



**BACHA KHAN MEDICAL  
COMPLEX-MTI, SWABI**

**Bidding Documents**

**Volume – II  
Technical Specification**

**DESIGNING, SUPPLY, INSTALLATION, TESTING & COMMISSIONING OF  
NEGATIVE AND POSITIVE PRESSURE FOR ISOLATION BLOCK**

**Manager Material Management  
BKMC/GKMC-MTI, Swabi**

**Manager Maintenance & Engineering  
BKMC/GKMC-MTI, Swabi**

**Hospital Director  
BKMC-MTI, Swabi**

Table of Contents

1.0 General Provisions HVAC works ..... page 03

2.0 Air Distribution system..... page 08

3.0 Duct Insulation..... page 14

4.0 Air Devices .....Page 30

5.0 Installation ..... Page 33

6.0 List of Approved Manufacturers/Suppliers.....page 36

7.0 Electrical Works.....page 38

8.0 Operation and Maintenance of HVAC System..... page 49

**GENERAL PROVISIONS  
HVAC WORKS**

**1.1 HVAC SYSTEM CONCEPT**

The building shall be air-conditioned by DX Coil Air Handling Units with matching VRF condensing outdoor Air-Conditioning unit.

**1.2 DESIGN CONDITIONS**

HVAC System has been designed for the conditions listed hereunder. These conditions are being given for the information of the Contractor to enable him to perform specified tests under these conditions.

**Summer outside Design Conditions**

- |    |                       |         |
|----|-----------------------|---------|
| a) | Summer Dry Bulb Temp: | 114.8°F |
|    | Wet Bulb Temp:        | 80°F    |

**Inside Design Conditions**

- |    |                           |                                    |
|----|---------------------------|------------------------------------|
| a) | All air-conditioned areas | 75°F $\pm$ 3°F<br>50% $\pm$ 10% RH |
|----|---------------------------|------------------------------------|

**1.3 MATERIALS**

All materials shall be of the highest grade, free from defects and imperfections, of recent manufacture and unused, and 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.

**1.4 WORKMANSHIP**

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

**1.5 MATERIALS**

All materials supplied shall be from approved manufacturers who are adequately represented in Pakistan by an Agent capable of providing installation, commissioning and after sales service. All major equipment shall be imported directly from the manufacturers through their local agents. Import of this equipment through warehouses/Export Houses will not be accepted.

- b) All material shall be of latest manufacture, not older than the year in which this contract is awarded and shall bear year of manufacture stamped on the manufacturer's name plate duly certified by the manufacturer.
- c) When a manufacturer's product is specified by name, or equivalent, it shall be in the sole judgment of the Consultant as to acceptability of any product which is offered as equal to that specified.

## **1.6 CHASES AND OPENINGS**

The contractor shall provide templates or details for chases and openings to be left in walls and partitions to accommodate work under HVAC scope of works.

## **1.7 PROTECTION**

The contractor shall keep 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.

## **1.8 CUTTING, PATCHING AND REPAIRING**

Required for proper installation and completion of HVAC works, including masonry work, concrete work, and 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 Consultant.

## **1.9 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 Consultant. 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 Consultant.

## **1.10 ACOUSTIC TREATMENT**

Sound measurements will be made at 5 feet above floor level in the area served and not more than 5 feet from the grilles, 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 has 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 the equipment he is offering is quiet and supplied with all necessary silencers to ensure satisfactory sound levels. Where silencers are required, these must be incorporated into the price quoted for such equipment, if these are not specified separately.

### **1.11 SAMPLES**

Contractor shall provide at his cost, samples of materials, instruments, gauges and electrical items, for approval by the Consultant before order is placed for the same. Consultant 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

1. G.I. sheet
2. Duct insulation and covering.
3. Insulation adhesive and tapes
4. Diffusers, grilles and registers
5. OA/EA louvers
6. All types of dampers.
7. Power cables
8. Duct hangers etc.

### **1.12 APPROVAL OF MATERIAL**

As soon as practicable after the award of contract, the contractor shall submit for approval of the Consultant specifications, drawing, catalogue diagrams and other descriptive data for all materials components. Which the contractor proposes for use under this contract.

For certain materials, data may be required to be submitted in accordance with a detailed form furnished by the Consultant. Items submitted shall be properly labeled to indicate item number, and other data required by the Specifications. All items shall be submitted time to permit proper consideration and action thereon without delaying the construction schedule.

### 1.13 TIME FOR DELIVERY

All material 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, when the material will be ready for inspection at site by the Consultant and shall supply lists covering each consignment in sufficient detail to enable Consultant to check the contents of the material, if he so desires.

