' tests, the plant shall be considered to be 'Virtually Complete' for the purpose of taking over by the employer.

In addition to the 'initial' tests the Contractor shall also give three continuous running tests of the plant of 24 hours duration each. The running tests shall be taken on the completion of the initial tests.

The Contractor shall provide all necessary tools, instruments, gauges, flow meter ammeter etc. as may be required for conducting the various tests. He shall also provide necessary lubricants and the required personnel for the tests. However, the employer shall provide water and power for the tests.

6. REJECTION OF DEFECTIVE PLANT:

If on test any portions of the plant, equipment or components are found to be defective or not fulfilling the intent or the meaning of the specifications, the same shall be replaced or repaired to the entire satisfaction of the engineer-in-charge, and their Consultants.

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

The employer reserves the right to operate all the equipment and complete system whether or not the plant is taken over after the initial test and commissioning. Any defects found during the initial or running tests shall be removed at a suitable time as decided upon by the employer and/or their Consultants.

7. Defect Liability Period:

The Contractor shall guarantee that all the material, machinery and components supplied, fabricated, designed and installed by him shall be free from defects due to faulty design material and/or workmanship, that the plant shall perform satisfactorily and the efficiency of the system and all the components shall not be less than the values laid down in the specifications and the capacities shall be within + or – 3% of the specified values. In case of deviation greater than + or – 3%, the Contractor shall replace the necessary components at no extra cost or alternately the employer shall be entitled to deduct a proportionate amount from payments due to the Contractor.

The period of **the defect liability shall be (12) twelve months** from the date of acceptance/virtual completion, during which period any or all components found to be defective shall be replaced free of charge and any shortcomings found in the system as specified shall be removed at no extra cost. The Contractor shall provide the necessary personnel and tools for fulfilling the above guarantee.

If the defects are not removed within a reasonable time the employer may arrange to do so at the Contractor's risk and cost, without prejudice to any other's rights.

8. PAINTING

All equipment and ancillary items such as piping, supports etc., will be painted in approved manner, using colour scheme as approved by the Consultant.

9. SAFE CUSTODY AND STORAGE :

Safe custody of all machinery and equipment supplied by the Contractor shall be his own responsibility till the final taking over by the employer. He should, therefore, employ sufficient staff for watch and ward at his own expenses. The employer may, however, allow the Contractor to use the Plant/AHU rooms, etc. for temporary storage of his equipment if such spaces are ready and available.

10. BYE-LAWS AND REGULATIONS:

The installation shall be in conformity with the Bye-laws, regulations and standards of the local authorities concerned, but if these specifications and drawings call for a higher standard of material and equipment than those required by above regulations and standards, then these specifications and drawings shall take precedence over said regulations & standards.

11. QUIET OPERATION AND VIBRATION ISOLATION:

All equipment shall operate under all conditions of load without any sound or vibration, which is objectionable in opinion of the supervisor. In case of rotating machinery, sound or vibration noticeable outside the room, if considered objectionable shall be corrected by Contractor at his own expense. All vibrating equipment located on terrace shall be mounted on steel structure and suitably vibration isolated. Where manufacturer has furnished specific instructions, relating to the material and equipment used in this project, covering points not specifically mentioned in these documents, each instruction shall be followed in all cases.

12. TEST READINGS:

All the equipment shall be supplied by the contractor after testing as required by various sections of specifications and test readings as required .

13. BALANCING, TESTING AND COMMISSIONING:

Balancing of all air and water systems and all tests as called for the specifications shall be carried out by the contractor through a specialist ground, in accordance with the specifications and ASHRAE guide lines and standards. **Performance test shall consist of three days of 10 hour each operation of system for each season.**

The results for summer and monsoon air conditioning in quadruplicate shall be submitted for scrutiny. Four copies of the certified manufacturer's performance curves for each piece of equipment, high lighting operational parameters for the project, shall be submitted along with the test certificates. Contractor shall also provide four copies of record of all safety and automatic control settings for the entire installation.

The installation shall be tested again after removal of defects and shall be commissioned only after approval by the department's representative. All tests shall be carried out in the presence of the representatives of the architect/engineer.

14. MATERIALS AND EQUIPMENTS:

All material and equipment's shall conform to the relevant Indian Standards and shall be of approved make and design. Makes shall be strictly in conformity with list of approved makes.

15. MODES OF MEASUREMENTS:

The modes of measurements shall be as per Clause 6A or as per BOB mode of measurement.

16. CONTRACTOR'S CONFIRMATION:

The contractor shall confirm adherence to safety codes, design requirements.

17. VARIATION IN QUANTITIES:

The quantities of ducting, insulation, grills & diffusers given in the 'schedule of quantities' are indicative only and may vary as per the final approved drawings. In case there is any variation in the quantities of the items actually installed from the quoted quantities, the same shall paid as per the relevant clause of the agreement.

18. CLEARING:

Before commissioning of the plant, all mechanical equipment and ductwork shall be flushed / blown clear to ensure that they are thoroughly cleaned.

19. ACCESSIBILITY:

The contractor shall verify the sufficiency of size of all equipment rooms, shaft openings and clearances for proper installation of equipment and ducting/piping. The contractor shall locate all equipment, which must be serviced, operated or maintained in fully accessible positions.

20. INTERPRETATION IN CASE OF CONTRADICTION WITHIN CONTRACT DOCUMENT:

In case of any contradictions between general conditions of contract, technical specifications, special conditions, bill of quantities, consultant's drawings or contractor's drawings, the most stringent of the lot shall prevail and interpretation by department in this regard shall be final.

21. COORDINATION WITH OTHER AGENCIES:

The contractor shall maintain close coordination with other connected agencies and offer maximum cooperation to ensure that the project can be smoothly completed in time.

22. Foundations of equipment's and connected Civil Works:

The AC contractor will execute all these works within tendered rates.

Any cutouts in walls / roof to be executed by contractor, The scope shall include proper finishing of wall.

23. Sub head Plumbing Item -

If required making required trenches, refilling and proper leveling of the surface will be done within quoted rates. Provision for road crossing and structural provision for entry of pipes / cables into the building will be provided by the department and is not within the scope of this tender.

24. This is a turnkey job.

Even if certain items are not included in the BOQ, but are required for comprehensive completion of the job, the AC Contractor will do the same without any extra cost.

25. Operation and Maintenance: included for defect liability period
26. The entire job will be executed by a specialized HVAC Contractor on turn key basis for:
 - a) Detailed design to ensure maintenance of specified conditions.
 - b) Preparation and Approval of detailed working Drawings.
 - c) Fabrication/ supply of required equipment's/ fabricated items/ materials after factory testing.
 - d) The entire work will be executed in conformity with the General Specification for HVAC Works 2017 of CPWD, with latest amendments (upto the stipulated date of submission of tender). These are printed publications available for purchase and the tenderer should procure these documents before tendering. The electrical work shall be executed as per CPWD electrical specifications, internal, external, substation in force with latest amendments.
 - e) Wherever an item is not covered by the CPWD Specifications, the same will be as per Manufacturers specifications/ specifications as approved by the Engineer-in-Charge.
27. **Specifications as per BOQ/ Additional Specifications will supersede the CPWD Specifications.**

TECHNICAL SPECIFICATION

SECTION - 1.0: VERTICAL/HORIZONTAL FLOOR MOUNTED AIR HANDLING UNITS

1 SCOPE

This section of the specification covers the supply, installation, testing and commissioning of double skin construction air handling units along with its accessories, conforming to these specifications and in accordance with requirement of the 'Schedule of Quantities', Drawings and 'Technical Schedule of Equipment'.

2 TYPE

The air handling units shall be double skin modular, draw through type comprising of various sections such as mixing chamber (wherever R .AIR and F.AIR are ducted.), pre filter section, chilled water coil section, fan section supply air plenum as per details given in Drawings and Schedule of Equipment.

3 CAPACITY

The air handling capacities, maximum motor HP, static pressure shall be as shown on Drawings and as indicated in 'Schedule of Quantities'.

4. CONSTRUCTION

4.1 AHU HOUSING / Casing:

4.1.1 The AHU housing shall be of double skin construction with main structure made of extruded aluminum hollow sections. The panels shall be double skin sandwich type with 0.6 mm pre painted GSS/ pre-plasticized on the outside and 0.6 mm galvanized sheet inside with 40 mm thick PUF insulation or equivalent material injected in between. These panels shall be screwed with soft rubber gasket fixed in built in groove of aluminum frame in between to make the joints airtight.

4.1.2 Framework for each section shall be joined together with soft Neoprene rubber gasket in between to make the joints airtight. Suitable airtight access doors /panels with nylon hinges and locks shall be provided for access to various sections for maintenance. The entire housing shall be mounted on roller-formed GSS channel framework having pressure die cast aluminum jointers.

4.2 Drain Pan

The drain pan shall be of 18 G stainless steel with necessary slope to facilitate fast removal of condensate. It shall be provided with drain connection of suitable size complete with 25 mm rigid insulation. Necessary arrangement will be provided to slide the coil in the drain pan. The drain pan shall be insulated with 12 mm thick close cell Nitrile insulation (self adhesive) or equivalent.

4.3 Cooling / Heating Coil

The chilled /hot water coil shall be of seamless copper tubes not less than 0.5 mm thick and 12mm OD. Coil face areas shall be such as to ensure rated capacity from each unit and such that air velocity across each coil shall not exceed 150 meters per minute. The coil shall be pitched in the unit casing for proper drainage. The fins shall be spaced by collars forming integral part of the fins. The tubes shall be staggered in the direction of airflow.

The fins shall be uniformly bonded to the tubes by mechanical expansion of the tube for minimum thermal contact resistance with fins. Fin spacing shall be 11 to 13 FPI. The coils shall be tested against leaks at a hydraulic pressure of 21-kg/sq. cm. This pressure shall be maintained for a period of at least 2 hours. No drop should be observed indicating any leaks. The water headers shall be complete with water in /out connections, vent plug on top and drain at bottom and designed to provide water velocity between 2 to 6 FPS.

4.4 Fan Section with Fan

The fan shall be backward curved, double inlet double width type. The wheel & housing shall be fabricated from heavy gauge galvanized steel. The fan impeller shall be mounted on a solid shaft supported to housing with angle iron frame & pillow block heavy-duty ball bearings. The fan shall be selected for a speed not exceeding 1000 RPM. The impeller & fan shaft shall be statically and dynamically balanced. The fan outlet velocity shall not be more than 550 MPM. Fan housing with motor shall be mounted on a common extruded aluminum base mounted inside the air handling housing on anti vibration spring mounts or cushy foot mounts of at least 90% vibration isolation efficiency. The fan outlet shall be connected to casing with the help of fire retardant double canvas or Neoprene rubber of imported Origin. The fan shall be selected for a noise level of less than 70 DB (A) at one meter distance.

4.5 Filter Section

Each unit shall be provided with a factory assembled filter section containing synthetic media washable air filters with efficiency of 90% down to 10-micron particle size. Filters shall have aluminum frame. Filter face velocity shall not exceed 150 meters per minute. Filter shall fit so as to prevent by pass. Holding frames shall be provided for installing number of filter cells in banks. These cells shall be held within the frames by sliding the cells between guiding channels.

Fine & HEPA filters(if any) shall be as described in BOQ

5. FRESH AIR INTAKES

Extruded aluminum construction duly anodized fresh air louvers with bird screen and extruded construction dampers shall be provided in the clear opening in masonry walls of the air handling unit room having at least one external wall. Fresh air louver, damper, pre filters, ducts and fresh air fan with speed regulator (wherever specified in 'Schedule of Quantities') shall be provided. Fresh air dampers shall be of the interlocking, opposed blade louver type. Blades shall be rattle free. Damper shall be similar to those specified in 'air distribution'. Fresh air fans and fresh air intakes shall be as per the requirements of 'Schedule of Quantities'.

6. ACCESSORIES

Each air handling unit shall be provided with manual air vent at highest point in the cooling /heating coil. In addition, the following accessories may be required at air handling units. Their detailed specifications are indicated in individual sections and quantities separately identified in 'Schedule of Quantities'.

- Stem type thermometer at each AHU coil inlet and outlet with tubing and gauge cocks and specification as per the section, 'Automatic Controls and Instruments'
- Pressure gauge with globe valves at inlet and outlet of each AHU coil with tubing and specifications as per the section, 'Automatic Control and Instruments'.
- Butterfly valves at inlet and outlet of the each coil.

- PICB valves at the outlet of each coil.
- Y strainer at inlet of each coil.
- Union and condensate drain piping from the unit up to the drain trap as described in section piping.
- Motorized three way mixing valves located in chilled /hot water lines connected to the coil. This valve shall be operated by the cooling/heating thermostat and shall control the flow of chilled/hot water as per section 'automatic controls and instruments'.
- Cooling /heating thermostat as per section
- 'Automatic Controls and Instruments' shall be located in return air stream.
- Flexible connection between the fan outlet and duct.
- Vibration isolators of at least 90% efficiency.

7. SAFETY FEATURES

Each handling unit must have safety features as under:-

- The fan access door must have micro switch interlocked with fan motor to enable switching off the fan motor automatically in the event of door opening. The access door shall further have wire mesh screen as an added feature, bolted on to the unit frame.
- Fan and motor base shall be properly earthed from the factory.
- All screws used for panel fixing and projecting inside the unit shall be covered with PVC caps to avoid human injury.

8. DRIVE

Fan drive shall be 3phase-squirrel cage totally enclosed fan cooled motor suitable for $415 \pm 10\%V$, 50 HZ AC supply. Motor shall be specially designed for quiet operation and motor speed shall not exceed 1440 RPM. Drive to fan shall be provided through belt drive arrangement with required no. Of belts for power transmission without slippage. Belts shall be of oil resistant type of approved make only.

9. DESIGN DATA FOR AIR HANDLING UNITS

- Fan outlet velocity shall not exceed 660 MPM.
- The air velocity across coil shall not exceed 150 MPM.
- The air velocity across air pre filter shall not exceed 150 MPM.
- Motor ratings shall be suitable for the duty. The motor shall be selected with a safety factor of at least 20% over and above the brake power.

The AHU fan shall be selected for a total static pressure as indicated in 'Schedule of Quantities'.

10. INSTALLATION

Air Handling Unit shall be installed inside the AHU room to permit the removal of all the parts of AHU for any maintenance work without dismantling other equipment such as plenum, pipes, ducts etc. Air handling unit installation shall be carried out as per manufacturer's recommendation and mounted on serrated rubber pads. The serrated rubber pads shall be in two layers with 16G GI sheet sandwiched in between.

11. PERFORMANCE DATA

Air handling unit shall be selected for the lowest operating noise level of the equipment. Fan performance rating and power consumption data with operating

points clearly indicated shall be submitted and verified at the time of testing, commissioning of the installation.

12. TESTING

Cooling/Heating capacity of various air-handling unit models shall be computed from the measurements of airflow and dry and wet bulb temperatures of air entering and leaving the coil.

Flow measurements shall be by anemometer and temperature measurements by accurately calibrated mercury in glass thermometer. Computed result shall conform to the specified capacities and quoted ratings. Consumption shall be computed from measurements of incoming voltage and input current.

13. VARIABLE FREQUENCY DRIVES (For AHUs):

13.1 It comprises the following:

- Built in dual 5% impedance DC link reactor (harmonic filters) on the positive and negative rails of the DC bus of the Variable Frequency Drive
- Built in EMC filters (electromagnetic compatibility filters) for restriction of conducted emissions to comply with IEC61800:3 (un restricted distribution) :2004 Category C 1 (50 meter)
- Three feedback PID controller having capability to simultaneously accept 3 feedback signals from temperature sensors or pressure sensors for process optimization and accordingly control the speed of the AHUs or pumps.
- Integral graphical keypad.

Note: (i) Cost of temperature sensor and control cables not included.

(ii) Separate Starter not required for switching on motor and pump.

13.2 Product compliance – The drive shall have comply to the following standards

- Low Voltage Directive 73/23/EEC with supplements
- EMC Directive 89/336/EEC with supplements
- Quality assurance system ISO 9001 and ISO 14001
- CE, UL, ULc and C-tick

13.3 Mechanical Protection

13.3.1 The enclosure shall be plastic type and tested in UL tests according to the ball impact test stated in UL746C.

The protection class shall be IP55.

13.4 Operating Parameters

- The drive shall be suitable for an ambient temperature of 40 deg C.
- The drive shall give an alarm signal when the heat sink temperature of the drive reaches 90 deg C and shall trip when the temperature reaches 95 deg C.
- To predict the noise level of the motor switching frequency shall be user selectable and can be selected according to the load conditions: 4 kHz or 8khz (for low noise operations)
- Overload Capacity: The drive shall be able to deliver 100% of the nominal current and 110% for 1 min. every 10 mins. (if repeatability is not mentioned, the drive shall be selected to ensure the proper RMS current rating)

- The drive shall have at least 2 critical frequency (band) selection to avoid the mechanical resonance problem.
- The drive shall have at least 7 programmable constant speeds ranging from 0-250 Hz.

13.5 Programming

- Control Panel : The drive shall have an alphanumeric control panel with LCD display and multiple languages. The control panel can be connected to and detached from the converter at any time. The panel can also be used to copy parameters to other converters with the same software revision.
- It shall be possible to view the Output Current, % Torque, the reference Frequency and one output variable (frequency, voltage etc. as per requirement. If Not, then separate display shall be provided to view the above parameters.
- At any point of time the status of the drive can be known through the Control Panel, i.e. remote/local, run/stop/fault etc.
- The drive shall have a sleep function to provide energy saving at low frequency. When the reference falls below a certain level, the drive shall go in energy optimizing mode.
- The drive shall have a **Fan controller**.

13.6 Protection features

- Over current
- Over voltage
- Under voltage
- Over temperature
- Output earth fault
- Output short circuit
- Input phase loss (3 phase)
- I/O terminal short circuit protection
- Motor overload protection: If the motor current I (out) exceeds nominal current I_N of the motor for a prolonged period, the drive shall automatically protects the motor against overheating by tripping. The trip time shall depend on the extent of the overload (I_{out} / I_N), the output frequency and f_{nom} . Times given shall also apply to a "cold start". Drive shall provide overload protection in accordance with the National Electric Code (US).
- Output over voltage protection: In the event of an overload, the drive shall first show an alarm and then trip.
- Stall protection
- Under load
- 13.5.13
- Stall protection
- Output over current
- Output short circuit
- Ground fault, motor cable
- Under load
- Network failure
- Low input signal level ($A_I < \min$)
- Panel fault
- Over voltage
- Under voltage

- External fault
- Automatic fault reset, under voltage
- Automatic fault reset, over voltage, over current
- Fault history 3

13.7 **Functions**

- Start; normal/flying/torque boost
- Start; pre-magnetising
- Stator resistance (IR) compensation
- Stop; ramp/coasting
- Stop; DC brake
- DC hold
- U/f -ratio; linear/square
- Acceleration/deceleration 1 (s) 0.1 ... 1800
- Acceleration/deceleration 2 (s) 0.1 ... 1800
- S-ramp; fast/medium/slow
- 7 Preset speeds
- 2 Critical frequencies
- Slip compensation
- Parameters in logical menus
- Motor field optimization for energy optimization
- Selectable switching frequency 4 / 8 kHz

13.8 **Mains Connections**

- Voltage: 3-phase, 380-480V +/-10%
- Frequency: 48-63hz
- Power Factor: 0.9

13.9 **Motor Connections**

- Voltage: 3-phase from 0 – U supply
- Frequency 0-250hz
- Acceleration time: 0.1 to 1800 secs
- Deceleration time: 0.1 to 1800 secs

13.10 **Programmable control connections: The drive shall have atleast the following inputs and Outputs.**

13.10.1 Two analog inputs:

Voltage signal: 0 (2) to 10 V, 200 kW single-ended
 Current signal: 0 (4) to 20 mA, 500 W single-ended
 Potentiometer reference value: $v_{10V} \pm 2\%$ max. 10 mA, 1 kW $\leq R \leq 10$ kW
 Response time: ≤ 60 ms
 Resolution: 0.1%
 Accuracy: $\pm 1\%$

13.10.2 One analog output: 0 (4) to 20 mA, load <500 Auxiliaire voltage: 24 V, max. 250 Ma

13.10.3 Five digital inputs:

- 12 V 24 V DC with internal or external supply, PNP and NPN
- Input impedance: 1.5 kW
- Response time: ≤ 9 ms

13.10.4 Two relay outputs:

- Switching voltage: 12 to 250 V AC or max 30 V DC/0.5 A
- Maximum continuous current: 10 mA to 2 A

Serial communication for the control panel or external control: Seamless communication with Modbus or N2 protocol on RS485

Design features

The drive shall have an in-built choke at the DC input side.

The distance between the motor and the drive is approximately 100 mts. An output choke shall be used as applicable.

SECTION - 2 : FILTERS

1.0 General

This section covers the general requirements for special type of filters to be installed in air moving equipment or air ducts.

2.0 Pre-filters (fabric type)

Synthetic fibre Pre-filters shall be in light weight aluminium framed with non woven synthetic fibre replaceable media. The filter shall have an efficiency of 90 percent down to 10 microns particles size when tested as per B.S.2831 standards. The filter frame shall be of aluminium and shall be suitable for mounting in Air handling units or ducts as required at site. The velocity across the face of the filter shall not exceed 500 FPM and the pressure drop across the filter shall not exceed 4mm. The filters shall be suitable for operation under 100 percent relative humidity and 120 deg.C temperature conditions.

3.0 Microvee filters (fine filters)

Microvee filters shall be of dry type. Filters media shall be made from washable non woven synthetic fibre replaceable media reinforced with HDPE cloth & Aluminum mesh, specially treated with antifungal and bactericidal agents to prevent growth of micro organisms. The filter media shall be treated to permit washing with water several times before discharged. The media shall be properly supported and spaced so that air flow through the filter is uniform. The filter shall be housed in aluminium frame work. Filters shall be designed to remove particle down to 5 micron size and with efficiency of 98.0 percent tested as per BS 2831 using Test Dust II. The filters shall be installed in the air handling units after the chilled water coils. They shall be capable of being replaced or removed for servicing without the use of special tools.

