

## **SPECIAL PROVISIONS**

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## SPECIAL PROVISIONS

### SP-01 GENERAL

#### SP-01.1 Location of Project

The HVAC system shall be installed in the Serobiology and BioTechnology at Dow University of Health Sciences, (Ojha Campus), Karachi.

#### SP-01.2 Building for the Project

The Building is under construction and the HVAC Contractor shall be responsible to intimate to Engineer any omission during civil construction with respect to provisions of space, openings in walls, floors, roof slabs, false ceilings, drain points and electrical requirements for HVAC Works.

#### SP-01.3 Use of Building

The building comprises of...

The Contractor is advised to study the architectural, structural, electrical and plumbing drawings to familiarize himself with the Building Plans/Layout.

#### SP-01.4 HVAC System Concept

a) Type of System:

Central HVAC System with Dual Fuel Double Effect Direct Fired Absorption Chillers-Heaters / Electric Chillers Air Cooled / Electric Chillers Water Cooled, Cooling Towers, Air Handling Units and Fan Coil Units Shall be adopted for this project. A operational cost shall be the major criteria of selection

b) Summer

During the cooling season, two (02) chiller with complimenting dual pumps where required should satisfy total cooling load of the building what .

Chillers - heaters will operate on part load if some of AHUs are switched-off.

c) Winter

During most of the heating season, one (1) chiller-heater with complimenting pumps will satisfy the total heating demand of the building.

During extreme weather conditions second chiller - heater can be switched on.

d) Plant Operation during Power Failures

As the cooling/heating will be required continuously during power break down or load shedding so all HVAC equipment shall be connected to emergency power.

**SP-01.5 Service Conditions for Auxiliaries**

a) Power Supply

Electrical Circuit Voltages:

Nominal, 3-Package: 415 volts

1-Package: 240 volts

For equipment ratings, 3-Package: 400 volts

1-Package: 230 volts

Fluctuation in voltage applied (+/-) 10% to equipment rated voltage.

Frequency: 50 HZ.

b) Water Supply will be available near Cooling Towers if installed located at roof of GENERATOR ROOM, GROUND FLOOR, at CPR, all air handling unit rooms and central plant room.

c) Water Disposal:

Floor drains will be connected to sewerage system of the Building.

**SP-01.6 Units**

The units used in these specifications are as under:

Unit System: SI/British/FPS

Gauge: US Gauges as per ASTM

TR: Ton of refrigeration equivalent to 12000 BTU/H (12 MBH) or 3516 W

**SP-02 WORK BY THE CONTRACTOR**

**SP-02.1 Scope of Work**

a) The work under this Contract comprises of all HVAC works including Design, supply, installation, balancing, testing, commissioning and operations maintenance during defect liability period.

b) The Contractor shall furnish all labour, materials, equipment tools, appurtenances, services, temporary work and storage necessary to

completely supply, install, test, commission, and maintain the heating, ventilating and air-conditioning (HVAC) system, all in the perfect operating conditions in accordance with these Specifications and Drawings. The Contractor shall also adjust, balance, re-adjust all the air and water systems as specified and shown. The Contractor shall commission, operate and maintain all the systems for a period specified in Clause SP-22 under Defect Liability Period.

- c) The contractor shall plan and coordinate his activities and schedules so as not to interfere with the work of other contractors. It shall also be his responsibility to maintain the facility constructed by him till the end of the Contract period.

Any problem of interface with other contractor shall be brought to the notice of the Engineer/Employer whose decision in this respect shall be final and binding on all parts.

The contractor shall inform the other contractor for the schedule of any construction activity well in advance giving him sufficient time to finish his part of job.

If any part of the work is damaged or has to dismantle or redone due to negligence/omission/incorrect position of the embedment etc. as part of the contractor, all such loses/expenses shall be borne by the Contractor.

- d) The Specifications are only general guidelines and by no means cover details of each equipment. These only spell out the intent of the requirement. The details have to be provided by the Contractor along with details of performance, construction and technical literature with the Bid. The specifications are to be read in conjunction with the Drawings.

All equipments and materials shall be brand new bearing stamped ratings as required by Equipment Schedules and must be approved by the Engineer prior to their use. Any doubts about the practicability and implementation of Specifications and details shown in the Drawings must be expressed alongwith submission of Bid. Inability of the Contractor to implement these specifications after the acceptance of the Contract shall be considered breach of Contract.

#### **SP-02.2 Services by the Contractor**

- a) Erection Supervisor

The Contractor shall provide competent Erection Supervisor to direct and be responsible for the erection, starting and operation of the Equipment supplied by the Contractor until issue of Substantial Completion Certificate. Further details concerning Erection

Supervisors are covered in Clause SP-17, "Erection Supervisors and Operating Staff". In addition, the Contractor shall also provide services of Factory Engineer authorized by manufacturer to direct and supervise the installation, testing commissioning.

b) Operation during Defect Liability Period.

The Contractor shall operate service and maintain HVAC system for a period mentioned in and as per requirements of Clause SP-22, "Defect Liability Period". The Contractor shall provide all personnel for operation and maintenance including one Supervisor. Qualifications, experience and number of all these personnel shall be subject to the Engineer's approval.

c) Training of Employer's Operative Personnel.

The Contractor shall arrange for free of cost on-site training of operative personnel, nominated by the Employer, in the operations and maintenance of all HVAC equipment and system. The period of training shall not be less than 15 (fifteen) days.

The group of operative personnel will comprise of Engineers/Supervisors and Technicians. The training shall be imparted by a qualified Engineer having at least ten (10) years experience in the operation and maintenance of similar HVAC systems.

The Trainer shall fully orient the group with the actual system and impart thorough training in the operation and maintenance of the system and equipment with the help of drawings, charts, hand-outs, diagrams, video aids, lectures, etc. Details and time of training shall be approved by the Employer/Engineer before training is commenced.

**SP-02.3 Erection Plant**

Under this clause the Contractor shall provide erection plant and tools for his own use during erection period only; he would take back these tools on completion.

Tools for maintenance after completion are to be provided under clause TP-10-04.

The Contractor shall furnish special erection plant and tools in accordance with the requirements of Clause SP-15, "Fabrication, Erection Testing and Maintenance Tools Plant and Instruments.

**SP-02.4 Related Works**

The Contractor shall provide all works related to HVAC system, whether specifically mentioned or not, except those specifically stated in exclusion Clause SP-03, "Work Not Included". These related works shall include, but not be limited to:

- a) Power supply and earthing shall be provided by the Employer and incoming power feeders and earth continuity conductors shall be terminated at locations as shown on the Drawings and/or as stated in the Technical Provisions, Section 7, Electrical Equipment and Controls. All electrical works from these points onward shall be the responsibility of the Contractor.
- b) Water supply shall be provided by others from overhead tank or city water main, in the main plant room, each AHU room and near cooling tower at ground level. Plumbing works from the points indicated on the drawing to make-up water point shall be the responsibility of the Contractor.
- c) All works related to water and cooling coil condensate disposal from HVAC system upto nearest floor drains shall be the responsibility of the Contractor.
- d) Cutting, patching and repairing in accordance with Section 1.0 of the Technical Provisions.
- e) Providing written information regarding location and sizes of door louvers, where required, to the persons responsible for door louvers, through the Engineer. This information shall be provided within thirty (30) days of issue of the Engineer's Order to Commence Work.
- f) All wood-work required for satisfactory completion of the project as specified except decorative wood work provided to conceal HVAC equipment.
- g) Providing shop drawings at scale (1:50) and other written information regarding Concrete Pads and foundations for HVAC equipment to the Civil Contractor through the Engineer. Catalogue cuts showing foundation details will not be accepted.
- h) Providing steel frames for inertia pads and cork sheet/neoprene sheet for other pad.
- i) All foundations for HVAC equipment including concrete foundations, housekeeping pads and concreting for inertia pads (where required) shall be provided by the HVAC Contractor.
- j) Coordinating HVAC installation with other trades work, by way of study of other trades drawings and pointing out the areas of conflict to the Engineer before installing items of HVAC system.



**SP-03 WORK NOT INCLUDED**

Work listed hereunder which may be required for satisfactory completion of the Project are not included in this Contract and will be provided by the Employer or other contractors appointed by the Employer:

- a) Decorative concealment of HVAC equipment and wood paneling.
- b) Door Louvers
- c) Protective fencing around HVAC equipment, if required.
- d) Concrete flooring and finishing, drain channels and steel gratings in central plant room.

**SP-04 DESIGN CONDITIONS**

HVAC System has been designed with conditions listed hereunder. These conditions are being given for information only.

**SP-04.1 Outside Design Conditions**

- a) Summer Dry Bulb Temp: (Max.) 115 °F
- b) Dry Bulb Temp: 108 °F  
(ASHRAE DESIGN 2.5%)
- c) Wet Bulb Temp: (Max.) 83 °F
- d) Daily range: (Max.) 45 °F
- e) Winter Dry Bulb Temp: 33 °F
- f) Wind Velocity:
  - Summer 10 MPH
  - Winter 15 MPH
- g) Climate: Tropical with dust storms in April-May-June and torrential Rains in July - August - September.
  - i) Latitude: 33 Degrees North
  - ii) Longitude 73 Degrees East
  - iii) Elevation 1930 ft

**SP-04.2 Inside Design Conditions**

- a) Office Area/ Conference Room
  - Summer dry bulb 74 °F – 78 °F
  - Summer RH % 50% - 60%

- Winter dry bulb 70 °F – 74 °F
- b) Cafeteria
  - Summer dry bulb 74 °F – 78 °F
  - Summer RH bulb 50% - 60%
  - Winter dry bulb 70 °F – 74 °F
- c) Hall / Prayer Hall
  - Summer dry bulb 74 °F – 78 °F
  - Summer RH bulb 50% - 60%
  - Winter dry bulb 70 °F – 74 °F
- d) Training Room/ Computer Lab/ Library/offices
  - Summer dry bulb 74 °F – 78 °F
  - Summer RH bulb 50% - 60%
  - Winter dry bulb 70 °F – 74 °F
- e) Wards/ ICUS/ CCUS/OTS
  - Summer dry bulb 73 °F – 77 °F
  - Summer RH bulb 50% - 60%
  - Winter dry bulb 70 °F – 74 °F

e) Noise Criteria:

Air inlets/outlets shall be selected by the Contractor to obtain the following noise criteria:

Offices/ Conference Room	NC 30-35
Cafeteria	NC 40-50
Hall/ Prayer Hall	NC 30-35
Training Room/ Computer Lab	NC 25-30
Library	NC 35-40
Wards/ ICUS/ CCUS/OTS .....	NC 25-30

**SP-04.3 Air Filtration**

Air filtration based on ANSI/ASHRAE Filter Test Standards 52-1-1992, "Atmospheric Dust Spot Efficiency". Filter efficiencies are stated in AHU Equipment Schedules.

**SP-05 DRAWINGS, EQUIPMENT SUBMITTALS, INFORMATION MANUALS, SAMPLES & CONTRACTOR'S OTHER SUBMISSIONS**

**SP-05.1 General**

All drawings, other information and samples must be supplied to the Engineer as laid down in these Specifications and as and when agreed during site meetings, in the Progress Chart or as instructed by the Engineer.

The Contractor shall submit, for approval, detailed submittals as specified and no material or equipment may be delivered to the job site or installed until the Contractor has in his possession the approved Data Sheet, Catalogue cuts or samples of particular material. Approval rendered on submittals shall not be considered as a guarantee of measurements or building conditions.

Where submittals are approved, said approval does not in any way relieve the Contractor from his responsibility for necessity of furnishing material or performing work as required by the Drawings and Specifications.

Failure of the Contractor in providing submittals in ample time for checking shall not entitle him to an extension of the Contract time and no claim for extension by reason of such default will be allowed.

**SP-05.2 Omitted Particulars**

All works and matters omitted from the Contract but which may reasonably be implied or inferred from them and in the opinion of the Engineer obviously are necessary for the efficiency, stability, completion and maintenance of the works and which are ordered by the Engineer to be carried out shall be executed by the Contractor accordingly as if they had been expressly described in or shown on the Contract documents and the costs thereof shall be deemed to be included in and covered by the Contract Price.

**SP-05.3 Drawings**

The Drawings will develop by contractor as turnkey project. The Building layout is attached as annexure III

**SP-05.4 Drawings Supplied by Engineer**

Deleted.

**SP-05.5 Shop Drawings**

The Contractor shall make detailed analysis of the requirements of the works. Based upon such analysis and working drawings supplied by the. he shall revise and amplify the Drawings and shall prepare detailed Shop Drawings at his own cost for complete HVAC System and Equipment. Initially he shall submit 3 preliminary copies each of all such Shop Drawings to the Engineer for obtaining approval. Once basic agreement is reached with the Engineer regarding the details then the Contractor shall

submit 6 copies each of all such Shop Drawings and one epia to the Engineer for obtaining approval of the Engineer. After obtaining approval and after having in possession these approved Shop Drawings, the Contractor shall use these Shop Drawings for fabrication, construction and installation.

The work described on any shop drawing submitted shall carefully be checked by the Contractor for all clearances, field conditions, maintenance of architectural conditions and proper coordination with all trades on the job. To this end, the Contractor during the shop drawing stage, shall ensure that he receives drawings of all other trades that might interfere with the proper installation of his work. No payment shall be made for any variations or alterations on site due to lack of knowledge of other trades. Any unresolved conflict between trades shall be referred to the Engineer for decision.

Equipment layout is to be detailed on shop drawings, showing the exact method of installing and clearly illustrating components to be used in making all connections.

The Contractor shall submit shop drawings of all sheet metal work for approval, before work is fabricated and installed. Ductwork drawings must show clearances between ductwork and masonry. All dampers, splitter dampers, fresh air inlets, exhaust outlets, connections to equipment and methods of support and any other details necessary for the satisfactory installation of the system must be indicated. Each type of grille, register, diffuser and louver is to be referenced in a schedule and the type and size clearly indicated at each location. Taper and flat sides of ductwork at all transitions must be indicated, and all equipment piping and ductwork must be located exactly by showing exact dimensions with column lines or other reference lines.

Duct bottom and piping centre-line height from finished floor level shall be marked with every change in level

Position of hangers and supports with type and method of installation of each hanger shall be given, detailing the type of hanger fixing with a reference number for each type

Piping drawings must be fully detailed, showing all piping in double line and indicating the precise size of fittings, valves and equipment. Positions of hangers and supports with reference numbers must be given showing the type and method of installation of each hanger detailing the type of hanger fixings with a reference number for each type.

All general layout drawings shall be drawn to 1:50 (1':1/4") scale. Details of hangers, methods of fixing of pipes and ducts, detailed cross section of pipe, ducts and risers, details of control and piping hook-ups to equipment shall be drawn to 1:10 (1':1") scale.

The Contractor shall prepare Drawings and Schedules showing precise details of holes in concrete, masonry, etc. and necessary sleeves required for passage of ducts and pipes and fitting of grills, registers, diffusers, louvers, plant, plant supports etc. Drawings and Schedules, approved by the Engineer must be available before any structural work requiring holes or other modifications, is constructed.

Signed and approved drawings shall not be departed from unless a signed variation order or site instruction is issued in writing by the Engineer. Drawings returned to the Contractor for alteration or amendments are to be resubmitted for approval.

Amended or altered drawings shall show the nature of the amendment or alteration in a revision block on the drawing, together with revision number or letter and the date of the revision.

The Contractor shall be responsible for any discrepancies, errors or omissions in the drawings and other particulars supplied by him whether such drawings and particulars have been approved by the Engineer or not, provided that such discrepancies, errors, or omissions are not due to inaccurate information or particulars furnished in writing to the Contractor by the Engineer.

**SP-05.6 As-Built Drawings**

The Contractor shall supply to the Engineer a set of "As-Built" drawings showing the Contract works as installed, together with any other information necessary for operation and maintenance. Six copies of each drawing (scale as per shop drawing) and other information shall be supplied, along with a reproducible and a soft copy.

**SP-05.7 Manufacturer's Data**

Manufacturer's performance data, certified factory drawings and/or curves of apparatus giving full information as to capacity, performance at different operating and ambient conditions, dimensions, materials, electrical data and all information pertinent to the adequacy of the submitted equipment shall be submitted for approval. One original and 5 copies of catalogues and other information shall be submitted.

Manufacturer's names, sizes, catalogue numbers and/ or samples of all materials shall also be submitted for approval.

Orders for equipment submitted for approval must be accompanied by relevant drawings, curves, technical data, catalogues and samples. Where data, certified drawings or other required information is not available until after orders have been placed, the Engineer shall give provisional approval until all requested drawings and information have been supplied to the Engineer and approved by him. It is the Contractor's responsibility to ensure that all necessary information is supplied to the Engineer in

accordance with the progress of works.

Should the Engineer give provisional approval only for an order due to lack of complete information and should the missing information not eventually meet with the approval, the Engineer shall not be held responsible for any delay incurred. For equipment where information from the manufacturers is likely to be delayed, it is essential that the Contractor places provisionally approved orders at the earliest possible date so as to ensure approval of orders in complete conformity with the progress of the works.

Submittals and shop drawings should, as far as possible, be complementary so that drawings and submittals can be cross-checked.

#### **SP-05.8 Samples**

Contractor shall provide at his cost, samples of materials, instruments, gauges and electrical items, for approval by the Engineer before order is placed for the same. Engineer may waive this requirement, if detailed published catalogues submitted by the Contractor provide sufficient information for approval. These samples shall include, but not limited to:

- i) G.I. sheet/PI(Thickness 22 to 40mm)/PPU, each gauge to be used
- ii) Pipes and fittings
- iii) Valves (all types), strainers, air vents, pressure gauges and thermometers
- iv) Duct insulation, liner and covering
- v) Pipe insulation and covering
- vi) Insulation adhesive and tapes
- vii) Diffusers, grilles and registers
- viii) OA/EA louvers
- ix) All types of dampers
- x) Power and control cables
- xi) Electrical items; push buttons, HOA & toggle switches, pilot lamp, contactor, relays, circuit breakers and isolating switches
- xii) Vibration isolating springs, pipe hangers and rollers
- xiii) Flexible duct connections
- xiv) Pipe flexible connection/expansion joints (when specified local)
- xv) Air filters
- xvi) Electrical conduits and fittings
- xvii) Paints
- xviii) Anchor bolts, studs, etc. for hanging arrangements
- xix) Round insulation flexible duct
- xx) Any other item required by the Engineer

#### **SP-05.9 Copies of Drawings and Specifications**

One set of Bidding Documents and two (2) sets of Drawings will be issued by the Employer to the Contractor free of cost after award of Contract. Additional sets will be provided at cost upon written request to the Engineer by the Contractor.

**SP-05.10 Sound Absorption Data**

The Contractor shall provide data for sound absorption from HVAC machinery, air terminals, etc. to ensure NC ratings as specified in SP-04 and TP-1.12.

**SP-05.11 Photographs and Progress Reports**

The Contractor shall arrange, at his cost, colour photographs of Works in progress at Site. At least six photographs per month shall be taken from approved locations, commencing with the first month upto the completion of the Works. A professional camera shall be used. The Contractor shall submit, not later than seventh of each month, a negative and six prints of 10x8 inch of each photograph taken during the previous month, with a brief report indicating progress of Works to date.

**SP-06 APPROVAL OF MATERIALS AND EQUIPMENT**

As soon as practicable after the award of Contract, the Contractor shall submit for the approval of the Engineer specifications, drawings, catalogue - cuts, diagrams and other descriptive data for all materials, components and equipment which the Contractor proposes for use under this Contract. For certain materials and equipment, data may be required to be submitted in accordance with a detailed form furnished by the Engineer. Items submitted shall be properly labeled to indicate the Contract number, project, manufacturer, source of supply, Contract Item number, and other data required by the Specifications. All items shall be submitted in sufficient time to permit proper consideration and action thereon without delaying the construction schedule. These data shall include original copies of proforma invoices for placing orders, a type written specification sheet of each SOP item, and technical literature (complete bound published catalogue) with relevant portions highlighted by a marker. Accessories to be included shall clearly be marked in catalogue and indicated in specification sheet.