### 1.14 STANDARDS AND CODE REQUIREMENTS

All materials under HVAC Scope of works shall be furnished in conformity with the latest edition of applicable standards of ASME, ASHRAE, ARI, SMACNA, and AMCA and applicable

\Government and local Codes governing the same. In case of conflict, the stricter requirements shown/ specified shall govern.

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, Refrigeration 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.
7. GOVERNMENT - Government of Pakistan
8. LOCAL-Local authorities of the city where the Project is located
9. AMCA — Air Moving and Control Association inc. USA
10. P.S. - Pakistan Standards.
11. B.S. - British Standards.

### 1.15 ERECTION SUPERVISORS AND OPERATING STAFF

#### **General**

The Contractor shall provide the services of Erection Supervisors and Operating Staff in accordance with the requirements of the Conditions of Contract as specified here in.

#### **Work by Erection Supervisors**

- 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 Supervisors shall cooperate with other Contractors to whatever extent is necessary to produce an installation satisfactory to the Consultant 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 Consultant for his decision. Upon such decision, the Erection Supervisor shall proceed with the work in accordance therewith, immediately.
- d) Should a disagreement arise between other Contractors and the Erection Supervisor, the matter shall be submitted without delay to the Consultant for his decision. Upon such decision, the Erection Supervisor shall proceed with the work in accordance therewith, immediately.
- e) Erection Supervisor shall be a qualified HVAC/ Mechanical Associate Engineer, having at least 5 years' experience in HVAC installation works of similar nature.
- f) If the Contractor fails to fulfill his obligations 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 agreed penalty amount 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 for his running bill/any payable sums.
- g) 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 Consultant.

### **Operating Staff**

The Contractor shall provide staff consist of 1(one) supervisor and 2 (two) operators 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 3 (three) years Diploma holder HVAC or Mechanical from Government College of Technology etc. And having 2 (Eight) years' experience of similar plants with automatic 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.

## 1.16 AS BUILT DRAWINGS

The Contractor shall supply to the Consultant a set of "As-Built" drawings showing the contract works as installed, together with any other information necessary for operation and maintenance. Three copies of each drawing and other information shall be supplied, along with a reproducible copy.

## 1.17 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 3copies of catalogues and other information shall be submitted.

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

## 2.0 EQUIPMENT

### 2.1 GENERAL:

The contractor shall supply and install of DX Coil AHU with latest type of all DC inverter system (outdoor units) of the capacity and rating as shown in the Bill of Quantities.

The units will have guarantee/warranty period of **3 year (36 months)** from the date of commissioning the units, and should any defects arise during this period which can be attributed to poor workmanship, improper materials, or defective manufacture of the air conditioning units, for which the consultant shall be the sole judge, the contractor shall be required to replace or repaired all defective parts, except compressors (burnt or otherwise) which shall be replaced with new compressors, all repairs and replacement shall be as desired by the consultant.

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.

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 specified

/Scheduled. All equipment shall be tested at factory for performance before shipment. All equipment furnished by the Contractor shall include vibration isolation mounting pads, anchor bolts, frames or any other mounting or supporting accessories.

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



## 2.2 MULTI SPLIT AIR-CONDITIONING UNITS (R410A):

### 2.2.1 Overview

#### **VRF All DC Inverter System:**

All equipment shall be brand new products from certified and approved manufacturers.

VRF system shall comprise refrigerant, outdoor unit (air-cooled), indoor DX fan coil device, liquid, air suction and pressure relief pipes, condensate pipe, branch-joints, connection tool Kit, and a separate micro-processor control system.

Indoor/outdoor units and other key parts shall be manufactured and assembled by the same manufacturer.

In case of fittings other than the standard ones from the manufacturer, approval shall be obtained before use.

The refrigerant for the VRF system shall be R-410a

The refrigerant for the VRF system shall comply with local regulations and ensure a higher COP value for the A/C equipment.

The VRF system shall satisfy the requirement for design indoor temperature.

Nameplate shall be attached to each product at a notable position, indicating the following, as a minimum:

- a) Product name, model and specification;
- b) Name and trademark of manufacturer;
- c) Date of production, product No. or batch number; and
- d) Output power, noise and other main parameters.

### 2.2.2 Features

The VRF All DC Inverter system shall have the following features:

#### **Variable-capacity compressors:**

All compressors should be DC Inverter type compressor controlling the cooling and heating capacity automatically according to the load.

Only DC inverter compressor shall be used in this system and it can directly intake gas to reduce loss of overheat and improve efficiency.

High-efficient permanent synchronous motors are required, to get better performance than traditional D.C. inverter compressors.

Compressors shall have 180° Sine Wave DC Speed Varying Technology to satisfy various places' demands for different temperature and shall be able to save a great deal of electricity and provide users with utmost comfort at the same time.