4. ECBC Mandatory Requirements for HVAC Works- It needs to be complied by HVAC Contractor

SECTION - 3: AUTOMATIC CONTROLS AND INSTRUMENTS – SPECIFICATIONS

1. SCOPE

The scope of this section comprises the supply, installation, testing and commissioning of automatic controls and instruments conforming to these specifications and in accordance with requirement of drawings and 'Schedule of Quantities'

2. PRODUCTS

2.1 PICB /Two / Three Way Valve

PICB/Two way or Three way motorized / modulating valve for each air handling units shall be provided in chilled water line at each air handling units as shown on the Drawings and included in Schedule of Quantities. Each valve shall be actuated by a space or duct mounted thermostat. Constant space condition shall be maintained by continuous proportional modulation of the chilled water through the coil. The valve shall revert to fully by pass position when fan is shut off. Motor shall be proportional modulating motor. Motor shall be suitable for 24 volts supply and shall have a cover mounted 220/24 volts transformer factory- installed. The unit shall be suitable for outdoor installation in the open space.

Two way or Three-way motorized valve for each fan coil unit shall be provided in chilled water lines at each fan coil unit as shown on Drawings and included in Schedule of Quantities. The valve shall be actuated by space thermostat. Constant space conditions shall be maintained by allowing all of chilled water to either pass through the coil or bypass the coil and mix with the chilled water return. The valve shall revert to fully bypass position when fan is shut off.

Valve shall be similar to Honeywell two-position diverting valves 15 cm (1/2 inch) diameter with flare connection. Valve shall be selected for water flow rate of 5-6 USGPM. Pressure drop across the valve shall not exceed 2 psi. Valve shall have the facility to replace motor & actuator without removing the valve body.

2.2 **Flow switches** shall be provided in the condensing water line (outlet) and chiller water line (outlet) only near the chilling machine. The control supply of chilling units shall be interlocked with these flow switches.

2.3 **Thermostats** shall be electrical mode, fixed differential type with sensing element located in the return air stream.

2.4 **Proportional control thermostats** for air conditioning application for actuating the two ways or three way modulating valve at each air-handling units, as shown on drawings and included in Schedule of Quantities. Thermostat shall be similar to Honeywell model T921B/T92A or equivalent, line voltage-cooling thermostat. Range shall be 56-84 degree F, differential shall be 3 degree F.

2.5 SNAP acting fixed differential thermostat for FCU shall be of Honeywell make and model T649A or

T4039 cooling thermostat or any approved equivalent with temperature range of 13-29 degree C differential 37 deg C with ON/OFF, HI/LOW fan switch, normal-cool setting switching off must break fan circuit.

1. INSTRUMENTS

- 3.1 Thermometer:** Thermometers shall be dial type 100 mm dia or V form industrial type. Body shall be aluminum alloy, anodized gold colored surface. The casing shall be adjustable side ways for reading from the front. The glass capillary shall be triangular in shape with blue mercury filled in glass for better visibility. Scale of reading shall be of the range 0 deg C to 60 deg C & +32 deg F to 150 deg F. Graduation of scale shall be 1 deg in both readings. Ranges of scales shall be 30-90 degrees F (0-50 deg C) for all conditioning applications of cooling only.

Thermometer shall be suitable for 15mm connection. Thermometer for chilled water shall be with long stem so that thermometer is removable without damaging the insulation ms socket to be welded on pipes shall be provided with thermometer. Thermometer shall be installed of chilled water supply and return at each air handling unit, supply and return of each chiller, condenser.

- 3.2 Pressure gauge -** shall be installed on suction header and at discharge side of each pump in the chilled water supply and return at each air handling unit, at inlet and outlet of each chiller. Suction side gauge at pump suction header shall be compound gauge with 150 MM dia, range 75 cm vacuum to 10 kg pressure. Discharge side gauge at pumps and at all other locations shall be 150mm range 0-10 kg per sq cm (0-150 PSI) Pressure

SECTION – 4 SHEET METAL WORKS AND ACCESSORIES - (MANUAL FABRICATION)

1. SCOPE

The scope of this section includes supply, fabrication, installation & testing of all sheet metal ducts, supply, installation, testing & balancing of all grills & diffusers as per specifications & drawings.

Except as otherwise specified all ductwork and related items shall be in accordance with these specifications.

Duct work shall mean all ducts, casings, dampers, access doors, joints, stiffeners, hangers & all accessories.

2. DUCT MATERIALS

The ducts shall be fabricated from galvanized steel sheets class VIII - Light coating of Zinc conforming to ISS: 277-1962 (REVISED) and with a galvanizing thickness of nominal 120 gm. per SQM surface area.

- i. Only new, fresh, clean (unsoiled) and bright GI/Aluminum sheets shall be used. The CLIENT/ BOB reserve the right to summarily reject the sheets not meeting these requirements. Fabrication of ducts shall be through Lock forming machines.
- ii. All duct work, sheet metal fabrication unless otherwise directed, shall strictly meet requirements, as described in IS:655-1963 with Amendment-I (1971 Edition)

Longer size of Duct	Sheet Thickness GI (MM)	Type of Joints	Bracing
Up to 750	0.63	GI Flange	-
751-1000	0.80	25x25x3 mm angle iron frame with 8 mm Dia nuts & bolts	25X25X3 MM @ 1M
1001-1500	0.80	40x40x5 mm angle iron frame with 8 mm Dia nuts & bolts	40x40x5 MM @1M
1501-2250	1.00	50x50x5 mm angle iron frame with 10 mm Dia nuts & bolts at 125 mm center	40x40x3 mm @ 1.2m to be braced diagonally.
2251 & above	1.25	50x50x6 mm angle iron frame with 10 mm Dia nuts & bolts at 125 mm center	40x40x3 mm @ 1.6m diagonally braced

- iii. Ducts larger than 450 mm shall be cross broken, duct sections up to 1200 mm length may be used with bracing angles omitted.
- iv. Changes in section of ductwork shall be affected by tapering the ducts with as long a taper as possible. All branches shall be taken off at not more than 45 Deg. Angle from the axis of the main duct unless otherwise approved by the Engineer-in-Charge.
- v. All ducts shall be supported from the ceiling/slab by means of M.S. rods of 10 MM Dia with M.S. angle at the bottom of size 40 mm x 40 mm x 6 mm for sizes up to 1500 mm at 3 m intervals. Above size 1500 mm upto 2250, support shall be provided with 10 mm dia. MS rod and MS angle size 50 mm x 50 mm at bottom at 2.5

m intervals. Above size 2250 mm support shall be provided with 12 mm dia MS rod and MS angle size 50 mm x 50 mm at bottom

3. INSTALLATION

- i. All ducts shall be fabricated and installed in workman like manner, generally conforming to relevant BIS codes. Round exposed ducts shall be die formed for achieving perfect circle configuration
- a. Ducts so identified on the drawing shall be acoustically lined and thermally insulated as described in the section 'Insulation' and as indicated in 'Schedule of Quantities'. Duct dimensions shown in drawings are overall sheet metal dimensions inclusive of the acoustic lining where required and indicated in 'Schedule of Quantities'.
- b. Ducts shall be straight and smooth on the inside with neatly finished joints. All joints shall be made airtight.
- c. All exposed ducts upto 60 cm width within conditioned spaces shall have slip joints. The internal ends of the slip joints shall be in the direction of airflow. Ducts and accessories within ceiling spaces visible from air-conditioned areas shall be provided with two coats of matt black finish paint.
- d. Change in dimensions and shape of ducts shall be gradual. Air turns shall be installed in all vanes arranged to permit the air to make the turn without appreciable turbulence.
- e. Ducts shall be fabricated as per details shown on drawings. All ducts shall be rigid and shall be adequately supported and braced where required with standing seams, tees of ample size to keep the ducts true to shape and to prevent buckling, vibration or breaking.
- f. All sheets metal connections, partitions and plenums required to confine the flow of air to and through the filters and fans shall be constructed of 18 Gauge GSS thoroughly stiffened with 25mm x 25mm x 3mm angle iron braces and fitted with all necessary inspection doors as required to give access to all parts of the apparatus. Doors shall be not less than 45cm X 45cm in size.
- g. Plenums shall be panel type and assembled at site. Fixing of MS angle iron flanges of duct pieces shall be with rivet heads inside i.e. Towards G.S. sheet and riveting shall be done from outside.
- h. Rubber gasket 3 mm thick shall be used between duct flanges and between duct and duct supports instead of felt in all ducting installation for complete sealing.
- ii. During the construction, the Contractor shall temporarily close duct openings with sheet metal covers to prevent debris-entering ducts and to maintain opening straight and square, as per direction of Engineer-in-Charge.
- a. Great care should be taken to ensure that the ductwork does not extend outside and beyond height limits as noted on the drawings.
- b. All duct work shall be of high quality approved galvanized sheet steel guaranteed not to crack or peel on bending or fabrication of ducts. All joints shall be tight and shall be made in the direction of airflow.
- c. The ducts shall be reinforced where necessary, and must be secured in place so as to avoid vibration of the duct on its support.

- d. All air turns of 45 degrees or more shall include curved metal blades or vanes arranged so as to permit the air to make the abrupt turns without an appreciable turbulence. Turning vanes shall be securely fastened to prevent noise or vibration. All ducts shall be fabricated and installed in accordance with modern design practice. The sheet metal gauges and fabrication procedures as given in I.S. specifications shall be adhered to and shall be considered as an integral part of these specifications.
- e. The ductwork shall be varied in shape and position to fit actual conditions at building. All changes shall be in accordance with accepted duct design and subject to the approval of the engineer-in-charge. The Contractor shall verify all measurements at building and shall notify the Engineer-in-Charge of any difficulty in carrying out his work before fabrication.
- f. Sponge rubber or approved equal gaskets shall be installed between all connections of sheet metal ducts to walls. Sheet metal connections shall be made to walls and floors by means of galvanized steel angles anchored to the building structure with anchor bolts and with the sheet bolted to the angles. Sheet metal connections shall be as shown in the drawings or as directed by Engineer-in-Charge.
- g. All ductwork shall be independently supported from building construction. All horizontal ducts shall be rigidly and securely supported, in an approved manner, with trapeze hangers formed of galvanized steel rods and galvanized steel angel/channel under ducts. All vertical ductwork shall be supported by structural members on each floor slab. Duct supports may be through galvanized steel insert plates left in slab at the time of slab casting. Galvanized steel cleat with a hole for passing the hanger rods shall be welded to the plates. Trapeze hanger formed of galvanized steel rods and angles / channels shall be hung through these cleats. Wherever use of metal insert plates is not feasible, duct support shall be through dash / anchor fastener driven into the concrete slab by electrically operated gun. Hanger rods shall then hang through the cleats.
- h. Where ducts pass through brick or masonry openings, it shall be provided with 25 mm thick TF quality thermo Cole around the duct prior to sealing of the opening.
- i. All ducts shall be totally free from vibration under all conditions of operation. Whenever ductwork is connected to fans, air handling units or blower coil units that may cause vibration in the ducts, ducts shall be provided with a flexible connection, located at the unit discharge. Flexible connections shall be constructed of fire retarding flexible heavy canvas sleeve at least 100 mm long but not more than 200 mm, securely bonded and bolted on both sides. Sleeve shall be made smooth and the connecting ductwork rigidly held by independent supports on both sides of the flexible connection. The flexible connection shall be suitable for pressure at the point of installation.
- j. Flanges and supports are to be black, mild steel and are to be primer coated on all surfaces before erection and painted with aluminum thereafter. Accessories such as damper blades and access panels are to be of materials of appropriate thickness and the finish similar to the adjacent ducting, as specified.
- k. The ductwork should be carried out in a manner and at such time as not to hinder or delay the work of the other agencies especially the boxing or false ceiling Contractors.

4. DAMPERS

At the junction of each branch duct with main duct and split of main duct, volume control dampers must be provided. Dampers shall be rigid in construction to the passage of air.

The volume dampers shall be of an approved type, lever operated and complete with suitable level links & quadrants, locking devices, which will permit the dampers to be adjusted and locked in any position.

The dampers shall be of opposed blade or louver type. The damper blade shall not be less than 1.25 mm (18) gauge and shall not be over 225 mm wide. Automatic and manual volume opposed blade dampers shall be complete with frames and bronze bearings as per drawings. Damper frames shall be constructed of 16 gauge steel

After completion of the ductwork, dampers are to be adjusted and set to deliver the required amount of air as specified in the drawings.

5. ACCESS PANEL

A hinged and gasket access panel shall be provided on ductwork before each control device that may be located inside the ductwork. Doors shall be provided with neoprene rubber gaskets. Angle joints shall be provided with neoprene rubber gaskets for leak tightness of the joints. Access door/panels shall be provided: - Near each smoke sensor Any other place specifically mentioned in the drawing or if asked by CLIENT/ BOB during execution stage.

6. MISCELLANEOUS

- a. Sponge rubber gaskets also to be provided behind the flange of all grills.
- b. Each shoot from the duct, leading to a grille, shall be provided with an air deflector to divert the air into the grille through the shoot.
- c. Inspection doors measuring at least 450 mm x 450 mm are to be provided in each system at an appropriate location, as directed by Engineer-in-Charge.
- d. Diverting vanes must be provided at the bends exceeding 600 mm and at branches connected into the main duct without a neck.
- e. Proper hangers and supports should be provided to hold the duct rigidly, to keep them straight and to avoid vibrations. Additional supports are to be provided where required for rigidity or as directed by Engineer-in-Charge.
- f. All duct supports, flanges, hangers and damper boxes etc. Shall be given 2 coats of red oxide paint before installation and one coat of aluminum paint after the erection, at no extra cost.
- g. All angle iron flanges are to be welded electrically and holes to be drilled.
- h. All the angle iron flanges are to be connected to the GSS ducts by rivets at 100 mm centers.

Section 17:- GRILLS / DIFFUSERS

1. SUPPLY AND RETURN AIR DIFFUSERS

Supply and return air diffusers shall be made of extruded aluminum section as specified in BOQ. The diffusers shall be powder coated in finish. Supply air diffusers shall be provided with screw operated opposed blade volume control devices of extruded aluminum in black anodized finish. The diffusers shall be suitable for concealed fixing arrangement and as approved by Engineer-in-charge/BOB.

The diffusers shall be provided with removable central core.

All diffusers shall be selected as per selection curves and in consultation with Engineer-in-charge / BOB. All diffusers shall have soft continuous rubber/foam gasket between the periphery of the diffusers and the surface on which it has to be mounted.

a. LINEAR GRILLS:

Linear continuous supply or return air grills shall be extruded aluminum construction with fixed horizontal bars at 15° inclination with flanges on both sides. The thickness of fixed bar louvers shall be 5mm in front and the flange shall be 20mm wide with round edges. The grille shall be suitable for concealed fixing and horizontal bars of the grille shall be mechanically crimped from the back to hold them.

Volume control device of extruded aluminum construction in black anodized finish shall be provided in S.A. duct collars.

b. DOUBLE ADJUSTABLE LOUVERED SUPPLY/ RETURN AIR GRILLS WITH HORIZONTAL /VERTICAL OR VERTICAL/ HORIZONTAL LOUVER ARRANGEMENT:

The grille shall be adjustable as each louver shall be pivoted to provide pattern with 0° to plus or minus 150° ARC upto 300° deflection down towards. The louvers shall hold deflection settings under all conditions of velocity and pressure. The rear louver of the register shall be in black shade.

Volume control device of extruded aluminum construction with black anodized finish shall be provided in S.A. grills.

c. EXHAUST AIR REGISTER:

Exhaust air register shall be made of extruded aluminum with fixed horizontal louvers at 40 degree angle setting on a 20 mm louvers pitch. The register shall have 20 mm wide flange with round edges all around. The register shall be suitable for front screw fixing.

Volume control device of extruded aluminum construction with black anodized finish shall be provided.

d. MULTI SLOT CEILING DIFFUSERS:

Multi slot ceiling diffuser shall be made of extruded aluminum with various slot width and air pattern deflectors. Deflectors in each slot provide an adjustable air pattern of 180 degree full. A special plenum shall be provided for each supply air diffuser. The linear diffuser shall have alignment strips to give straight look while installation.

Hit & miss type volume control damper of extruded aluminum construction with mill finish shall be with multi-slot supply air diffuser.

e. LINEAR CEILING MOUNTED DIFFUSERS:

Linear ceiling mounted air terminals shall be made of extruded aluminum surface mounted one way or two way pattern. The linear terminal shall have alignment strips to give straight look while installation. Volume control device of extruded aluminum construction in mill finish shall be provided in S.A. diffuser.

f. FRESH AIR INTAKE LOUVERS:

Fresh air intake louvers 50 mm deep (minimum) wherever required as per shop drawing will be made of extruded aluminum construction duly anodized or powder coated. Bird/insect screen will be provided with the intake louvers. The blades are inclined at 45° on a 40 mm blade pitch to minimize water ingress. The lowest blade of the assembly shall extend out slightly to facilitate disposal of rainwater without falling in door/wall on which it is mounted.

Wherever specified, the intake louvers shall be provided with factory fitted all aluminum construction volume control dampers in black anodized finish.

g. LAMINAR FLOW DIFFUSERS

i. Introduction

Diffusers are available for flush mounting in the ceiling. Suitable angle frames are also provided for the modular panel construction. The units are available in three standard sizes for top entry complete with opposed blade dampers

ii. Description

LFD laminar flow diffusers are constructed from 18 swg Aluminium sheet, perforated face with approx 50% perforation. The perforated front face is openable hinge type complete with key operated dampers from front.

iii. Sizes

Available in standard sizes of 600 x 600 mm, 900 x 600 mm & 1200 x 600 mm or as mentioned in the BOQ.

iv. Features

- Suitable for modular panel assemblies.
- Top entry with opposed blade dampers.
- Pivoting type face plate for damper operation from front.
- Easy maintenance and cleaning

v. Finished Standard

- a) Epoxy Polyester Powder Coated off white/pure white
- b) Natural anodised.

2. MOTORIZED COMBINED SMOKE & FIRE DAMPERS – SPRING RETURN

All supply and return air ducts at AHU room crossings (or ducts as applicable) and at all floor crossings shall be provided with approved make fire and smoke dampers of at least 90 minutes fire rating certified by CBRI ROORKEE as per UL 555:1973

Fire damper blades & outer frame shall be formed of 1.6 mm galvanized sheet steel. The damper blade shall be provided on both ends using chrome-plated spindles in self-lubricated bronze bushes. Stop seals will be provided on top and bottom of the

damper housing made of 16 g galvanized sheet steel. For preventing smoke leakage side seals will be provided.

In normal position damper blade shall be held in open position with the help of a 24 V operated electric actuators thereby providing maximum air passage without creating any noise or chatter.

The damper shall be actuated through electric actuator. The actuator shall be energized with the help of a signal from smoke detector installed in AHU room/R.A. duct/damper. The A/C Contractor shall also provide smoke detector. The fire damper shall also close due to Temp. rise in S.A. ducts thru the electric temp. sensor factory set at 165 Deg. F micro switches with bake lite base will be provided to stop fan motor and give open & close signal at remote panel in case of motorized actuator.

Each dampers in case of motorized smoke-cum-fire damper shall have its own panel which will incorporate necessary circuit required to step down voltage available from power supply to shown status of the damper (open or close), to allow remote testing of damper & indication in event of damper closure due to signal from smoke sensor/temp. sensor& reset button. Additional terminal will be provided to have signal (sound beep or visual) in central control room.

Damper actuator shall be spring return so as to close the damper in the event of power failure automatically and open the same in case of power being restored.

Spring return action of the actuator shall be an in-built mechanism and shall not be mounted externally.

The damper shall be installed in accordance with the installation method recommended by the manufacturer.

3. PAINTING

All grilles, and diffusers shall be powder coated in color as approved by Engineer-in-charge/BOB before installation.

All ducts immediately behind the grilles/diffusers etc. Are to be given two coats of black paint in Matt finish.

4. TESTING

After completion, all duct system shall be tested for air leakage.

The entire air distribution system shall be balanced to supply the air quantity as required in various areas and the final balance of air quantity through each outlet shall be submitted to the engineer-in-charge for approval. Measured air quantities at fan discharge and at various outlets shall be identical to or less than 5% in excess of those specified and quoted. Branch duct adjustments shall be permanently marked after air balancing is completed so that these can be restored to their correct position if disturbed at any time.

Section 18:- SHEET METAL WORKS –(FACTORY FABRICATED)

1. GENERAL
 - i. The work under this part shall consist of furnishing labour materials, equipment and appliances as specified necessary and required to install all sheet metal and other allied work to make the air conditioning supply, ventilating, and exhaust system ready for operation as per drawings.
 - ii. Except as otherwise specified all duct work and related items shall be in accordance with these specifications.
 - iii. Ductwork shall mean all ducts, casings, dampers, access doors, joints, stiffeners and hangers.
2. DUCT MATERIALS
 - i. The ducts shall be fabricated from galvanized steel sheets class VIII conforming to ISS:277-1962 (revised) or aluminium sheets conforming to ISS:737-1955 (wherever aluminium ducts are specified).
 - ii. All duct work, sheet metal thickness and fabrication unless otherwise directed, shall strictly meet requirements, as described in IS:655-1963 with amendment-I (1971 edition)
 - iii. GOVERNING STANDARDS:- Unless otherwise specified here, the construction, erection, testing and performance of the ducting system shall conform to the SMACNA-1995 standards (“HVAC Duct Construction Standards-Metal and Flexible-Second Edition-1995” SMACNA)
3. RAW MATERIAL
 - i. Ducting
 - i. All ducting shall be fabricated of LFQ (Lock Forming Quality) grade prime G.I. row material furnished with accompanying Mill test Certificates.
 - ii. Galvanizing shall be of 120gms/sq.m. (total coating on both sides).
 - iii. In addition, if deemed necessary, samples of raw material, selected at random by CLIENT/ BOB’s site representative shall be subject to approval and tested for thickness and zinc coating at contractor’s expense.
 - iv. The G.I. raw material should be used in coil-form (instead of sheets) so as to limit the longitudinal joints at the edges only irrespective of cross-section dimensions.
 - ii. Duct Connectors and Accessories
All transverse duct connectors (flanges/cleats) and accessories/related hardware are such as support system shall be zinc-coated (galvanized)
4. FABRICATION STANDARDS
 - i. All ductwork including straight sections, tapers, elbows, branches, show pieces, collars, terminal boxes and other transformation pieces must be Rolastar factory-fabricated or Techno Fabriduct or equivalent. Equivalency will require fabrication

by utilizing the following machines and processes to provide the requisite quality of ducts and speed of supply.