**SP-07 TIME FOR DELIVERY**

All equipment plant and machinery shall be delivered at Site on such dates so as to ensure adherence to scheduled dates stated in Programs of works submitted by the Contractor and approved by the Engineer subsequent to the award of contract. The Contractor shall keep the Engineer informed of the progress of the shipment and notify them approximately 3 weeks in advance, in writing, as to when the equipment will be ready for inspection at Site by the Engineer and shall supply lists covering each consignment in sufficient detail to enable Engineer to check the contents of the packages, if he so desires.

**SP-08 STANDARDS AND CODE REQUIREMENT**

- SP-08.1 All equipment and materials under HVAC Scope of Works shall be furnished in conformity with the latest edition of Applicable Standards of ASME, ASHRAE, ARI, SMACNA, TIMA, AMCA and applicable Government and Local Codes governing the same. In case of conflict, the strict requirements shown/specified shall govern. All equipment shall be rated and tested as per standards listed in ASHRAE Handbook (latest Edition).
- SP-08.2 Abbreviations for Codes and Standards referred in the Contract are as under:
- 1) ASME - American Society of Mechanical Engineers
  - 2) ASTM - American Society for Testing & Materials
  - 3) ASHRAE - American Society of Heating, Refrigerating and Air-conditioning Engineers
  - 4) NFPA - National Fire Protection Association, USA
  - 5) ARI - Air-conditioning and Refrigeration Institute, USA
  - 6) SMACNA - Sheet Metal and Air-conditioning Contractors National Association, USA
  - 7) GOVERNMENT - Government of Pakistan
  - 8) LOCAL - Local authorities of the city where the Project is located
  - 9) I.E.E. - Institute of Electrical Engineers, London
  - 10) NEMA - National Electrical Manufacturers Association, USA
  - 11) AMCA - Air Moving and Control Association Inc., USA
  - 12) P.S. - Pakistan Standards.
  - 13) B.S. - British Standards.
  - 14) TIMA - Thermal Insulation Manufacturer's Association, US

**SP-09 STANDARDS OTHER THAN THOSE SPECIFIED**

Where the specifications provide requirements for material or equipment by specifying a standard such as for example, one of the American Society of Heating, Refrigerating and Air conditioning Engineers which has its origin in one country, it is not the intention to restrict the requirements solely to that standard and that country. Other standards, including standards of other countries, will be accepted provided the requirements thereof, in the sole opinion of the Engineer are atleast equal to the requirements of the standards specified. The Contractor may propose to the Engineer an equivalent standard other than that specified, in which case he shall submit the proposed standards and all other information to demonstrate and prove his proposed standard is equivalent in all significant respects to the standard specified. All submissions must be made in the English language

**SP-10 PERMIT**

The Contractor shall secure and pay for any necessary approvals, permits and inspections from Government or other controlling agencies where applicable as required by law, before commencing any work so as to avoid all delays during erection and turn over the official records of granting of



permits to the Engineer. No reimbursements shall be made for such payments.

**SP-11 SHOP INSPECTION, DAMAGES AND MATERIAL ORDER**

**SP-11.1 Inspection**

All major equipment to be supplied under this Contract which has been manufactured or shop-assembled in or outside Pakistan shall be subject to inspection (if the Employer so desires) by Employer or its authorized representative at its point of original manufacture or final shop assembly before its dispatch to SITE. The Contractor shall make necessary arrangements and provide all the facilities required for such inspection. The cost of travel, boarding and lodging of Employer, his authorized representative or the Engineer shall be the responsibility of the Contractor.

The following equipment shall be inspected and tested at the manufacturer's works:

- 1) Chillers
- 2) Air Handling Units
- 2) Centrifugal Pumps
- 3) Electrical Control Panels

**SP-11.2 Material Orders**

Triplicate copies of material or equipment orders required in this Contract shall be furnished to the Engineer. All orders shall state the specification designation under which the material is to be furnished and shall bear reference to the drawing number, if any, pertinent thereto. Orders shall also state that material is subject to inspection and testing and shall show the required date of delivery of the material to destination.

**SP-11.3 Acceptance of Materials**

The acceptance of any material or equipment prior to shipment shall in no way relieve the Contractor of any of his responsibilities for meeting all of the requirements of the specifications and shall not prevent subsequent rejection if such material or equipment is later found to be defective.

**SP-11.4 Damages, During Transportation, Storage & Installation**

The Contractor shall be responsible for any damage of the Equipment/material during transportation to site, storage and until satisfactory handling over the works to the. The Contractor shall replace any damaged equipment/ materials at his own cost.

**SP-12 NAMEPLATES**

The Contractor shall provide and attach to each major piece of equipment, a metal name and rating plate to be approved by the Engineer, giving the name and address of the manufacturer, the date and rating data. All ratings shall be in the British system. Large lettering on any of the parts will not be permitted. All ratings shall be in the unit system adopted for the project, unless otherwise authorized by the Engineer.

**SP-13 DIRECTED AND REQUIRED ETC.**

Unless otherwise stated, wherever in the Specifications or upon the Drawings the words, "directed", "required", "permitted", "ordered", "designated", "prescribed" or words of like import are used, it shall be understood that the direction, requirement, permission, order, designation, or prescription of the Engineer is intended, and similarly the words "approved", "accepted", "satisfactory", or words of like import shall mean approved by, or acceptable or satisfactory to the Engineer unless otherwise indicated.

**SP-14 SEQUENCE OF ERECTION**

The sequence of erection of the Equipment shall conform to the requirements of the civil construction and of the Erection Instructions. Such information will be furnished to the Contractor by the Engineer upon request.

**SP-15 FABRICATION, ERECTION, TESTING AND MAINTENANCE TOOLS PLANT & INSTRUMENTS**

SP-15.1 The Contractor shall furnish special plant and tools for the complete and proper fabrication erection and maintenance tools, plant and instruments of the HVAC Equipment. Tools shall include the type of tools not normally available in the market as standard tools and is generally manufactured especially for use with the HVAC Equipment. All lifting devices shall be accurately machined to fit the parts to be handled. The wrenches and tools for maintenance, insofar as practicable, shall be mounted on a suitable hardwood or steel board arranged for wall mounting and provided with means for ready identification. The Contractor shall also provide refrigerant charging Plant if and when required. No separate payment shall be made for providing Plant and Tools and the Contractor may withdraw the Plant and Tools after its use.

SP-15.2 The Contractor shall furnish and install sign board showing information about the project, name of Employer, Engineer and the Contractor, as directed by the Engineer.

**SP-16 MATERIALS AND EQUIPMENT TO BE IMPORTED**

Imported materials and equipment, whether procured from local market or imported especially for this project by the Contractor shall include, but not limited to the items listed hereunder. The Engineer may however issue a Variation later for use of locally fabricated item, if he is satisfied that specified requirements will be met.

- a. Dual fuel double effect direct fired water absorption chiller – heater with burner
- b. Cooling tower
- c. Air-handling units.
- d. Fan coil units.
- e. Seamless schedules 40 MS pipes, fittings and specialties.
- f. Valves and specialties.
- g. Automatic controls
- h. Instruments and gauges
- i. Piping expansion joints and flexible connectors.
- j. Vibration Isolators for fans, chillers, pumps, when specified as imported.
- k. Duct and piping Insulation, sound liner, insulation tape, sealing tape, duct sealer and adhesive.
- l. Electrical circuit breakers, contractors, relays, indications and measuring instrument, for electrical panel.
- m. Testing and balancing Instruments
- n. Chemical feeders & chemicals.

## **SP-17 ERECTION SUPERVISORS AND OPERATING STAFF**

### **SP-17.1 General**

The Contractor shall provide the services of Erection Supervisors and Operating Staff in accordance with the requirements of the Conditions of Contract, of sub-clause SP-02.2 Services by the Contractor, and as specified herein

### **SP-17.2 Work by Erection Supervisor**

- a) The Erection Supervisor shall direct the activities of Contractor's employees as they concern the installation, commissioning balancing and testing of the Equipment furnished under this Contract. The Contractor through his Erection Supervisor shall cooperate with other Contractors to whatever extent is necessary to produce an installation satisfactory to the Engineer in accordance with the requirements of the time schedule, the Drawings and the Specifications.
- b) Erection Supervisor shall be present from the Commencement of Work and remain on Site until the substantial completion.
- c) Should a disagreement arise between other Contractors and the Erection Supervisor, the matter shall be submitted without delay to

the Engineer for his decision. Upon such decision, the Erection Supervisor shall proceed with the work in accordance therewith, immediately.

- d) Erection Supervisor shall be a graduate HVAC or mechanical engineer, registered with Pakistan Engineering Council, having at least 7-8 years experience in HVAC installation works of similar nature.
- e) If the Contractor fails to fulfill his obligations under clause SP-02.2(a) and also fails to provide the Services of the Erection Supervisor having the minimum qualifications as stated in sub-clause (d) of this Clause then the Contractor would be obligated to pay to the Employer an amount of Rs.1500 per day for the number of days when the services of such Erection Supervisor are not provided. The Employer would be entitled to deduct the amount due from the Contractor in this regard from his running Bill/any payable sums.
- f) Provision of (e) above shall not apply when the Erection Supervisor is on authorized legal leave (casual), sick leave and official holidays only. His absence up to a period of ten (10) days will also be allowed when the contractor intends to replace the Erection Supervisor with the consent of the Engineer.

### **SP-17.3 Operating Staff**

The Contractor shall provide staff to operate the HVAC system continuously for twelve (12) hours a day during the Defect Liability Period and whenever the HVAC facilities required. Operating supervisor shall be a graduate HVAC or mechanical engineer, registered with Pakistan Engineering Council having at least five (5) years experience in HVAC operation of similar plant or a three (3) year diploma holder from Government College of Technology in HVAC Technology having at least ten (10) years experience of similar plants with DDC controls. The Contractor shall also arrange to provide proper training to Employer's staff to operate the HVAC system to the entire satisfaction of the Employer. All costs incidental to providing operating staff including staff salaries shall be deemed to be included in relevant item of Schedule of Prices. No separate payment shall be made to the Contractor for fulfillment of his obligations under this clause.

### **SP-18 RIGHT TO OPERATE PLANT**

The Employer reserves the right to operate any and all Equipment after it has been Commissioned and prior to substantial completion of whole Works. All repairs or alterations found to be necessary during such operation, and required of the Contractor, shall be made by the Contractor at such time as directed by the Engineer. The repairs or alterations shall be

made in such a manner and at such a time as will cause the minimum interruption in the use of the Equipment by the Employer.

**SP-19 ERECTION INSTRUCTIONS**

Erection Instructions in form of published installation manual, as furnished by the manufacturer of each HVAC equipment listed hereunder shall be provided by the Contractor.

1. Dual fuel double effect direct fired absorption chiller - heater
2. Air handling units
3. Pumps
4. Fans
5. Expansion tank
6. Air separator
7. Automatic controls system
8. Chemical feeder
9. Cooling tower
10. Fan coil units
11. Major components of electrical panels
12. Instruments and gauges.

These instructions shall include full and detailed instructions for the guidance of the Erection Supervisor as to all procedures and precautions to be observed in erecting, assembling and adjusting the Equipment and as to the use of the Erection Plant. It shall include or be accompanied by drawings, clearly showing erection marking and particularly any matchmaking and shall embody in particular a full statement as to erection tolerances to be observed.

These shall also include full instructions for the maintenance of the Equipment not only during the period of Contractor's liability but more particularly during its operating life. The directions shall be set out simply, clearly and systematically. In particular this section shall include a full list of all routine checks and their timing, directions as to fault finding, detail of all routine attentions (such as greasing), in the form of check sheets for daily, weekly, monthly, quarterly, half-yearly, yearly and any other periodic checks recommended by the manufacturer. This section should also provide detailed and complete instructions for trouble shooting, maintenance and all necessary adjustments to the Equipment Technical leaflets and brochures in respect of all equipment supplied under the Contract including all relays, instruments, switches, controllers, regulators etc., should be supplied with the erection instruction. This should also include complete catalogue of spare parts with exploded views of the equipment and relevant part numbers to facilitate identification and ordering of spares throughout the operating life of the Equipment.

The Contractor shall submit 6 copies to the Engineer for approval.

**SP-20 WATER, POWER AND GAS DURING ERECTION AND TESTING**

Water, and power supply FOR ERECTION AND Preliminary TESTS shall be the responsibility of the Contractor. Water, power and gas supply for Balancing & Commissioning Performance Tests and Reliability Trial Tests and operation during Defects Liability Period will be provided by the Employer.

**SP-21 SPARE PARTS**

The Contractor shall furnish spare parts as per list given in the Annexure-3. The Contractor shall also furnish recommended spare parts with the recommendation of manufacturer of equipment and provide a list of such spares in the Annexure-3. The spare parts listed shall serve all Equipment furnished.

The Contractor shall furnish the essential spare parts as listed in Schedule of Essential Spare Parts appended to Equipment Schedules. The Contractor shall also furnish recommended spare parts selected by the Employer at the applicable unit rates, from the lists provided by the Bidders. Payment for recommended spare parts will be made from the amount set out in Schedule of Prices against items "Recommended Spare Parts". The spare parts listed shall serve all Equipment furnished. These spare parts shall not be used during Defects Liability Period, or earlier.

The Contractor shall supply, at his own cost any spare parts required during the Defects Liability Period.

**SP-22 DEFECTS LIABILITY PERIOD**

The Contractor shall operate service and maintain complete HVAC System for a period of three hundred and sixty five (365) days after date of issuance of Certificate of Completion. The plant shall be operated in accordance with provisions of Clause SP-02.2(b), SP-17.3 and as specified herein, and shall include supply of operating staff, consumables, all necessary adjustments, greasing, oiling and cleaning and the furnishing of necessary tools, instruments supplies and parts to keep the system in perfect operation, except such parts made necessary by misuse or neglect not caused by the Contractor.

The cost of operating the plant during Defects Liability Period shall be paid by the Employer to the Contractor under Schedule of prices item named "HVAC System Operation during Defects Liability Period As specified"

**SP-23 APPROVAL FROM GOVERNMENT**

The Contractor shall arrange and be responsible for all tests, test reports and approvals regarding electrical works under this contract, any other works under this Contract requiring tests/Government approvals. All the requirements to be completed for this purpose, whether specified or not shall be at the cost of the Contractor. The Contractor shall handover all

test results and approval certificates to the Engineer within one week of obtaining such approval.

**SP-24 PERFORMANCE GUARANTEE:**

The Contractor shall be required to furnish a Performance Guarantee in accordance with Conditions of Contract.

**SP-25 SITE FACILITIES**

Except for the Site facilities specifically stated in Conditions of Contract and/or Special Provisions, no other site facility shall be provided by the Employer to the Contractor.

**SP-26 SUFFICIENCY OF RATES AND CURRENCY FOR PAYMENT**

All rates and amounts filled in the SOP by the Contractor for equipment/material whether locally procured or imported shall be deemed to include, but not limited to, the cost of items, custom duties, sales tax and surcharges, freight, marine insurance, local duties, sales tax and surcharges, clearance charges, inland transport and insurance, octroi, L/C opening charges, bank charges, etc. Payments to the Contractor shall be made in local currency.

**SP-27 IMPORT LICENSE**

The Contractor will arrange the import licenses if required for all the imported Equipment, Plant, Tools and Machinery to be incorporated in permanent works. All the costs and charges for arranging import licenses will be paid by the Contractor. The Contractor shall be responsible to arrange foreign exchange for import of all equipment and materials.

**SP-28 GUARANTEES AND WARRANTIES**

**SP-28.1 Performance Guarantee**

The contractor shall guarantee the performance of the complete HVAC system, viz.-a viz. his workmanship for the work executed at site, and quality of material, as specified. He shall replace the material/workmanship, whenever found not meeting the specified requirements, at his own cost.

**SP-28.2 Manufacturer's Warranties**

The contractor shall obtain manufacturer's standard warranties for all equipment extended for a period upto completion of Defects Liability Period at his own cost. In case the completion of Defects Liability Period is delayed, the contractor should obtain further extension of warranties. The contractor shall be responsible for cost of such extension, if the delay is

due to his fault, otherwise the cost of such extension shall be reimbursed to him on production of acceptable documentary evidence of such costs.

**SP-29      PACKING OF EQUIPMENT AND MATERIALS**

All equipment and material shall be adequately packed at the manufacturer's works to protect them against damage, scratching, corrosion, dust, rain and moisture during handling, transportation and storage. The packaging shall be rigid enough to withstand normal service incidental to shipping and handling. Wherever necessary, crates/boxes shall be provided with lifting hooks attached by means of vertical rods or plates to strong bottom supports to enable rigging.

The following information shall appear inside all packages:

- a) Stock or identification number
- b) Description of contents/packing list
- c) Quantity of each item
- d) Invoice number
- e) Year of manufacture

**SP-30      INSPECTIONS AND TESTS**

**SP-30.1      Inspection by Engineer at Site**

The Engineer shall inspect the works in progress at site as and when considered necessary by the Engineer and the Contractor shall provide full access and assistance to the Engineer for carrying out inspection to verify the conformity of works to general lay-out of HVAC System as designed and as shown on Drawings and as specified. Such inspection if made shall not relieve the Contractor from any obligations under the Contract.

**SP-30.2      Tests**

- A) General
  - i) All Tests as specified shall be carried out unless otherwise specified. The Engineer shall witness the tests.
  - ii) The Contractor shall give the Engineer at least seven days notice in writing of the date on which any equipment will be ready for inspection and/or testing as provided in the Specifications and unless the Engineer shall attend within seven days of the date which the Contractor has stated in his notice the Contractor may proceed with the tests in the Engineers absence and shall forthwith forward to the Engineer five duly certified copies of test readings, on the forms prescribed by the Engineer. The Engineer shall give twenty four hours notice in writing of his intention to attend any test.



- iii) The Contractor shall provide all labour, materials, electricity, fuel, stores, apparatus machines and instruments as may be necessary to carry out tests, unless otherwise specified.
  - iv) The cost of all tests carried out by the contractor under this Clause shall be borne by the Contractor if such tests are clearly intended by or provided for in the Specifications or Schedule of Prices.
  - v) As and when any equipment or HVAC System or part thereof shall have passed any inspection/test the Engineer shall furnish to the Contractor a certificate in writing to that effect.
  - vi) The Engineer may reject any part or parts of Equipment, and HVAC System which he shall after inspection/ testing decide is not in accordance with the Specifications and Drawings and he shall give to the Contractor within fourteen days of such inspection/ testing notice in writing of such rejection stating therein the grounds upon which his decision is based.
  - vii) The test results shall be filled out by the Contractor in the forms proposed by the Contractor and approved by the Engineer. Six copies of filled out forms shall be submitted to the Engineer for review and approval.
- B) Once the inspection/test certificate has been obtained by the contractor, as stated in A (v) above, the contractor shall test and balance the system in accordance with NEBB (National Environmental Balancing Bureau), USA, code of practices. The Contractor shall be responsible for all remedial measures if any, required. The Contractor shall be responsible for the following:
- Supply and fixing of any test hole covers, paint, gauges, gadgets, testing and balancing instruments, or any such thing which is necessary to carry out this work.
- To provide all supervision, labour and materials required to carry out these balancing works.
- C) Preliminary Inspection & Tests
- Preliminary Inspection/Tests as specified in Technical Specifications shall be carried out on all or any major HVAC equipment and such other equipment as the Engineer may require, on completion of installation of that equipment or at such time which the Engineer may require.
- D) Balancing & Commissioning

Balancing and Commissioning shall be carried out on all or any major equipment, as Specified in Technical Specifications, when such is ready for operation.