The condenser fan motors shall be DC Inverter type and shall have Step less speed regulation ranges from 5Hz to 65Hz. Compared with traditional inverter motors, it shall be more

Efficient. It shall have Sensor less control technology to guarantee lower noise, less vibration and steadier operation.

In auto energy saving mode, system shall be able to self-adjust parameters according to the operation status, thus to lower the cost of electricity with up to 15% of energy saving. In compulsory energy saving mode, system shall limit power output forcibly with up to 20% of energy saving.

**System shall have automatic energy auto-allocation technology.**

System shall be able to remember the highest temperature outdoors. When night comes, system shall automatically turn to quiet mode. There shall be option of Quiet modes which can be set according to actual needs.

System shall also be able set in this mode to ensure low noise as long as unit is operating. The minimum of low noise degree shall be 50dB (A).

The indoor units of VRF all DC inverter system shall have DC Inverter motors to realize step less regulation. According to indoor temperature or people's actual needs, users shall set this mode through the indoor wire control.

The system shall have its working voltage range from 320V-460V and in the places with unsteady voltage; this system shall be able to run satisfactorily.

The cooling or heating mode shall have option to be deactivated during a certain season to avoid the mode conflict in case of miss operation.

The outdoor unit shall be able to be linked with a fire alarm signal. In case of emergency, unit shall automatically turn off to avoid risk or further loss.

The outdoor unit shall be able to receive a power signal of electricity shortage. In some places like first-class hotels, diesel generator may sometimes be used to provide electricity.

In this case, this signal will be received and only VIP rooms can be provided with air conditioning service.

When a certain indoor unit needs to be repaired, it shall be powered off without any interruption to the system's operation.

First-grade oil separator shall have a filtered expansion valve with a 98% of separation efficiency; Second-grade oil separation will separate the remained 2% refrigerant oil with 95% of separation efficiency. General Efficiency shall be 99.9%.

The operating priority sequence of the outdoor unit modules shall be changed without restart when the system accumulatively operates for 12 hours, to maximize the service life of the system

Each module shall be an independent sub-system, and the whole system won't fail down even if partial malfunction occurs. Upon malfunction of any one of the modules, there shall be option of emergency operation after simply manual setup on the outdoor PCB switches.

The system shall be without liquid receiver and the excess refrigerant will be stored in the piping, which would minimize the refrigerant charging volume and enhance the control accuracy of the refrigerant.

Based on the actual status of each unit and compressor, system shall regulate compressor's operation and realize oil balance.

Refrigerant shall be taken into a compressor by an intake pipe and then runs through the cooling system. It shall control oil level and the minimum oil each compressor needs and therefore realize oil balance.

Dual electronic expansion valve with its 960 grades of regulation shall precisely regulate refrigerant's flow between outdoor unit and indoor unit.

The best heating or cooling performance shall be realized in the most energy-saving way. DC inverter compressor and D.C. inverter fan will also be operating in this way to ensure high efficiency.

The VRF all DC inverter system shall realize a combination of 4 outdoor unit modules (maximum). When error is occurred to one of the modules, the others shall perform the emergency operation to sustain the air conditioning. All the compressors in each single

module shall be DC Inverter based, when one compressor has error, others shall perform the emergency operation. Double-fan design shall ensure that one fan can still work even if the other one has error.

Outdoor unit fan shall have 4 levels of static pressure that can be set, up to 80Pa, when an outdoor unit needs to be placed indoors. The VRF all DC inverter system shall realize a combination of 4 models (maximum) and connect as many as 80 indoor units.

The cooling capacity of the outdoor units should adjust automatically, according to the number of operating indoor unit(s).

The maximum total pipe length should not be greater than 1000 m.

The maximum actual pipe length between indoor unit and outdoor unit should not be greater than 175m.

The maximum height difference between indoor unit and outdoor unit should not be greater than 90m.

The maximum distance between the first branches to the farthest indoor unit should not be greater than 40m.

The maximum height difference between indoor units should not be greater than 15m.

The system should offer at least 5 basic modules, which could be freely assembled in 2-, 3- and 4-unit's modular combinations as per requirement.

The system should offer 2HP increments of capacity range, which should meet customer needs accurately and the maximum capacity combination should be up to 88HP.

The system should have an inner-screw copper heat-exchanger, which can create higher heat exchange efficiency and powerful heating capacity especially in low ambient temperature. Outdoor heat-exchange area should be adjusted by running load. The system should have dual EXV, which should achieve up to 960 steps refrigerant adjusting precision to ensure precise control of refrigerant and raise system circulation efficiency.

The combination of one main and one auxiliary four-way valve should control the outdoor heat exchanger and outdoor air flow independently and according to the load, adjust the heat exchange volume of outdoor unit accurately and prevent wasting the capacity in part load time. Main 4-way valve should be used as the traditional 4-way valve, while the auxiliary 4-way valve should be used to adjust the heat-exchanger area of outdoor unit when in cooling mode.