- ii. Coil lines to ensure location of longitudinal seams at comes/folded edges only to obtain the required duct rigidity and low leakage characteristics. No longitudinal seams permitted along any face side of the duct.
- iii. All ducts, transformation pieces and fittings to be made on CNC profile cutlers for required accuracy of dimensions, location and dimensions of notches at the folding lines.
- iv. All edges to be machine treated using lock formers, flanges and roller for fuming up edges.
- v. Sealant dispensing equipment for applying built-in sealant in Pittsburgh lock where sealing of longitudinal joints are specified.

5. SELECTION OF G.I. GAUGE AND TRANSVERSE CONNECTORS

Duct Construction shall be in compliance with 1" (250 Pa)w.g. static norms as per SMACNA.

All transverse connectors shall be the Rolamate 4-bolt slip-on flange system or Techno Fabriduct imported makes of similar 4-bolt systems with built-in sealant if any to avoid any leakage additional sealant to be used.

The specific class of transverse connector and duct gauge for a given duct dimensions will be 1"(250 Pa) pressure class.

Non-toxic, AC-applications grade P.E. or PVC Casketing is required between all mating flanged joints. Gasket sizes should conform to flange manufacturer's specification.

6. DUCT CONSTRUCTION

The fabricated duct dimensions should be as per approved drawings and all connecting sections are dimensionally matched to avoid any gaps.

7. DIMENSIONAL TOLERANCES:

- a. All fabricated dimensions will be within +/- 1.0 mm of specified dimension. To obtain required perpendicularity, permissible diagonal tolerances shall be +/- 1.0 mm per meter.
- b. Each and every duct pieces should be identified by color coded sticker which shows specific part numbers, job name, drawing number, duct sizes and gauge.
- c. Ducts shall be straight and smooth on the inside Longitudinal seams shall be airtight and at comers only, which shall be either Pittsburgh or Snap Button Punch as per SMACNA practice, to ensure air tightness.
- d. Changes in dimensions and shape of ducts shall be gradual (between 1:4 and 1:7). Turning vanes or air splitters shall be installed in all bends and duct collars designed to permit the air to make the tum without appreciable turbulence.
- e. Plenums shall be shop/factory fabricated panel type and assembled at site.
- f. Factory Fabricated ducts shall have the thickness of the sheet shall be as follows.

S. No.	Size of Duct	Sheet Thickness	Fastener Size	Type of Joints		Bracing with GI tie rods of following sizes	Support Angle
				For Rolastar duct & Rolamate flanges	For Techno Fabriduct and flanges		
1	Upto 750 mm	0.63 mm	3/8"	Fabricated out of G.I. sheet of 24 gauge at every 1.2 m internal.	The flanges shall be made out of the same duct sheet and all the four corner shall be fitted for fitting the bolt	Cross tie rods to be fitted of suitable dia GI rod for each piece of duct	25x25x3 mm
2	751 mm to 1000 mm	0.80 mm	3/8"	E-24 type flange, shall be fabricated out of 24 G sheet at every 1.2 m internal.			25x25x3 mm
3	1001 mm to 1500 mm	0.80 mm	5/8"	E-22 type flange shall be fabricated out of 22 G sheet at every 1.2 m internal.	The flanges shall be made out of the same duct sheet and all the four corner shall be fitted for fitting the bolt	Cross tie rods to be fitted of suitable dia GI rod for each piece of duct	40x40x5 mm
4	1501 mm to 2250 mm	1.00 mm	5/8"	J-16 type flange, shall be fabricated out of 16G sheet at every 1.2 m internal.			40x40x6 mm angle
5	2251 mm and above	1.25 mm	5/8"	J-16 type flange, shall be fabricated out of 16G sheet at every 1.2 m internal.			50x50x6 mm with MS rods of 12 mm dia.

- g. The gauges, joints and bracings for sheet metal duct work shall further conform to the provisions as shown on the drawings.
- h. Ducts larger than 600 MM shall be cross broken, duct sections upto 1200 MM length may be used with bracing angles omitted.
- i. Changes in section of ductwork shall be affected by tapering the ducts with as long a taper as possible. All branches shall be taken off at not more than 45 DEG. Angle from the axis of the main duct unless otherwise approved by the Engineer-In-Charge.
- j. All ducts shall be supported from the ceiling/slab by means of M.S. Rods of 10 MM (3/8") DIA with M.S. Angle at the bottom. The rods shall be anchored to R.C. Slab using metallic expansion fasteners.
8. INSTALLATIONS
- i. During the construction, the contractor shall temporarily close duct openings with sheet metal covers to prevent debris entering ducts and to maintain opening straight and square, as per direction of Engineer-In-Charge.
- ii. Great care shall be taken to ensure that the duct work does not extend outside and beyond height limits as noted on the drawings.
- iii. All duct work shall be of high quality approved galvanized sheet steel guaranteed not to crack or peel on bending or fabrication of ducts. All joints shall be air tight and shall be made in the direction of air flow.
- iv. The ducts shall be re-inforced with structured members where necessary, and must be secured in place so as to avoid vibration of the duct on its support.
- v. All air turns of 45 degrees or more shall include curved metal blades or vanes arranged so as to permit the air to make the abrupt turns without an appreciable turbulence. Turning vanes shall be securely fastened to prevent noise or vibration.
- The duct work shall be varied in shape and position to fit actual conditions at building site. All changes shall be subjected to the approval of the Engineer-In-Charge. The contractor shall verify all measurements at site and shall notify the Engineer-In-Charge of any difficulty in carrying out his work before fabrication.
- vi. Sponge rubber or approved equal gaskets of 6 MM maximum thickness shall be installed between duct flanges as well as between all connections of sheet metal ducts to walls, floor columns, heater casings and filter casings. Sheet metal connections shall be made to walls and floors by means of wooden member anchored to the building structure with anchor bolts and with the sheet screwed to them.
- vii. Flanges bracings and supports are to be Rolamate or Techno Fabriduct. Accessories such as damper blades and access panels are to be of materials of appropriate thickness and the finish similar to the adjacent ducting, as specified.
- viii. Joints, seams, sleeves, splitters, branches, takeoffs and supports are to be as per duct details as specified, or as decided by Engineer-In-Charge.
- ix. Joints requiring bolting or riveting may be fixed by Hexagon nuts and bolts, stove bolts or buck bolts, rivets or closed centre top rivets or spot welding. Self tapping screws must not be used. All jointing material must have a finish such as cadmium plating or Galvanized as appropriate.
- x. Fire retarding flexible joints are to be fitted to the suction and delivery of all fans. The material is to be normally double heavy canvass or as directed by Engineer-In-Charge. On all circular spigots the flexible materials are to be screwed or clip

band with adjustable screws or toggle fitting. For rectangular ducts the material is to be flanged and bolted with a backing flat or bolted to mating flange with backing flat.

- xi. The flexible joints are to be not less than 75 MM and not more than 250 MM between faces.
- xii. The duct work should be carried out in a manner and at such time as not to hinder or delay the work of the other agencies especially the boxing or false ceiling contractors.
- xiii. Duct passing through brick or masonry, wooden frame work shall be provided within the opening. Crossing duct shall have heavy flanges, collars on each side of wooden frame to make the duct leak proof.

9. DOCUMENTATION TO MEASUREMENTS

For each drawing, all supply of ductwork must be accompanied by computer-generated detailed bill of material indicating all relevant duct sizes, dimensions and quantities. In addition, summary sheets are also to be provided showing duct areas by gauge and duct size range as applicable.

Measurement sheet covering each fabricated duct piece showing dimensions and external surface area along with summary of external surface area of duct gauge-wise.

All duct pieces to have a part number, which should correspond to the serial number, assigned to it in the measurement sheet. The above system will ensure speedy and proper site measurement, verification and approvals.

10. TESTING

After duct installation, a part of duct section (approximately 5% of total ductwork) may be selected at random and tested for leakage. The procedure for leak testing should be followed as per SMACNA- "HVAC Air Duct Leakage Test Manual: (First Edition).

A. Ducts

SCOPE

The scope of this section comprises the supply and application of insulation conforming to these Specifications.

Insulation material shall be non toxic , chemically inert , non combustible, non ignitable, shall have zero ozone depletion potential, zero calorific value no heat evolution and shall be inherently proof against rotting , mould and fungal growth and attack by vermin.

The materials shall comply with following standards.

BS 476: Part 4 – Non Combustible

BS 476: Part 5 – Not easily Ignitable (Class P)

BS 476: Part 6 – Fire propagation Index ($I < 12$)

BS 476: Part 7 - Surface spread of flame (Class 1)

The material should comply to Class'O' fire rating as per BS 476 part 6&7.

The product shall be able to work effectively at ambient temperature range of -100°C to 150 °C

B. AHU / DUCT ACOUSTIC LINING/AHU ROOM ACOUSTIC LINING (Insulation Thickness & Density as per BOQ)

Insulation material for Duct Acoustic Lining shall be open cell antimicrobial nitrile rubber with self adhesive. The thermal conductivity of the material for air-conditioning application shall not exceed 0.047 W/m.K at 20 deg C. Thickness of the material shall be as specified for individual application as per schedule of quantity.

Ducts so identified and marked on drawings and included in Schedule of Quantities shall be provided with acoustic lining of thermal insulation material for a distance of minimum 5 meters as follows:

The inside surface for the ducts shall be covered with nitrile rubber with self adhesive, and provided with 22 gauge GI Channels 25 x 25 mm screwed back to back and fixed on the inside of duct, spaced not more than 60 cm center to form a frame work of 60 x 60 cms square. Cut panels 60 x 60 cms of resin bonded fiber glass shall be fitted in the squares.

1.MATERIAL

Thermal insulation material for Duct & Pipe insulation shall be Closed Cell Nitrile Rubber insulation. Thermal conductivity as per **DIN EN 12667 / EN ISO8497** of the insulation material shall not exceed 0.038 W/m²K or 0.212 BTU / (Hr-ft².°F/inch) at an average temperature of 30°C. Density of the nitrile rubber shall be 40-60 Kg/m³, The product shall have temperature range of -40°C to +105°C as per EN 14706, EN 14707 and EN 14304. The insulation material shall be fire rated for Class 0 as per BS 476 Part 6 : 1989 for fire propagation test and for Class 1 as per BS 476 Part 7, 1987 for surface spread of flame test. The material also pass UL 94 Test for Vertical Burning and Horizontal Burning and FM Approved. Water vapour permeability shall be not less than 0.024 per inch (2.48 x 10⁻¹³ Kg/m.s.Pa i.e. $\mu \geq 7000$: Water vapour diffusion resistance) as per **EN 12086 & EN13469**.

For Non-Exposed Ducts, the Nitrile Rubber insulation shall be with factory laminated embossed aluminium foil of minimum 60 micron thickness having weight of 193 gsm as per EN ISO 2286-2.

For Exposed Ducts the Nitrile Rubber insulation shall be with factory laminated with 3-layered non-metallic composite cladding of minimum 230 micron thickness of metallic appearance with aluminum as an intermediate layer and tested for UV resistance as per EN ISO 4892-2 Method A.

For Chilled Water / Hot Water piping insulation, nitrile rubber insulation shall be additionally cladded with a 3-layered non-metallic composite cladding of minimum 350 micron thickness having total weight of $\geq 500\text{g/m}^2$, of metallic appearance with aluminum as an intermediate layer and tested for UV resistance as per EN ISO 4892-2 Method A. The Class shall be tested for Class 0 Fire performance as per BS 476 Part 7 & 6 having a flammability index ≤ 5 as per AS1530.2. The cladding material is to be applied with 30 – 50mm overlap to be fixed with plastic rivets and finished with a silver self-adhesive tape. All bends, T- Sections and end caps shall be cladded with thermoformed fittings for pipes of upto 80mm dia.

For Condensate Drain Piping / Refrigerant Piping, the insulation material shall be factory laminated with chemically treated glass cloth of 7mill /0.18mm thickness and tested for UV Resistance as per EN ISO 4892-2 Method A.

The Material shall comply to BS 6853 for smoke toxicity values. The material shall comply to CFC / HCFC free material as per US EPA 5021A-2003. The material shall be Lead, mercury and asbestos free and should have zero Global Warming Potential and Ozone depleting Potential. Thermal conductivity of insulation material shall not be effected by aging as per **DIN 52616 standard**.

Insulation shall be in tube form for pipe dia upto 80mm and above 80mm sheets shall be used for piping.

Thickness of the insulation shall be as specified for the individual application. **Each lot of insulation material delivered at site shall be accompanied with manufacturer's test certificate for density and thickness.** Samples of insulation material from each lot delivered at site may be selected by Owner's site representative and gotten tested for thermal conductivity and density at Contractor's cost. Adhesive used for sealing the insulation shall be rubber based contact adhesive in a blend of solvents free from benzene, non-flammable and with low VOC content (maximum 850 gm/l as per IGBC guide lines) strictly as per manufacturer's recommendations.

Ducting insulation thickness shall be as per table below.

Ducting position	Thickness
SA duct in RA path	13 mm
Ducted return air system	SA duct: 19 mm RA duct: 13 mm
Both SA & RA exposed	Both 25 mm

2 DUCT INSULATION

External thermal insulation shall be provided as follows :

The thickness of insulation material shall be as shown on drawings or identified in the schedule of quantity. Following procedure shall be adhered to:

Duct surfaces shall be cleaned to remove all grease, oil, dirt, etc. prior to carrying out insulation work. Measurement of surface dimensions shall be taken properly to cut closed cell insulation to size with sufficient allowance in dimension. Cutting of insulation sheets shall be done with adjustable blade to make 90⁰ cut in thickness of sheet. Hackshaw or blades are not acceptable tools for cutting the insulation.

Material shall be fitted under compression and no stretching of material shall be permitted. All longitudinal and transverse joints shall be sealed by providing 50 mm wide Self Adhesive aluminum tapes / silver tapes as per the insulation material finish

as per manufacturer recommendations. The insulation installers shall be certified by manufacture.

Direct contact between Duct and hanger shall be avoided. Hangers shall pass outside the Duct Support. Insulation Manufacturer shall supply duct supports having PET foam as load taking member embedded in flexible elastomeric foam nitrile rubber sheet with outer metal face having aluminium metal) so that the insulation material is joint with insulation material on both side of pipe support for Nitrile and the weight of pipe is transferred to the PET saddle.

3 PIPING INSULATION

All chilled water, refrigerant, and condensate drain piping shall be insulated in the manner specified herein. Before applying insulation, all pipe shall be brushed and cleaned. All MS pipes shall be provided with a coat of zinc chromate primer. Thermal insulation shall be applied as follows or as specified in drawings or schedule of quantity:

Chilled Water Piping Insulation thickness shall be as follows;

For Insulation on Piping Outside the Plant Room:

Pipe nominal bore	Thickness
Upto 80mm NB Dia	25mm
Above 80mm NB Dia	32mm

For Insulation on Piping Inside the Plant Room:

Pipe nominal bore	Thickness
Upto 25mm NB Dia	32mm
Above 25mm upto 50mm NB Dia	38mm
Above 50mm upto 125mm NB Dia	44mm
Above 125mm NB Dia	50mm

Condensate Drain Piping Insulation thickness shall be as follows;

Pipe nominal bore	Thickness
All NB Dia Pipes	19 mm

Insulating material in tube form (minimum upto 100 dia pipes) shall be sleeved on the pipes. On piping, slit opened tube from insulating material shall be placed over the pipe and adhesive shall be applied as suggested by the manufacturer. Adhesive must be allowed to tack dry and then press surface firmly together starting from butt end and working towards centre. Wherever flat sheets shall be used it shall be with self-adhesive and cut out in correct dimension using correct tools. Scissors or Hacksaw-blade shall not be allowed. All longitudinal and transverse joints shall be sealed by providing 50 mm wide self adhesive silver tapes as per manufacturer recommendations. The adhesive shall be strictly as recommended by the manufacturer. The insulation shall be continuous over the entire run of piping, fittings and valves. All valves, fittings, joints, strainers etc. in chilled water piping shall be insulated to the same thickness as specified for the main run of piping and application shall be same as above. Valves bonnet, yokes and spindles shall be insulated in such a manner as not to cause damage to insulation when the valve is used or serviced.

Direct contact between pipe and hanger shall be avoided. Hangers shall pass outside the saddle. Insulation Manufacturer shall supply PUF saddles with pre-laminated insulation sheet of both side (PUF saddle sandwich between nitrile insulation material on both side with outer metal shell made of aluminium) so that the insulation material is joint with insulation material on both side of pipe support for Nitrile and the weight of pipe is transferred to the PUF saddle in the center.

The non-mettalic cladding material is to be applied with 30 – 50mm overlap to be fixed with plastic rivets and finished with a silver self-adhesive tape. All bends, T-Sections and end caps shall be cladded with thermoformed fittings for pipes of upto 80mm dia. For higher dia pipes, the cladding sheet is to be cut in required shape and applied on insulation material.

Manufacturer's installation manual shall be submitted and followed for full compliance. All insulation work shall be carried out by skilled workmen specially trained and certified by manufacturer in this kind of work. All insulated pipes shall be labeled (S.R. or R.R.) and provided with 300 mm wide band of paint along circumference at every 1200 mm for colour coding. Direction of fluid shall also be marked. Un-insulated MS pipes shall be painted throughout and direction of fluid marked. All painting shall be as per relevant BIS codes.

4 DUCT ACOUSTIC LINING

Open Cell Nitrile Rubber

Duct acoustic lining material shall be Nitrile Rubber open cell foam. Thermal conductivity of the insulation material shall not exceed $0.047 \text{ W/m}^{\circ}\text{K}$ at an average temperature of 20°C . Density of the nitrile rubber shall be $140 - 180 \text{ Kg/m}^3$. The material should withstand maximum surface temperature of $+85^{\circ}\text{C}$ and minimum surface temperature of -20°C . The material should conform to Class 1 rating for surface spread of Flame in accordance to BS 476 Part 7 & HBF, HF 1 & HF 2 in accordance to UL 94, 1996.

Insulation should have antimicrobial product protection, and should pass Fungi Resistance as per DIN EN ISO 846 Method A for fungal resistance and Method C for bacteria resistance.

The insulation should pass Air Erosion Resistance Test in accordance to ASTM Standard C 1071-05 (section 12.7).

Thickness of the material shall be 12 mm thick specified for the individual application and with noise absorption proprieties (NRC \geq 0.55 for 15mm Thick) as per IS: 8225 / ISO 354 / ASTM423C. The insulation should be installed as per manufacturer's recommendation.

14.7. ACOUSTIC LINING OF MECHANICAL ROOMS

DELETED.

14.8 PUMP INSULATION

Chilled water pump shall be insulated to the same thickness as the pipe to which they are connected and application shall be same as above. Care shall be taken to apply insulation in a manner as to allow the dismantling of pumps without damaging the insulation.

14.9 SHELL INSULATION

The chiller shells shall be factory insulated in accordance with the manufacturer's standards.

14.10 COLD WATER AND EXPANSION TANK INSULATION

Cold water tank, and chilled water expansion tank shall be insulated as per manufacturer's standard.

14.11 MEASUREMENT OF INSULATION

Unless otherwise specified measurement for duct and pipe insulation for the project shall be on the basis of centre line measurements described herewith

- a. Pipe Insulation shall be measured in units of length along the centre line of the installed pipe, strictly on the same basis as the piping measurements described earlier. The linear measurements shall be taken before the application of the insulation. It may be noted that for piping measurement, all valves, orifice plates and strainers are not separately measurable by their number and size. It is to be clearly understood that for the insulation measurements, all these accessories including cladding, valves, orifice plates and strainers shall be considered strictly by linear measurements along the centre line of pipes and no special rate shall be applicable for insulation of any accessories, fixtures or fittings whatsoever.
- b. Duct Insulation shall be measured on the basis of surface area along the centre line of insulation thickness. Thus the surface area of externally thermally insulated be based on the perimeter comprising centre line (of thickness of insulation) width and depth of the cross section of insulated or lined duct, multiplied by the centre-line length including tapered pieces, bends, tees, branches, etc. as measured for bare ducting.

Note: The Insulation manufacturer has to send their engineers at site and train the insulation contractors ensuring proper application and workmanship of the insulation material.

Section 19:- PIPING / DUCT /EQUIPMENT INSULATION:

Material

- Insulation material shall be Closed Cell Elastomeric Nitrile Rubber.
- Density of Material shall be between 50+/-10% Kg/m³
- Thermal conductivity of elastomeric nitrile rubber shall not exceed 0.035 W/mP^{OP}K at an average temperature of 0P^{OP}C.
- The insulation shall have fire performance such that it passes Class 1 as per BS476 Part 7 for surface spread of flame as per BS 476 and also pass Fire Propagation requirement as per BS476 Part 6 to meet the Class 'O' Fire category as per 1991 Building Regulations (England & Wales) and the Building Standards (Scotland) Regulations 1990.
- Water vapour permeability shall not exceed 0.017 Perm inch (2.48 x 10-14 Kg/m.s.Pa), i.e. Moisture Diffusion Resistance Factor or 'μ' value should be minimum 7000.
- Complete pipe insulation shall have 200 g/m² factory laminated, treated woven Glass Cloth coating for mechanical and UV protection.

Thickness of the insulation shall be as specified for the individual application.