E) Performance Tests

These tests as specified in Technical Provisions shall be carried out on each equipment of HVAC system after successful completion of Commissioning of that equipment, during appropriate season, on the dates proposed by the Contractor and approved by the Engineer. The Engineer keeping in view the weather conditions may fix the test date on any equipment of HVAC system within 6 months of Completion of Commissioning of that equipment.

F) Reliability Trial Tests

i) During the Defects Liability Period the Contractor shall inform the Engineer in writing of his readiness to commence the Reliability Trial Test of HVAC System or part thereof. Cooling or Heating Tests shall be carried in appropriate season and the Engineer shall, within fourteen (14) days of receipt of such information shall forward his consent for commencement of Reliability Trial Test as specified in Technical Specifications, after having satisfied that all the requirements for such Tests have been completed.

ii) If any Reliability Trial Test be not fulfilled to the satisfaction of the Engineer, such test shall be repeated at such time as the Engineer.

## **TECHNICAL PROVISIONS**

## TECHNICAL PROVISIONS

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# **SPECIFICATIONS**

## **TECHNICAL PROVISIONS**

### **SECTION 1 - GENERAL REQUIREMENTS**

#### **1-01 MATERIAL**

All materials shall be of the highest grade, free from defects and imperfections, of recent manufacture and unused, and of the classification and grades designated, conforming to the requirements of the latest issue of the appropriate specifications cited herein. All materials, supplies, and articles forming part of major equipment and not fabricated by the manufacturer of the equipment shall be the products of the recognized reputable manufacturers.

#### **1-02 WORKMANSHIP**

Workmanship and general finish shall be of the highest grade, in accordance with the requirements specified herein, and the best modern standard practice.

#### **1-03 EQUIPMENT**

- a) For ratings and characteristics of manufactured equipment, Equipment Schedule as appended to Technical Provisions shall be followed.
- b) All equipment shall be manufactured by companies, which have had at least ten years previous experience in the design and manufacture of equipment of comparable type, capacity and operating conditions. Unless otherwise approved by the Engineer.
- c) Where the requirement of this Clause make any equipment proprietary or non-obtainable, the Engineer reserves the right to waive any portion or portions of it as required to obtain the intent of the technical specifications (s).
- d) When a manufacturer's product is specified by name, or equivalent, it shall be in the sole judgment of the Engineer as to acceptability of any product, which is offered as equal to that specified.
- e) Where two or more units of the same class of equipment are furnished, product of the same manufacturers shall be used: component parts of entire system need not be product of same manufacturer.

#### **1-04 CHASSES AND OPENINGS**

The Contractor shall provide shop drawings, templates or details for chases and openings to be left in concrete walls, concrete partitions, and floor or roof slabs to accommodate work under HVAC scope of works.

#### **1-05 PROTECTION**

The Contractor shall keep pipe, duct and other openings closed to prevent entry of foreign matter. All fixtures, equipment and apparatus shall be covered and protected against dirt, water, chemical or mechanical damage, before and during the construction period. All fixtures, apparatus, or equipment damaged including damaged shop coats of paint shall be restored to original conditions prior to Commissioning and also again prior to Final Acceptance. All bright finished shafts bearing housings and similar items shall be protected until in service: no rust will be permitted.

#### **1-06 CUTTING, PATCHING AND REPAIRING**

Required for proper installation and completion of HVAC works, including masonry work, concrete work, carpentry work, painting and re-painting shall be performed by skilled craftsmen in respective trades, at expense of the Contractor. Construction shall be cut only after obtaining written permission from the Engineer.

#### **1-07 LINES, LEVELS AND SPACES**

The Contractor shall check dimensions at the building site and establish lines and levels for work specified in Specifications. The Contractor shall check with work of other trades to ensure proper clearance of piping, ductwork, conduit and other items. Any deviations observed between drawings and actual construction shall be brought to the notice of the Engineer. The erection supervisor shall regularly inspect, during progress of civil works, the areas allocated for installation of HVAC equipment and any conflict observed shall immediately be reported to the Engineer.

#### **1-08 MACHINERY GUARDS**

All moving parts of machinery are to be protected by strong guards to adequately protect all personnel working on or in the vicinity of equipment.

Wherever possible, moving parts should be protected by guards supplied by the equipment manufacturer. All guards must be strongly attached to equipment and should be designed for easy removal for access, servicing, adjustment and maintenance.

**1-09 TOOLS**

The Contractor shall supply in a toolbox, full sets of tools suitable for maintenance of all components of the plant furnished by him including the electrical equipment, for use by the Employer after completion of Maintenance Period. List of Tools shall be subject to approval by the Engineer.

**1-10 OIL AND GREASES**

The oils and greases shall be supplied in sealed containers. These shall be of suitable quality sufficient for the initial charge plus hundred percent (100%) extra. The quantity, grade of oil and greases and their manufacturer shall be approved by the Engineer the extra oils and greases shall be reserved for use by the Employer after completion of Defects Liability Period.

**1-11 SPARE PARTS**

The spare parts for HVAC System shall be duplicates of the original parts furnished and interchangeable therewith.

**1-12 ACOUSTIC TREATMENT**

The noise criteria for different areas stated in Special Provisions is to be obtained.

Sound measurements will be made at approximately five (5) feet above floor level in the occupied area served and not more than five (5) feet from the grills, diffusers or other air devices being tested. Instruments for sound measurement shall be provided by the Contractor.

Provision is to be made to minimize noise and vibration. However, different manufacturers equipment have varying sound and vibration characteristics and it is, therefore, the responsibility of the Contractor to ensure that the requirements in these specifications are fully met by the equipment he is offering. If the Contractor has any requirements for additional vibration or sound isolation, these must be incorporated into the price quoted.

All equipment installed should not be audible inside the occupied areas and the Contractor must ensure that all equipment he is offering is quiet and have satisfactory sound levels. Where silencers are required, these must be incorporated into the price quoted.

**1-13 ACCESS PANELS**

The Contractor shall mark locations of, and give sizes of, access panels required in false ceiling and wall paneling for adjustment and maintenance of HVAC Equipment, such as Dampers, Fire Dampers,

valves, ceiling-hung equipment, etc. This information shall be provided to the Engineer before commencement of false ceiling work by the concerned persons.

**1-14 SEALING OF OPENINGS**

The contractor shall seal all openings in external walls and roof where HVAC ducts/pipes penetrate in external membrane. The sealing shall be air tight to prevent penetration of outside air and water into building. The method and materials for sealing shall be subject to Engineer's approval.

**SECTION 2 – EQUIPMENT**

**2-01 GENERAL**

All equipment shall be of such overall dimensions, operating weights, service area requirements and configuration that it can be located where shown on the plans without any adverse effect on its performance and clearance requirements. Any change in other trades work, anticipated by offering alternate equipment, shall be estimated by the Contractor and its cost shall be included in the quoted price for HVAC Works.

Provision for clearance and service spaces shall be made around all mechanical equipment as recommended by equipment manufacturers. All equipment supplied under this section shall be brand-new, factory manufactured and factory assembled (unless otherwise specified) and complete in all respects. The type, characteristics, capacity ratings, component sections of all equipment shall be as Scheduled.

All equipment furnished by the Contractor shall include vibration isolation mounting pads, anchor bolts, frames or any other mounting or supporting accessories.

All power driven equipment shall include drives, motors and adjustable motor foundation bases and accessories including machinery guards where applicable.

All equipment shall be complete with all accessories necessary to serve the intended purpose, whether specified or not.

All equipment installed on roof or intermediate floors shall include suitable vibration isolators to prevent any vibration traveling to building structure.

**2-02 CHILLERS - HEATERS**

**2-02.1 General**

This shall be dual fuel direct-fired double effect absorption chillers-heaters of characteristics and capacity as shown in "Equipment

Schedule” Direct Fired Absorption Chiller-Heater. Technical deviations from this specification may be considered when these fulfill the intended purpose.

Chillers-heaters shall be manufactured as per latest industry standards of USA or Japan or other equivalent standards. The ratings shall be in accordance with ARI/JIS Standards.

The chillers-heaters shall be externally insulated as per recommendations of chiller-heater manufacturer.

The chillers-heaters shall have microprocessor based controls compatible, with Microprocessor-based control system of this project including interface equipment if necessary.

Unit shall be complete chiller-heater package and shall include an evaporator/absorber section, condenser/low temperature concentrator section, high temperature concentrator/economizer section and complete burner assembly.

The shell material is to be of carbon steel fusion welded seams with carbon steel tube supports.

Tubes in absorber, evaporator and condenser shall be seamless copper in low pressure generator copper-nickel alloy tubes.

All tubes shall be roll expanded into steel sheets except high pressure generator tubes, which shall be welded at both sides.

#### **2-02.2 Partial Load Efficiency**

During partial load operation the machine shall allow reduction of fuel consumption with maximum efficiency. The control of fuel consumption up to 50% shall be included in the machine.

#### **2-02.3 Refrigerant**

The initial charge of Refrigerant and Lithium Bromide solution shall be provided separately to be charged at site at the time of commissioning.

#### **2-02.4 Chilled Water**

The chilled water and hot water outlet temperature as specified shall be maintained constant by providing automatic temperature controller which shall sense chilled/hot water outlet temperature and shall control the fuel control valve. The flow metering device shall be provided for control of chilled water flow and should provide display for water flow rate on chiller control/ HVAC Central Controller.

#### **2-02.5 Condenser Water**

Chiller shall be designed to operate on entering cooling water

temperature and fouling factor as given in the equipment schedule.

## **2-02.6 Capacity Control**

The capacity of unit shall automatically be adjusted between 10 to 100% of the full load capacity. An automatic start-stop thermostat shall be provided to stop the chiller when chilled water outlet temperature falls below the pre-determined field adjustable specified temperature.

## **2-02.7 Burner**

A fuel burner as scheduled, capable of operating on natural gas and on high speed diesel shall be included.

The burner must be complete in all respects for full automatic control to operate the chiller-heater within the specified limits with precision and safety.

If the burner/chiller combination is operating outside the set points, but within operating limits, operator is to rectify minor deviations. However, in case the deviations result in the burner/chiller combination working outside the operating limits, the machine must provide for automatic shut down within safe limits.

It is expected that the burner system will cover the following functions for which all necessary ancillaries/auxiliaries will be factory fitted and wired/connected.

- a) Safety control circuiting

Key operated master control switch (four sets of key to be provided).

- b) Safety interlocks comprising of:

1. High/low temperature switch
2. Low liquid level cut-of switch
3. Forced draft fan interlock
4. Low/high gas pressure switches

- c) Main burner fuel system

1. Fuel Automatic shut-off valves (i.e. wire controlled fuel safety shut off valves)
2. Main fuel variable valves (with position indicators)
3. Mechanical remote control (i.e. wire controlled fuel safety shut off valves).
4. Pilot flame, automatic, fuel shut-off valves
5. Pilot/Main burner fuel interlock switch
6. Spark Ignition indication
7. Pilot flame Ignition Indication

8. Main Flame Ignition Supervision (Photo- electric or equivalent sensor)
9. Pilot Flame 2 to 4 second failure response time -3 cycles
10. Main Flame failure response - 5 to 9 second; 2 to 4 cycle

The Machine shall shut down automatically due to any one or more of following causes:

1. Ignition failure
2. Forced Draft fan failure
3. Main Flame Failure
4. Low & High Gas pressure
5. Low & High Liquid level

The Auxiliaries/Ancillaries to be factory fitted or loose-supplied for field installation to each fuel burner system are mentioned below. It is not an exhaustive list but only an indication of the various components that may be taken to make up a complete system.

- d) Pilot and Main burners
- e) Flame Scanners
- f) Ignition Transformer
- g) Protection Relays
- h) Microprocessor based Burner Control Panel incorporating pilot and/Main Ignition initiating devices complete with deviation and cycle controls, Hours Run Meter, Key operated Master Switch, Various electronic/electrical interlocks /relay etc., programmed to function in conjunction with operating Parameters of the Chiller.
- i) Main & Pilot burner automatic safety shut-off valves.
- j) Main & pilot burner mechanical remote control (wire operated) fuel safety shut-off valve.
- k) Pilot gas regulator
- l) Main burner variable discharge fuel control valves (for metering fuel)
- m) Pilot gas regulator
- n) Pressure, temperature and level sensor as appropriate.
- o) Strainers for fuel (duplex type)
- p) Temperature and pressure gauges
- q) Flow meter for monitoring fuel
- r) Tubing, both rigid and flexible as appropriate lagged and armored where applicable.

## **2-02.9 Status Diagnostic**

Unit status and diagnostic control monitor on the panel shall define status. The unit control system shall be interconnected with the other safety interlocks such as water flow sensors etc. for proper unit operation.

The control panels of the chillers-heaters should have provision for

hooking-up to main HVAC control panel.

**2-02.9 De-crystallization**

A system shall be provided to transfer hot solution directly from the generator to absorber during crystallization systems to return the unit automatically to normal operation.

**2-02.10 Thermometer Wells**

Thermometer wells shall be provided at the inlet/outlet of chilled water and condenser water circuits.

**2-02.11 Co-efficient of Performance**

Direct fired absorption chiller/heater shall be of minimum COP 1.3 from the approved make.

**2-02.12 Flue Collar**

Chiller/Heater shall have flue collar for connection to breaching with structural angle flange and bolts.

**2-02.13 Rating**

The chillers/heater shall have a capacity and characteristics as shown in Equipment Schedules.

**2-02.14 Essential Spares for Chillers**

Sr. No.	Spare Parts	Qty	Unit
1	Absorber pump	1	No.
2	Refrigerant pump	1	No.
3	Purge pump	1	No.
4	Sight glasses	3	Nos.
5	Gaskets for absorber evaporator & condenser	1	Set
6	Packing (sight glass)	3	Nos.
7	Inhibitor	25	Liters
8	Relays	1	Set
9	Temperature controller (Refr)	2	Nos.
10	Protect Relay	1	No.
11	Flow switch	1	No.
12	Temperature sensor	1	No.
13	Temperature sensor (Ext. Gas)	1	No.
14	Fuse	2	Nos.
15	Pressures Switches	1	Set
16	Flame detector	1	No.
17	Transformer	1	No.
18	Pilot solenoid valve	1	No.
19	Control motor	1	No.
20	Shut-off gas valve	2	Nos.
21	Pilot regulator	3	Nos.
22	Timers	1	Set
23	Microprocessor Card	1	Set
24	Lithium bromide	10% charge for each chiller	



## **2-03 CHEMICAL FEEDER AND CHEMICALS**

### **2-03.1 Chilled/Hot Water Chemical Feeder**

The Contractor shall provide chemical feeder for chilled/hot water system. Gravity Bypass Feeders shall be installed at the pumps as shown on Drawings. Gravity Bypass Feeder shall be complete with necessary valves. Make of Feeder shall be subject to Engineer's Approval.

### **2-03.2 Condenser Water Chemical Feeder**

The Contractor shall provide chemical feeding system comprising of electrically operated pump with manual start/stop button and suitable piping system with necessary number of drums to feed various types of chemicals required for the treatment of condenser water system. The make of chemicals and its feeding system shall be subject to Engineer's approval.

### **2.03.3 Chemicals**

**2.03.3.1** Sufficient chemicals for Preliminary Tests, Balancing Commissioning and Reliability Trial Tests and Operation during Maintenance Period shall be included. In addition to the above, sufficient quantities of chemical for further one year operation shall be handed over to the Employer at the expiry of Maintenance Period.

#### **2.03.3.2 Chemicals for Chilled/ Hot Water**

The quantities of chemicals shall be based on system volume stated in Expansion Tank schedule and 104 weeks with 24 hours & 7 days a week operation. Over and above chemicals for initial and passive doze of 2 weeks shall also be supplied.

#### **2.03.3.3 Chemicals for Condenser Water**

The quantities of chemicals shall be based on system volume with 6 days a week & 12 hours operation for 58 weeks. Make-up quantity shall be calculated on 80% average load. Over and above chemicals for initial and passive doze of 2 weeks shall also be supplied. Sufficient chemicals, as described in Clause 2-03.3.1 shall be furnished.

## **2-04 EXPANSION TANK**

Expansion tanks shall be horizontal type for ceiling suspension, designed, fabricated, tested, inspected and stamped as per ASME Code for Unfired Pressure Vessels, (Design pressure rating shall be 150 PSIG max.). The expansion tank shall be selected for maximum

operating temperature for various applications. Tank shall be fitted with refrigeration type sight glass, sight glass valves, air release fitting in bottom of tank incorporating air tube, hose and bottom drain.

## **2-05 AIR SEPARATORS**

The Contractor shall supply and install centrifugal air separators for chilled water and hot water piping as shown on drawings. Air separator shall be of cylindrical design, vertical, with inlet, outlet, drain and expansion tank connection. It shall be designed fabricated, tested, inspected for 150 PSIG maximum water operating pressure, for required system flow rates.

## **2-06 PUMPS**

### **2.06.1 General**

Before placing order for pumps the Contractor shall check the total required dynamic head for the System with equipment actually proposed by the Contractor and approved by the Engineer. The dynamic head may be different than Scheduled value due to Contractors proposed equipment. The contractor shall submit the total head calculation for actual pipe circuit and equipment selection for Engineer's approval. No compensation will be paid to the Contractor, if actual head requirements are above the schedule values.

Pumps shall be of type as specified in Equipment Schedule with casings designed for working pressure at least one and a half times the total pressure on the casing. Flange connections shall correspond to casing working pressure.

Certified test curves of pump performance shall be furnished for approval showing horsepower, total dynamic head and efficiency versus water flow.

Each pump shall be driven by a constant speed motor through a flexible coupling. Motor horsepower shall be selected in a way that the motor shall not be overloaded at any point on the characteristic curve when operating at design speed.

Each pump shall be guaranteed to circulate not less than the quantity of water against the required circulating head when operating continuously, without overheating the motor or bearings, etc. When more than one pump are required to operate in parallel, the pumps performance curves when operating in parallel shall be provided to show that required flow at the specified head will be obtained. Pumps shall not transmit vibration to the building and shall operate without producing noise, audible anywhere in the building, outside the space in which the pumps are installed. Flexible connections shall be provided at pump suction and discharge.

Pumps shall have stainless steel shaft and mechanical seals.

Pumps and motor shall be mounted on common base frame and shall have been factory aligned. Specifications for electric motors shall be as given under Section – 7 “Electrical Equipment and Controls”.

## **2-07 AIR HANDLING UNITS (EUROVENT CERTIFIED)**

### **2-07.1 General**

The characteristics and capacities of air handling units shall be as scheduled. The configuration of component sections shall be as scheduled and as shown on Drawings. All AHUs shall complete with drives, motors, and belts. These shall include mixing box with dampers, filters and humidifiers when scheduled. Filter specifications are given separately in this section.

AIR HANDLING UNITS WITH VFD MOTORS AND MOTORIZED DAMPERS ON SUPPLY, RETURN AND MIXING / FRESH AIR SECTIONS.

EACH AIR HANDLING UNIT SHOULD HAVE VOLUME CONTROL DAMPERS ON EACH SECTION; ACCESS DOORS WITH GLASS / VISION PANEL ON EACH SECTION.

THE CONTROL PANEL OF EACH AIR HANDLING UNIT SHALL BE PROVIDED WITH AIR TIGHT DOORS AND LOCKING SYSTEM.