Pipe Insulation

All chilled water, refrigerant and condensate drain pipe shall be insulated in the manner specified herein. An air gap of 25 mm shall be present between adjacent insulation surfaces carrying chilled water or refrigerant. Before applying insulation, all pipes shall be brushed and cleaned. All Pipe surfaces shall be free from dirt, dust, mortar, grease, oil, etc. Nitrile Rubber insulation shall be applied as follows:

- Insulating material in tube form shall be sleeved on the pipes.
- On existing piping, pre slit, self adhesive tube with factory laminated woven glass cloth coating shall be placed. Remove the release paper and make a seam joint. Cover the joint with integral glass cloth flap. Butt joints shall be sealed with adhesive and shall be covered with same glass cloth (slit opened tube of the insulating material (slit with a very sharp knife in a straight line) shall be placed over the pipe and) adhesive shall be applied as suggested by the manufacturer.
- Adhesive must be allowed to tack dry and then press surface firmly together starting from butt ends and working towards centre.
- Wherever flat sheets shall be used, Factory cut sheets shall be used (it shall be cut out in correct dimension.) All longitudinal and transverse joints shall be sealed as per manufacturer recommendations.
- The insulation shall be continuous over the entire run of piping, fittings and valves.
- All valves, fittings, joints, strainers, etc. in chilled water piping shall be insulated to the same thickness as specified for the main run of piping and application shall be same as above. Valves bonnet, yokes and spindles shall be insulated in such a manner as not to cause damage to insulation when the valve is used or serviced.

The detailed application specifications are as mentioned separately. The manufacturer's trained installer should only be used for installation.

Recommended Adhesive

In all cases, the manufacturer's recommended Adhesive (SR-998) should be used for the specified purpose.

Pump Insulation

Chilled water pump shall be insulated to the same thickness as the pipe to which they are connected and application shall be same as above. Care shall be taken to apply insulation in a manner as to allow the dismantling of pumps without damaging the insulation.

Shell Insulation

The chiller shells shall be factory insulated in accordance with the manufacturer's standards.

Cold Water & Expansion Tank Insulation

Cold water tank, and chilled water expansion tank shall be insulated as per manufacturer's standard.

Parameters for Selection of Thickness

- a) Design Basis: Condensation Control
- b) Region: Coastal Area
- c) Application: Outdoor & Indoor
- d) Design Conditions: 30 Deg. C & 82 % RH

i) Thickness of Insulation

- a) Chilled Water Pipe Line Temperature 7.0 Deg. C

Indoor Application (Conditioned / Semi Conditioned Space)

Up To 50 mm Pipe Size	- 25 mm Thick Insulation
Above 50 mm & Up To 150 mm Pipe Size	- 32 mm Thick Insulation
Above 150 mm Pipe Size	- 38 mm Thick Insulation
Chilled Water Tank	- 32 mm Thick Insulation

Outdoor Application / Non Conditioned Space

Up To 50 mm Pipe Size	- 32 mm Thick Insulation
Above 50 mm & Up To 150 mm Pipe Size	- 38 mm Thick Insulation
Above 150 mm & Up To 600 mm Pipe Size	- 44 mm Thick Insulation
Chilled Water Tank	- 44 mm Thick Insulation

ii) Drain Water Pipe Line Temperature 15.0 Deg. C

Up To 50 mm Pipe Size - 19 mm Thick Insulation

iii) Refrigerant Pipe Line Temperature 3.0 Deg. C

Up To 50 mm Pipe Size - 25 mm Thick Insulation

Above 50 mm & Up To 100 mm Pipe Size - 32 mm Thick Insulation

D) DUCT INSULATION:

1. PRE-INSULATED DUCT WORK :- PRE-INSULATED ALUMINIUM POLYISOCYANURATE /POLY URETHANE FOAM DUCTWORK

The following preferred ductwork system to be installed:

Pre-insulated aluminium ductwork made of Polyisocyanurate sandwich panels, comprising an expanded Polyisocyanurate rigid foam board faced on both sides by aluminium foil.

Physical characteristics of the panels shall be as follows:

Thickness of Panels	Air Conditioned		Plant Rooms		Exposed To Weather	
	20mm		30mm		30mm	
Thickness of aluminium	80/80	Microns	80/200	Microns	80/200	Microns
Density of the foam	45	Kg/m ³	48	Kg/m ³	48	Kg/m ³
Finishing of aluminium	Embossed	Embossed	Embossed	Embossed	Embossed	Embossed

Both sides of the aluminium foils shall be lacquered with a 3g/m² weatherproof and ultraviolet rays protection polyester lacquer.

All the panels shall have to be embossed with the name of the manufacturer and production date.

Thermal insulation characteristics shall be as follows:

Insulating material: Close cell rigid expanded polyurethane foam, CFC free, density 45 to 48 Kg/m³, material physiologically and chemically inert and insoluble, vermin proof, fungus proof, non metabolisable.

Thermal conductivity: 0.022 W/mK or better.

Water absorption shall be less than 0.5% by 24 hours immersion test.

Water vapour diffusion: $M = \infty$ resistance.

The aluminium foil covering the panel to be maintained intact after installation to ensure vapour barrier continuity.

Proposed material should have minimum 5 years installation reference in the region.

The panel manufacturer should be of European/Foreign origin.

All the panels to be used should be labelled by authorised international fire laboratories.

The panel manufacturer shall comply with Fire Mideast Product Listing (MPL) and Factory Production Control Certificate (FPC), by authorised international laboratories.

The panel shall be tested and comply with the following standards:

- a. NFPA 101 Life Safety Code Class 'A'
- b. ASTM E84 Class "1"
- c. NFPA 255
- d. UL 723
- e. Toxicity Index shall not exceed 5.7 according to NES 713
- f. Class 'O' according to BS 476 Part 6 & 7

Temperature Range:

No relevant reduction of insulation, chemical or physical characteristics of the panels to be measurable, when conveying air in the temperature range of -35°C to $+110^{\circ}\text{C}$.

Installation shall be supervised & certified by the manufacturer's representative.

5-years warranty shall be offered for the insulation material characteristics.

Joint System:

The joints between the ducts shall be using tiger connectors or male – female connection system for small sizes up to 500mm and for bigger sizes more than 500mm aluminium /polymer invisible flanges and slide-in-channel to be used and to be connected by special cover corners, having a holding pin, which goes inside the flange and the insulation, to avoid any field connection and to give the system more strength.

Ductwork shall be installed, using supports, as described in DW144 & according to manufacturer's requirements. Maximum distance between supports shall not exceed:

- 4000mm for ducts with section not exceeding 1200 x 1000mm
- 2000mm for ducts with section exceeding 1200 x 1000mm.

QUALITY CHECKS ON DUCTING

S.No	DESCRIPTION	YES - OK NO - X	REMARKS
1	Whether material adheres to Fabrication Standards as specified (Look form Quality Sheets)		
2	Valid for construction Drawings. at site.		
3	Cross breaking, bracings / reinforcements are as per standard.		
4	Air tightness of transverse / Longitudinal Joints ensured.		
5	Grease and heat resistant sealant for kitchen exhaust duct.		
6	Neoprene gaskets for pharmaceutical and clean room projects used		
7	Check following aspects of duct supporting system		
7.1	Hanger spacing		
7.2	Anchor bolts size and quality		
7.3	Primer painting of supports		
7.4	Check allowable load on trapeze angle for bigger ducts		
8	Check whether contractor has provided		
8.1	Vanes in elbows		
8.2	Clinched collar at take Offs		
8.3	Splitters		
9	Check transitions & offsets slopes & fabrication.		
10	Whether the installed ducting is as per layout approved, check locations, headroom etc.		
11	Whether grilles / diffusers are as per approved shade.		
12	Check the method of installation for Grilles / Diffusers		
13	Repair / paint damaged surfaces.		
14	Check the coordination of following activities as per the given sequence:-		
14.1	Main Ducts Cut for taking collars		
14.2	Match / Fabricate collar taking false ceiling		

S.No	DESCRIPTION	YES - OK NO - X	REMARKS
	framework for diffuser into account		
14.3	Fix grilles / diffuser framework in false ceiling		
14.4	Install the collar		
14.5	Install diffuser		
15	All elbows / turning points and branches to be properly supported		
16	Access door is provided at serviceable position for fan and fire damper		
17	Air balancing for room is studied		
18	Air replacement is considered for air exhausted from room.		
19	PVC or stainless steel material is used for corrosive fume exhaust system.		
20	Anti vermin netting installed for louvers removable and serviceable.		
21	Water or gas vent outlet is not installed near air intake louver.		
22	Kitchen exhaust is not short circuited to outdoor air intake louver.		
23	Kitchen room pressure is slightly below the surrounding area.		
24	Sound level of fan is studied.		
25	Face velocity for louvers / grills / diffusers is studied.		
26	Air distribution of the room is studied.		
27	Cross break all flat surfaces to prevent vibrations or buckling due to air flow.		
28	Sides of ducts having collar for grills should not be cross broken to facilitate alignment of grills.		
29	All bends and collars should have vanes.		
30	If duct passes through fire chamber increase sheet thickness.		
31	Kitchen exhaust ducts to be tapered at bottom for oil / grease collection.		
32	Avoid flanged joints in kitchen exhaust duct above false ceiling.		
33	When aluminum ducts are used with steel angles,		

S.No	DESCRIPTION	YES - OK NO - X	REMARKS
	steel to be painted with Zinc chromate paint		
34	Provide check nuts with duct hangers		
35	Ducts below 250 mm should not be more than 1 m long to facilitate proper joining.		
36	Plenums should have flanged and bolted ends for rigidity and easy maintenance.		
37	Avoid 'U' bends in ducts		
38	Provide long radius bends and offsets.		
39	No collars to be taken from top.		
40	Install duct spool pieces near equipment for easy removal.		

Section 20:- PIPING AND FITTINGS

1. SCOPE

The scope of this section comprises the supply and laying of pipes required for chilled water; condenser water & drain water conforming to these specifications and in accordance with the requirement of the 'Technical Schedule of Equipments' and 'Schedule of Quantities'

2. WATER PIPING

i. MATERIAL

Water piping fittings and valves shall be of the following makes or approved equal make and shall conform to IS standards as indicated below.

a. Pipes

- i. UPTO150MM :- MS, Class C (Heavy Class) as per IS 1239 (Part I & II) 1990/1992**
- ii. 200MM & ABOVE:- Welded Black Steel Pipe Class 2 (6.35 MM Thickness). As per IS 3589 (LATEST)**

All welding shall be done by qualified welders and shall strictly conform to Standard Code of practice for manual metal arc, welding of Mild Steel.

First butt weld of each welder shall be fully radio graphed by HVAC contractor under guidance of BOB for testing purposes. Upon approval of welding joints the concerned welder shall be allowed to carry further welding of pipes. Rest of the welds shall have 100% visual inspection.

All welded joints (except pipe welded end-to-end) shall be made by use of forged one-piece welding flanges, caps, nozzles, elbows, branch outlets and tees of approved make. Cut samples shall be submitted for approval, if directed. All such fittings etc., shall be of a type which maintain full wall-thickness at all points, simple radius and fillets, and proper bevels or shoulders at ends. All jobs welding shall be done by the electric arc welding process in accordance with the following: -

All joints shall have 45-degree bevel type, pipe mill-beveled or machine-beveled by the contractor.

All scale and oxides shall be removed with hammer, chisel or file and bevel left smooth and clean.

Pipe lengths shall line up straight with abutting pipe ends concentric.

Both conductors from the welding machine shall be extended to locations at which welding work is being done. The leads from welding machine to location of welding work shall be held together with tape or other approved means as to prevent induced current in structural steel, in piping or in other metals within the building. The ground lead shall be connected to length of pipe through joints in pipe, structural steel of building or steel pipe supports.

b. GATE & GLOBE VALVES

Make: As approved shall be heavy duty non rising spindles as per IS 780, 778 and flanges as per is 1536 and factory tested for 10Kg/ sq cm test pressure

S.No	Size	Construction	Ends
A	15 TO 40 MM	Gun metal body	Screwed
B	50 MM and above	Cast Iron Body & spindle valve, seat wedge etc., of Brass or Gun Metal	Flanged

c. **BALANCING VALVES**

The balancing valves control and shut off valves with built in pressure drop and flow measuring facility shall be provided in the water outlet pipes of condensers and chillers, AHUs or wherever shown in tender drawings.

- i. 15-50 mm Size: Gunmetal ASTM B-6 2 Screwed ends conforming to BS 5154
- ii. 65mm and above: Cast iron, flanged ends with stainless steel trim.

The valves shall have PTFE/SS disc with special erosion/corrosion proof sealing. The valves shall have temper proof adjustable and lockage arrangement for required water quantity after commissioning. The valves shall be complete with pressure test cock and drain cocks.

To enable accurate and practical operation, measurement of flow and differential pressure shall be made with a computerized balancing instrument which shall enable the operator to read the flow directly without the use of diagrams or tables. In addition to measuring flow rate, differential pressure and temperature, computerized balancing instrument shall have a computer programs to provide the following functions:-

To balance the HVAC installation and calculate the necessary valve settings, based on system measurements.

To store the results of balancing.

To log measured values from a valve (differential pressure, flow rate or temperature)

To printout saved data in computerized measurement protocol (CMP) consisting of:-

- Name and size of Balancing Valve (BV)
- Presetting position of BV
- AP at BV
- Flow at BV
- Design Flow

Flanges shall be of approved make. The supply of flanges shall form part of piping (not separately identified in Schedule of Quantities) and shall also include supply of bolts, washers, nuts and suitable rubber insertion gaskets (minimum 3 mm thick).

d. **BUTTERFLY VALVES**

Body: Cast Iron

Seat: Resilient lining mounded black nitrile rubber

Disc: SG Iron conforming to IS: 1865 SG 400/12 & BS 2789 GR 420/12 Nylon Coated

The handle shall have arrangement for locking in any position.. Valve shall be suitable for 16 Kg/Cm2 working pressure.

e. **BALL VALVES**

All ball valves and ball valves with Y strainer shall be bronze forged body construction with chrome plated bronze ball and handle of stainless steel constructions. These are separately identified in Schedule of Quantities.

f. **NON RETURN VALVES**

Non return valves shall be dual plate check valve provided as shown on the Drawings, and identified in Schedule of Quantities conforming to relevant Codes and in accordance with the following Specifications

Size	Construction	Ends
50 to 150 mm	Body cast iron, gun metal plate	Flanged
200 to 450 mm	Body cast iron, plate carbon steel with 13% chrome overlay	Flanged

The spring and hinge/stop pin shall be SS304 and bearing PTFE material. Valves shall be suitable for not less than 10 Kg per sq. cm. gage working pressure.

g. **STRAINERS**

i. Strainers shall be 'Y' type or Pot type Strainers as shown on drawings and included in BOQ. 'Y' Strainer shall be fabricated out of MS 'C' class pipe two sizes higher than that of Strainer pipe size. Flanges as per B.S. 10 shall be provided at inlet and outlet connectors. The body shall be pressure tested at 10 kg/cm2 and shall be hot dip galvanized. Permanent magnet shall be provided in the body of the Strainer to arrest MS particles. Filter element shall be of non-magnetic 20 gauge SS sheet with 3 mm perforation. Strainers shall be provided at in let of each Air Handling Unit and Pump as shown in drawings and included in BOQ.

Pot Strainers body shall be fabricated out of MS plate IS 226. Thickness of sheet shall be as per size of the strainer chamfered pipes with flanges shall be provided at inlet / outlet connections of the strainer. The tangential entry of water shall create a centrifugal action and due to velocity shall separate sediments and deposit on the inner surface of Filter Element and at bottom of the Strainer. Butterfly valves shall be provided at inlet/outlet connections as shown in drawing and included in BOQ. The strainer body shall have two separate chambers properly sealed to avoid mixing of filtered and unfiltered water. A powerful magnet shall be provided in the body to arrest MS particles. Filter element of Pot Strainer shall be of non-magnetic 18 gauge SS sheet properly reinforced to avoid damage of the element. A cone with sufficiently to flush out foreign particles. This arrangement shall avoid frequent opening of Pot Strainer for cleaning of filter element. Gage connection shall be provided at inlet and outlet connection. A set of MS flanges with tongue and groove arrangement and neoprene rubber gasket shall be provided on the top cover and Pot Strainer flange with sufficient bolts and nuts to make the joint watertight. Bearing loaded top cover lifting and swinging arrangement shall be provided. The Pot strainer body shall be properly de-rusted and epoxy coated from inside and outside. Manufacturers Test Certificate shall be provided with each Pot Strainer.

Size of various Pot Strainer, Filter Element and Thickness of MS sheet shall be as detailed below:-

Size (mm)	Pot Dia. (mm)	Pot HT (mm)	Element Dia. (mm)	Element HT (mm)	MS Plate Thickness (mm)
50	300	400	200	240	6
80	350	450	250	250	6
100	450	500	300	280	6
125	500	600	330	340	8
150	540	700	360	390	8
200	610	815	400	470	8
250	800	955	550	510	8
300	1000	1105	750	580	8
350	1190	1300	895	678	12
400	1350	1500	1020	785	12
450	1518	1700	1060	890	12
500	1690	1800	1100	900	12
600	2000	2200	1500	1160	12

The Y-Strainer & Pot Strainer confirming to SSPL 107 & SSPL 106 shall have cast iron body and factory tested at works at 16 Kg/sq.cm pressure. The screen shall be made out of 3 mm perforated stainless steel sheet. It should be easily removable when required to be cleaned. Isolating butterfly valves at either end of the pot strainer shall be provided.

Each pot strainer shall be provided with a Test Certificate.

- ii. All chilled water piping and fittings shall be pressure tested, painted and then insulated as described under the section "Insulation".

h. AUTO AIR VENT VALVES

- i. Air vent valves shall be provided at all higher points in piping system for venting and of following sizes:-

Up to 100 mm dia pipes : 25 mm dia.

- ii. Air vent valves shall be Gun metal and tested up to pressure of Class I pressure rating.

i. FITTINGS

The dimensions of the fittings shall conform to IS 1239/69 Part II (as per latest amendment) unless otherwise specified in specification.

All bends in sizes up to and including 150 mm dia shall be readymade of heavy-duty, wrought steel of appropriate class.

All fittings such as branches, reducers etc in all sizes shall be fabricated from pipes of same dia and thickness and length at least twice the dia of pipe.

The branches may be welded straight to main line.

Blank ends are to be formed with flanged joints and 1 mm thick blank insertion of rubber gasket between flange pair for 150 mm and over in case where a future extension is to be made otherwise blank end discs of 6 mm thickness are to be welded on with additional cross stiffeners.

The tender drawings show schematically the size and location of pipes but this is for contractor's guidance only. Pipe runs may be changed to meet the site conditions.

3. PIPING INSTALLATION

- a. All piping work shall be carried out in workman like manner causing minimum disturbance to the existing services.
- b. Piping shall be of steel, primer coated with rust preventive paint and finished with approved shade. Pipe supports shall not exceed the following spacing: -

MAXIMUM SPACING OF PIPE SUPPORTS

Pipe Size (MM)	Spacing (Mtr)	Rod Size
25	2	10 mm
30 to 75	2.5	10 mm
100 and above	3.0	12.5 mm

Pipe hangers shall be fixed on walls and ceiling by means of metallic Raw bolts or approved shear fasteners.

- c. Piping shall be properly supported on, or suspended from, stands, clamps, and hangers as specified and as required. The contractor shall adequately design all the brackets, saddle, anchors, clamps and hangers and be responsible for their structural sufficiency.
- d. Vertical risers shall be parallel to walls and columns. Risers passing from floor to floor shall be supported at each floor by clamps or collars attached to pipe and with a 10 mm thick rubber pad or any resilient material. Where pipes pass through the terrace floor, suitable flashing shall be provided to prevent water leakage. Risers shall also have a duck foot elbow or steel support welded to the pipe at the lowest point. On risers drain valves shall be provided at heels.
- e. Pipe sleeve of 50 mm larger than the pipe diameter shall be provided wherever pipes pass through walls and the annular space filled with felt and finished with retaining rings. In case of an insulated pipe the diameter shall be inclusive of insulation.
- f. Insulated piping shall be supported in such a manner as not to put undue pressure on the insulation. Metal sheet shall be provided between the insulation and clamp, saddle or roller extending at least 150 mm on both sides of clamp, saddle or roller.

i. PRESSURE GAUGES AND THERMOMETERS

- a. One pressure gauge each shall be provided to measure pressure at the inlet and outlet of each cooling coil, shall be not less than 100 mm Dia and shall be complete

with shut off (globe) valve. Care shall be taken to protect pressure gauge during pressure testing, range shall not exceed 50% above normal measurement.

- b. Thermometer shall be stem type and shall be provided at inlet and outlet of each cooling coil.

4. TESTING

- a. All water piping shall be tested to hydrostatic test pressure of at least one and a half times the maximum operating pressure but not less than 10 kg/sq cm for a period of not less than 24 hours. All leaks and defects in joints revealed during the testing shall be rectified to the satisfaction of the BOB.
- b. Pipes repaired subsequent to above pressure shall be retested in same manner.
- c. Piping may be tested in section and such sections shall be securely capped.
- d. The Contractor shall ensure that proper noiseless circulation of fluid is achieved through all coils and other heat exchange equipments in the system concerned. If proper circulation is not achieved due to air bound connections, the 'Contractor' shall rectify the defective connections. He shall bear all the expenses for carrying out above rectifications involving tearing up and refinishing of floor walls etc as required.
- e. The Contractor shall give sufficient notice to all other agencies at site, of his intention to test a section or sections of piping and all testing shall be witnessed and recorded by Engineer in- charge at site.
- f. The contractor shall provide temporary pipe connections to initially by-pass condenser/chiller and circulate water through condenser / chilled water pipe lines for minimum 8 hours. Water should be drained out from the lowest point. The temporary lines shall be removed and blanked with dead flanges. Pot strainers and Y strainers shall be cleaned and fresh water filled in the circuits.
- g. After the piping has been installed, tested and run for at least three days of eight hours each, all un-insulated exposed piping in plant room shall be given two finish coats, 3 mills each of approved colour, conforming to relevant BIS Codes. The direction of flow of fluid in the pipes shall be visibly marked with identifying arrows. For painting of insulated and clad pipes refer to insulation section.
- h. After testing, all systems shall be chemically cleaned. After cleaning, the pipe work should be rinsed multiples times until the system is neutral. The contractor shall make a report conforming the above to Engineer in charge for records.
- i. The Contractor shall provide all materials tools equipments, services and labour required to perform the test and to remove water resulting from cleaning and testing.

5. BALANCING

- a. After completion of the installation, all water systems shall be adjusted and balanced to deliver water quantities as specified.
- b. Instruments required for the water balancing (computerized balancing instrument) shall be accurately calibrated in an approved manner before taking any measurements. Calibrated orifices and portable flow meters shall be used to balance the water flow. Orifices used for testing and balancing shall be installed with straight length up stream and down stream as recommended by the manufactures and shall be left permanently installed in the system.

- c. Automatic control valve and three way valves shall be set for full flow conditions during balance by procedure. Water circuit shall be adjustable by balancing cocks provided for balancing. These shall be permanently marked after balancing is completed so that they can be restored to their correct positions of disturbed.

6. PAINING

In case of pipes to be insulated after thorough anti grease and rust removal treatment, clean the pipe and then apply two coats of epoxy primer before applying in insulation treatment as specified elsewhere. All uninsulated pipes after de rusting will be provided with two coats of epoxy primer followed by epoxy paint of approved shade.

i. FIRE BREAKS INSULATION

Firebreaks shall be provided in all ducts for internal lining/external thermal insulation after a run of 10 m center to center. There shall be a discontinuity of the insulating material in the form of MS angle of a minimum of 50 mm x 50 mm x 3 mm size. At the interface of the MS angle and insulating material, proper care of tucking in of the insulating material shall be taken so as to prevent erosion.

Section :- 6 - ELECTRIC WIRING

1. General:

The electric wiring of motors for compressors, pumps, air handling units etc. As well as controls, heaters etc. and earthing of all equipment shall be carried out as per specifications given hereunder

2. Power Cabling for Motors, Heaters etc:

2.1 Unless otherwise specified, the power cables shall be PVC insulated, and PVC sheathed aluminium conductor, armoured cables to 1100 V grade conforming to IS 1554. The power cables shall be of 2 core for single phase, 4 core for sizes upto and including 25 sq.mm, 3-1/2 core for sizes higher than 25 sq.mm for 3 phase. Where high voltage equipments are to be fed, the cables shall be rated for continuous operation at the voltages to suit the same.

2.2 Power cables shall be of sizes as indicated in the tender specifications. In all other cases, the sizes shall be as approved by the Engineer-in-Charge, after taking into consideration the load, the length of cabling and the type of load.

2.3 Cables shall be laid in suitable metallic trays suspended from ceiling, or mounted on walls, or laid directly in ground or clamped on structures, as may be required. Cable ducts shall not be provided in plant rooms. Cable trays shall be fabricated from slotted angle/solid angles to make ladder type cable tray, designed with adequate dimensions for proper heat dissipation and also access to the cables. Alternatively, cable trays may be of steel sheet with adequate structural strength and rigidity, with necessary ventilation holes therein. In both the cases, necessary supports and suspenders shall be provided by the Air-conditioning Contractor as required.

2.4 Cable laying work shall be carried out in accordance with IS 1255/1967, Indian standard code of practice. The scope of work for the Air-conditioning Contractor shall include making trenches in ground and refilling as required, but excludes any masonry trenches for the cable work.

3.0 CONTROL WIRING

3.1 Control wiring in the plant rooms and AHU rooms shall be done using control wire as per IS 1554 PVC insulated and PVC sheathed, 2.5 sq.mm copper conductor, 1100 V grade, cables drawn in ISI marked steel or PVC conduits. The control cables interconnecting the plant room and the AHU rooms shall be of multi-core armoured type only, and suitable for laying direct in ground.

3.2 The number and size of the control cables shall be such as to suit the control system design adopted by the Air-conditioning Contractor.

3.3 ISI marked steel conduit pipes, wherever used, shall be of gauge not less than 1.6 mm thick for conduits upto 32 mm dia and not less than 2.0 mm thick for higher sizes. All conduit accessories shall be threaded type with substantial wall thickness.

3.4 Control cables shall be of adequate cross section to restrict the voltage drop.

3.5 Runs of control wires within the switchboard shall be neatly bunched and suitably supported/clamped. Means shall be provided for easy identification of the control wires.

3.6 Control wiring shall correspond to the circuitry/sequence of operations and interlocks approved by Engineer-in-Charge.

3.7 In cold storage involving temperatures below zero deg. C, polythene cables shall be used instead of PVC cables.

4.0 Laying

4.1 The cables shall be laid, as per drawings or along a short and convenient route between switch board and the equipment, either in trenches, on wall or on trays.

Hangers, supported from the slab. Cable routing shall be checked on the site to avoid interference with structure, equipment etc. Where more than one cables are running close to each other, proper spacing should be provided between them

4.2 The radius of bends of the cable should not be less than 12 times the radius of cable to prevent undue stress and damage at the bends, the cables should be supported and fixed on M.S.supports,when running in trenches, wall or ceiling suspended hangers when laid under ground the cables should be covered with sand and protected with cement concrete covering. suitable G.I. pipe shall be used wherever cable is laid across road, crossing of other services and when passing through R.C.C.

4.3 Wooden bushes shall be provided at the ends of pipes through which cables are taken.

5. Earthing:

5.1 Pipe Earth Electrode

G.I. pipe shall be of medium class 40 mm dia 4.5 m.long in length. galvanising of the pipe shall conform to relevant is. G.I. pipe electrode shall be cut tapered at the bottom and provided with holes of 12 mm dia drilled not less than 7.5 cm from each other upto 2m of length from bottom. The electrode shall be buried in the ground vertically with its top not less than 20 cms below ground level.

5.2 Plate Earth Electrode

For plate electrode minimum dimensions of the electrode shall be as under:

- i. G.I. plate electrode : 60cm x 60cm x 6mm thick.
- ii. Copper plate electrode: 60cm x 60cm x 3mm thick.

The electrode shall be buried in ground with its faces vertical and top not less than 3 m below ground level.

In case of plate earth electrode a watering pipe of 20 mm dia of medium class gi pipe shall be provided and attached to the electrode. A funnel with mesh shall be provided on top of

this pipe for watering the earth. In case of pipe electrode a 40mm x 20mm reducer shall be used for fixing the funnel. The watering funnel attachment shall be housed in masonry enclosure of not less than 30cm x 30cm x 30cm. A cast iron/ms frame with cover having locking arrangement shall be suitable embedded in the masonry enclosure.

5.3 Loop Earthing

Loop earthing shall be providing for all mountings of main board and other metal clad switches and db's with G.I. strip of size specified but not less than 14 swg copper or 12 swg gi or 4 sq mm aluminium wire. The earthing lead from electrode owner's shall be suitably protected from mechanical injury by a 15 mm dia pipe in case of wire and 40 mm dia medium class G.I. pipe in case of strip. Metallic covers or supports of all medium pressure or ht apparatus or conductor shall in all cases be connected to not less than two separate and distinct earths.

5.3.1 All equipment connected with electric supply shall also be provided with double earthing continuity conductors. The size of G.I. earthing conductors shall be :-

Earthing should be carried out as per is-3043

Size of phase wire sq.mm aluminium tape/wire (swg)	Size of G.I. conductor aluminium tape/wire (swg)
185	25 mm x 4 mm (strip)
150	25 mm x 4 mm (strip)
120	20 mm x 3 mm (strip)
Size of phase wire sq.mm	Size of G.I. conductor aluminium tape/wire (swg)
95	20 mm x 3 mm (strip)
70	4 swg
50	4 swg
35	6 swg
25-6	6 swg
4	8 swg

6. Miscellaneous :

6.1 The final connections to the equipment shall be through flexible connections where the equipment is likely to be moved back and forth, such as on slide rails.

6.2 An isolator switch shall be provided at any motor which is separated from the main switch panel by a wall or partition or other barrier or is more than 15 metres away from the main panel.

6.3 Two separate and distinct earthing conduits shall be connected from the equipment upto the main switch board panel.

6.4 The entire installation shall be tested as per electricity rules and I.S. 732-1973/is-3043 with amendments 1,2&3 prior to the commissioning of the plant and a suitable test report furnished by competent local authorities. The test report will be obtained by contractor himself at his own expenses.

6.5 All exposed hangers etc. shall be given 2 coats of suitable paint of approved colour, when all work has been completed.

Section : - 7:- TESTING, ADJUSTING AND BALANCING

The AC Contractor shall have a dedicated experienced, specialized, approved, testing and commissioning (T&C) team /agency responsible for coordination with other trades, preparation of T&C plan method statement & T&C procedures, organizing & scheduling the T&C activities along with the progress of works, supervision any re-testing, coordination with third parties for commissioning & certification, organizing & performing testing for satisfaction of all Statutory Bodies, T&C record documentation & handover

1. **General**

- a. Testing, adjusting and balancing of heating, ventilating and air-conditioning systems at site.
- b. Testing, adjusting and balancing of HVAC Hydronic system at site.
- c. Testing, adjusting and balancing of exhaust system at site.

Comply with current editions of all applicable practices, codes, methods of standards prepared by technical societies and Associations including:

ASHRAE : 2007 HVAC Application.

SMACNA : Manual for the Balancing and Adjustment of air distribution system.

- d. AC Contractor shall submit a Test, adjust, balance procedure/method statements/charts for approval to Client.

2. **Performance**

- a. Verify design conformity.
- b. Establish fluid flow rates, volumes and operating pressures.
- c. Take electrical power readings for each motor.
- d. Establish operating sound and vibration levels.
- e. Adjust and balance to design parameters.
- f. Record and report results as per the formats specified.

3. **Definitions**

- a. Test : To determine quantitative performance of equipment.
- b. Adjust :To regulate for specified fluid flow rates and air patterns at terminal equipment (e.g. reduce fan speed, throttling etc.)
- c. Balance : To proportion within distribution system (submains, Branches and terminals) in accordance with design quantities.

4. **Testing, Adjusting and Balancing (TAB) Procedures**

The following procedures shall be directly followed in TAB of the total system. Before commencement of each one of the TAB procedure explained hereunder, the AC Contractor shall intimate the Client about his readiness to conduct the TAB procedures in the format given in these specifications.

5. **Description of System and Requirements**

Adjust and balance the following system to provide most energy efficient operation compatible with selected operating conditions.

- a. All supply, return and outside air systems.
- b. All exhaust air systems.
- c. All chilled water systems.
- d. All cooling tower (condenser) water systems.
- e. Emergency purge systems.

6. **Air Systems**

I. Air Handlers Performance

The TAB procedure shall establish the right selection and performance of the AHUs with the following results :

- a. Air-IN DB and WB temperature.
- b. Air-OUT DB and WB temperature.
- c. Dew point air leaving.
- d. Sensible heat flow.
- e. Latent heat flow.
- f. Sensible heat factor.
- g. Fan air volume.
- h. Fan air outlet velocity.
- i. Fan static pressure.
- j. Fan power consumption.
- k. Fan speed.

II. Air distribution

Both supply and return air distribution for each AHU and for areas served by the AHU shall be determined and adjusted as necessary to provide design air quantities. It shall cover balancing of air through main and branch ducts.

III. The Preparatory Work

To conduct the above test, following preparatory works are required to be carried out including the availability of approved for construction shop drawings and submittals:

- a. All outside air intake, return air and exhaust air dampers are in proper position.
- b. All system volume dampers and fire dampers are in full open position.
- c. All access doors are installed & are air tight.
- d. Grilles are installed & dampers are fully open.
- e. Provision and accessibility of usage of TAB instruments for traverse measurements are available.
- f. All windows, doors are in position.

- g. Duct system is of proper construction and is equipped with turning vanes and joints are sealed.
- h. Test holes and plugs for ducting.

7. **Hydronic System Balancing**

I. The Hydronic system shall involve the checking and balancing of all water pumps, piping network (main & branches), the heat exchange equipment like cooling and heating coils, condensers and chillers and cooling towers in order to provide design water flows.

II. The essential preparation work, must be done by the HVAC Contractor prior to actual testing, adjusting and balancing of HVAC system and ensure following :

- Availability of co-ordinated drawings and approved submittals and system sketch with design water flows specified thereon.
- Hydronic system is free of leaks, is hydrostatically tested and is thoroughly cleaned, flushed and refilled.
- Hydronic system is vented.

III. The AC Contractor shall confirm completion of the basic procedures and prepare check lists for readiness of system balance.

- a. Check pumps operation for proper rotation and motor current drawn etc.
- b. Confirm that provisions for TAB measurements (Temperature, pressure and flow measurements) have been made.
- c. Open all shut-off valves and automatic control valves to provide full flow through coils. Set all balancing valves in the preset position, if these values are known. If not, shut all riser balancing valves except the one intended to be balanced first.

Balancing work for both Chilled Water System and Condenser Water System shall be carried out in a professional manner and test reports in the specified format shall be prepared and presented to the Client / Consultant for endorsement.

8. **Readiness for Commencement of Tab**

Before starting of any of the tests, the readiness to do so should be recorded as per the prescribed check list.

9. **Tab Instruments**

I. Air Measuring Instruments

a. For measuring DB and WB temperature, RH and dew point, microprocessor based TSI USA make VelociCalc Plus Meter, Model 8386, or equivalent shall be used. This instrument shall be capable of calculating the sensible, latent total heat flows, sensible heat factor and give printouts at site and have data logging/downloading facility.

b. For measuring Air velocity, DB temperature and Air volume, TSI USA make VelociCalc meter model 8386/ 8345 or equivalent shall be used. It shall be able to provide instant print out of recorded Air volume readings.

c. Pitot tube.

d. Electronic Rotary Vane Anemometer TSI make or equivalent.

- e. Accubalance Flow Measuring Hood TSI make or equivalent.

[All above instruments shall have a valid certification from a reputed testing institution.]

II. Hydronic Measuring Instruments

a. For measurement of water flow across balancing valves, instruments as provided by the manufacturer of the valves specific to the type of valves shall be need. This shall include but not be limited to differential pressure manometers. Temperature shall be measured using electric thermometers from thermowells provided at strategic location by the HVAC Contractor. The water balancing shall be carried out being computer simulation program provided / certified by the balancing valve manufacturer.

III. Rotation Measuring Instrument

a. Electronic Digital Tachometer.

IV. Temperature & RH Measuring Instrument

a. TSI VelociCalc model 8386 / VelociCalc model 8345 or equivalent.

V. Electrical Measuring Devices

a. Clamp on Volt ammeter.

b. Continuity Meter.

VI. Vibration and Noise Levels

Vibration and alignment field measurements shall be taken for each circulating water pump, water chilling unit, air handling unit and fan driven by a motor over 10 HP. Readings shall include shaft alignment, equipment vibration, bearing housing vibration, and other test as directed by the PMC.

Sound level readings shall be taken at ten (10) locations in the building as selected by the Contractor / Client. The readings shall be taken on an Octave Band analyzer in a manner acceptable to him. The AC Contractor shall submit test equipment data and reporting forms for review. In order to reduce the ambient noise level the readings shall be taken at night. All test shall be performed in the presence of Client / Consultant or his authorized representative.

Section : - 8:- PAINTING WORK

This section deals with painting of various equipment / material supplied under this contract. It gives basic guidance for painting as specified below:-

Application : The original colour of all equipments like water chilling machines, air-handling units etc. which if get damaged during transportation or during installation shall be painted in original shade with the two coat of paint to give a final finish.

All chilled water pipes shall be painted as per standard code of practice and arrows shall be marked to indicate direction of flow of water.

Colour Scheme For The Equipments / Materials

Description	Standard Colour & Reference	Lettering Colouring
Exposed Duct Work (other than plant room)	As per E-I-C Directions	As per E-I-C Directions
Air Conditioning Duct Work (Plant Rooms)	BSS 111 Pale Blue	Black
Ventilation Duct Duct Work (Plant Rooms)	BSS 111 Pale Blue	Black
Conditioner Casings Air Handling Units, Filter Plenums	BSS 111 Pale Blue	Black
Electrical (Conduit Ducts and Motors)	BSS 557 Light Orange	Black
Chilled Water Pipe	Jade Green	Black
Drains	Black	White
Vents	White	Black
Fans	BSS 111 Pale Blue	Black
Valves and Pipe Line Fittings	White with black handles	Black
Beltguards	Black and yellow diagonal stripes (45 25 mm wide)	
Switchboards- exterior – interior	BS 366 Light Beige	White
Machine Bases, Inertia Bases and Plinths	Charcoal	Grey
Chilling M/C	As Per Manufacturer's Standard	
Pump-sets	Battle ship grey	

Description	Standard Colour & Reference	Lettering Colouring
Condenser water pipes	Light green	Black
Electrical panels/sub-panel/ remote control console	Light grey powder coated RAL 7032 as per DIN	
Supports for ducts		Silver

Section : - 9 IDENTIFICATION OF SERVICES

General

This section comprises of identification of services for each piece of equipment

Valve Labels and Charts

Each valve shall be provided with a label indicating the service being controlled, together with a reference number corresponding with that shown on the Valve Charts and “ as fitted” drawings. The labels shall be made from 3 ply (black / white/ black) Traffolyte material showing white letters and figures on a black background. Labels to be tied to each valve with chromium plated linked chain. The labels shall be suitable for minimum 40 characters with font size of 24 minimum. Labelling scheme of each equipment to be submitted for approval from Client / Consultant.

A wall mounted, glass covered plan to the endorsement of the Client / Consultant shall be provided and displayed in each plant room showing the plant layout with pipe work, valve diagram and valve schedule indicating size, service, duty, etc.

All AC equipments shall be provided with permanent mounted identification labels and unique tagging numbers. The shop drawings shall also include these tagging numbers for easy identification on site. It should be co-ordinated with BMS also to ensure consistent equipment tagging among drawings, BMS display and site installation.

Identification of Services

Pipe work and duct work shall be identified by colour bands 150 mm. wide or colour triangles of at least 150 mm. / side. The bands of triangles shall be applied at termination points, junctions, entries and exits of plant rooms, walls, in ceiling spaces, ducts and control points to readily identify the service, but spacing shall not exceed 4.0 metres.

Pipe Work Services

For pipe work services and its insulation the colours of the bands shall comply with BS.1710: 1971. Basic colours for pipe line identification:

Pipe Line Contents	BS. 4800 Colour Reference	Colour
Water	12 D 45	Green
Steam	10 A 03	Grey
Oils	06 C 39	Brown
Gas	08 C 35	Yellow / Brown
Pipe Line Contents	BS. 4800 Colour Reference	Colour
Air	20 E 51	Blue
Drainage	00 E 53	Black
Electrical	06 E 51	Orange

Colour code indicator bands shall be applied as colour bands over the basic identification colour in the various combinations as listed below :-

Pipe Line Contents	Colour Bands to BS. 4800
Water Services :	
Cooling	00 E 55
Fresh / drinking	18 E 53
Boiler feed	04 D 45/00 E 55 / 04 D 45
Condensate	04 D 45/14 E 53 / 04 D 45
Chilled	00 D 55/14 E 53 / 00 D 45
Central Heating Services :	
Below 100 Deg. C	18 E 55/04 D 45/18 E 53
Above 100 Deg. C	04 D 45/18 E 53 /04 D 45
Cold Water Storage	
Tanks:	00 E 55/18 E 53/00 E 55
Hot Water Supply	00 E 55/04 D 45/00 E 55
Hydraulic Power	04 C 33
Sea / River Untreated	Basic Colour only
Fire Extinguishing	04 E 53
Steam Services :	Basic Colour only
Air : Compressed	Basic Colour only
Vacuum	White
Town Gas : Manufactured	14 E 53
Natural	10 E 53
Oils :	
Diesel	00 E 55
Lubricating	14 E 53
Hydraulic Power	04 C 53
Transformer	04 D 45
Drainage and other fluids :	Basic Colour only
Electrical Services :	Basic Colour only

In addition to the colour bands specified above all pipe work shall be legibly marked with black or white letters to indicate the type of service and the direction of flow, identified as follows:-

High Temperature Hot Water	HTHW
Medium Temperature Hot Water	MTHW
Low Temperature Hot Water	LTHW
Chilled Water	CHW
Condenser Water	CONDW
Steam	ST
Condensate	CN

Pipe shall have the letters F and R added to indicate flow and return respectively as well as directional arrows.

Duct Work Services :

For Duct work services and its insulation the colours of the triangles shall comply with BS.1710 : 1971. The size of the symbol will depend on the size of the duct and the viewing distance but the minimum size should not be less than 150 mm. length per side. One apex of the triangle shall point in the direction of airflow.

Services	Colour	BS.4800 Reference	Colour
Conditioned Air	Red and Blue	04 E 53 / 18 E 53	
Ward Air	Yellow	10 E 53	
Outdoor air	Green	14 E 53	
Exhaust / Extract / Recirculated Air	Grey	AA 0 09	
Foul Air	Brown	06 C 39	
Dual Duct System Hot Supply Air	Red	04 E 53	
Cold Supply Air	Blue	18 E 53	

In addition to the colour triangles specified above all duct work shall be legibly marked with black or white letters to indicate the type of service, identified as follows:-

Supply Air	S
Return Air	R
Outdoor Air	O
Exhaust Air	E
Smoke Extract Duct	M
Spill Air	A

The colour banding and triangles shall be manufactured from self adhesive cellulose tape, laminated with a layer of transparent ethyl cellulose tape.

Section : - 10:- LIST OF ABBREVIATIONS

Followings List of Abbreviations shall have been used in preparing the Tender Specifications, Bill of Quantities & Drawings.