KEEPING IN VIEW THE ENERGY CONSERVATION SYSTEM, EACH FAN – MOTOR SHALL BE PROVIDED WITH V-TYPE BELTS AND MULTIPULLEY ARRANGEMENTS.

AHUs shall be of imported origin as mentioned in equipment schedule or list of approved equipment/material or approved by the Engineer.

For purpose of calculation of motor BHP, specified external SP and AHU manufacturer's internal SP should be added. Filter pressure drop shall be part of internal SP, which shall be calculated on average of clean (initial) and filter manufacture-recommended dirty (final) pressure drop. Published recommendation of filter manufacturer shall be furnished alongwith technical submittal. In case published recommendation is not available, a recommendation on the printed stationery of filter manufacturer shall be acceptable provided the manufacturer certified that no such published data is available. Motor HP shall be at least 120% of calculated BHP.

The air handling units shall meet the requirements of ARI 430-86 and ASHRAE 51-85 standards and shall be factory tested according to the requirements of the these standards.

## 2-07.2

### Construction

These shall be factory assembled draw-through packaged air handling unit of capacities and characteristics as scheduled. Air handling units shall be horizontal or vertical with component and configuration as scheduled and shown on the drawings.

Large AHUs may be shipped in sections e.g. Fan Coil Section, filter section, mixing box section for ease of transportation and rigging.

Coils shall be of copper construction with mechanically bonded smooth aluminum fins, suitable for chilled water and hot water applications.

Fan shall be double inlet centrifugal (Backward/Airfoil) mounted on a common shaft. Fan impeller shall be statically and dynamically balanced and shall have permanently lubricated bearings. Fan shall be belt driven with adjustable sheaves. Fan motor shall be variable frequency drive (VFD) capable of modality by standalone control unit in AHU room. Fan shall have spring isolation from the casing.

Casing shall be made of sheet steel and finished with baked enamel. (Or approved by the Engineer) The casing shall be double skin with minimum 1-1/2 inch thermal insulation between the skins and removable panel type. AHU shall be equipped with factory fabricated filters and filter boxes with side access door.

A condensate drain pan, with double wall construction and insulation in between, shall be provided. Inner pan shall be finished with a factory applied coating of corrosion resistant material. Insulation, adhesive and inner coatings to COM. ply with NFPA-90A Standard. Other types of drain pans shall be acceptable.

Flat filters installed in Air Handling Units, shall be permanent, impingement, dry type, washable, all metal, panel type, at least 2 inch thick unless otherwise scheduled. Media shall be aluminum screen, arranged in alternate layers of flat and herringbone-crimp, 4 layers of each per one inch reinforced and enclosed in a frame of 16 gauge galvanized steel with flush mitered corners. Initial pressure drop at 500 FPS shall not exceed 0.1 inch WG. Holding frame shall be factory-built of 16 gauge steel; with felt air seal. Filters shall have at least 35% efficiency on 0-5 microns range when tested in accordance with ASHRAE Standard 52-76.

Bag filter (if schedule) in AHUs shall be extended surface dry type non-supported pocket, cartridge filter. Average efficiency shall not be less than 90% when tested as per ASHRAE standard 52. Initial resistance at 500 FPS shall not exceed 1/2 inch.

Humidifiers shall be of water spray type complete in all respect. Water shall be sprayed through a water atomizing nozzle with at least 70% efficiency. Booster water spray pump, water tank, pan make-up inlet

with float valve and droplet eliminator shall be part of humidifier.

## **20.8 COOLING TOWERS (CTI CERTIFIED)**

The cooling tower(s) shall be of type, characteristics and capacity as scheduled in Equipment Schedules. It shall be double or single flow as scheduled. Packaged type, induced draft cross flow, super low noise square vertical discharge cooling tower with PVC internal piping and shipped in knocked down condition for field assembly.

The tower shall be heavy duty type designed to provide more wetted surface for uniform water distribution and higher heat transfer rate.

The casing shall be of steel or Fiberglass (FRP) construction with all frame members bolts, nuts, washers and steel shall be galvanized. Louvers may be integral with fill.

Hot water distribution basin shall have non-ferrous diffusing type metering orifices.

The PVC louvers, fill and eliminators shall be self extinguishing for fire resistance and shall be impervious to rot, decay, fungus or biological attack. Eliminators shall ensure entrainment of moisture in air and drift loss of less than 0.1% of the total water circulated. Stainless steel positioning rods shall be provided for holding & keeping the fill in correct position.

Fans shall have die cast aluminum blades with fine finish. Blades shall be adjustable and individually attached to the hub. Fans shall be belt driven. Fan motors and drive shall be heavy duty type suitable for cooling tower application. The motor shall be two speed type. Temperature sensor shall be provided in the cold water basin to set the motor to low or high speed.

Float operated make-up valve and sump complete with suction screen and anti-cavitations device shall be provided.

The Cooling Tower shall be supplied complete with galvanized steel access ladder for safe access to fan deck and access door for access to inside of tower. Galvanized steel handrails, knee rails, toe board and heavy gauge galvanized wire mesh fan guard shall be provided around tower perimeter. The cooling tower controls shall be compatible with HVAC Controls.

## **2-09 FAN COIL UNITS (EUROVENT CERTIFIED)**

Fan coil units shall be of capacity and characteristics as scheduled and shown on the drawings. All FCUs shall be of make and country of

manufacture similar to AHUs unless otherwise approved by the Engineer.

Unit shall be of blow-through design and shall be wall mounted/ceiling-hung type as scheduled complete with combination hot/chilled water coil, motor(s), fan(s) and drain pan. The unit shall have one or more quiet operating centrifugal fans directly connected to extend motor shafts. Motor fan assembly shall be easily detachable from coil section. The coil and drain pan shall be readily reversible. The coil shall be supplied with drains and vent cocks so located as to permit drain and vent of coil regardless of position. The fan and motor assembly shall be readily removable and shall be provided with a quick disconnect on the motor chord.

Unit motor shall be of capacitor run type with at least three speeds of operation. Motors shall be equipped with oil cups for lubrication with the oil cups located for easy accessibility.

Fan coil rating shall be such that after considering room effect, the sound level shall not exceed NC rating specified in special provision in second through 8th octave band. Calculation of sound pressure level shall be submitted by the Contractor to the Engineer for his approval.

Filters installed in FCU (if scheduled) shall be permanent impingement dry type, washable all metal, panel type at least ½ inch thick. Media shall be aluminum clean arranged in alternate layers of flat and herringbone- crimp, reinforced and enclosed in a 16 gauge G.I. Frame with flush mitered corners. Initial pressure drop at 500 FPS shall not exceed 0.05 inch WG. FCU thermostat shall be digital type with LCD display of room temperature. FCU thermostats shall be integrated with BMS through network controller.

## **2-10 FILTERS OTHER THAN INSTALLED IN FILTER BOXES OF AHUs**

Filters shall be permanent, impingement, dry type, washable, all metal, panel type, at least 2 inch thick, unless otherwise scheduled. Media shall be aluminum screen, arranged in alternate layers of flat and herringbone- crimp, 4 layers of each per 1 inch reinforced and enclosed in a frame of 16 gauge galvanized steel with flush mitered corners. Pressure drop at 500 FPS shall not exceed 0.12 inch WG. Holding frames shall be factory- built of 16 gauge steel; with felt air seal. Filters to be installed with return air grilles shall be ½ inch thick.

Filters shall have at least 25% efficiency (85% arrestance) on 0.5 microns range when tested in accordance with ASHRAE Standard 52-76.

## **2-11 FANS**

### **2-11.1 General**

These specifications are for all fans other than fitted inside AHUs and/or FCUs. The characteristics and capacity of all fans be as schedule.

All fans shall have been rated per AMCA standard 210- 74 or ASHRAE standard 51-75 or equivalent. Wheels shall be heavily rigidly constructed and accurately balanced both statically and dynamically, and be free from objectionable vibration or noises. Actual brake horsepower of fan and drive shall not exceed nameplate rating of motor driving fan. Motor shall be included.

### **2-11.2 Propeller Fans**

Propeller fans shall be direct driven type complete with motor, angle iron frame, back draft dampers and mounting accessories. Blades shall be of steel and factory adjusted for pitch. Blades of back draft damper shall have a link rod and the design shall be such that damper remains in full open position without rattling when the fan is operating.

### **2-11.3 Tube Axial Fans**

These shall be axial flow, duct mounted, circular in shape of characteristics and capacities as scheduled. Fans shall be direct or belt driven as scheduled. Fan motors above 1/2 HP shall be 3-phase induction type and 1/2 HP or smaller shall be single phase split-capacitor. Motors for direct drive fans shall be mounted within fan casing and impeller attached to the motor shaft end. The fan casing shall have flanges with holes for connection to duct work. Fans shall be complete with mounting frames, bolts and accessories, as required.

### **2-11.4 Centrifugal Fans**

These shall be forward curve or back-wardly curved air-foil fan as scheduled, complete with housing, motors, drive equipment, supports, vibration isolators and inertia bases of slide rails as required and as scheduled. Shaft shall be cold drawn, hot rolled or forged steel ground to close tolerances for perfect bearing fit and shall be provided with keys and keyways for impeller hubs and fan pulleys.

Housing shall be heavy gauge steel suitably braced to provide stiffness to housing and rigid supports for bearings. Fan blades shall be continuously welded to backplate.

All bearing shall be cast pillow block, ball or roller bearings, self-aligning type. Bearings shall be selected for 60,000 hours minimum life

based on continuous operation at operating fan RPM.

Fan outlet shall be equipped with removable angles and bolts for attaching canvas or other flexible connections. Fan housing shall be provided with access panels and drain plugs.

Centrifugal fans shall be designed to have weatherproof construction and should be suitable for exposed installation.

#### **2-11.5 In Line Centrifugal Fans**

These shall be centrifugal in line type, of characteristics and capacities as Scheduled. Fans shall be belt driven as Scheduled. Fan motors above 1/2 HP shall be 3-phase induction type and 1/2 HP or smaller shall be single phase split capacitor. Motors for direct drive fans shall be mounted within fan casing and centrifugal impeller attached to the motor shaft end. Motors for belt driven fans shall be mounted on fan casing. Motor base shall be adjustable type with pivot at one end for easy and accurate belt adjustment. The fan inlet shall have an aerodynamic design to ensure turbulence free airflow at discharge. Centrifugal impeller blades shall be backward inclined or aerofoil type. Fan casing and impeller shall be made of heavy gauge steel. Impeller shall be dynamically balanced and shall have cast iron hub. The fan bearings shall be self-aligning ball bearing type. Fan shall have an inner cylinder and belt duct to protect bearings and drive from the air system. Fan motor and drive shall have weatherproof cover. A bolted access shall be provided in the fan casing for cleaning and inspection. The fan casing shall have flanges with holes for connection to ductwork. Fans shall be complete with mounting frames, brackets for ceiling suspension, bolts and accessories, including belt guard and spring vibration isolators as required.



## SECTION 3 - FOUNDATIONS AND SUPPORTS

### 3-01

#### GENERAL

All equipment, piping and ductwork where used shall be mounted on or suspended from foundations and supports, all as specified, as shown and as required. All concrete foundations where required, including thickened structural slab, housekeeping pads and concrete for inertia pads will be provided by the Employer or other Contractor appointed by the Employer or HVAC Contractor as described in Special Provisions Clauses SP-02 & SP-03.

Shop drawings, other information and templates for all concrete foundations where used, shall be provided by Contractor as per recommendations of the manufacturer of the equipment. Necessary integral steel framings, concrete reinforcing rods welded to frame, required anchor bolts, spring mountings, and neoprene pads, shall be provided by the Contractor. The Contractor shall cooperate with those doing the flooring work to ensure proper installation of all these elements.

Foundations and vibration isolation mountings for various equipment, piping, and ductwork where used shall be as per requirements specified. Vibration isolators where used shall be of approved make.

Springs used for vibration isolation shall be single, open coil type and laterally stable, having a ratio of loaded height to mean coil diameter not greater than 1.25. To preclude possibility of spring coils "shortening" when motor starts or slows down, the springs shall be selected so that there remains when the spring is design loaded, a reserve deflection of between 25 and 30% of maximum deflection of free spring. When fully compressed, maximum stress in steel should not exceed yield stress of spring material. Springs shall be unhoused and held well clear of any part of suspended mass. Isolated system if supported on a flat slab type base shall be held clear of supporting structure or pad by the minimum distance thought necessary for efficient housekeeping or 1 inch. Lower end of each spring shall be supported on a rigid, square steel base plate sufficiently thick to withstand a bearing pressure of 427 kPa. This plate should be complete with 3 thickness of type W neoprene waffle pad between under inside of plate and supporting structure. A 16 gauge steel shim plate bonded to pad surfaces shall separate adjacent thicknesses. Spring base plate shall also be bounded to top layer of pad. Pad area should be chosen to suit hardness of neoprene. For 40 durometer neoprene, bearing pressure on supporting structure shall be 276-352 kPa when spring is design loaded. Waffle pads may have to be cut away in the middle of pads since pads shall have same overall dimensions as spring baseplate.

All pipe hangers must be insulated from the building by cork inserts between the hanger bar fixing and the connection to the structure. Details of the Contractor's method of achieving this shall be submitted

to the Engineer for approval. All ceiling hung equipment having fans and motor as integral part of equipment shall have adequate vibration isolators.

All ceiling hung equipment having fans and motor as integral part of equipment shall have adequate vibration isolators.

Flexible duct connections, as specified elsewhere, shall be fitted wherever ducts cross building expansion joints, at suction and discharge end of each air handling unit and fan wherever ducts are connected to such unit, and/or wherever shown on the drawings. Supply outlet of concealed ceiling-mounted fan coil unit shall also be connected to Fan-coil with flexible connection.

Details of all vibration isolators, flexible connections and bases shall be submitted to the Engineer for approval.

## **3-02 MOUNTING OF EQUIPMENT**

### **3-02.1 Floor or Roof Mounted Equipment**

All floor or roof mounted equipment shall be generally placed on at least 4 inch concrete house keeping pads, unless otherwise indicated. The pads shall be constructed on 1 inch thick cork-sheet. Protective curbs shall be provided on all sides of the pad to protect the cork sheet edges. Special attention shall be given to the equipment at roof and intermediate floors and heavy equipment like Pumps and Chillers shall be mounted on spring isolators / inertia pads. The spring isolators shall preferably be supplied by equipment manufacturer and shall be from manufacturers specializing in manufacturing of vibration isolators. Manufacturer's recommendations for prevention of vibration and noise travel to the structure shall be adopted. The foundation details shall be subject to the approval of the Engineer.

### **3-02.2 Wall Mounted Equipment**

All equipment installed through wall shall have 20 gauge galvanized sheet metal which shall remain in place permanently. Sleeves shall be packed with non combustible glass fiber insulation minimum of 1.5 lb/cu.ft density and sealed with sealant. Equipment installed through walls shall have supporting wall brackets.

### **3-02.3 Air Inlets/Outlets**

All wall grilles/EA-OA louvers shall be fixed to wooden frames and not to the ceiling material/wall masonry. Metallic frames may be used with metallic frame false ceilings. Wooden wall frames shall be grouted and finished by Contractor.

### **3-02.4 Ceiling-Hung Equipment**

All ceiling-hung equipment shall be hung from ceiling (concrete slab) and shall not rest on false ceiling.

**3-02.5 Floor Mounted Equipment**

All floor-mounted equipment shall be resting directly on the raised floor pad (or supported from wall when approved by the Engineer).

**3-03 VIBRATION ISOLATION**

Vibration isolation bases shall be provided and installed under all pumps, to prevent the transmission of vibration to the building structure, as shown on Drawings.

Where fans and motors are integral parts of factory assembled air handling units and the fans and motors are not spring isolated from the air handling unit, the entire unit shall be mounted on vibration isolators.

Inertia pads where indicated shall be reinforced cement concrete pad, at least 4 inch thick with 4 inch steel channel all around to protect concrete edges. Reinforcing rods shall be welded to channel frame.

Floor mounted Fans with belt drives shall be mounted on continuous rails with sliding base for motor adjustment and fan-rails shall be mounted on vibration isolators as specified above. When shown on Drawings, continuous rails shall be mounted on Inertia pads and pads shall be mounted on vibration isolators.

Flexible pipe connectors shall be installed in piping to prevent vibration and noise travel. Location and construction of these connectors are specified in Section on "Piping, Fittings, Valves and Specialties."

## **SECTION 4 - DUCTING AND SHEET METAL WORK**

### **4-01 GENERAL**

#### **4-01.1 Ducting Material**

All duct work shall be of galvanized steel sheet unless otherwise indicated on Drawings. Galvanized steel shall be of lock forming quality (LFQ) and shall have a galvanized coating of 8 oz total for both sides of one square meter of a sheet. The GI sheet shall conform to ASTM A-525 and ASTM-90. Duct work shall also be Pre-Insulated Polyurethane Ducts with  $52 \pm 2$  KG/CUM minimum density of 22 to 40 mm thickness.

Galvanized steel sheet shall be Cut Lengths coated by the Hot-Dip Method and manufactured per ISO Standard 3575-76 zinc coating designation Z-275, and base metal quality 02.

#### **4-01.2 Structural Steel**

Structural Steel shall be M.S. members rolled from Pakistan Steel billets or equivalent conforming to ASTM designation A-36 standard specifications for structural steel.

#### **4-01.3 Canvas Cloth**

Canvas Cloth shall have specified weight with flame retardant quality.

#### **4-01.4 Painting**

All steel work in connection with supports for ductwork etc. exposed to the elements is to be painted with two coats of an approved rust preventive paint.

All exposed metal surface of hangers, brackets, etc. must be painted with two under-coats and two finishing coats of enamel paint of approved colour. G.I. sheet is not to be painted. However, all uninsulated pipe work and valves are to be painted as stated above.

Identification bands shall be painted on uninsulated ducting, or on insulation at frequent intervals. Lettering shall be agreed with the Engineer.

All duct hangers in concealed locations shall be given one coat of black asphalt paint before being concealed.

### **4-02 DUCT CONSTRUCTION**

All sheet metal ductwork shall be of a standard construction and erected in a first class workmanlike manner. The ductwork shall be

constructed as per SMACNA Low Velocity Duct Construction Standards

Where specified, duct work shall be provided with interior insulation. Ducts shall be straight and smooth on the side, with joints neatly finished. Where ducts are lined with interior insulation, the dimensions required shall be for the net free area after insulation is applied. Ducts shall be anchored securely to the structure in an approved manner and shall be installed so as to be completely free from vibration under all conditions of operation.

Sheet metal ducts shall be properly braced and reinforced with steel angles, or other structural members approved by the Engineer Unless otherwise required, the internal ends of all slip joints shall be installed in the direction of flow.

Finished work shall show no flaking or peeling within 1/4" of a cut edge. The construction and gauge of material, size and spacing of stiffeners for duct work shall be as follows:

Larger Dim. of Duct (in.)	Gauge (US)	Traverse Joint Type/Size (Inch)	Interm Bracing, Angle Size (Inch)	Max. Spacing between Traverse Joint &/or Interm Reinforcement
Thru 12	26	Drive slip/-	-	-
13 thru 18	24	Drive slip/-	-	
19 thru 30	24	Pocket lock/1	1x1x1/8	5
31 thru 42	22	Pocket lock/1	1x1x1/8	5
43 thru 54	22	Pocket lock/1-1/2	1-1/2x1-1/2x1/8	5
55 thru 60	20	Pocket lock/1-1/2	1-1/2x1-1/2x1/8	5
61 thru 84	20	Angled reinforced standing seam	1-1/2x1-1/2x1/8	5
85 thru 96	18	Angled reinforced standing seam	1-1/2x1-1/2x1/4	2.5
Over 96	18	Angled reinforced standing seam	1-1/2x1-1/2x1/4	2.5

Other types of Traverse joints allowed as per ASHRAE/ SMACNA Standards shall be acceptable, subject to Approval of Engineer, in places where pocket lock is not possible due to tight space.

All angles for bracing shall be painted with one coat of approved rust-inhibitive paint before fixing to duct.

All duct work in the finished areas shall be run parallel to the beams wherever possible. All outlet opening and open ends shall be kept closed with sheet metal caps during construction. Rectangular duct shall be constructed by breaking the corners and grooving the

longitudinal seams. Elbows and transition sections may be formed with Pittsburgh corner seams but complicated fittings shall be constructed with double seams. Angle bracing shall be of steel and shall be carried out on all four sides of the ducts. All bracing is to be in accordance with the current addition of the ASHRAE Hand Book/SMACNA Standards.

#### **4-03 ELBOWS**

Ducts shall be built with curves and bends, where required, to affect an easy flow of air. Curved elbows shall have a centre line radius at least equal to 150% of the width of the duct unless otherwise indicated. All duct curves having an inside radius smaller than the width of the curve shall be equipped with approved single thickness vanes.

Vertical ducts shall have full size bends where horizontal branches are taken off unless otherwise indicated, and/or approved.

Where square elbows are used in changing directions, approved and aerodynamically correct vanes as per latest SMACNA Duct Construction Standards shall be used.

These turning vanes must be free from vibration when the system is in operation.

#### **4-04 HANGERS**

Hangers and supports shall be fastened to the structure in a manner approved by the Engineer. All fastening shall be such as to ensure permanent stability and to be capable of supporting at least three times the applied load.

Galvanized sheet metal ducts less than 20" in width (larger dimension) may be suspended by means of galvanized iron straps extended along the bottom of the duct to form a trapeze, only if hanger length above the duct is not more than 12".

All other ducts shall be suspended by means of iron bars securely fastened to the angle iron bracing or angle iron placed under the duct. Bars shall be fastened to bracing only on un-insulated ducts.

Bars shall be welded to angles at ceiling, attached therein by anchor screws and heavy iron washers. Where horizontal ducting is fixed to walls, columns, supported from floor slabs, etc. angle iron frames are to be fabricated and fitted to support rectangular ductwork and associated equipment.

Vertical ducts are to be supported by steel angles bolted to at least two sides of the duct and on the complete circumference of the ducts where the larger duct dimension is greater than 24 inch.

Angle iron extensions shall be either grouted or bolted to the structure. Hangers spacing and sizes shall be as follows.

Larger Duct Dim. (Inch)	Strap Size (Inch)	Bar Dia (Inch)	Bottom Angle Size (Inch)	Maximum Spacing (Feet)
Thru 12	1" x 22 ga.	3/8	1x1x1/8	8
14 thru 18	1" x 22 ga.	3/8	1-1/4x1-1/4x1/8	8
19 thru 30	1" x 18 ga.	3/8	1-1/2x1-1/2x1/8	8
31 thru 42	1" x 18 ga.	3/8	1-1/2x1-1/2x1/8	8
43 thru 54	1" x 16 ga.	3/8	1-1/2x1-1/2x1/8	7
54 over	1" x 16 ga.	1/2	2x2x1/4	6

Hanger rods shall be cross-braced whenever the length of rod above duct work is more than 3 ft. to prevent swing of ducts.

All structural steel including hanger rods and angle iron shall be painted with one coat of approved rust- inhibitive paint before installing.

#### **4-05 QUADRANTS FOR VOLUME DAMPERS**

All dampers other than dampers behind registers and diffusers shall be fitted with substantial locking quadrants, mounted outside the duct in an accessible position. On insulated ducts the quadrants shall be fastened to bearing plates flush with the outside finish of the insulation.

#### **4-06 DAMPERS**

##### **4-06.1 Volume Dampers (V.D)**

A substantially constructed manual volume damper of the butterfly or multiple blade type as per latest SMACNA Duct Construction Standards shall be fitted where shown on the Drawings and at all branch entries or exits with main ducts for balancing purposes. Dampers shall have galvanized or painted steel interlocking blades of 8" maximum blade width. Blades shall be fabricated from 16 gauge steel with seamed edges and a maximum length of 4 ft. It should be noted that these dampers, shall be separate and independent from the dampers, hereinafter specified. Volume Dampers are not required where splitters Dampers, as specified hereinafter, are installed.

##### **4-06.2 Splitter Dampers (S.D)**

At each point of division in a supply trunk duct where a branch is taken off a trunk duct, an adjustable splitter or deflecting damper, one gauge heavier than the duct with operating rod and locking quadrant as above, shall be installed. These deflecting dampers shall be permanently set and locked in position after completion of the installation and adjustment with fans running.

Operating rods are to be full blade length extending through the duct to externally mounted bearing plates. Construction shall be as per latest SMACNA Duct Construction Standards.

#### **4-06.3 Fire Dampers (F.D)**

Fire dampers are to be installed as shown on the drawings. Frame shall be 4"x1"x1/8" galvanized steel channel with 16 gauge thick blades. Blades shall have an overlap of 1" and shall be fixed on self-lubricating bronze type bearings.

Dampers shall be complete with linkage rod and fusible link rated at 160 deg F. Damper construction shall meet NFPA 90-A requirements, and shall have the "hour" fire-rating not less than the fire rating of the plane where installed. Fire dampers shall be air tight when in close position.

#### **4-07 FLEXIBLE DUCT CONNECTIONS**

Flame proof flexible connections shall be furnished and installed on all suction and discharge connections of fans and air-conditioning units for prevention of transmission of vibration through the ducts to occupied spaces.

Flexible connections also be provided wherever ducts cross building expansion joints.

Flexible connections shall be factory fabricated of imported origin, made from chemically impregnated canvas or other material approved by the Engineer. Connections shall fit closely and are to be secured in an airtight fashion at connections to ductwork, fans and apparatus. The unclamped section of the flexible connection between apparatus and ductwork shall not be less than 6" in length. Flexible connections shall not be painted or insulated. Samples of the material shall be presented to the Engineer for approval before installation.

#### **4-08 ACCESS DOORS AND PANELS**

Wherever necessary, suitable access openings, doors and frames to permit inspection, operation and maintenance of all filters, controls, dampers, bearings or other apparatus shall be provided in ducting. Doors shall be of double construction, of not lighter than 20 gauge metal sheet and shall have sponge rubber gaskets around their entire perimeter. On insulated duct work the space between the inner and outer door sheets shall be insulated as specified for the ductwork. All access doors in sheet metal shall have air tight seal, shall be hung on heavy flat hinges and shall be secured in the closed position by means of wing type nuts and screws or coin operated catches.



**4-09 SLEEVES**

Where ducts pass through walls, partitions, or floors, wooden sleeves shall be provided by the Contractor and these sleeves shall remain in place permanently. Sleeves shall be packed with non-combustible glass- fiber insulation, minimum of 1.5 lbs/cu.ft. density and sealed with sealant.

**4-10 TEST WELLS**

The Contractor shall provide test wells for measurement of air velocity and static pressure for balancing purpose. These wells made up of a brass nipple with screwed caps are to be fixed into the duct or casing on the downstream sides of each fan, filter, AHU, FCU and branch volume damper in each branch supply duct, and on upstream side of branch volume damper in each branch return. The design of test well shall be subject to Engineer's approval.

**4-11 FLEXIBLE ROUND INSULATED DUCTS**

This shall be round insulated duct, factory made with 1 1/2" thick fiberglass blanket wound round a coated helix wire coil and fiberglass inner mesh liner. Thermal conductance shall not be more than 0.27 btu/hr-sft-deg F at 75 °F and shall meet the fire safety requirement of UL 181 Class 1 air duct. Flexible round duct shall be as manufactured by certain Teed (USA) or approved equal.

**4-12 BREACHING/FLUE STACK**

The contractor shall provide welded steel breaching/stack for size and configuration as required and as per recommendations of the manufacturer. Fabrication shall be by welding using no less than 3.4 mm thick plate conforming to ASTM A 36 or A 283. Structural angle flanges for breaching and boiler connection shall be provided. Stack shall be terminated as shown on drawings and at at least five (5) feet above cooling tower fan level and shall be provided with weather cap on top.

## **SECTION 5 - PIPING, FITTINGS, VALVES & SPECIALITIES**

### **5-01 GENERAL**

- 5-01.1** Each part of the piping system shall be complete in all details and provided with all control valves and accessories necessary for satisfactory operation.
- 5.01.2** The Tender Drawings indicate generally the routes of all main piping and sizes are shown on Drawings for quotation purpose. The Engineer reserves the right to change the runs and sizing of piping to accommodate conditions during construction.
- 5.01.3** All piping shall comply with the requirements of the ANSI B31.1 Code for Power Piping. The other pressure vessels shall comply with ASME Boiler and Pressure Vessel Code Section VIII.
- 5-01.4** All piping shall be grouped wherever practicable and shall be erected to present a neat appearance. Pipes shall be parallel to each other and parallel or at right angles to structural members of the building and shall give maximum possible headroom.
- 5-01.5** All pipe drops shall be truly vertical. No joints shall be formed in the thickness of walls, floors or ceilings. The Contractor is responsible for ascertaining the thickness of plaster and other wall finishes, skirting heights, cill lengths and floor finishes.
- 5-01.6** Piping shall not pass in front of doorways or windows and shall be generally arranged so that it is at least 3" above finished floor level and at least 1" from finished wall faces. Sufficient space is to be allowed for accessibility for servicing.
- 5-01.7** Piping shall be pitched for proper circulation and drainage. Runouts shall be graded in such a manner as to prevent air traps being formed within them when the mains expand or contract. Automatic or manual vents are to be provided at high points. All automatic vents shall be piped to suitable drains.
- 5-01.8** All drain piping shall pitch down in direction of flow. All drains from items such as drip pans of air conditioners and air handlers shall be piped to spill over an open sight drain, floor drain, roof gutter or other acceptable discharge points and shall be terminated with a plain end unthreaded G.I. Pipe, 6" above the drainage. Drain piping from all air handling units except fan coils shall have 3" water seal unless indicated otherwise.
- 5-01.9** All low points of the system must be fitted with drain valves to permit the complete drainage of the system. Bottoms of all risers must have dirt pocket the size of the riser of at least 12" long with a drain valve fitted. All water piping to equipment and valves shall be connected with

either flanges or unions for dismantling and removal. All piping shall be reamed after cutting to remove all burrs.

- 5-01.10** Approved pipe fittings shall be used and bending of pipes will not normally be allowed except for black steel pipe 2" diameter and under which shall be permitted where space conditions allow for a bending radius of at least 10 times the diameter of the pipe. A hydraulic pipe bender shall be used to bend all pipes. Bends showing kinks, wrinkles, or other malformations, will not be acceptable.
- 5-01.11** Piping shall not be installed passing through ductwork or directly under electric light fixtures, unless indicated otherwise.
- 5-01.12** In placing pipes through sleeves, near walls, partitions or in chases, care must be taken to provide sufficient space for pipe fittings and covering.
- 5-01.13** Where pipes are held in vices, as when screwing, care shall be taken to ensure that the pipe surface is not damaged. Any pipework so damaged shall not be fitted.
- 5-01.14** All pipes stored on site shall be kept clean and off the ground and where possible stored under cover. Pipes corroded beyond normal "stock-rust" condition shall not be used. Special care should be taken to prevent dirt entering into pipes. The Contractor shall note that a valve fitted to the open ends of a disconnected pipe is not considered satisfactory to prevent entry of foreign matter. Screwed iron caps or plugs or plastic covers shall be used to seal pipe ends. Wood, rag, paper or other inadequate plugs will not be permitted.
- 5-01.15** Before connecting upto return mains, the system of piping must be blown and flushed out. After flushing, all strainers shall be opened and baskets cleaned.
- 5-01.16** Liberal allowance shall be made for expansion and contraction of pipes by means of changes in direction or by the inclusion of expansion joints in the piping system. Flexible connections shall also be provided whenever piping cross building expansion joints. Not less than 2 Pipe Guides as approved by the Engineer shall be used on both sides of expansion joint/loop.
- 5-01.17** All steel work in connection with supports for pipes exposed to the elements is to be painted with two coats of an approved rust preventive paint.

All exposed metal surface of hangers, brackets, etc. must be painted with two under-coats and two finishing coats of enamel paint of approved colour. G.I. sheet is not to be painted. However, all uninsulated pipe work and valves are to be painted as stated above.

Identification bands shall be painted on piping or on insulation at frequent intervals. Lettering shall be agreed with the Engineer. All pipe hangers in concealed locations shall be given one coat of black asphalt paint before being concealed.

## 5-02 PIPING, FITTINGS & ACCESSORIES

### 5-02.1 Pipe Schedule

Sr. No.	Service	Size	Specifications
(a)	Seamless Steel		
(i)	Chilled/hot & condenser water	All sizes	Schedule 40 black seamless steel, ASTM A 106 Grade B or equivalent
(ii)	Chemical Feed, natural Gas and high speed diesel oil	All sizes	Schedule 40 black seamless steel, ASTM A 106 Grade B or equivalent
(b)	Galvanized steel		
(i)	Cooling Coil condensate drain	All sizes	Galvanized steel, Light Quality BSS 1387
(ii)	Make-up water, and drain copper	All sizes	Galvanized steel, Light Quality BSS 1387
(c)	Piping for auto vents discharge	1/4"	Copper, Type K

### 5-02.2 FITTINGS

#### 5-02.2.1 General

Fittings shall conform to following Schedule; in piping 6" and larger, "stub-in" type connections will be permitted when branch line is at least four pipe sizes smaller than main run.

#### 5-02.2.2 Fittings Schedule

Sr. No.	Service	Size	Specifications
(a)	Seamless Steel Piping		
(i)	Chilled/hot & condenser water	2.5" & smaller	150 lb black steel threaded fittings, ANSI B 16.11, ASTM-A105.
(ii)	Chilled/hot and condenser water	3" & larger	Schedule 40 black welded steel, welding fittings to ANSI B 16.9
(iii)	Chemical feed,	All	150 lb black cast iron

	natural gas, and diesel oil	sizes	screwed fittings to ANSI B 16.4
(b)	Galvanized Steel Piping		
(i)	Cooling coil condensate drain	All sizes	150 lb malleable iron galvanized screwed fittings to ANSI B16.3
(ii)	Make-up water/drain	All sizes	150 lb malleable iron galvanized screwed fittings to ANSI B16.3

## 5-02.3 UNIONS AND FLANGES

### 5-02.3.1 General

Unions and flanges shall be provided where indicated and/or required for proper installation and maintenance of the system. They shall conform to the respective schedule given hereunder.

Flanges shall have bolt holes drilled and raised faced and fitted with black mild steel bolts, nuts and washers.

If equipment has different flanges to the type specified then mating flanges must be supplied of the same rating to connect to this equipment.

Extend flange bolts through nut at least four full threads when made up.

### 5-02.2.2 Union Schedule

Sr. No.	Services	Size	Description
a)	All services using black steel pipe	All sizes	150 lb malleable iron screwed, conical seat type
b)	All services using galvanized steel pipe	All sizes	150 lb malleable iron, galvanized screwed, conical seat type

### 5-02.2.3 Flange Schedule

Sr. No.	Services	Size	Description
a)	Services using black steel pipe	All sizes	ANSI 150 lb weld-neck or slip-on as indicated or required.
b)	All services using galvanized steel pipe	All sizes	ANSI 125 lb galvanized cast iron screwed pipe

### 5-02.4 Pipe Supports and Anchors

All supports for steel piping shall be ferrous. Brackets or supports shall be set out so that they do not obstruct the access to valves, flanges or other fittings requiring maintenance.

All pipework shall be supported by means of approved clips or hangers at centres as specified. In the event of two or more pipes being carried by a single support the spacing shall be for the shorter interval.

All vertical drops shall be supported so as to prevent sagging or swinging. Unless otherwise indicated, pipe hangers are to be spaced as follows:

<b>Nominal Pipe Size (Inch)</b>	<b>Maximum Span (Feet)</b>	<b>Minimum Rod Dia (Inch)</b>
1 and smaller	6	3/8
1 ¼ - 1 ½	8	3/8
2 – 2 ½	10	3/8
3	10	1/2
4	12	1/2
5	14	5/8
6	16	5/8
8	20	7/8
10	20	7/8
12	20	7/8
14	20	1
18	20	1

Piping at all equipment, and control valves shall be supported to prevent strains or distortions in the connected equipment, valves and control valves. Piping shall be supported to allow for removal of equipment valves and accessories with a minimum of dismantling and without requiring additional supports after these items are removed.

All channels, angles, plates, clamps etc. necessary for the fastening hangers shall be furnished by Contractor. All hangers shall be properly sized for the pipe to be supported. Oversized hangers shall not be permitted, without Engineer's approval.

All hangers shall be provided with lock nuts and have provisions for vertical adjustment of pipes.

Individual horizontal piping shall be supported by hangers consisting of malleable split rings with malleable iron sockets, or steel clevis type hangers, or roller hangers as directed by the Engineer.

Pipe stands with base flanges and adjustable type yokes shall be used for pipes supported from the floor.

Vertical piping shall have heavy wrought iron or steel clamps securely bolted on the piping with the end extensions bearing on the structure of the building.

Piping shall be anchored where required to localize expansion to prevent undue strain on piping and branches. Anchors shall be entirely separate from hangers and shall be heavy forged or welded construction of approved design.

Hangers for cold piping shall have hardwood inserts or high density insulation capable of withstanding the compression and allowing the hanger to support the pipe without any metal contact.

Upper ends of iron rods shall be welded to angles attached to ceiling (concrete slab) by anchor screws and heavy iron washers.

#### **5-02.5 Pipe Sleeves**

All pipe penetrating through walls, partitions and slabs shall have sleeves having an internal diameter at least 1" larger than the outside diameter of the pipe or of the insulation passing through the sleeves. Pipes passing through interior masonry or concrete floor shall be provided with sleeves of galvanized standard wrought steel pipe flush with walls and ceilings and extending 1" beyond external surface of wall or above finished floor.

On the exposed pipes, passing through floors, wall, partitions plaster furrings, split type nickel plated circular steel plates, 3" larger in outside diameter than the outside diameter of the pipe or pipe covering, shall be provided.

#### **5-02.6 Flashing Sleeves**

Flashing sleeves are to be provided where pipes pass through water proof membranes. Flashing sleeves details are to be submitted to the Engineer for approval but generally they shall be provided with an integral flange set into the membrane. The associated pipe shall also have a flange and sealed with approved mastic.

### **5-03 VALVES AND SPECIALITIES**

#### **5-03.1 General**

Valve and piping specialties shown on drawing are only schematic and all required valves and specialties are not necessarily shown on drawings.

The Contractor shall furnish all shut-off valves, check valves, drain cocks, dirt traps, automatic vents, manual vents, relief valves, strainers and other specialties as are required for proper operation of the whole system.

All valves of size 2" and larger shall have cast iron body and renewable bronze seal rings, bronze spindles and self packing feature so that

they can be packed while open and under pressure.

All valves smaller than 2" shall be of brass body with threaded connection.

All valves shall be of design and construction to conform to the 1.5 time the maximum design pressure (minimum 150 psi at 250 °F) of the system, but not less than PN-16. All valves shall be provided with epoxy/ powder coating as per standards. The valve rings/ cope shall be made of Teflon.

**5-03.2 Plug Valves**

Plug valves shall be used for drain cocks and stop cocks at air vents.

**5-03.3 Pressure Reducing Valves**

Pressure reducing valves shall be used where shown on the drawings.

**5-03.4 Balancing Valves**

Circuit setter type valves as specified hereunder shall be used for balancing purpose where shown on drawings.