AABC	:	AMERICAN AIR BALANCING COUNCIL
ACH	:	AIR CHANGE PER HOUR
AC	:	AIR CONDITIONING
ACMV	:	AIR CONDUCTING AND MECHANICAL VENTILATION
AHU	:	AIR HANDLING UNIT
ANSI	:	AMERICAN NATIONAL STANDARD INSTITUTE
ARI	:	AMERICAN REFRIGERATION INSTITUTE
ASHRAE	:	AMERICAN SOCIETY OF HEATING, REFRIGERATION AND AIRCONDITIONING ENGINEER
ASME	:	AMERICAN SOCIETY OF MECHANICAL ENGINEERS
ASTA AUTHORITIES	:	ASSOC.CIATION OF SHORT - CIRCUIT TESTING
ASTM	:	AMERICAN SOCIETY OF TESTING AND MATERIALS
ATG	:	AIR TRANSFER GRILLE
AWS	:	AMERICAN WELDING SOCIETY
BAS	:	BUILDING AUTOMATION SYSTEM
BIS	:	BUREAU OF INDIAN STANDARD
BMS	:	BUILDING MANAGEMENT SYSTEM
BTU	:	BRITISH THERMAL UNIT
CDW	:	CONDENSER WATER
CFM	:	CUBIC FEET PER MINUTE
CHW	:	CHILLED WATER
CMS	:	CENTRAL MONITORING SYSTEM
CRCA	:	COLD ROLLED COLD ANNEALED
CSA	:	CANADIAN STANDARD ASSOC.CIATION
CT	:	COOLING TOWER
CTI	:	COOLING TOWER INSTITUTE
DB	:	DISTRIBUTION BOARD
DDC	:	DIRECT DIGITAL CONTROLLER
DOL	:	DIRECT ON LINE
DFA	:	DELHI FIRE AUTHORITY
DIA	:	DIAMETER
DIDW	:	DOUBLE INLET DOUBLE WIDTH

DX	:	DIRECT EXPANSION
EA	:	EXHAUST AIR
EEPROM	:	ELECTRICAL ERASABLE PROGRAM
ELCB	:	EARTH LEKAGE CIRCUIT BREAKER
ETL	:	ELETRICAL TESTING LABORATORIES
EPA	:	ENVIRONMENTAL PROTECTION ACT
FCU	:	FAN COIL UNIT
F/A	:	FLOOR ABOVE
F/B	:	FLOOR BLOW
FCC	:	FIRE COMMAND CENTRE
FD	:	FIRE DAMPER
FFL	:	FINISHED FLOOR LEVEL
FPM	:	FEET PER MINUTE
FPS	:	FOOT PER SECOND
FRP	:	FIBERGLASS REINFORCED PLASTIC
GI	:	GALVANISED IRON
GPM	:	GALLON PER MINUTE
GSS	:	GALVANIZED STEEL SHEET
H/L	:	HIGH LEVEL
HDG	:	HOT DIP GALVANIZED
HDPE	:	HIGH DENSITY POLY ETHANE
HFC	:	HYDRO FLURO CARBON
HP	:	HORSE POWER
HVAC	:	HEATING, VENTILATION & AIR CONDITIONING
IAQ	:	INDOOR AIR QUALITY
IEC	:	INTERNATIONAL ELECTROCHEMICAL COMMISSION
IKW	:	INDICATED KILO WATT
IPD	:	INITIAL PRESSURE DROP
ISO	:	INTERNATIONAL STANDARD ORGANIZATION
KW	:	KILO WATT
L	:	LITRE
LCD	:	LIQUID CRYSTAL DISPLAY
L/L	:	LOW LEVEL
L/S	:	LITRE PER SECOND

LSZH	:	LOW SMOKE ZERO HALOGEN
LT	:	LOW TENSION
M	:	METER
MAX.	:	MAXIMUM
MCB	:	MINIATURE CIRCUIT BREAKER
MCC	:	MOTOR CONTROL CENTRE
MFD	:	MOTORIZED FIRE DAMPER
MIN	:	MINIMUM
MM	:	MILLIMETER
NBC	:	NATIONAL BUILDING CODE
NC	:	NOISE CRITERIA
NEC	:	NATIONAL ELECTRIC CODE
NFPA	:	NATIONAL FIRE PROTECTION ASSOC. CIATION
NPLV	:	NET PART LOAD VALUE
NIST	:	NATIONAL INSTITUTE OF STANDARDS & TECHNOLOGY
NEMA ASSOC. CIATION	:	NATIONAL ELECTRICAL MANUFACTURERS
NPSH	:	NET POSITIVE SUCTION HEAD
NTS	:	NOT TO SCALE
OA	:	OUTDOOR AIR
PHE	:	PUBLIC HEALTH ENGINEERING
PLC	:	PROGRAMMABLE LOGIC CONTROLLER
P.C.	:	PERSONAL COMPUTER
PSIG	:	POUNDS PER SQUARE INCH GAUGE
PUF	:	POLYURETHANE FOAM
RA	:	RETURN AIR
RAD	:	RETURN AIR DUCT
RCC	:	REINFORCED CEMENT CONCRETE
RH	:	RELATIVE HUMIDITY
RPM	:	REVOLUTIONS PER MINUTE
SA	:	SUPPLY AIR
SAD	:	SUPPLY AIR DUCT
SMACNA NATIONAL ASSOC. CIATION INC	:	SHEET METAL & AIR CONDITIONING CONTRACTORS
STD	:	STANDARD

T/A	:	TO ABOVE
TAB	:	TESTING, ADJUSTING AND BALANCING
T/B	:	TO BELOW
TCC	:	TERMINAL CONTROL CENTRE
TFA	:	TREATED FRESH AIR
TOA	:	TREATED OUTDOOR AIR
TP	:	THREE PHASE
TR	:	TONS OF REFRIGERATION
TVOC	:	TOTAL VOLATILE ORGANIC COMPOUNDS
VAV	:	VARIABLE AIR VOLUME
VFD	:	VARIABLE FREQUENCY DRIVES
VIP	:	VIBRATION ISOLATING PAD
VSPS	:	VARIABLE SPEED PUMPING SYSTEM
XLPE	:	CROSS -LINKED POLYETHYLENE
SISW	:	SINGLE INLET SINGLE WIDTH
UL	:	UNDERWRITERS LABORATORIES INC.
WG	:	WATER GAUGE

Section : - 11:- NOISE & VIBRATION CONTROL

Scope of Work

This section deals with design, supply, installation, testing and commissioning of noise and vibration control equipment and accessories.

Standards

The testing of all noise control equipment and the methods used in measuring the noise rating of air conditioning plant and equipment shall be in accordance with the relevant sections of the following British Standards, unless otherwise stated:

BS 4718: 1971	Methods of Test of Silencers for Air Distribution Systems
BS 2750:	Laboratory and Field Measurement of Airborne Sound
Parts 1-9:1980	Insulation of Various Building Elements
	Recommendations for Field Laboratory Measurement of Airborne and Impact Sound Transmission in Buildings
BS 3638: 1987	Methods of Measurement of Sound Adsorption in a Reverberation Room
BS 4773:	Acoustic Testing.
Part 2: 1976	
BS 4856:	Acoustic performance without additional ducting of forced
Part 2: 1976	fan convection equipment.
Part 5: 1976	Acoustic performance with additional ducting of forced fan convection equipment
BS 4857:	Acoustic Testing and Rating of High Pressure Terminal
Par 2:1978 (1983)	Reheat Units.
BS 4954:	Acoustic Testing and Rating of Induction Units.
Par 2:1978 (1987)	
BS 5643:	1984 Glossary of Refrigeration, Heating, Ventilating and Air Conditioning Terms

General

The air conditioning contractor must take all necessary precautions to have minimum noise generation and its transmission generated by moving plant and equipment to achieve acceptable limits for occupied areas. In addition to the noise level criteria particular attention must be given to the following details at time of ordering plant and equipment and their installation :-

All moving plant / equipment shall be statically and dynamically balanced at manufacturers works and certificates issued.

The isolation of moving plant, machinery and apparatus including lines equipment from the building structure.

Where duct work and pipe work services pass through walls, floors and ceilings, or wherever supported shall be surrounded with a resilient acoustic absorbing material to prevent contact with the structure and minimise the outbreak of noise from plant rooms.

The reduction of noise breakout from plant rooms and the selection of externally mounted equipment and plant to meet ambient noise level requirements of the Specifications.

Electrical conduits and connections to all moving plant and equipment shall be carried out in flexible conduit and cables to prevent the transmission of vibration to the structure and nullify the provisions of anti-vibration mountings.

All duct connections to fans shall incorporate flexible connections, except in cases where these are fitted integral within air handling units.

All resilient acoustic absorbing materials shall be non flammable, vermin and rot proof and shall not tend to break up or compress sufficiently to transmit vibration or noise from the equipment to the structure.

Where practicable, attenuators shall be built into walls and floors to prevent the flanking of noise the duct work systems and their penetrations sealed in the manner previously described. Where this is not feasible, the exposed surface of the duct work between the attenuators and the wall subjected to noise infiltration shall be acoustically clad as specified.

Ambient noise from cooling tower also shall be assessed to determine the suitable attenuators that can reduce the noise so as not affecting the adjoining public area.

Sound Attenuators

Attenuators shall be provided in ducts in accordance with acceptable noise level criteria & if specified in BOQ. Attenuators shall be constructed from high quality pre-galvanised steel sheet casings with lock formed joints along the casing length. Angle iron cross jointing flanges shall be fitted to silencer casings, drilled as required and finished with red oxide primer paint. Acoustic splitters shall be formed by channel section pre-galvanised sheet steel framework retaining acoustic fill of a density to attain the required performance. Splitters shall have round ends to give smooth entry and exit conditions to minimise air pressure drops. The acoustic fill shall be protected from the air flow by 22 swg minimum perforated galvanized sheet steel. All attenuators shall be selected against a maximum allowable air pressure drop of 100 Pa. It will be the responsibility of the AC Contractor at the time of placing orders for fan equipment to obtain from the manufacturers, certified sound power levels to enable the selected duct silencers to be checked against the original design information, prior to orders being placed.

Anti-vibration Mountings.

All items of rotating and reciprocating plant and equipment shall be isolated from the structure by the use of anti-vibration materials, mountings or spring loaded supports fixed to either concrete bases, inertia blocks or support steels. Centrifugal fans and motors within air handling units shall be isolated from the frame of the air handling unit by suitable anti-vibration mountings. Fan discharge air connections shall be fitted with approved flexible connections. Axial flow fans shall be mounted on steel legs as diaphragm plates supported on neoprene in shear anti-vibration mountings, or suspended using spring loaded hangers to suite the application. Centrifugal pumps shall be mounted on inertia bases consisting of reinforced concrete sub-base, anti-vibration mountings and concrete filled steel upper plinth.

The AC Contractor shall be responsible for providing the steel upper plinth and mountings. Pipe work connections to circulating pumps, chillers, cooler coils and other heat exchanger equipment shall be made with flexible connections as per piping Specifications. The construction of the anti-vibration mountings shall generally comply with the following: -Enclosed Spring Mounting (Caged or Restrained Springs) Each mounting shall consist of cast or fabricated telescopic top and bottom housing enclosing one or more helical steel springs as the principle isolation elements, and shall incorporate a built-in leveling device. The springs shall have an outside diameter of not less than 75% of the operating height, and be selected to have at least 50% overload capacity before becoming coil bound. The bottom plate of each mounting shall have bonded to it a neoprene pad designed to attenuate any high frequency energy transmitted by the springs. Mountings incorporating snobbery of restraining devices shall be designed so that the snubbing damping or restraining mechanism, is capable of being adjusted to have no significant effect during the normal running of the isolated machine. The manufacturers shall provide restrained isolator on chillers subject to approval.

Open Spring Mountings

Each mounting shall consist of one or more helical steel springs as the principal isolation elements, and shall incorporate a built-in leveling device. The spring shall be fixed or otherwise securely located to cast or fabricated top and bottom plates, and shall have an outside diameter of not less than 75% of the operating height, and shall be selected to have at least 50% overload capacity before becoming coil-bound. The bottom plate shall have bonded to it a neoprene pad designed to attenuate any high frequency energy transmitted by the springs.

Neoprene-in-Shear Mountings

Each mounting shall consist of a steel top plate and base plate completely embedded in oil resistant neoprene. Each mounting shall be capable of being fitted with a leveling device, and bolt holes in the base plate and tapped holes in the top plate so that they may be bolted to the floor and equipment where required.

Inertia Bases For Pumps

The inertia base shall be an all welded mild steel channel frame the minimum depth of which shall be 1/12 of the longest span between isolator but not less than 150 mm. filled with concrete the density of which shall be 2300 kg/m³.

The inertia base shall be sufficiently large to provide support for all parts of the equipment, including any component, which overhands the equipment base, such as suction, and discharge elbows on centrifugal pumps.

The frame shall include pre-located equipment anchor bolts fixed into position and housed in a steel sleeve allowing minor bolt location adjustment.

Isolator support brackets shall be welded into the corners of the base and suitably re-enforced for the load of the equipment and base.

Additional reinforcing roads shall be provided at 200 mm. centres to ensure the concrete and frame is adequately stiffened against distortion.

Reference Design Standard

Following standard & guidelines shall be adopted while designing the HVAC System.

- i) National Building Code of India (NBC 20016) with latest revision.
- ii) Energy Conservation Building Code (ECBC 2007) or latest
- iii) ASHRAE latest Hand Books.
 - a) Fundamentals
 - b) HVAC Systems and Equipment
 - c) HVAC Applications
 - d) Refrigeration
 - e) HVAC Design Guidelines for Health Care Facilities.
 - f) ASHRAE Standard 170.
- iv) Duct construction standards as per relevant latest BIS codes & SMACNA standards.
- v) Air filters as per ASHRAE 52.1-1992 or latest and 52.2-2007 or latest
- vi) Indoor Air quality as per ASHRAE 62.1-2010 or latest
- vii) Motors, Cabling, Wiring and accessories as per latest BIS codes.
- viii) National Electric Codes (NEC) latest version
- ix) ANSI / ASHRAE / IESNA standard 90.1-2009 or latest: Energy standard for building except low rise residential buildings.
- x) ASHRAE standard 55: Thermal Comfort.

BIS Code & Guidelines

Followings are the few list of Bureau of Indian Standards Codes for guidelines.

IS : 277 - 1992	Galvanized steel sheet (Plain & Corrugated) wire for fencing.
IS : 554 - 1985 (Reaffirmed 1996)	Dimensions for pipe threads where pressure tight joints are required on the threads.
IS : 655 - 1963 (Reaffirmed 1991)	Metal air ducts.
IS : 659 – 1964 (Reaffirmed 1991)	Air conditioning (Safety Code)
IS : 660 – 1963 (Reaffirmed 1991)	Mechanical Refrigeration (Safety Code)
IS : 694 - 1990 (Reaffirmed 1994)	PVC insulated (HD) electric Cables for working voltage upto and including 1100 volts.
IS : 732 - 1989	Code of practice for electrical wiring.
IS : 780 - 1984	Sluice valves for water works purposes.

IS : 822-1970 (Reaffirmed 1991)	Code of procedure for inspection of welds.
IS : 1239 (Part - I) - 1990	Mild steel tube
IS : 1239 (Part - II) - 1992	Mild steel Tubulars and other wrought steel pipe fittings.
IS : 1255 - 1983	Code of Practice for installation and maintenance of Power Cables upto and including 33 KV rating (Second Revision)
IS : 1554 - 1988 (Part – I)	PVC insulated (Heavy Duty) electric cables for working voltages upto and including 1100 volts.
IS : 1897 – 1983 (Reaffirmed 1991)	Copper bus bar / strip for electrical purposes
IS : 2379 - 1990	Colour code for the identification of Pipelines.
IS : 2551 - 1982	Danger notice plate
IS : 3043 - 1987	Code of practice for earthing.
IS : 3103 – 1975 (Reaffirmed 1999)	Code of practice for Industrial Ventilation.
IS : 3837 – 1976 (Reaffirmed 1990)	Accessories for rigid steel conduit for electrical wiring.
IS : 4736 – 1986 (Reaffirmed 1998)	Hot-dip zinc coatings on steel tubes.
IS : 4894 - 1987	Centrifugal Fan.
IS : 5133 - 1969 (Part-I)	Boxes for the enclosure of electrical (Reaffirmed 1990) accessories.
IS : 5216 - 1982	Guide for safety procedure and practices (Part-I) (Reaffirmed 1990) in electrical work.
IS : 5312 (Part-I) - 1984	Swing - check type reflux non (Reaffirmed 1990) return valves for water works
IS : 5424 – 1989 (Reaffirmed 1994)	Rubber mats for electrical purposes.
IS : 5578 & 11353-1985	Marking and identification of conductors
IS : 6392 – 1971 (Reaffirmed 1988)	Steel pipe flanges.

IS : 8623 - 1993	Low voltage switchgear and control gear assemblies (Requirement for type / partly type tested assemblies)
IS : 8623 - 1993	Bus Bar trunking system (Part - II)
IS : 8828 - 1996	Circuit Breakers for over current protection for house hold and similar installation.
IS : 9537 – 1981 (Part II)	Rigid Steel Conduits for electrical wiring
IS : 10810 - 1988	Methods of test for cables.
IS : 13947-1993 (Part-I)	General rules for low voltage switch gears and control gears.
IS : 13947-1993 (Part-II)	Circuit Breakers IEC 947 - 2
IS : 13947 - 1993 (Part-III)	Switches, disconnectors and fuse for low voltage switch gear and control gear.
IS : 13947 - 1993 (Part-IV)	Low voltage switch gear and control gear for contactors and motor starters
IS : 13947 – 1993 (Part-V)	Control Circuit Devices.
BS : EN:779 – 1993	Filters
IEC	Relevant Sections.

Section : - 12 SAFETY CODES

1. SCOPE

The scope of this sub-section is the minimum safety requirements to be observed during manufacture and erection of the HVAC system as specified herein in addition to the safety norms generally followed:-

2. I.S. STANDARDS

The safety code for mechanical refrigeration IS: 660 and safety code for air conditioning IS: 659 shall be observed.

3. SAFETY REQUIREMENTS

Some of the important safety requirements are as under but not limited to the same:-

- a. There shall be maintained in a readily accessible place, first aid appliances including adequate supply of sterilized dressings and cotton wool.
- b. The injured person shall be taken to a public hospital without loss of time.
- c. Suitable and strong scaffolds shall be provided for workmen for all works that cannot be safely done from ground.
- d. No portable single ladder shall be over 8 meters in length. The width between side rails shall not be less than 30 cm (clear) and the distance between two adjacent rings shall not be more than 30 cms, when a ladder is used, an extra mazdoor shall be engaged for holding the ladder.
- e. The excavated material shall not be placed within 1.5 meters of the edge of the trench or half of the depth of trenches whichever is more. All trenches and excavations shall be provided with necessary fencing and lighting.
- f. Every opening in the floor of a building or in a working platform to be provided with suitable means to prevent the fall of persons or materials by providing suitable fencing or railing whose minimum height shall be one meter.
- g. No. Floor, roof or other part of the structure shall be so overloaded with debris or material as to render it unsafe.
- h. Workers employed on mixing and handling materials such as asphalt, cement mortar or concrete & lime mortar shall be provided with protective footwear and rubber hand gloves.
- i. Those engaged in welding works shall be provided with protective eye shields and glove.
- j. No paint containing lead or lead products to be used except in the form of paste or readymade paint.
- k. Suitable facemasks shall be supplied for use of workers when the paint is applied in the form of spray or surface having lead paint dry rubbed and scraped.
- l. Overalls shall be supplied by the Contractor to the painter and adequate facilities shall be provided to enable the working painter to wash during cessation of the work.
- m. The ropes used in hoisting or lowering material or as a means of suspension, shall be of adequate quality and adequate strength and free from defects.

- n. All site personnel shall wear safety helmets whenever they are in the construction/ erection areas.

Section 13:- MODES OF MEASUREMENTS

1. UNIT PRICES IN THE SCHEDULE OF QUANTITIES

The item description in the 'Schedule of Quantities' is in the form of a condensed resume. The unit price shall be held to include every thing necessary to complete the work covered by this item in accordance with the specifications and drawings. The sum total of all the individual item prices shall represent the total price of the installation ready to be handed over.

i. THE UNIT PRICE OF THE VARIOUS ITEMS SHALL INCLUDE THE FOLLOWING:

All equipments, machinery, apparatus and materials required as well as the cost of any tests which the BOB may request in addition to the tests generally required to prove quality and performance of the equipments.

All the labour required supplying and installing the complete installation in accordance with the specifications.

Use of any tools, equipments, machinery, lifting tackle, scaffolding, ladders etc. Required by the Contractor to carry out his work.

All the necessary measures to prevent the transmission of vibration.

The necessary material to isolate equipments foundations from the building structure, wherever necessary. Storage and insurance of all equipments apparatus and materials.

The Contractor's unit price shall include all equipments, apparatus, material and labour indicated in the drawings and/or specifications in conjunction with the item in question, as well as all additional equipments, apparatus, material and labour usual and necessary to make in question on its own (and within the system as a whole) complete even though not specifically shown, described or otherwise referred to.

2. MEASUREMENTS OF SHEET METAL DUCTS, GRILLES/DIFFUSERS ETC.

i. Sheet Metal Ducts

5.2.i.1. Duct Work shall be measured on the basis of external surface area of ducts. Duct measurements shall be taken before application of the insulation. The external surface areas shall be calculated by measuring the perimeter comprising overall width and depth, including the corner joints, in the center of each duct section, multiplying with the overall length from flange face to flange face of each duct section and adding up areas of all duct sections. Plenums shall also be measured in similar manner.

5.2.i.2. For tapered rectangular ducts, the average width and depth shall be considered for perimeter, whereas for tapered circular ducts, the diameter of the section midway large and small diameter shall be adopted, the length of tapered duct section shall be the center line distance between the flanges of the duct section.

5.2.i.3. For special pieces like bends, tees, reducers, branches and collars, mode of measurement shall be identical to that described above using the length along the centerline.

5.2.i.4. The quoted unit rate for external surface of ducts shall include all wastage allowances, flanges and gaskets for joints, nuts and bolts, hangers and angles with double nuts for supports, rubber strip 3 mm thick between duct and support, vibration isolator suspension where specified or required, inspection chamber / access panel.

Splitter damper with quadrant and lever for position indication, turning vanes, straightening vanes, and all other accessories required to complete the duct installation as per the Specifications. These accessories shall NOT be separately measured nor paid for.

ii. Grilles/Diffusers

5.2.ii.1. Grilles and registers - width multiplied by height, excluding flanges. Volume control dampers shall form part of the unit rate for registers and shall not be separately accounted.

5.2.ii.2. Diffusers - cross section area for airflow at discharge areas, excluding flanges. Volume control dampers shall form part of unit rate for supply air diffusers and shall not be separately accounted.

5.2.ii.3. Linear diffusers - shall be measured by cross - sectional areas and shall exclude flanges for mounting of linear diffusers. The supply air plenum for linear diffusers shall be measured with ducting as described earlier.