Globe valves shall be used for balancing purpose where shown on drawings.

Shut-off valves shall be installed on both sides of all equipment. Balancing valves shall be installed where required for flow balancing. Make of valves shall be subject to Engineer's approval.

**5-03.5 Gate Valves**

Gate valves shall be used for shut-off purposes. All valves shall be designed for packing under pressure when fully open.

**5-03.6 Relief Valves**

Relief valves shall be provided for over-pressure protection. Valves shall have flanged-end connections except for valves 1" and smaller.

**5-03.7 Globe Valves**

All globe valves shall be of cast iron with bronze disc valve. Each globe valve shall be constructed with internal seal to prevent leakage around rotating elements

**5-03.8 Circuit Setter Type Valves**

These valves shall be calibrated cast iron with bronze disc valve equipped with readout valves. Each readout valve shall be fitted with an integral check valve designed to protect the user from being wetted



when setting up to monitor flow. An integral pointer shall register degree of valve opening. Each balance valve to be constructed with internal seals to prevent leakage around rotating element. Balance valve shall be ITT B&G (USA) model CB or approved equal.

The Contractor shall arrange for the Read-out kit specified by the manufacturer for balancing flow through the valves without any additional cost.

**5-03.9 Non-Return/Check Valves**

Non-return/check valves shall be non-slam check valves, spring loaded with stainless steel torsion spring. The valves body shall be of cast-iron with lapped bronze seat, and spring loaded twin balanced flappers of bronze. The flappers shall open and close at low differential pressures to prevent damaging effects of water hammer created on pump shut-down.

**5-03.10 Strainers**

Approved strainers shall be fitted in the suction line of pumps, at make-up connections and at each automatic control valve of all apparatus of an automatic character whose proper functioning would be interfered by dirt on the seat, or by scoring of the seat. All strainers shall be pressure tested at works.

All strainers shall be cast iron or bronze bodies of ample strength for the pressure to which they shall be subjected and with suitable flanges or tapings to connect with the piping they serve.

Strainer basket screens shall be stainless steel and shall be of ample strength to prevent collapsing the basket under shock loading. Perforations shall be in accordance with the following table:

<b>Pipe Size</b>	<b>Perforation Size ( inch )</b>	<b>Number of Perforations per sq. in.</b>
All Sizes	3/64	225

Valve dirt blow-out connection suitably piped to the nearest floor drain.

**5-03.11 Air Vents**

Wherever possible, all water pipework systems shall have manual venting at all high points in the system. Where this is not possible an automatic air vent shall be fitted and connected to the nearest drain. Air vents shall be of the flat type, and of appropriate sizes and working pressures. They shall be fitted with a suitably sized gate type lock

shield valve. Manual vents shall be fitted with hose-nozzles.

### **5-03.12 Flexible Pipe Connectors**

Flexible connectors shall be provided wherever pipes cross building expansion joints, at suction and discharge side of each pump and at connections to chillers, and/or wherever shown on the Drawings. These connectors shall be such that the working pressure, temperature and movement encountered will not be more than 75% of that allowable for the joint. One side of joints must have all piping and/or adjacent equipment adequately anchored. The other side must be supported, aligned and guided so as to allow free movement without imposing unnecessary stresses on the joints.

Connectors shall have integral duck and rubber flanges. They shall have individual solid steel ring reinforced with a carcass of highest grade woven cotton or acceptable synthetic fibre. Joints shall be constructed to pipeline size and to meet working pressures, conditions and face measurements as designated. They shall be of archetype construction with the number of arches (corrugations) dependent of the projected movement. All joints must be finish- coated with suitable paint to prevent ozone attack. Split back-up (or retaining) rings shall be furnished and fitted.

### **5-03.13 Thermal Expansion Joints**

Thermal expansion joint bellows shall be fully annealed type 321 stainless steel sheet stock rolled into a tube and seam welded with latest technology in forming the corrugations. The bellows shall be designed to take linear thermal expansion as well as axial load.

The end connections will be fixed flanged type and shall be of stainless steel conforming to ANSI dimensions welded directly to the integral ends of the bellows.

The thermal expansion bellows shall be designed to absorb the thermal expansion of at least  $\pm 50$  mm and working pressure of 16 bars.

## SECTION 6 – INSULATION

### 6-01 GENERAL

**6-01.1** The Contractor shall provide insulation for the services and equipment specified hereafter. Insulation shall be as per following Insulation Schedule.

**6-01.2** Insulation material shall be complete with vapour barrier protection covering and jacketing (where specified), adhesives, insulation tape, duct sealer and/or sealing tape, fastening material, and jacketing for outdoor ducting and piping.

**6-01.3** Identification bands shall be painted on insulation at frequent intervals. Lettering shall be agreed with the Engineer.

All exposed insulation in the plant room is to be painted to approved colours with one undercoat and one finishing coat of enamel paint. All steel pipework and other steel equipment specified to be insulated shall be thoroughly wire brushed to the satisfaction of the Engineer and painted with one coat black cold asphalt paint before insulation is applied.

### 6-01.4 Insulation Schedule

Sr. No.	Services	Thick-ness (Inch)	Insulation Type	Vapour Barrier	Protection
a)	Indoor supply/return duct				
i)	Concealed to vision outdoor-air duct passing through conditioned space	1	Glass fibre blanket	Reinforced aluminum foil	8-Oz canvas
ii)	Exposed to vision and plant rooms	2	Glass fibre blanket	Reinforced aluminum foil	4-Oz canvas with water proof paint. GI/A1. sheet metal jacketing.
iii)	AHU rooms	2	Glass fibre blanket	Reinforced aluminum foil	4-Oz canvas with water proof paint.
b)	Supply ducts, upto 10 feet from fan discharge and sheet metal air plenums	1	Acoustic liner applied inside with outside insulation as Item 6-02 (a)	Same as 6.02 (a)	
c)	Chilled/hot water piping, fitting valves & specialties				

i)	Indoor	See 6-02(h)	Sectional glass fibre	Reinforced aluminum foil	4-Oz canvas
ii)	AHU rooms	See 6-02(h)	Sectional glass fibre	Reinforced aluminum foil	4-Oz canvas with water proof paint.
iii)	Central plant room and outdoor	See 6-02(h)	Sectional glass fibre	Reinforced aluminum foil	4-Oz canvas with water proof paint. GI/A1. sheet metal jacketing.
d)	Cooling coil condensate drain piping	1/8	(Self adhesive vinyl aluminum tape)	Reinforced aluminum foil	--
e)	Chiller	As per recommendation of chiller-heater manufacturer			
f)	Expansion tank and air separator	1	Glass fibre blanket	Reinforced aluminum foil	1/2" thick 8 Oz canvas water proof paint metal jacketing.
g)	Chilled/hot water pumps	3	Granulated cork	-	GI sheet sectional jacket in box form.
h)	Insulation thickness if not specified above shall be as under:				
i)	Water pipe	Upto 2" 2-1/2" to 5" 6" and above	--	--	1" thick 2" thick 2-1/2" thick
ii)	Valves and other specialties	Thickness shall be same as applied to connected pies.			--
l)	Flue stack / breaching	2	Mineral fiber	--	1" thick reinforced magnesia further with G.I sheet metal jacket.

## 6-03 INSULATION MATERIALS

### 6-03.1 Duct Insulation

Insulation material for ducts and sheet metal air plenums shall be flexible glass fibre, 0.75 lbs/cu.ft. density and maximum conductivity of 0.27 Btu/hr.sq.ft./inch at 75 deg F

### 6-03.2 Piping Insulation

**Piping insulation shall be sectional glass fibre as specified above in Insulation Schedule, bounded to conform to the pipe. All glass fibre pipe insulation shall**

**have a density at least 4 lb/cu.ft. and maximum conductivity of 0.27 Btu/hr.sq.ft.°F/inch at 75 Deg F. 6-03.3 Vapour Barrier for Duct and Pipe Insulation**

Vapour barrier when specified shall be factory applied flame retardant re-inforced aluminum foil, 0.02 mils thick.

**6-03.4 Acoustic Liner Material**

Acoustic liner shall be 1.5 lbs/cu.ft. density fibre-glass with neoprene scrim on inside surface and thermal conductivity value shall not exceeding 0.27 Btu/hr.sft Deg F/inch at 75 Deg F. Material shall conform to TIMA Standard AHC-101-1975 with latest revisions.

**6-03.5 Cooling Coil Condensate Pipe Insulation**

Shall be 1/8" thick pipe insulation vinyl aluminum 'foam' with aluminum foil self adhesive tape 3" wide.

**6-03.6 Chiller-Heater Insulation shall be as per recommendation of Chiller-Heater Manufacturer**

**6-03.7 Expansion Tank and Air Separator Insulation**

Shall be glass fibre, at least 3 lbs/cu.ft. density.

**6-03.8 Chilled/Hot Water Pumps Insulation**

Shall be granulated cork filled in sectionally constructed, suitably braded removable boxes of 20 gauge GI sheet.

**6.03.9 Insulation for Breaching/Flue Stack**

Shall be spun mineral fiber with thermal conductivity not exceeding 0.56 BTU/(hr) (Sq.ft.)(F)/inch at 600 deg.F. Insulation shall have wire netting jacket on one side and copper clad or brass wire mesh jacket on the other side.

**6-03.10 Insulation Protection Material and Accessories**

**6-03.10.1 Canvas**

4 Oz or 8 Oz per square yard as specified in Insulation Schedule.

**6-03.10.2 Jacket**

26 / 28 gauge (US) galvanized steel sheet or aluminum sheet.

**6-03.10.3 Water Proof Paint**

As approved by the Engineer

**6-03.10.4 Wire Netting**

1" hexagonal mesh, 20 gauge (US), galvanized.

**6-03.10.5 Metal Lathe**

Expanded metal lathe with 1/2 inch diamond mesh.

**6-03.10.6 Banding**

1/2" x 1/48" galvanized steel or aluminum bands.

**6-03.10.7 Insulation Tape**

Insulation tape for joints shall be of aluminum foil type, 2 inch wide, equivalent to Scotch No.473.

**6-03.10.8 Adhesive**

Adhesive for thermal insulation shall comply with ASTM Standard C 916-79 or equivalent. Adhesive for acoustic liner shall comply TIMA Standard AHC-101-1975 or equivalent.

**6-03.10.9 Duct Sealer**

Sealer for duct joints shall be butyle rubber cauking, weather proof and water resistant, conforming to U.S. Federal Specification TT-S-001657 Type 1, as manufactured by Woodmont Products, INC, USA, or approved equal.

**6-03.10.10 Duct Sealing Tape**

Duct sealing tape shall be 3 inch wide self-adhesive vinyl cloth tape.

**6-04 INSULATION APPLICATION**

**6-04.1 General**

All Thermal and accoustic insulating materials shall be installed as specified hereinafter.

Insulation shall be installed in a smooth, clean, workmanlike manner and joints shall be tight and finished smooth.

All surfaces to be insulated shall be dry and free from loose scale, dirt,

oil or water when insulation is applied. Insulation shall be applied in such a manner that there will be no air circulation within the insulation or between the insulation and the surface to which it is applied.

Surface imperfections in the insulation such as clipped edges, small joints or cracks and small voids, or holes not over 1 inch square shall be filled with like insulating material.

Where a vapour barrier is fixed on site it shall be fixed in such a manner as to obviate the possibility of moisture penetration. It shall be fixed where required by means of an approved type bituminous compound or approved equal for tightness.

Insulation for all services shall only be applied until after testing and approval for tightness obtained from the Engineer, unless otherwise instructed in writing by the Engineer.

Insulation for all services shall be continued through sleeves. The insulation on exposed risers shall extend through the floor. Where insulated pipes are indicated on drawings as embedded in the thickness of walls, the insulation thickness may be reduced to 1 inch only.

Insulation is to be applied where indicated on the drawings or called for in these specifications.

#### **6-04.2 Duct Insulation**

Before applying insulation, either sealing tape or duct sealer shall be applied on all corners of traverse joints for air tightness.

The insulation shall be fixed on ducts with a suitable adhesive as specified. Adhesive shall be applied on at least 75% surface area. In addition to the fixing by adhesives, insulation on the underside of ducts exceeding 18 inch width must have mechanical fasteners of an approved pattern to prevent insulation sagging, or alternatively bands as specified above shall be used at intervals not exceeding 4 feet.

All joints on the insulation shall be sealed with 2 inch aluminum foil tape. The tape shall only be fixed to the vapour seal and not to the bare insulation and, therefore, joints in the insulation shall not occur longitudinally at corners of ducts. If it is unavoidable to have joints at longitudinal corners then the insulation must be cut back and the vapour seal folded over the bare edge of the insulation so that the tape adheres only to the vapour seal.

#### **6-04.3 Duct Insulation Protection**

Indoor Exposed Duct: Insulation shall be covered over the vapour seal

with a single layer of canvas with generous overlaps. The canvas shall be fixed with an approved adhesive.

#### **6-04.4 Piping and Accessories Insulation**

All pipes, fittings, valves and equipment requiring insulation in accordance with Insulation Schedule, shall be insulated with material specified under "Insulation Materials".

Longitudinal joints of pipe insulation shall be sealed with an overlap of vapour seal firmly fixed with an approved/specified adhesive. Circumferential joints shall be sealed with insulation tape.

#### **6-04.5 Pipe Insulation Protection**

##### **(a) Indoor Pipe Exposed, and Plant room piping.**

This finishing shall be used where the insulation is exposed to view.

The 8 Oz canvas wrapped around insulation shall be wrapped and fixed with approved adhesive.

The canvas shall be finished with three coats of Benjamin Foster's "Selfas" or other equal and approved. This finish shall be over the canvas wrapped around vapour barrier integral with the insulation.

##### **(b) Outdoor Exposed Piping**

The insulation shall be covered with stout gauge, G.I. sheet or aluminum metal jacketing. This finish shall be over the 8 Oz canvas applied as specified in (a) above.

#### **6-04.6 Insulation for Equipment having Renewable Heads**

Insulation which is applied to equipment having renewable heads and/or access plates shall be applied in a manner which will permit easy removal and replacement of the insulation. In general this shall be accomplished by encasing the insulation in sheet metal boxes which shall be bolted together.

#### **6-04.7 Condensate Drain Piping**

Self adhesive pipe insulation tape, as specified above, shall be spiral-wrapped around pipe, with 50% overlap.

#### **6-04.8 Expansion Tank Insulation/Air Separators Insulation**

Glass fibre insulation fixed with adhesive shall be finished with canvas jacket applied and saturated with adhesive. Insulation shall be further



held with metal bands. Canvas shall be covered with approved gauge G.I./Aluminum sheet metal jacketing.

**6-04.9 Chilled/Hot Water Pumps Insulation**

Insulation shall be granulated cork filled in sectionally constructed, suitably braced removable boxes of 24 gauge G.I. sheet.

**6-04.10 Insulation for Breaching/Flue Stack**

Breaching and flue ducts shall be protected with one layer of magnesia, reinforced with wire netting. Outdoor flue ducts shall have G.I. sheet jacketing over magnesia.

**6-05 PIPE INSULATION PROTECTION SHIELDS**

Insulation shields shall be used at all hangers supporting insulated pipe to protect the insulation wherever fiberglass pipe insulation is installed. Where hangers and insulation shields are installed the insulation shields shall bear only an insulation material which is of such density that it will not compress, crush or deform. Density at these points shall not be less than 6 lb/cu.ft. Thickness and k- factor shall be at least equal to general run of insulation. Insulation manufacturer shall confirm suitability of insulation support without any visible compression.

Shields shall consist of 10 gauge galvanized steel plate. The plate shall be curved to fit the contour of the insulation and shall cover the lower 180 degree of the surface. Shields shall be secured to the insulation by means of galvanized steel or aluminum bands, and shall not be less than 10" in length.

## **SECTION 7 - ELECTRICAL EQUIPMENT AND CONTROLS**

### **7-01 SCOPE**

- a) The Contractor shall supply all panel boards, starting equipment, circuit breakers, busses, isolators, conducting cables, wiring, conduits, earth conductors, etc., for the entire HVAC system.
- b) The earthing system shall consist of supply and installation of earth continuity conductor and running earth conductor all along the cable length. All material such as earth continuity conductors, earth connecting points, including the installation material and accessories shall be supplied and installed by the Contractor as specified.
- c) For further details refer to Clause 7-02, "Distribution and Control Scheme".

### **7-02 DISTRIBUTION & CONTROL SCHEME**

HVAC Contractor shall furnish and install one Main Electrical Panel (MEP-HVAC) to be located in HVAC plant room.

All HVAC equipment shall be served by MEP-HVAC.

The Employer, through other Contractor, will provide incoming feeders from dual source LT panel to MEP-HVAC sized to handle total HVAC load connected to these panels with 4 feet loose termination. The HVAC Contractor will make connections to MEP-HVAC. Earthing conductors between MEP-HVAC and earthing electrodes will also be provided by Employer.

All electrical works downstream of MEP (including MCC-1 to MCC-16) shall be in HVAC Contractor's Scope of Work.

### **7-03 GENERAL**

All electrically operated equipment shall comply in all respects with the relevant B.S Standards including dimensional standards where these exist, except in so far as this Specification is at variance therewith.

All electrically operated equipment shall be so designed that it will continue to function without damage to itself or otherwise, if the voltage and/or frequency vary within the following tolerances.

- Voltage plus or minus TEN percent.
- Frequency plus or minus SIX percent.

The entire installation shall be in accordance with the requirements

and to the entire approval of the Electricity Department of the Government and the approval of the Engineer.

All electrically operated equipment shall be suitable for continuous and prolonged operation in an ambient temperature 50°C. This temperature makes no allowance for local rises in air temperatures due to the operation of the equipment itself or of heat produced in or by adjacent equipment such as compressors, condensers or heaters. The maximum operating temperature in standards specified shall be observed. Allowance for local high ambient temperature shall be made by reducing the permitted rises of temperature above ambient.

#### **7-04 ELECTRICAL MOTORS**

Unless otherwise indicated in these Specifications or in the Schedules, all motors which are not factory supplied by equipment manufacturer shall be totally enclosed fan cooled, of squirrel cage construction and of approved manufacturer. All such local manufactured motors shall be of Siemens make or approved by the Engineer.

Insulation on all motors shall be equal to Class F (IP 55). All motors shall be designed for continuous operation in the ambient temperature of 122 °F (50 °C).

All motors and accessories such as protection and control devices etc. shall comply in all respects with NEMA, current B.S. Standards and I.E.E. Regulations. Single phase motors shall be capacitor-start induction run construction, unless otherwise indicated or specified.

All motors shall be quiet operating guaranteed to fulfill specified requirements without producing any sound audible outside of plant rooms. All belt- driven motors shall have adjustable bases and set screws to maintain proper belt tension, with proper belt guards. Motors installed in the building should be super silent sleeve bearing type.

The starting current of all motors above 10 hp. shall not exceed twice its rated full load current. For motors of rating 10 hp. and below the starting current shall not exceed 7 times its rated full load current or one hundred amps, per line, which ever is larger.

#### **7-05 MOTOR STARTERS AND ISOLATION**

Each three phase motor shall be provided with a protective automatic starter to disconnect the supply in case of:

- Failure of the supply
- Serious drop in voltage
- Flow of excess current
- Failure of any phase (single phasing)

All starters shall be properly de-rated for operation in an ambient temperature of 122 °F (50 °C).

Manual starters may be used for motors 1/2 hp and less and shall include thermal overload protection and disconnect switch. These should only be used when no automatic switching is intended.

DOL starters shall be used only on motors of 10 HP and less.

All motors, control gear and ancillary equipment shall be protected by H.R.C. fuses or circuit breakers in addition to the protective starter mentioned above. Such fuses shall be part of the control gear. The isolator shall be integral with control gear.

Single phase motors shall be protected by circuit breakers with overload protection. Where several starters are mounted in a panel rack or bank, each starter shall have separate H.R.C. fuses or circuit breaker isolator. Manual starters for single phase motors should only be used when no automatic switching is intended.

Where starter operating circuits and ancillary apparatus are energized by an auxiliary supply other than the main power circuit to the motor the isolator shall incorporate auxiliary contacts to effectively isolate all poles of phases of such auxiliary supplies. Where necessary, two isolators shall be used.

All starters not in a central panel shall have a sheet metal enclosure with a removable lid and cover and necessary brackets for mounting on panel or wall. A clear schematic diagram of the starter circuit shall be fixed inside the cover of each starter.

All magnetic starters subject to manual start shall have momentary contact start and stop buttons built into cover. All magnetic starters subject to electrical interlock or automatic control shall have hand-off automatic switches built into cover.

All coils, cores, insulation, contacts and trippers to starters and relays and all parts subject to wear and arcing shall be renewable.

## **7-06**

### **POWER AND CONTROL WIRING**

All power wiring from the point of supply as described in previous sections, to each equipment shall be carried out by the HVAC contractor. All control wiring from each equipment to applicable control panels and motor control center and for complete BMS shall also in scope of HVAC contractor.

All conduits supplied by the Contractor for power and control wiring shall be of heavy gauge 16 SWG steel, manufactured and tested in accordance with BS 31.

The conduit shall be protected by two base coats of red oxide antirust paint and finished in first quality black enamel paint.

The conduit accessories, such as sockets, elbows, bushings, bends, etc., required for installation of conduit shall be furnished by the Contractor. The accessories shall conform to the same quality and specifications as for the conduits. All outlet boxes, inspection boxes, junction boxes, saddles, clamps etc., wherever required shall be provided by the Contractor.

Flexible steel conduits shall be installed at termination to equipment which is subjected to vibration. The flexible conduit shall consist of single-strip galvanized steel which shall be spirally wound, dust tight, mechanically continuous and strong. Where necessary, flexible conduit shall be adequately supported. All accessories for installation of flexible metal conduit shall be provided with an overall rubber covering. At all terminations, the conduit shall be held firmly in position by approved type of glands.

All LT cables for power and control system shall be copper conductor, PVC insulated for single core and PVC insulated PVC sheathed for multicore. All cables shall be of specified voltage grade complying with BS 6346 and/or BS 6004. The PVC insulation shall comply with BS 6746. Conductor shall be stranded or solid high conductivity soft annealed copper complying with BS 6360.

All multicore and single core sheathed cables for circuits operating upto 250 volts shall be 300/500 volts grade. All single core unsheathed cables shall be of 450/750 volt grade.

All power cables for main feeders, main to sub-main feeders, power equipment, etc., shall be multi-core copper conductor, armored or unarmored and shall be of 600/1000-volt grade.

Cable manufactured by M/s. Pakistan Cables Ltd, M/s. Pioneer Cables Ltd and Newage Cables or approved equivalent shall be used.

All cables shall have phase identification colours on insulation of each core. The colour code for three phase circuits shall be red, yellow and blue for phase conductors and black for neutral conductor. Where insulated earth conductor is installed, it shall have green or green and yellow insulation.

Single-phase circuits shall have red for phase and black for neutral conductor.

All DC circuits shall have red for positive and black for negative conductor

## **7-07 APPARATUS CONTROL PANELS (MCC/ACP)**

The panel shall be of sufficient size and dimensions to house various equipment for the installation. The panel shall be provided with lock and double set of keys. The panel shall be minimum of 14 gauge steel painted with powder coating inflammable paint. It shall be of the unit construction single fronted or double fronted type. It will be constructed such that doors are interlocked, preventing access to the devices installed inside without switching off the Main Circuit Breaker on incoming line.

This panel will contain the following equipment (but not limited to)

Circuit breaker on incoming line.

Circuit breakers, one for each outgoing line.

Starters with thermal overload protection for equipment which does not have factory supplied and/or equipment-mounted starter.

Relays, toggle switches, push button stations, hand-off-auto (HOA) switches - Labels on all components.

Terminal strip.

Relays and other devices for Temperature and Automatic Controls furnished by Controls Manufacturer for field installation.

Pilot lights, one for each starter, red for equipment operating.

All internal wiring and accessories clipped individually to the panel and arranged parallel or at right angles.

All indications shall be visible from the front of the panel. Prior to installation, the contractor shall submit for approval of the Engineer the electrical diagram of the whole installation and the suggested electric panel layout showing samples of instruments and components.

## **7-08 LOCAL ISOLATING SWITCHES (LIS)**

The Contractor shall provide local isolating switches moulded-case type enclosed in metal boxes for disconnecting all power to the equipment in emergency and during maintenance, for all equipment controlled by remote MCC or ACP. These switches shall be installed near the equipment within visual range and shall be weather proof for outdoor installation.

## **7-09 COMPONENTS**

The HVAC panels shall be provided with all components as specified and as necessary for the satisfactory operation of the HVAC system. Typical specifications are given hereunder:

### **7-09.1 Bus Bars**

The bus bars shall be made of high conductivity electrolytic copper and shall be completely isolated and mechanically braced for the specified fault level. The phase identification of bus bars shall be by colours applied on full length of bus bars and these shall be red, yellow and blue for phases and black for neutral. The earth bus bar shall be green.

The bus bars shall be triple pole. The neutral and earth shall be of appropriate size to meet the electrical and mechanical requirements of the system. The temperature rise shall not exceed 30°C at rated current.

#### **7-09.2 Circuit Breakers**

The circuit breaker shall be triple pole, moulded case, manually operated type with front drive grip handle. ON-TRIP-OFF indication shall be provided on all circuit breakers. The circuit breakers shall have the following protections and setting range unless otherwise shown on the drawings:

- Adjustable three pole, manual reset thermal overload release of setting range 80 to 100% of rated current.
- Magnetic triple pole short circuit release having range according to manufacturer's standard range.
- The incoming circuit breaker shall have two numbers each of potential free normally open and closed auxiliary contacts rated for 2 amp, 230 VAC. The incoming circuit breaker shall also have ON, TRIP and OFF indicating lamps. The circuit breaker shall have specified rupturing capacity, without the use of back-up fuses. Auxiliary release and trip coils shall be provided for desired operation and/or interlockings as required.

#### **7-09.3 Push Buttons**

Push Buttons shall be momentary make/break contact type (normally open/normally close). These shall be suitable for flush mounting. Push Buttons shall have round/square head. These shall have red and green colors for 'ON' 'OFF' switching operation respectively.

#### **7-09.4 Ammeters and Voltmeters**

All ammeters and voltmeters shall be flush mounting, moving iron, spring controlled type. The front dimensions shall be 96 x 96 mm.

The Ammeters shall have appropriate measuring scales to suit the rated currents of connected equipment and shall indicate an accurate and readable value of the measured current. The Ammeters shall have appropriate overscale range to cater for the initial transient high starting currents.

The meters shall be of accuracy class 1.5 according to BS-89 and 90 and suitable for connection to 5 Amps secondary of current transformers or directly through shunt. A red mark shall be provided at the working voltage on the scale of all voltmeters.

**7-09.5 Selector Switches**

Ammeter and voltmeter selector switches shall be complete with front plate, grip handle, and R-Y-B and OFF position for ammeters and RY-YB-BR-RN and OFF position for voltmeter.

**7-09.6 Air Break Contactors**

The contactor shall be air break, triple pole, 400V AC suitable for the type of duty to be performed. The main contacts shall be silver tipped, butt type with double break per pole. Each contactor shall be provided with 230 VAC single phase operating coil, and minimum two normally open and two normally closed auxiliary contacts wired upto terminals. The number of working auxiliary contacts shall be provided according to the system requirements.

**7-09.7 Indicating Lamps**

Indicating lamps shall be suitable for flush mounting, complete with base, 230 volt incandescent lamp and shall have rosettes of suitable colour (green for ON, Red for OFF and Amber for TRIP).

**7-09.8 Line up Terminals**

Line up terminals wherever provided for control or power circuits shall be suitable for voltage and size of conductors.

The line-up terminals for controls shall be suitable for channel mounting. All necessary accessories such as end-plates, fixing clips, transparent label holder caps and label sheets with marking shall be provided.

**7-09.9 Current Transformers**

Air cooled, ring type current transformers shall be provided having transformation ratio as required. The current transformers shall be of suitable burden having accuracy class 1.0 and have 5 amps secondary.

**7-09.10 Load Break Switches**

Triple pole rotary 500 Volts AC on-load isolating switches of current rating as specified shall be provided complete with front drive grip handle and front plate.



### **7-09.11 HRC Fuses**

HRC fuses shall be provided complete with fuse bases, fuse etc. The fuses shall have a fusing factor as specified for class QI.

### **7-09.12 Control Selector Switches**

The selector switches for lights and other controls shall be rotary cam type, having required number of positions, complete with knob and front plate with position indication.

### **7-09.13 Frequency Converters (Inverter)**

See specifications given under section-8 "Building Management and Control System".

### **7-09.14 Labels**

Each equipment on the panel shall be identified by a nameplate. Metallic nameplate with 6mm high etched letters shall be attached to the panel or integral with it. Lettering shall be cut into the plate to a depth of not less than 0.4 mm and shall show a contrasting colour produced by filling with enamel or lacquer. Painting of lettering directly on the surface of the plate or panel will not be permitted.

### **7-09.15 Outdoor Installation**

All MCC/ACPs mounted outdoor or on roof shall be of weather proof construction minimum IP 54 rated suitable for operation at 50°C ambient temperature condition.

## **7-10 EARTHING**

### **7-10.1 General**

For scope of work refer to **clauses 7-01 and 7-02.**

All HVAC equipment with electricity connection and all MCCs, ACPs and LISs panels shall have their frames, carcasses and all metal parts not normally carrying current, effectively and continually connected to the general mass of the earth. Each equipment and panel shall be separately connected to a main earth continuity conductor.

### **7-10.2 Earth Continuity Conductors**

Earth continuity conductor shall be round, hard drawn, bare electrolytic copper wire of appropriate sizes as approved by the Engineer. All

fixing accessories, earthing clips, sweating sockets, lugs, thimbles, etc., shall be provided for a complete earthing installation.

## **7-11 CONDUITS AND CONDUIT ACCESSORIES**

### **7-11.1 Material Description**

The conduit for wiring shall be of polyvinyl-chloride material for use in concealed to vision locations and G.I. pipe in exposed locations including vertical shafts. All other accessories shall be subject to Engineer's Approval.

### **7-11.2 Application of PVC Conduit**

Manufactured smooth bends shall be used where conduit changes direction. Bending of conduit by heating or otherwise shall be allowed at special situation only, for which approval of Engineer shall be necessarily required. The use of sharp 90 degree bend and tees shall not be allowed. The bends shall have enlarged end to receive conduit without any reduction in the internal diameter at joint. Round Junction Boxes shall be provided with one piece PVC Cover plate which shall be installed on the box by means of galvanized screws. Pull box shall be installed in conduit runs, wherever required to limit the pulling length of cables. Pull Boxes should be installed in conduit runs to limit the pulling lengths as required. The rectangular inspection or pull boxes shall be 16 S.W.G. thick sheet steel having nipples to receive PVC conduit with force fit. The sheet steel box shall be painted inside and outside with black enamel paint over a base coat of red oxide antirust paint, as approved by Engineer. The minimum length of inspection box shall not be less than four times the cables manufacturer's recommended bending radius of the cable. Bushes shall be used at pipe terminations and PVC solution for jointing of pipes.

### **7-11.3 Application of G.I. Conduit**

Application of G.I. conduit shall be similar to PVC conduit as specified above, except that pipes shall have threaded socket connections. Pipes and fittings shall be as specified in Piping Section, finished with 2 coats of aluminum paint.

## **7-12 MOTOR CONTROL CENTRE**

- a) All magnetic starters installed in MCC/ACPs not located in central plant room shall have auxiliary contacts for remote switching (on and off), in addition to Local switching, and remote operating status indication.

- b) Remote switching and indications as described in (a) above, shall be through Supervisory Panel located in central plant room. All interconnecting wiring, conduiting, indications and switching devices and accessories shall be furnished and installed by the Contractor.
  
- c) Outgoing power supply from MEP to chiller control panels shall consist of two independent circuits; one for controls and one for chiller load. Both circuits shall have independent circuit breakers on out going feeders so that chiller control circuit remains energized when power to chiller load circuit is switched off.

### **7-13**

#### **EQUIPMENT SWITCHING CONTROL**

- a) All magnetic starters installed in MCC/ACPs not located in central plant room shall have auxiliary contacts for remote switching (on and off), in addition to Local switching, and remote operating status indication.
  
- b) Remote switching and indications as described in (a) above, shall be through Supervisory Panel located in central plant room. All interconnecting wiring, conduiting, indications and switching devices and accessories shall be furnished and installed by the Contractor.
  
- c) Outgoing power supply from MEP-HVAC to chiller control panels shall consist of two independent circuits; one for controls and one for chiller load. Both circuits shall have independent circuit breakers on out going feeders so that chiller control circuit remains energized when power to chiller load circuit is switched off.

## **SECTION 8 - AIR INLETS AND OUTLETS**

### **8-01 GENERAL**

Before placing orders for these items, the Contractor shall check that all items to be supplied by the manufacturer comply for spread, throw, drop and noise, with capacities and characteristics as indicated on the drawings and schedules. All outlets shall be specifically selected for their particular application and designed for quiet operation. All items are to be approved by the Engineer.

All air inlets/outlets shall be of material as indicated on the Drawings and Schedules, and/or as specified.

Colour and finish shall be subject to Engineer's approval. Ceiling diffuser face and margin sizes and styles shall be coordinated with false ceiling/boxing type. All devices shall have substantial approved gaskets to completely prevent streaking on walls or ceilings due to leakage.

Where ceiling panels and ceiling diffusers are of different size, ceiling diffuser shall be centered in ceiling panel. Duct routing may slightly be adjusted, if necessary, for this purpose or duct drops for diffuser necks may be offset up to a max. of 30 degrees. or diffuser locations having requirement of greater than 30 degrees offset, flexible round insulated duct connection shall be used.

All wooden frames for wall inlets/outlets (where not mounted directly on the duct) shall be 3/4" thick set permanently in the walls. These frames shall be provided by the Contractor. The Contractor shall be responsible for all cuttings of walls, fixing of wooden frames in walls and repair of masonry/plaster required for fixing side-wall inlets/outlets. The Contractor shall furnish wooden frames for wall inlets/outlets to those responsible for civil construction for installation at locations indicated on shop drawings prepared by the Contractor for this purpose.

Ceiling inlets/outlets shall not be supplied on false-ceiling. Cutting of false ceiling (tiles) shall be the responsibility of the HVAC Contractor. Manufacturer's certified free area for each type and size of grille, register, linear/square diffuser and louver shall also be provided for the purpose of air balancing.

All air inlets/outlets shall be manufactured as per Tuttle & Bailey standards of air inlets/outlets.

### **8-02 GRILLES**

All side wall outlets and inlets shall be of sizes and characteristics as

scheduled and shown on the Drawings.

Double deflection type grilles shall have vertical front bars and horizontal back bars.

All supply outlets shall have opposed blade dampers, finished in black paint, fixed to the outlet and shall be operatable with a removable key inserted from front of the grille.

All return and/or exhaust inlets shall have similar dampers if scheduled.

### **8-03 CEILING DIFFUSERS**

Ceiling diffusers shall be of the sizes and characteristics as scheduled and shown on the Drawings.

Ceiling diffusers shall be furnished with volume dampers as furnished by the diffuser manufacturer, finished in black paint.

Volume control for these diffusers shall be accessible through the diffuser from below the ceiling and shall maintain their setting when adjusted. Each diffuser shall be provided with sponge rubber or felt gasket. Return diffusers shall be similar to supply diffusers unless otherwise indicated. Inner core shall be removable and shall be mounted on outer frame. (Throw pattern for supply diffusers shall be as shown on Drawings by arrows or as shown in schedule).

Ceiling diffusers intended for use with flexible round insulated duct shall have suitable inlet box.

Plastic/Fiber glass Supply air & return air Diffusers / Registers for MRI Room.

Aluminum Linear Slot Diffusers/grilles (4 Slots, 3/4" per slot).

SS 304 OR MS Powder coated HEPA Filter Modules / Housings / Plenums for OTS, complete in all respect.

### **8-04 TRANSFER GRILLES**

Transfer grilles shall be of the type and characteristics as scheduled. These shall be installed on both sides of wall where no false ceiling is provided, or, where transfer grille is installed below false ceiling level unless otherwise scheduled. Transfer grilles shall be sight-tight where indicated.

### **8-05 EA/OA LOUVERS**

All louvers shall be of approved construction as per AMCA standard 500-74. All louvers shall be fitted with aluminum mesh bird and anti

vermin screens. The design of the OA inlet louver blades shall be suitable to arrest rainwater, sand and dust from incoming outdoor air. Sizes are to be as given on the Drawings. Louvers shall be complete in all respects with mounting accessories. Louvers shall be of Scheduled material and finish. Design of OA and EA louvers shall be similar. All EA louvers shall have backdraft dampers upstream of louvers.

## 8-06

### AIR FILTERS

#### 1. General:

Each air system shall have its own air filters, and shall be of capacities and sizes as given in specifications herein, scheduled or required.

The air-handling unit filter shall be mounted in an air-tight flat or angular filter box of galvanised steel or aluminum sheet so that they can be removed from either end for replacement and cleaning. In an air handling unit the filter section shall be a standard module from the AHU manufacturer.

In selecting the sizes of the air filters, the space available in the Plant Room and air handling units etc., should be kept in view.

The tenderers shall provide the following information for each of the air filters proposed to be supplied by them.

Capacities in CFM and media air velocity.

initial and Recommended Final air pressure drop in inch of WG (Pa) for each type of filters.

Manufacturer's performance guarantee certificate and technical bulletins.

The Contractor shall install a multi-blade damper in the plenums of air handling unit having high efficiency filters to balance the air system when the filtering media is new with low initial resistance.

#### 2. Type F-1: Viscous Impingement Filter:

Shall be 2 inch (50mm) thick, permanent viscous impingement, washable, all metal, panel type. Media shall be aluminum mesh screen arranged in alternate layers of flat and herring bone crimp screens, enclosed in an 18 gauge aluminum frame with flush mitred corners. Resistance to air flow of a clean filter shall not exceed 0.12 inch wg (30Pa) at 3.6 CFM per sq.inch (0.011 cu.m/sec/sq.cm.) of net face area.

The filters shall be selected for face velocities not exceeding 550 fpm (3.0 m/s.).

Provide filter adhesive in suitable containers in sufficient quantity for one year's requirement, based on operating the system for 10 months on 24 hour basis. Provide a filter washing tank in accordance with

detail shown on drawing.

3. Type F-2: Replaceable Panel Filter:

This filter shall consist of 50mm thick glass fibre mat coated with dust binding adhesive (Viscosine) as the filtering media. The filtering media shall be fixed into a U-shaped metal frame and a metal grid shall be provided for additional support.

Filter media shall be of thick resilient spun fibre structure of variable density and shall provide synthetic dust weight arrestance of 86% based on (Eurovent 4/5) ASHRAE 52-76 Test Method.

The filter shall be supplied with a 50mm deep galvanised steel cell (holding) frame with quick release clamps or hinge type spring clips for positive airtight clamping of the filter.

The filter shall have a rated face velocity of 2.50 m/s (500 fpm) with maximum Initial Resistance of 60 Pascals (0.24") WG and Final Pressure Drop of 180 Pascals (0.72") WG.