5.2.ii.4. Fire dampers - shall be measured by their cross sectional areas perpendicular to the direction of airflow. Quoted rates shall include the necessary collars and flanges for mounting, inspection pieces with access door, electrical actuators and panel No special allowance shall be payable for extension of cross section outside the air stream.

5.2.ii.5. Flexible connection - shall be measured by their cross sectional areas perpendicular to the direction of airflow. Quoted rates shall include the necessary mounting arrangement, flanges, nuts and bolts and treated-for-fire requisite length of canvas cloth.

5.2.ii.6. Exhaust Hoods - shall be measured by their cross sectional area at the capture point of fumes, parallel to the surface of kitchen equipments. Quoted rates shall include the grease filters, provision for hood light, suspension arrangement for the hood, profile to direct the air to ventilation ducts and provision for removable drip tray.

5.2.ii.7. DAMPERS

Measurement of dampers shall be as per internal cross sectional area of the damper

3. MEASUREMENTS OF PIPING, FITTINGS, VALVES, FABRICATED ITEMS

i. Pipes

5.3.i.1. All pipes shall be measured in linear meter (to the nearest cm) along the axis of the pipes and rates shall be inclusive of all fittings e.g., tees, bends, reducers, elbows etc. Deduction shall be made for valves in the line.

5.3.i.2. The rate quoted shall be inclusive of cutting holes, exposing reinforcement in wall and ceiling and floors and making good the same and inclusive of all items as specified in specifications and 'Schedule of Quantities'.

5.3.i.3. Rates quoted shall be inclusive of providing and fixing vibration pads and wooden pieces. Wherever specified or required by the project engineer.

5.3.i.4. Flexible connections, wherever required or specified shall be measured as part of straight length of same diameter with no additional allowance being made for providing the same.

5.3.i.5. The length of the pipe for the purpose of payment will be taken through the centerline of the pipe and all through the fittings (e.g., tees, Bends, reducers, elbows, etc.) As through the fittings are also presumed to be pipe lengths. Nothing extra whatsoever will be paid for over and above for the fittings for valves and flanges section 3.2 below applies.

ii. Valves and Flanges

5.3.ii.1. All the extra CI & CM flanged valves shall be measured according to the nominal size in mm and shall be measured by number. Such valves shall not be counted as part of pipe length hence deduction in pipe length will be made wherever valves occur.

5.3.ii.2. All gun metal (gate & globe) valves shall include two nos. Of flanges and two numbers 150 mm long ms nipples, with one side threaded matching one of the valves and other welded to the MS Slip-on-flange. Rate shall also include the necessary number of bolts, nuts and washers, 3 mm thick insertion gasket of required temp., grade and all items specified in the specifications.

5.3.ii.3. The rates quoted shall be inclusive of making connections to the equipments, tanks, pumps etc. And the connection made with an installed pipe line shall be included in the rates as per the 'Bill of Quantities'.

iii. Structural Supports

Structural supports including supports fabricated from pipe lengths for pipes shall be measured as part of pipe line and hence no separate payment will be made. Rates shall be inclusive of hoisting, cutting, jointing, welding, cutting of holes and chases in walls, slabs or floors, painting supports and other items as described in specifications, drawings and 'Schedule of Quantities'.

iv. Insulation

Unless otherwise specified measurement for duct and pipe insulation for the project shall be on the basis of centerline measurements described herewith.

a) Pipe Insulation

This service shall be measured in units of length along the centerline of the installed pipe, strictly on the same basis as the piping measurements described earlier. The linear measurements shall be taken before the application of the insulation.

It may be noted that for piping measurement, all valves, orifice plates and strainers are separately measurable by their number and size. It is to be clearly understood that for the insulation measurements, all these accessories including cladding, valves, orifice plates and strainers shall be considered strictly by linear measurements along the centerline of pipe and no special rate shall be applicable for insulation of any accessories, fixtures or fittings whatsoever.

b) Duct Insulation and Acoustic Lining:

This service shall be measured on the basis of surface area along the centerline of insulation thickness. Thus the surface areas of externally thermally insulated or acoustically lined duct shall be based on the perimeter comprising centerline (of thickness of insulation) width and depth of the cross section of insulated or lined duct, multiplied by the centerline length including tapered pieces, bends, tees, branches etc. as measured for bare ducting.

4. TRAINING OF CLIENT'S PERSONNEL

a. The Vendor/Contractor shall train the CLIENT Purchaser's engineering personnel in the shops, where the equipments will be manufactured and or in their collaborator's works and where possible, in any other plant where equipments manufactured by the Vendor/Contractor or his collaborator is under installation or test to enable those personnel to become familiar with the equipments being furnished by the Vendor/Contractor, either at his works or at his Sub-Vendor's/Sub-Contractor's works or at site.

b. The period of training shall be adequate and mutually agreed upon by the CLIENT/BOB and the Vendor/Contractor.

- c. The training shall be so oriented as to make the CLIENT's personnel proficient in operating the equipments.
- d. The CLIENT's personnel shall also be trained for routine maintenance work and lubrication, overhauling, adjustments, testing and replacement procedures to be adopted for the equipments offered.
- e. The Vendor/Contractor shall train the CLIENT/BOB's personnel in carrying out minor repairs, if need arises, during the operation of the equipments.
- f. The charges for training the CLIENT/BOB's personnel, if any, be included in the price for supply of erection, testing and commissioning.

6. SYSTEM TESTING ADJUSTMENT AND BALANCING

1. SCOPE

- a) Testing, adjusting and balancing of heating, ventilating and air-conditioning systems at site.
- b) Testing, adjusting and balancing of HVAC Hydronic system at site.
- c) Testing, adjusting and balancing of exhaust system at site.

Comply with current editions of all applicable practices, codes, methods of standards prepared by technical societies and associations including:

ASHRAE: 1999 HVAC Application

SMACNA: Manual for the Balancing and Adjustment for air distribution System

2. PERFORMANCE

- a) Verify design conformity.
- b) Establish fluid flow rates, volumes and operating pressures.
- c) Take electrical power readings for each motor.
- d) Establish operating sound and vibration levels.
- e) Adjust and balance to design parameters
- f) Record and report results as per formats specified.

3. DEFINITIONS

Test: To determine quantitative performance of equipments.

Adjust: To regulate for specified fluid flow rates and air patterns at terminal Equipments (e.g. reduce fan speed, throttling etc.)

Balance: To proportion within distribution system (sub mains, branches and Terminals) in accordance with design quantities.

4. TESTING, ADJUSTING AND BALANCING (TAB) PROCEDURES

The following procedures shall be directly following in TAB of the total system.

Before commencement of each one of the TAB procedure explained hereunder, the contractor shall intimate the Engineer-In-Charge about his ready to conduct the TAB procedures in the format given in these specifications.

5. DESCRIPTION OF SYSTEM AND REQUIREMENT

Adjust and balance the following system to provide most energy efficient operation compatible with selected operating conditions.

- All supply, return and outside air systems.
- All exhaust air systems
- All chilled water systems.
- All cooling tower (condenser) water systems.
- Emergency purge systems

6. AIR SYSTEMS

a) Air Handlers Performance

The TAB procedure shall establish the right selection and performance of the AHUs with the following results.

- Inlet air Dry and Wet bulb temperatures.
- Outlet air Dry and Wet bulb temperatures.
- Air leaving dew point temperature
- Sensible heat Pickup
- Latent heat Pickup
- Sensible hat factor

b) Air distribution

Both supply and return air distribution for each AHU and for areas served by the AHU shall be determined and adjusted as necessary to provide design air quantities. It shall cover balancing of air through main and branch ducts utilizing telescoping probes of Electronic Rotating Vane Anemometers and Accubalance for grilles and diffusers.

c) The Preparatory work

To conduct the above test, following preparatory works are required to be carried out including the availability of approved for construction shop drawings and submittals.

All outside air intake return air and exhaust air dampers are in proper position.

All system volume dampers and fire dampers are in full open position.

All access doors are installed & are airtight.

Grilles are installed & dampers are fully open.

Provision and accessibility of usage of TAB instruments for transverse measurements are available.

All windows, doors are in position.

Duct system is of proper construction and is equipped with turning vanes and joints are sealed.

7. HYDRONIC SYSTEM BALANCING

The Hydronic system shall involve the checking and balancing of all water pumps. Piping network (main & branches), the heat exchange equipments like cooling and heating coils, condensers and chillers and cooling towers in order to provide design water flows.

The essential preparation work, must be done by the HVAC contractor prior to actual testing, adjusting and balancing of HVAC system and ensure following:

- a. Availability of co-ordinate drawings and approved submittals and system sketch with design water flows specified thereon.
- b. Hydronic system is free of leaks, is hydrostatically tested and is thoroughly cleaned, flushed and refilled.
- c. Hydronic system is vented.
- d. The contractor shall confirm completion of the basic procedures and prepare checklists for readiness of system balance.
- e. Check pumps operation for proper rotation and motor current drawn etc.
- f. Confirm that provisions for TAB measurements (Temperature, pressure and flow measurements) have been made.
- g. Open all shut-off valves and automatic control valves to provide full flow through coils. Set all balancing valves in the preset position, if these values are known. If not, shut all riser balancing valves except the one intended to be balanced first.
- h. Balancing work for both Chilled Water System and Condenser Water System shall be carried out in a professional manner and test reports in the specified format shall be prepared and presented to the BOB / Engineer-In-Charge for approval.

8. READINESS FOR COMMENCEMENT OF TAB

Prior to commencement of any test, the readiness to do so should be recorded as per the prescribed checklist.

9. TAB INSTRUMENTS

i. Air measuring Instruments

- a. For measuring DB and WB temperature, RH and dew point, microprocessor based TSI USA make VelociCalc Plus Meter, Model 8386, or equivalent shall be used. This instrument shall be capable of calculating the sensible, latent total heat flows, sensible heat factor and give printouts at site and have data logging/downloading facility.
- b. For measuring Air velocity, DB temperature and Air volume, TSI USA make VelociCalc meter model 8345 or equivalent shall be used. It shall be able to provide instant print out of recorded Air Volume readings.
- c. Pitot tube.
- d. Electronic Rotary Vane Anemometer TSI make or equivalent.
- e. Accubalance Flow Measuring Hood TSI make or equivalent.

[All above instruments shall have NIST testification (US Institute of Science and Technology) Calibration Certificate]

ii. Hydronic Measuring Instruments

For measurement of water flow differential pressure and temperature, CBI measuring instrument Tour & Anderson AB Sweden or equivalent shall be used. The instrument shall

have a built-in-microcomputer capable of giving readings for pressure differential flow rate and temperature.

iii. Rotation Measuring Instrument

- Electronic Digital Tachometer

iv. Temperature & RH Measuring Instrument

- TSI VelociCalc model 8386 and VelociCalc model 8345 or equivalent.

v. Electrical Measuring Devices

- Clamp on Volt ammeter
- Continuity Meter

vi. Vibration and Noise Levels

Vibration and alignment field measurements shall be taken for each circulating water pump, water chilling unit, air handling unit and fan driven by a motor over 10 HP. Readings shall include shaft alignment, equipments vibration, bearing housing vibration, and other test as directed by the Engineer-In-Charge.

Sound level readings shall be taken at ten (10) locations in the building as selected by the Engineer-In-Charge. The readings shall be taken on an Octave Band Analyzer in a manner acceptable to him. The contractor shall submit test equipments data and reporting forms for review. In order to reduce the ambient noise level the readings shall be taken at night. All tests shall be performed in the presence of BOB / Engineer-In-Charge.

Section 12:- LIST OF BUREAU OF INDIAN STANDARD CODES

IS 1239 (Part– I) 1979	Mild Steel Tube
IS 1239 (Part – I) 1982	Mild Steel Tubular and Other Wrought Steel Pipe Fittings
IS 4736 – 1986 (Reaffirmed)	Hot Dip Zinc Coatings of Steel Tubes
IS 823-1964	Code of Procedure For Manual Metal Arc Welding of Mild Steel
IS 780-1984	Service Valves For Water Works Purpose
IS 778-1980	Copper Alloy Gate, Globe and Check Valves For Water Works Purpose
IS 1536-1976	Flanges Configuration
IS 5312 (Part –I) 1984	Swing Check Type Reflux Non Return Valves For Water Works
IS 2379-1963	Color Code For Identification of Pipelines
IS 554-1975	Dimension For Pipe Thread Where Pressure Tight Joints Are Required On Threads
IS 655-1963 (Reaffirmed 1991)	Metal Air Ducts
IS 277-1992	Galvanized Steel Sheet For Fencing
IS 4064 Part II-1978	Specific Requirements For Direct Switches of Individual Motors
IS 3854-1969	Switches For Domestic & Similar Purpose
IS 732 (Part III-1902)	Inspection and Testing of Installation
IS 659 – 1964 (Reaffirmed 1991)	Air Conditioning Safety Code
IS 660 – 1963 (Reaffirmed 1991)	Mechanical Refrigeration (Safety Code)
IS 4894 – 1991	Test Code For Centrifugal Fan
IS 3103 – 1975 Reaffirmed 1994	Code of Practice For Industrial Ventilation
IS 7240 – 1981	Application & Finishing of Thermal Insulation Material
IS 325	Specifications For Three Phase Induction Motor
IS 3142 – 1993	V Grooved Pulley
BS-EN-779 – 1993	Particulate Air Filters For General Ventilation

IS 702 – 1988	Industrial Bitumen
IS 8183 – 1993	Bonded Mineral Wool
IS 2494 – 1993	V Belts For Industrial Purposes
IS 2062 – 1992	General Purpose Steel
ASHRAE Hand Books	American society of heating, refrigeration and air conditioning books <ul style="list-style-type: none">- Applications 1999- Fundamentals 1997- System and equipments 1996- Indoor air quality 62 – 1999

FIELD DEVICES

1.1.1. ELECTRIC AND ELECTRONIC CONTROLS RELATED EQUIPMENT

A. General Requirements

All controls shall be capable of operating in ambient conditions varying between 0-55 deg. C and 90% R.H. non-condensing.

All Control devices shall have a 20 mm conduit knockout. Alternatively, they shall be supplied with adaptors for 20 mm conduit.

B. Ancillary Items

When items of equipment are installed in the situations listed below, the BAS contractor shall include the following ancillary items :

(i) Weather Protection

All devices required to be weatherproofed are detailed in the Schedule of Quantities. IP ratings for the equipment is mentioned in the respective section.

(ii) Pipework Immersion

Corrosion resisting pockets of a length suitable for the complete active length of the device, screwed 1/2" (13 mm) or 3/4" (20 mm) NPT suitable for the temperature, pressure and medium.

(iii) Duct Mounting (Metal or Builders Work)

Mounting flanges, clamping bushes, couplings, locknuts, gaskets, brackets, sealing glands and any special fittings necessitated by the device.

Additional features

(i) Concealed Adjustment: All two position switching devices shall have concealed adjustment unless detailed otherwise in the Schedule of Quantities.

(ii) Operating Voltage : All two position switching devices shall operate on 230 v a.c and all accessible live parts shall be shrouded. An earth terminal shall be provided.

1.1.2. TEMPERATURE SENSOR

Temperature sensors for space, pipes and ducts, shall be of the Resistance Temperature detector (RTD) type or thermistor. These shall be two wire type and shall conform to the following specifications :

- 1) Immersion sensors shall be high accuracy type with a high resistance versus temperature change. The accuracy shall be atleast ± 0.33 degrees F and sensitivity of atleast 2 ohm/F.
- 2) Immersion sensors shall be provided with separate stainless steel thermo well. These shall be manufactured from bar stock with hydrostatic pressure rating of atleast 10 kgf/cm².
- 3) The connection to the pipe shall be screwed 3/4 inch NPT (M). An aluminum sleeve shall be provided to ensure proper heat transfer from the well to the sensor. Terminations to be provided on the head. Flying leads shall not be acceptable.
- 4) The sensor housing shall plug into the base so that the same can be easily removed without disturbing the wiring connections.

- 5) Duct temperature sensors shall be with rigid stem and of averaging type. These shall be suitable for duct installation.
- 6) Outdoor air temperature sensor shall be provided with a sun shield.
- 7) The sensors shall not be mounted near any heat source such as windows, electrical appliances etc.

The temperature sensors may be of any of the following types :

- 1) PT 100, PT 1000, PT 3000
- 2) NI 100, NI 1000
- 3) Balco 500.
- 4) Thermistor

1.1.3. HUMIDITY SENSOR

Space and duct humidity sensors shall be of capacitance type with an effective sensing range of 10% to 90% RH. Accuracy shall be + 3% or better. Duct mounted humidity sensors shall be provided with a sampling chamber. Wall mounted sensors shall be provided with a housing. The sensor housing shall plug into the base so that the same can be easily removed without disturbing the wiring connections. The sensors shall not be mounted near any heat source such as windows, electrical appliances etc.

1.1.4. FLOW METER

Water flow meters shall be either Ultrasonic type or electromagnetic type. For electromagnetic flow meter, Teflon lining with 316 SSelectrodes must be provided. The housing shall have IP 55 protection. Vendors shall have to get their design/selection approved by the BOB, prior to the supply.

The exact ranges to be set shall be determined by the contractor at the time of commissioning. It should be possible to 'zero' the flowmeter without any external instruments, with the overall accuracy of atleast $\pm 1\%$ full scale.

1.1.5. PRESSURE TRANSMITTER FOR WATER

Pressure transmitters shall be piezo-electric type or diaphragm type. (Bourdon Tube type shall not be acceptable). Output shall be 4-20mA or 0-10V DC and the range as specified in the data sheet depending on the line pressure. Power supply shall be either 24 V AC, 24 V DC or 230 V AC. Connection shall be as per manufacturer's standards. The pressure detector shall be capable of withstanding a hydraulic test pressure of twice the working pressure. The set point shall fall within 40%-70% of the sensing range and detector shall have sensitivity such that change of 1.5% from the stabilized condition shall cause modulation of the corrective element. The sensor must be pressure compensated for a medium temperature of -10 o C to 60o C with ambient ranging between 0 o C to 55 o C.

1.1.6. DIFFERENTIAL PRESSURE SWITCH FOR PIPE WORK

These shall be used to measure pressure differential across suction and discharge of pumps. The range shall be as specified in the data sheet. Switch shall be ON with increase in differential. Housing for these shall be weather proof with IP 55 protection. The pressure switch shall be capable of withstanding a hydraulic test

pressure of 1.5 times the working pressure. The set point shall fall in 40-70% of the scale range and shall have differentials adjustable over 10%-30% of the scale range. The switches shall be provided with site adjustable scale and with 2 NO/NC contacts.

1.1.7. DIFFERENTIAL PRESSURE SWITCH FOR AIR SYSTEMS

These shall be diaphragm operated. Switches shall be supplied with air connections permitting their use as static or differential pressure switches.

The switch shall be of differential pressure type complete with connecting tube and metal bends for connections to the duct. The housing shall be IP 54 rated. The pressure switches shall be available in minimum of 3 ranges suitable for applications like Air flow proving, dirty filter, etc. The set point shall be concealed type. The contact shall be SPDT type with 230 VAC, 1 A rating.

The switch shall be supplied suitable for wall mounting on ducts in any plane. It should be mounted in such a way that the condensation flow out of the sensing tips. Proper adaptor shall be provided for the cables.

The set point shall fall within 40%-70% of the scale range and it has differentials adjustable over 10%-30% of the scale range.

The switches shall be provided with site adjustable scale and with 2 NO/NC contacts.

1.1.8. AIR FLOW SWITCHES

Air flow switches shall be selected for the correct air velocity, duct size and mounting attitude. If any special atmospheric conditions are detailed in the Schedule of Quantity the parts of the switches shall be suitably coated or made to withstand such conditions. These shall be suitable for mounting in any plane. Output shall be 2 NO/NC potential free. Site adjustable scale shall also be provided.

1.1.9. AIR PRESSURE SENSOR

The pressure sensor shall be differential type. The construction shall be spring loaded diaphragm type. The movement of the membrane in relation to the pressure should be converted by an inductive electromagnet coupling which would give an output suitable for the controller. The pressure sensor shall be in a housing having IP 54 ratings in accordance with IEC 529. Suitable mounting arrangement shall be available on the sensor. The sensor shall come complete with the PVC tubes & probes.

1.1.10. WATER FLOW SWITCH

These shall be paddle type and suitable for the type of liquid flowing in the line. Output shall be 2NO/2NC potential free.

1.1.11. TRANSDUCERS FOR ELECTRICAL SERVICES

Electrical transducers shall be integrated electronic type and rack mounted on the field. These shall work on 230 V supply with the output being standard type i.e. 4-20 mA, 0- 10 Volts etc.

Power factor, Voltage, Current, Frequency and Kilowatt transducers shall have standard output signal for measurement for the specified variable.

Kilowatt-Hour metering (if any) shall be poly-phase; three- element with current transformer (CT) operated type. The metering shall feature high accuracy with no

more than +/- 1% error over the expected load range. The coils shall be totally encapsulated against high impulse levels.

1.1.12. LEVEL SWITCH

The level switches shall have to meet the following requirement :

Type	:	Float Type/Capacitance type/Conductivity type
Mounting	:	To suit application.
Connection	:	Flanged ANSI 150 lbs RF Carbon steel
Float material	:	316 SS
Stem Material	:	316 SS
Output	:	2 NO, 2 NC potential free
Switch Enclosure	:	IP 55

1.1.13. DIGITAL THERMOSTATS

Thermostats for FCU's should be Digital on/off OR Modulating Type for Actuating 2 way or 3 way Valves (On-off/Modulating)

Thermostats should display Room Temp and Set point simultaneously which is easy to read from at least 6-8 feet distance.

Thermostats should have Fan Speed Control Switch (Low-Med-High-Auto). Auto Mode should be able to save energy by automatically reducing the Fan Speed when Room Temp Achieves Set Point.

LCD Display should be available in Blue or Green Backlit for ease in viewing the Room Temperature and Set point.

Thermostats should work on 230V PS for on-off models and 24V for Modulating Thermostats

The User Settings should be retained in Thermostat Memory in case of Power Failure

The Switching Relays should be separately wired and should be mounted inside the Junction Box, so that the Thermostat front is sleek in mounting. Thermostat Thickness should be 17mm or less

Thermostats should have Energy Savings Feature with dual setpoint which can be interlocked with Occupancy Sensor or Hotel Key Card input. This should be indicated in the LCD Display in the mode it is being operated. This Programming should be possible by Hotel maintenance Staff.