4. Type F-3: Medium Efficiency Bag Filters:

These filter shall be extended surface air filters, pocket type having a minimum of 8 pockets; with either a retainer device designed to give full top, bottom and side support to each pleat, or with the kpleats so designed as not to require a supporting retainer. Retainer device, if used, shall be of galvanised wire with PVC coating.

Filter media shall be ultra-fine fibre-glass specifically manufactured for filtration.

Filters shall be provided with holding frames lined with sealing gasket with quick release clamps, for side access application, designed to ensure a positive seal against leakage of unfiltered air. The filters shall have a rated filter face velocity of 500 FPM (2.5 m/s.), providing a maximum Initial Resistance of 0.24 inch of WG. (60 Pa), and a Recommended Final Resistance of 1 inch WG. (250 Pa). Filter depth shall be 22 inches (560mm). Filter shall provide an efficiency of 60-65% based on ASHRAE 52-76 Atmospheric Dust Spot Efficiency (Eurovent 4/5).

5. Type F-4: High Efficiency Bag Filters:

These shall be similar to medium efficiency Bag Filters specified above, except that the filters shall have a minimum of eight pockets and shall have a rated filter face velocity of 500 FPM (2.8m/s), providing a maximum Initial Resistance of 0.35 inch of WG. (88 Pa), and a Recommended Final Resistance of 1 inch WG (250 Pa). Filter depth shall be 22 inches (560mm). Filters shall provide an efficiency of 90-95% based on ASHRAE 52-76, Atmosphere Dust Spot Efficiency (Eurovent 4/5).

6. Type F-5: High Efficiency Pleat Filters:

These shall be of high efficiency extended surface supported pleat type, consisting of a galvanised steel holding frame and replaceable filter.

The holding frame shall be of 16 gauge galvanised steel, minimum 70mm in depth, and designed to provide positive seal against leakage of unfiltered air. The frames shall be provided with integral spring type latches to firmly hold the filter against neoprene rubber gaskets.

The filters shall be made from water-resistant ultra-fine glass fibres. The media shall be pleated and shall have crimped aluminum separators to maintain uniform spacing between pleats. The filter casing shall be of galvanised steel.

The rated filter velocity shall be 500 FPM (2.5m/s) providing a maximum Initial Resistance of 0.60 inch of WG (150 Pa) AND A recommended Final Resistance of 2.4 inch WG (600Pa). Filter depth shall be 292mm. The filters shall have an Atmospheric Dust Spot Efficiency of 90-95%, based on ASHRAE 52-76 Test Method, (Eurovent 4/5).

7. Type F-6: High Efficiency Particulate air (HEPA) Filter 99.95% DOP:

These shall be high efficiency extended surface support pleated type with galvanised sheet steel filter casing. The Filter shall be manufactured from water and temperature resistant ultra-fine glass fibre paper media with neoprene rubber gasket and durable elastic compound. The media shall have close parallel pleats and shall be evenly close positioned by corrugated aluminum separator in order to maintain uniform spacing between pleats.

Particulate filter media shall be made specifically for the separation of suspended particles, aerosols, toxic dusts, viruses, bacteria, germs, etc..

The filter mounting bank (cell frame) shall be made from gas tight welded aluminum flat profile section with aluminum cell supporting angels and turn buckle clamps for proper airtight sealing of the filter cell with aluminum framing system to prevent leakage of unfiltered air.

The filters shall have a rated face velocity of 1.5 m/s (300 fpm) providing a maximum Initial Pressure Drop of 125 pascals (0.50 inch WG) and Recommended Final Pressure Drop of 600 Pascals 2.4 inch WG. Filter depth shall be 292 mm.

The filter shall have an extraction efficiency of 96% + based on particle size of 0.3µm and as per particulate filter class 'R' according to DIN 24184 test method or 99.95% DOP test method.



8. Type F-7: HEPA Filter – 99.995% DOP:

These shall be similar to HEPA filters, (type F-6) specified above, except that the rated face velocity of 1.5 m/s (300 fpm) shall provide a maximum Initial Pressure Drop of 250 Pa (1.00 inch WG), and a Recommended Final Pressure Drop of 600 Pa (2.4 inch WG).

The filter shall have a certified extraction efficiency of 99.995% based on particle size of 0.3M and as per Particulate Filter Class 'S' according to DIN 24184 Test Method or 99.995% on DOP Test Method.

9. Type F-8: HEPA Filter Ceiling Module (99.990% DOP):

These shall be of Absolute Filter, consisting of a Filter hood (Ceiling module) of aluminum painted white, integrated with Filter cell suitable for Clean Room Class 10,000 applications. The face guard (perforated grid) shall be of aluminum painted white.

The filter shall be made from water and temperature resistant high quality ultra-fine fiberglass paper media specifically made for terminal filter applications for Clean Rooms.

The filter casing shall be of aluminum fitted with continuous neoprene gasket on face in order to provide a positive seal against leakage of unfiltered air.

The housing shall be aluminum, with all metal to metal joints bonded to prevent leakage. Two room side sampling ports shall allow checking of static pressure or contamination levels of the air entering the module. The center part shall also be used to adjust the damper-diffuser, installed in a  $\phi$  250mm venture shaped inlet collar. The modules shall be supplied with a one piece anodized aluminum face guard.

The filter media shall be folded into closely spaced uniform shallow pleats providing optimum pleating geometry and achieving constant speed laminar air flow.

The nominal face velocity shall be 0.80 m/s (160 fpm) providing a maximum Initial Pressure Drop of 250 pascals (1.00 inch WG) and Recommended Final Pressure Drop of 600 pascals (2.40 inch WG).

The total thickness of the filter ceiling module integrated with Filter shall be 178mm Spigot (inlet collar) shall be  $\phi$  250mm.

The filter shall have an extraction Efficiency of 99.995% based on particle size of 0.3 $\mu$ m and as per Absolute Filter Grade S according to DIN 24184 test method or 99.990% as per DOP test method. The evaluation of extraction efficiency shall be by a Particle Counter or DOP aerosol for particle size of 0.3 $\mu$ m.

10. Type F-9: HEPA Filter Ceiling Module (99.999% DOP):  
These shall be same as Type F-8 HEPA Filter Ceiling Modules, except that these shall be suitable for Clean Room Class 1000 applications. The filters shall have an extraction efficiency of 99.999% based on particle size of 0.1M as per Absolute filter grade 'T' according to DIN 24184 Test Method. The evaluation of extraction shall be by CNC particle counter or DOP aerosol for particle size of 0.1M.

1. Cleaning Room In-Line Filter Housing:

This shall be an in-line filter housing for HEPA filters, constructed out of 0.040 inch (1.02mm) thick aluminum and provided with 40mm flanged end, suitable for installation on a branch duct leading to a clean room diffuser. The filter housing shall be provided with a specially designed filter clamping system using neoprene gaskets and turnbuckles which shall prevent air bypass. Clamping system shall maintain constant pressure regardless of vibration or minute shrinkage of filter cell sides. The housing shall be provided with an extended aluminum door frame with gaskets. The depth of the housing shall be 26 inches. Housing shall be similar to AMERICAN AIR FILTER Model "CRILH".

12. Magnehelic Gages:

At Filters: Each bank of high efficiency filter and HEPA filter shall be provided with an appropriate station to determine pressure drop, consisting of magnehelic gage, probes, flexible tubes and mounting arrangement.

At Operation Theatres or Other Positive or Negative Pressurised areas: At the outside of the sterile area install a magnehelic gage to read sterile area pressure with respect to corridor pressure. For this purpose probes shall be installed in the sterile area and in the corridor, and connected with flexible tubing to the magnehelic gage.

## **SECTION 9 - INSTRUMENTS AND GAUGES**

### **9-01 GENERAL**

All necessary gauges, and pipeline thermometers and other indicating and measuring instruments as required, specified and shown shall be furnished and installed by the Contractor. All gauges and thermometers shall have labels indicating their function.

Instruments shall include but not limited to:

Pressure gauges.  
Thermometers for water piping  
Testing and Maintenance instruments

These instruments shall be installed as shown on Drawings. Portable testing and maintenance instruments shall be supplied in carrying cases.

### **9-02 PRESSURE GAUGES**

Pressure gauges shall be of the Bourdon tube type.  
Working parts shall be of corrosion resisting metals.

Dial diameter shall be 4.5" and shall permit easy reading from floor with black numerals on white background.

Range shall place operating pressure at or near the middle of scale. Dial face shall be calibrated in psi and KPa in suitable increments with a range not less than one and half times the maximum operating pressure. Pressure gauges shall be complete with shut- off cock and necessary tubing with socket adapter.

When gauges are mounted on a panel board they shall be flush mounted.

### **9-03 THERMOMETERS**

Thermometers for water line shall be mercury in steel with metal guard steel bulb and separable sockets screwed 3/4" dia., 9" length. Thermometers shall be complete with well for piping.

Calibrations shall be in degrees Fahrenheit with suitable increments. Range shall place operating temperature at or near the middle of scale. Range shall not be less than one and half times the maximum operating temperature.

### **9-04 TESTING AND MAINTENANCE INSTRUMENTS**

The Contractor shall supply following testing and maintenance instruments

1. 1 No. Digital meter with probes for measuring of air velocity at duct, filters and grilles, static pressure and relative humidity.
2. 1 No. Tachometer
3. 6 Nos. Insertion type duct thermometer
4. 2 Nos. Dry bulb and wet bulb measuring Sling thermometer
5. 1 No. Clamp-on Ammeter
6. 1 No. Clamp-on Ultrasonic water flow meter suitable for measuring water flow rates in pipe lines of sizes used in this project.
7. 1 No. Water flow meter suitable for measuring water flow rates use with balancing valve (Direct Flow Display).
8. 1 No. Digital Sound level measuring meter

Details of these instruments with catalogues shall be submitted to the Engineer for approval.

## **SECTION 10 - PAINTING & EQUIPMENT IDENTIFICATION**

### **10-01 GENERAL**

All material and labour for painting and identification of services shall be provided by the Contractor, as specified hereunder:

### **10-02 PAINTING**

All steel work in connection with supports for pipes ductwork etc. exposed to the elements is to be painted with two coats of an approved rust preventive paint.

All exposed metal surface of hangers, brackets, etc. must be painted with two under-coats and two finishing coats of enamel paint of approved colour. G.I. sheet is not to be painted. However, all uninsulated pipe work and valves are to be painted as stated above.

All machinery and equipment which have been painted in factory to the satisfaction of the Engineer shall have a finishing coat of paint before Final Acceptance if the factory paint is damaged during transportation, storage or installation.

Identification bands shall be painted on uninsulated ducting, piping or on insulation at frequent intervals. Lettering shall be agreed with the Engineer

All exposed insulation in the plant room is to be painted to approved colours with one undercoat and one finishing coat of enamel paint. All steel pipework and other steel equipment specified to be insulated shall be thoroughly wire brushed to the satisfaction of the Engineer and painted with one coat black cold asphalt paint before insulation is applied.

Internal surfaces of grilles, diffusers and register boxes and connections visible to occupants of rooms, shall be painted by Air Distribution Contractor with two coats of dull black paint or other colour as directed by the Engineer.

All pipe and duct hangers in concealed locations shall be given one coat of black asphalt paint before being concealed.

All steel pipe, cradles, vibration isolation rails that will be covered, partially covered, set in cement or fill, or not accessible when the installation is completed, shall be given two coats of black asphalt paint.

### **10-03 MANUFACTURER'S NAMEPLATES**

Each unit or equipment shall be identified by a permanently attached nameplate made of brass or other corrosion resistant material. Plates

shall not be less in size than 1.5 inch x 3 inch Plates shall bear information pertaining to unit as follows:

System and unit designation from Schedule of Equipment.

Manufacturer's name and address (only distributor's or agent's name and address will not be accepted).

Rated capacity.

Temperature, pressure or other limitations.

Electrical Data

#### **10-04 VALVE TAGS, CHARTS AND NAME PLATES**

Valve Tags, dampers and controls shall be designated by distinguishing numbers in English on the charts or diagrams. The Contractor shall provide stamped brass tags for all designated items with numbers corresponding to those on the charts.

The tags shall be not less in size than 1-1/2 inch in diameter with depressed black numbers of 1/2 inch height.

The Contractor shall provide separate lists designating the location and function of each valve, dampers and control.

The charts, diagrams and lists shall be of sizes, type and character as approved.

## **SECTION 11- INSPECTION TESTING AND COMMISSIONING**

### **11-01 GENERAL**

- 11-01.1** The whole of the works supplied under this Contract shall be subject to inspection and tests by the Employer and/or Engineer should he so require, during manufacturing erection and after completion. The inspection and tests shall include, but not be limited to, the requirements of this Section of the Specifications.
- 11-01.2** For this purpose the Engineer shall, at all reasonable times, be allowed free and ready access to the Contractor's shop and the shops of his suppliers for the purpose of inspecting the specified equipment components, or any other parts, and obtaining information as to the progress of the work. Failure on the part of the Engineer at this or any other time, to discover or reject materials or work which do not meet specified requirements shall not be deemed an acceptance thereof nor a waiver of defects therein.
- 11-01.3** Specific tests required by the various items of the Plant, Parts, materials and equipment shall be treated in accordance with the specifications of the corresponding clauses of the Specifications.
- 11-01.4** The Contractor shall submit to the Engineer, one month prior to the date of commencement of the balancing and performance tests, six (6) copies of the complete test procedure. The procedure, method and points of measurement as well as the method of calculation shall be approved by the Engineer before any test is carried. Six (6) copies of the test results shall be furnished to the Engineer for his approval.
- 11-01.5** The Contractor shall supply all necessary testing and balancing instruments, which shall include, (but not limited to) the instruments listed in Section 10, INSTRUMENTS AND GAUGES, and carryout any test of any kind on a piece of equipment, apparatus part of system or on a complete system if the Engineer requests such a test for determining specified or guaranteed data, as given in the Specifications or in the Schedule of Equipment. Necessary skilled staff shall be provided by Contractor.
- 11-01.6** Any damage resulting from the test shall be repaired and/or damaged material replaced with intimation to the Engineer, all to the satisfaction of the Engineer, and at no extra cost to the Employer. Skilled staff shall again be provided by the Contractor.
- 11-01.7** In the event of any repair or any adjustment having to be made, other than normal running adjustment, the tests shall be void and shall be recommenced after the adjustment or repairs have been completed.
- 11-01.8** All testing, balancing and final adjustment shall be in accordance with the provision of the applicable ASHRAE Standards, or other approved

relevant standards.

**11-01.9** The Contractor shall test a piece of equipment, apparatus, parts of system or a complete system in accordance with method and Schedule of Tests provided by the Engineer to determine Specified or Guaranteed data, given in the Specifications, Schedule of Equipment and Contractor's Data Sheets.

**11-01.10** The contractor shall be responsible for carrying out tests on the material/equipment/installation furnished by him.

**11-02 PRELIMINARY INSPECTION & TESTS**

**11-02.1 General**

All equipment shall be inspected and tested to determine the completeness and general conformance to specified requirements, when operated independent of overall HVAC System, for noise, vibration, electrical data.

**11-02.2 Piping System**

Pressure tests on part or whole of piping network shall be applied only before connection of equipment and appliances.

In no case shall piping, equipment or appliances be subjected to the pressure exceeding their rating.

Tests shall be completed and approved before any insulation is applied on pipes, valves and fittings, and before these are concealed. Tests shall be performed in the presence of and to the satisfaction of the Engineer or his representative. Any leaks or defects discovered by the tests shall be repaired and the system retested as above, all at no additional cost to the Employer.

The prescribed pressure shall be maintained for four (4) hours.

**11-02.3 Ductwork**

Inspection on ductwork shall be carried out by Contractor's supervisor in the presence of Engineer's representative to the satisfaction of the Engineer.

All joints in ducts and at outlets shall be physically inspected for air leakage. All dampers shall be tested for proper operation.

Ducts, plenums and casing shall be inspected and made substantially air tight before covering with insulation or concealing in the masonry. The terms substantially airtight shall be construed to mean that no air leakage will be noticeable through the senses of feeling or hearing.



#### **11-02.4 Equipment**

All HVAC equipment shall be inspected for visible damage, operation of moving parts, noise and vibration. Tests shall be carried out with readings of RPM, ampere, voltage, etc. to verify the name plate data.

#### **11-02.5 Electrical Equipment**

All electrical panels shall be cleaned and adjusted on site before application of power. The following tests shall be carried out:

- 1) Wire and cable continuity tests.
- 2) Insulation resistance tests, phase to phase and phase to earth, on all circuits and equipment, using 500 volts megger. The megger reading shall not be less than one meg.ohm.
- 3) Earth resistance between metallic conduit systems and earth must not exceed half (1/2) ohm.
- 4) Phasing out and phase rotation tests.
- 5) Operating tests on all protective relays to prove their correct operation before energizing the main equipment.
- 6) Operating tests on all starters, circuit breakers, etc.

### **11-03 BALANCING AND COMMISSIONING**

#### **11-03.1 Air and Water Balancing**

All air handling and ventilating equipment, ductwork air inlet and outlets, air volume control dampers, and water valves shall be adjusted and balanced to deliver within 10% of the specified quantities indicated on the Drawings. Where the equipment or systems depend upon controls for proper operation, functioning and performance, the Engineer may ask the Contractor that the later shall be operated simultaneously with the equipment or system during tests.

If the air quantities cannot be delivered without exceeding the speed range of the sheaves or the available horsepower, the Engineer shall be notified before proceeding with the balancing of air distribution system.

Any addition/replacements required to meet the specified flow rates shall be the responsibility of the Contractor at his own cost.

The balancing and commissioning work will be done by a specialized firm/approved by the Engineer, having working experience of more

than five (05) years alongwith working experience of atleast five (05) projects of similar nature.

### **11-03.2 Commissioning**

Upon completion of air and water balancing and when the whole or part of HVAC System is substantially complete and ready for operation as specified, the Contractor shall carry out Commissioning. Appropriate Seasons are not necessary and the purpose of the commissioning is to start-up the whole or part of HVAC System with manual and/or automatic controls and to put the whole or part of HVAC plant in operation to make it ready to provide cooling and/or heating.

The Commissioning shall be considered completed when complete HVAC plant put into operation and made ready to provide either cooling or heating as directed by the Engineer. The Engineer may direct the Contractor to commission part of central plant along with part of AHUs, FCUs and distribution network. This will be considered as partial commissioning.

### **11-04 PERFORMANCE TESTS**

Each equipment of HVAC plant shall be tested for performance after successful completion of Commissioning of that equipment to determine the Specified and Guaranteed Data at Specified Operating Conditions as shown in Equipment Schedule and Specifications. These tests shall be carried out in appropriate seasons.

The test data shall not deviate by more than five percent (5%) from the Guaranteed capacity data.

Should any part of the apparatus or system fail to meet the specification requirements, it shall be adjusted, repaired or replaced to the satisfaction of the Engineer by the Contractor at his own cost. The complete Performance Test shall than be repeated.

### **11-05 RELIABILITY TRIAL TEST**

After completing the above Preliminary Tests, adjustments, Commissioning and Performance Tests, the Contractor shall carry out Reliability Trial Tests for the whole or part of system.

The trial tests, both for summer and winter, shall last for a period of 14 consecutive days during which time the whole or part of the system, as the case may be, shall operate continuously without major adjustment or repair to the satisfaction of the Engineer.

Should any part of the apparatus or system fail to operate continuously as specified, it shall be adjusted, repaired or replaced to the satisfaction of the Engineer and the Reliability Trial Tests shall be repeated for another 14 consecutive days for continuous operation without major adjustment or repair.

**Reliability Trial Tests should be carried out during appropriate seasons in Defects Liability Period.**

# **EQUIPMENT SCHEDULE**