Thermostats should be similar or equivalent to Honeywell Halo Series Digital Thermostats Model T6861(on/off) or T6865(modulating) version.

1.1.14. Pressure Independent Dynamic Balancing Valve (ranges from 25mm to 150mm)

The Valve should have self Dynamic Flow Control Valves that are pressure independent, two way, Modulating to accept digital/analog input BMS/Controller

signals and should provide position feedback signal to the control system. The Feedback signal should have the feedback feature of the Valve/Actuator itself without any need of any additional accessory/instrument/device.

- PICV should be capable of maintaining the max flow rate atleast +/-4% Accuracy
- The PICV Should be capable of maintaining Linear Temperature Control, Pressure Independence and Electric Modulation in one Valve body.
- The Flow rates should be field settable electronically upto 60% of the valve Max set Flow rate
- The Differential Pressure Ranges for which the valve can maintain the flow rates should be mentioned in the Product literature
- Valve Actuator housing shall be rated to IP54
- Actuator shall be driven by a 24Vac power supply and shall accept universal Input signals like 0/2-10Vdc or 4-20mA signal
- Actuator shall be capable of providing feedback Signal of 0/2-10Vdc to the Control System/BMS
- PICV should have an option for adjusting the Flow Characteristics as per AHU in every PICV to ensure Linear Temp Control.
- PICV should have an option for changing the Max Flow Rates in future and no additional Instrument should be required. Flow Values can be changed by entering in LCD Display only and not by any DIP Switches or Setting Dial to improve accuracy.
- PICV shall provide full valve Authority
- PICV Valve body shall be rated at least PN16
- Max Close off Pressure shall be mentioned in the Product Datasheet.
- Min Working Differential Pressure shall be 30Kpa
- Valve shall be Internal BSP Threaded from DN25 to DN50 and Flanged end Connection for DN65 to DN150
- Min Stroke Length of the Valve shall be 20mm
- Media Temperature : 0-130 deg C
- Valve shall be of Brass/Bronze Construction upto DN50 and Cast Iron upto DN150
- Shut off Leakage shall be 0.1 Kvs

1.1.15. Motorized Butterfly Valve

Valve Body

Type of Valve	:	Butterfly Valve
Body Material	:	Cast Iron or Ductile Iron Body
Disc Material	:	Nickel plated Ductile Iron
Stem	:	SS416
Liner Material	:	EPDM

Nominal Static Body Rating	:	PN16
Tightness	:	Bubble Tight
Medium Temperature	:	-10 deg C to 120 deg C
Pipe Connection	:	ISO7005-2
Actuator		
Type	:	Electric
Motor Supply	:	230 Vac, 50hz/60Hz
Travel Angle	:	90 deg +/- 5 deg
Enclosure	:	IP67 Waterproof
Indicator	:	Continuous Position Indicator
Space Heater	:	15W 220V Anti Condensation
Stall Protection	:	Built-in thermal protection Cut off at 125 ± 5 Reset at 95 ± 5.
Manual Override	:	By Handwheel, nonclutch design
Torque Limit Switches	:	2 nos
External Coating	:	Dry Aluminium Alloy in Painted Black

1.1.16. Modulating type FCU valves

PIBC Two way modulating type FCU valve

The two way FCU valve should be design in such a way that it can withstand a static pressure of 20 bar and a burst pressure of 100 bar.

The ports are designated in such a way that flow through the two way valve can be in either direction.

The valve shall be designed to handle the fluid temperature from 1degreeC to 95degreeC

It can withstand the differential pressure upto 4 Bar.

The valve is of bronze body with stainless steel stem and Noryl cover.

The FCU valve shall have a minimum stroke length of 10mm so that it has the sufficient distance to travel.

The hydronic FCU valves shall been designed to meet the European standard EN 60730-2-8.

The actuator shall require the power supply of 220 Volts AC so that no transformer is required.

The actuator is easily removable from the valve so that in case the actuator fails at site it can be easily replaced without affecting the integrity of the water system.

The actuator shall have the provision to operate manually.

The actuator shall meet the low voltage directive 73/23/EEC. The actuator shall be selected in such a way that the maximum power consumed by the actuator is 6 Watt.

1.1.17. Snap Acting Digital Thermostats

Thermostats for FCU's should be Digital on/off for Actuating 2 way or 3 way Valves (On-off/Modulating)

Thermostats should display Room Temp and Set point simultaneously which is easy to read from at least 6-8 feet distance.

Thermostats should have Fan Speed Control Switch (Low-Med-High-Auto). Auto Mode should be able to save energy by automatically reducing the Fan Speed when Room Temp Achieves Set Point.

LCD Display should be available in Blue or Green Backlit for ease in viewing the Room Temperature and Set point.

Thermostats should work on power supply of 230V for on-off models.

The User Settings should be retained in Thermostat Memory in case of Power Failure

The Switching Relays should be separately wired and should be mounted inside the Junction Box, so that the Thermostat front is sleek in mounting. Thermostat Thickness should be 17mm or less

Thermostats should have Energy Savings Feature with dual set point which can be interlocked with Occupancy Sensor or Hotel Key Card input. This should be indicated in the LCD Display in the mode it is being operated. This Programming should be possible by Hotel maintenance Staff.

Thermostats should be similar or equivalent to Honeywell Halo Series Digital Thermostats Model T6861 (on/off) version.

2. EXECUTION

2.1. INSTALLATION

- A. All work described in this section shall be performed by system integrators or contractors that have a successful history in the design and installation of integrated control systems.
- B. Install system and materials in accordance with manufacturer's instructions, and as detailed on the project drawing set.
- C. Drawings of the BMS network are diagrammatic only and any apparatus not shown, but required to make the system operative to the complete satisfaction of the Engineer-in-charge shall be furnished and installed without additional cost.
- D. Line and low voltage electrical connections to control equipment shown specified or shown on the control diagrams shall be furnished and installed by this contractor in accordance with these specifications.
- E. Equipment furnished by the HVAC Contractor that is normally wired before installation shall be furnished completely wired. Control wiring normally performed in the field will be furnished and installed by this contractor.

2.2. WIRING

- A. All electrical control wiring and power wiring to the control panels, NAC, computers and network components shall be the responsibility of the this contractor.

- B. The electrical contractor shall furnish all power wiring to electrical starters and motors.
- C. All wiring shall be in accordance with the Project Electrical Specifications, the National Electrical Code and any applicable local codes. All BMS wiring shall be installed in the conduit types specified in the Electrical Specifications unless otherwise allowed by the National Electrical Code or applicable local codes. Where BMS plenum rated cable wiring is allowed it shall be run parallel to or at right angles to the structure, properly supported and installed in a neat and workmanlike manner.

Ultraviolet Germicidal Irradiation (UVGI)

System for AHU Cooling Coil

Technical Specification

PART 1 GENERAL

1.01 a) UVGI System shall be provided with the primary aim of achieving substantial reduction in bacteria count, both airborne and on cooling coil surface. The UVGI System shall preferably be 100% indigenous to ensure following:

- a. Cost effective approach
- b. Easy availability of replacement lamps and other parts

1.01 b) Selection Criteria/Basis of Design:

- a. The UVGI system shall be designed to cover the entire face area of the cooling coil
- b. The face velocity of dehumidified air over the coil will be 500 FPM or lower.
- c. The UVGI system shall achieve near total elimination of bacteria/biomass on the cooling coil. Subsequently, the UVGI system will be kept in on position 24/7 (even when the AHU is switched off or is not in operation) to ensure that the bacteria does not reappear.

1.02 QUALITY ASSURANCE:

UL Compliance: Comply with UL Standard 1995 as applicable to usage of UVGI system in HVAC Equipment.

1.03 DELIVERY, STORAGE AND HANDLING:

- a) Store UVGI System in a clean dry place and protect from weather and construction traffic. Handle the system carefully to avoid damage to components, enclosures and finish. Do not install damaged components; replace and return damaged components to equipment manufacturer.
- b) Comply with manufacturer's installation instructions placement, wiring and testing.

PART 2 – PRODUCTS

1.04 UVGI SYSTEM

A. GENERAL

1. Acceptable Manufacturers: ENSAVIOR, AEROPURE, STERIL-AIRE, RUKS.
 - a. Single ended Four pin lamps as shown on Schedule or Drawings.
 - b. Independent lab's certificate for wavelength and reflectance shall be submitted.
2. Quality Assurance:
 - a. Qualifications: Each component and product is to be inbound and outbound tested before shipment under Mil Standard 105E and ANSI/ASQCZ 1.4.

b. Output Verification: When tested in accordance with the general provisions of IES Lighting Handbook, 1981 Applications Volume, total output per one inch arc length shall not be less than 10 $\mu\text{W}/\text{cm}^2$, at one meter.

3. Warranty:

- a. Fixture and the system shall be warranted to be free from defects for a period of one year.

B. DESIGN REQUIREMENTS

1. Irradiation–The UVGI system and fixtures are to be installed in sufficient quantity and in such an arrangement so as to provide an equal distribution of UVC energy on the coil and in the drain pan. To maintain energy efficiency, the UVC energy produced shall be of the lowest possible reflected and shadowed losses.
2. Intensity –Shall be measured by a Solid State Photodiode UV Sensor at the coil. Calibration wavelength is 254 nm. Accuracy is to be $\pm 10\%$ and be NIST traceable. Read by a Display module with a 3.5 digit LCD screen/panel. Irradiance range shall preferably be 0-1999 $\mu\text{W}/\text{cm}^2$ with a resolution of 10 $\mu\text{W}/\text{cm}^2$. This shall not be part of the system but only a measurement tool.
3. Installation–UVGI system and fixtures shall be installed downstream of the cooling coil at right angles to the coil fins, such that UVC energy bathes all surfaces of the coil and drain pan. The internal wiring for UV system shall be supplied by manufacturer/strategic business partner/authorized dealers of manufacturer business partners only.

C. EQUIPMENT

1. Units shall be high output, HVAC-type, germicidal UVC light sources, factory assembled and tested. Components shall include a housing, high efficiency electronic power source, sockets and lamps, all constructed to withstand HVAC environments.
2. Housings shall be made of robust materials, with Units having electrical connectors on both ends to simplify gang wiring and wiring to power.
3. Reflectors shall be constructed of high spectral finished aluminum alloy with a minimum 85% reflectance of 254-nm UVC energy.
4. High efficiency electronic power sources shall be 115 or 208/230VAC. They shall be UL listed to comply with UL Standard 1995 and capable of igniting each Lamp at temperatures from 35-165 $^{\circ}\text{F}$. They shall be equipped with RF and line noise suppression.
5. UV lamp shall be fabricated out of Quartz Glass and of the high output, hot cathode, T5 (15mm) diameter, and medium bi-pin type. They shall produce 95% of their energy at 254 nm. UVGI system shall not produce ozone or other secondary contamination. The lamp shall be high output type and should not be lower than 800 mA.
6. The UV lamps should be made in India for ease of spares availability and faster deliveries. The contractor shall specify the make and origin of the UVGI system being offered.
7. Output verification shall be carried out in accordance with the general provisions of IES lighting handbook, 1981 application volume, total output per one inch arc length shall not be less than 10 $\mu\text{W}/\text{cm}^2$, at one meter.

8. The UVGI System and fixtures are to be installed in quantity mentioned as per BOQ and in such an arrangement so as to provide an equal distribution of UVC energy on the coil and in the drain pan and to maintain energy efficient UVC energy produced shall be of the lowest possible reflected and shadowed losses.
9. The system shall have a separate IP-54 Control Panel consisting of:
 - a. Electronic Ballast
 - b. Run hour meter
 - c. Mains on indicator lamp
 - d. MCB
10. The Life of lamp shall be 9000 hours after which it shall be replaced.
11. The Lamp construction should include "Getter" in order to provide continuous filtration of any impurities throughout the life cycle of lamp.
12. The Lamp shall be tested by an approved Indian Lab for output performance of 254 nm.

PART 3 – INSTALLATION

3.11 INSTALLATION OF UVGI SYSTEM

- A. Coordinate with installation of HVAC equipment and install the UVGI system as indicated after such equipment is properly installed.
- B. HVAC contractor/AHU manufacturer shall provide an interlock switch, if required, on the access to the UVGI system to turn the lights off when the access is opened.
- C. Install provided Caution Labels on appropriate location.

3.12 COMMISSINING AND TRAINING:

The system shall be commissioned by the Supplier's personnel authorized by the manufacturer. The client's operator/engineer shall be trained in the operation and routine maintenance for a period of at least one working day.

3.13 SPARES:

The Supplier shall confirm that sufficient stock of spares is held by them to ensure trouble free and continuous operation of the system and particularly the lamps shall be kept at a place from where it can be made available at site within 36hrs.

While submitting the bid, the price for spare lamps for one more additional year beyond warranty, shall also be submitted by the contractor.

GENERAL NOTES:

1. The rate for each item of work included in the Schedule of Quantities shall, unless expressly stated otherwise, include cost of :
 - a All materials, fixing materials, accessories, appliances tools, plants, equipment, transport, labour and incidentals required in preparation for and in the full and entire execution, testing, balancing, commissioning and completion of work called for in the item and as per Specifications and Drawings.
 - b Wastage on materials and labour.
 - c Loading, transporting, unloading, handling/double handling, hoisting to all levels, setting, fitting and fixing in position, protecting, disposal of debris and all other labour necessary in and for the full and entire execution and for the job in accordance with the contract documents, good practice and recognize principles.
 - d Liabilities, obligations and risks arising out of Conditions of Contract.
 - e The unit rate for all equipment or materials in Indian Rupees shall include cost of equipment and materials including all taxes and duties and also including forwarding, freight, insurance and transport into Contractor's store at site, storage, installation, testing, balancing, commissioning and other works required.
2. The contractor shall perform Nitrogen test and vacuum test on refrigerant piping. Start and stop timing & pressure maintained shall be checked and the readings recorded shall be counter signed by consultant / client's representative.
3. The contractor shall submit computer generated / measured reports of the system for a duration of one hour indicating pressures, temperatures, voltage, power consumed, etc
4. Cable glands shall be compression type, heavy-duty chromium plated.
5. All cable termination to have lugs/ thimbles.
6. INSTRUCTION / MAINTENANCE MANUAL

The Contractor shall prepare and produce instruction, operation and maintenance manuals in English for the use, operation and the maintenance of the supplied equipment and installations and submit to the Client / Consultant in (3) copies at the time of handing over. The manual shall generally consist of the following:

 - i Description of the project.
 - ii Operating instructions.
 - iii Maintenance instructions including procedures for preventive maintenance.
 - iv Schematic & control wiring diagrams.
 - v Commissioning Certificate.

7. The thickness of copper piping shall not be less than mentioned below:

PIPE DIA		Thickness (MM)	TEMPER GRADE
MM	Inches		
6.35	1/4"	0.80	Annealed / SOFT
9.52	3/8"	0.80	
12.7	1/2"	0.80	
15.88	5/8"	0.99	
19.05	3/4"	0.80	HARD
22.22	7/8"	0.80	
25.4	1"	0.99	
28.58	1 1/8"	1.1	
31.75	1 1/4"	1.1	
34.92	1 3/8"	1.21	
38.1	1 1/2"	1.35	
41.28	1 5/8"	1.43	
44.45	1 3/4"	1.6	
47.6	1 7/8"	1.6	
50.8	2"	2	
53.98	2 1/8"	2.1	

List of Approved Makes

S. No	Items	Approved Makes
1	AHUs (all types) with Cooling coils	Edgetech/ Zeco/ VTS/System Air/Flakwood
2	VFD for AHUs	Danfoss/ Siemens/ABB/Allen Bradley/Fuji electric/ VTS/Honeywell
3	Fan coil units	Carrier/ETA/Zeco/Edgetech
4	Centrifugal fans for AHUs/fresh air/exhaust fan/kitchen scrubber	Kruger/Nicotra/Comefri/Wolter/Greenheck
5	Propeller fan	Alsthom/Khaitan/Crompton/GE/Wolter
6	Grills/Diffusers	Carryair/Ravistar/Airmaster/Air flow/Brightflow
7	Fire Dampers UL Listed	Ravistar/Air flow/Carryair/Greenheck/ Bright flow
8	Fire Damper Motors /Actuator	Belimo/Siemens/Honeywell
9	GI sheet for metal duct	Jindal/SAIL / Tata
10	Factory fabricated duct	Zeco/Techno/ Rolastar/ Technofeb
11	Hessian (fire treated)	Navair/pyroguard
12	MS/GI pipe	Jindal Hissar/Tata / Prakash Surya
13	Pre-insulated chilled water pipe	Zeco/seven star
14	Thermometer	Taylor/H Guru/Fiebig
15	Flow switch	Rapidcool/Siemens/Johnson controls / Honeywell
16	Auto Airvent	Rapid cool/Anergy
17	Filters (pre / fine / Hepa)	AAF/Purolator/Thermadyne/Spectrum
18	Flexible pipe connection	Resistoflex/Kanwal
19	Gun Metal Valve	Audco/Leader/Zolloto
20	Butterfly/Non return/Check Valve	Audco/Advance/Castle/SKS/Cim
21	Motorised butterfly valve	Bellino/Honeywell/Siemens/Nibco
22	Ball/Gate/Globe Valve	CIM/Rapidcool/Leader/Castle/Emerald/Sant
23	Ball valve with Y-strainer	CIM/Rapidcool/Leader/Castle/Emerald/Sant
24	Pot/Y-Strainer	CIM/Rapidcool/Leader/Castle/Emerald/Sant
25	Suction Guide	Anergy/ Armstrong/Xylem
26	Pressure Gauge	H Guru/Fiebig/Emerald/Taylor
27	2/3 way modulating control valve for AHU	Honeywell/Siemens/Danfoss/Belimo
28	Room thermostat/humidistat	Honeywell/Siemens/Danfoss/Belimo
29	Dial thermometer(capillary Type)	Penn/H Guru/Feig/Emerald
30	Pre-moulded PUF section for insulation	LLyod/Malanpur/Beardsel/Supreme
31	Closed cell nitrile rubber with aluminium foil	Armaflex /Vidoflex /Supreme / Aerocell
32	PUF pipe supports	Malanpur / Lloyd / Beardsel
33	Aluminium tape	Johnson / Birla 3M
34	Vibration isolator	Resistoflex / Dunlop
35	V Belt	Dunlop / Fenner

36	Paints	ICI/Asian/Nerolac/Berger
37	Ultra violet germicidal Irradiation system	Ruks /Ensavior Technologies Pvt Ltd
38	Aluminium sheets	Hindalco/Balco/Nalco
39	Mineral wool insulation	Lloyd insulation/UP Twiga/Kimmco
40	Closed cell fire retardant XLPE(for duct insulation)	Trocellen/K-Flex/ Supreme
41	Tarfelt/CPRX compound	Shalimar tar product/Asian
42	Dash fastners	Fisher/HILTI
43	Welding Rods	Advani/L&T
44	Electrical Panels	Tricolite Electrical Industries / Control & Switchgears Pvt. Ltd. / Sterling & Wilson / Milestone / Adlec Control System Pvt. Ltd. / Advance Panels & Switchgear Pvt. Ltd. / Indo Asian /
45	Electric Motors	ABB / Siemens / Kirloskar / Grundfos / Crompton / NGEF
46	MCCB	Schneider Electric (NSx Series) / Siemens (VL Series) / L&T (D-Sin / Legrand (DPX ³) / ABB (TMax) / C&S (Winbreak-1/2)
47	MCB	Schneider Electric ACTI-9 (N) / Legrand (DX3) / Hager/ L&T (Exora) / ABB (S200M) / Siemens (Betaguard) / C&S (Wintrip2) / Indoasian (Optipro)
48	MCB DB	Legrand (EKINOX-3) / L&T (EXORA) / Hager / Schneider (ACTI-9) / ABB (Elegance) / C&S(Winclass) / Indoasian (Optipro)
49	Power/control cables	Finolex / Universal / Polycab / Nicco / RPG Cables / KEI / Havells / RRRKabel / Bonton / Grandlay
50	Starters/contactors/OL Relays/push buttons/ Rotary switches/changeover switch/fuse and fittings/1-phase preventor/indicating Lamp/	Schneider Electric / L&T / BCH / Siemens / Legrand / ABB / C&S / Hager
51	Voltmeter/Ammeter	AE / Rishab / L&T / C&S / Conzerve
52	CT/PT	Automatic Electric / Matrix / Precise / L&T / Kappa
53	Cable tray	Pilco / Slotco / MEM / BEC / Steelways / Legrand
54	Cable lugs	Comet / Dowells / Hax Brass (Copper Alloy India) / Jainson / Action
55	Immersion temp. Sensors	Siemens/Schneider/Honeywell /Johnson Control
56	Outside Air temp. & RH	Siemens/Schneider/Honeywell/Dwyer/Johnson Control

57	Air Differential Pressure	Siemens/Schneider/Honeywell/Beck /Johnson Control
58	Outside Air temp. Sensors	Siemens/Schneider/Honeywell /Johnson Control
59	Wall mount Temperature & RH Sensor	Siemens/Schneider/Honeywell/Dwyer/Johnson Control
60	Water Differential Pressure switches	Siemens/Kele/Beck/Johnson Control
61	Water Differential Pressure Transmitter	Huba/Siemens/Honeywell /Johnson Control
62	Air Differential Pressure Transmitter	Siemens/Schneider/Honeywell /Johnson Control
63	Electromagnetic Type Flow Meter	Khrone Marshall/Landis & Gyr
64	Cabling & conduiting	
65	Signal & Communication Cable	Fusion Polymer/Lapp/Beldon
66	MS Conduit	BEC / NIC / AKG / RMCON
67	UV-Oxidation System	Ruks/Trimed/OTTPL//Oraipl
68	Tube Axial Fans	Kruger / Nocotra / Comefree / Flakwood / W olter / Greenheck
69	Pressure independent Balancing valve	Danfoss /Flowcon /TA /Belimo / Honeywell /Johnson Control