The structure of the system and the piping work should be simple, so that the installation is easy. Each series of indoor units should have the same pipe dimension, and all the pipes should be connected by flare nut.

The system should have simple refrigerant piping system without any complicated maintenance work

### **Controls:**

The system should have Individual control, group control, network control options.

The system should have network control system that can realize intelligent management to the A/C system,

The system shall have auto debugged features like:

Automatically allocate ODU and IDU addresses

automatically calculate numbers of ODU and IDU

Automatically detects errors;

Automatically starts debugging.

VRF Central Controller shall adopt CAN communication technology.

## DX Coil AHU with VRF Condenser & AHU Kit

### General features of Hygienic air handling units shall be as follows:

- Modular construction.
- Application flexibility.
- Perfect Thermal break.
- No materials that cause threat to human health.
- No Material which facilitates the growth of harmful microorganisms.
- Internal surfaces of the units are made of wear-resistant materials.
- Easy for maintenance.
- Easy for cleaning inside the units and its components.

### COMPONENT FEATURES

- DX coil hygienic air handling unit shall be provided with AHU kit connected with VRF All DC inverter condensing unit.
  - VRF All DC Inverter condensing unit shall be connected to air handling unit through AHU kit, this kit shall include electronic expansion valve for capacity modulation as per load requirement.
  - Control box shall also be provided for control and communication between indoor (AHU) & outdoor (VRF All DC Inverter condenser)
  - Casing & construction of the unit shall include extruded aluminum profile with built-in thermal break system and these profile frames shall join by means of strong nylon corners.
  - Panel shall be double skin with sandwiched insulation, powder coated hot-dipped galvanized outer skin. Inner skin shall be stainless steel. Access doors shall be provided for all sections to facilitate access to all internal components for maintenance and cleaning. Hinged access door for fan and filter section shall be provided.
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- All panels shall be internally insulated with polyurethane foam insulation.
  - Painted Hot dip galvanized sheet metal or structural steel base frame shall be provided.
  - Direct driven plug fan shall be provided in hygienic air handling unit so that it can be easily inspected, checked and cleaned.
  - Unit shall be provided with steam humidifier & dehumidifier.
- 
- Unit shall be provided with G4 class Pre-filter & F9 class secondary filter.
  - Mixing box with fresh air and return air dampers shall be provided.
  - Condensate drain pan for cooling coil & humidifier section shall be made of stainless steel & also it shall be insulated.

### 2.2.6 Pre-shipment Inspection:

1. The Contractor shall make all the arrangements like visa, tickets, boarding and lodging conveyance etc. for BKMC Swabi representatives for the pre-shipment inspection. The Competent authority have right to finalize two persons for pre- shipment inspection.
2. Contractor shall inform at least six weeks before the date of inspection. Nose pirate payment shall be made to the Contractor for the Pre-shipment inspection; Contractor shall include its price in the quote of VRF Units/ DX Coil AHU units.
3. Following tests on full load shall be carried out at factory, and log sheets shall be verified by the Client and Consultant prior to the shipment of the equipment.
  - All DC inverter VRF ODU/IDU
  - DX Coil AHUS Units
  - Functioning of all Safeties and Controls
  - Leak Test Report
  - Pressure Test report
  - Certificate for Tube wall thickness
  - Function of all Safeties Controls

## 3.0 REFRIGERANT PIPING AND SPECIALITIES

### 3.1 GENERAL

The Tender Drawings indicate generally routes of all piping and the Contractor shall provide all fittings and accessories necessary for satisfactory installation and operation of the systems.

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.

All pipe drops shall be truly vertical. No joints shall be formed in the thickness of walls, floors or ceilings. The Contractor shall be responsible for ascertaining the thickness of plaster and other wall finishes, skirting heights, call lengths and floor finishes.

Piping shall not pass in front of doorways or windows and shall be generally arranged so that sufficient space shall be allowed for accessibility for servicing.

All drain piping shall pitch down in direction of flow. All drains from such items as drip pans of air conditioners shall spill over and open sight drain, floor drain or other acceptable discharge points and terminated 150 mm above the drainage.

Approved pipe fittings shall be used and bending of pipes will not normally be allowed. All 90° elbows used shall be of long radius type, except where space limitations restrict the use of long radius.

Piping shall not be installed passing through ductwork or directly under electric light fixtures.

## 3.2 REFRIGERANT PIPING AND SPECIALITIES

Refrigerant piping shall be copper tubing, type L (minimum), bright annealed, dehydrated and sealed, soft tempered tubing shall be used where bending is required and where flare joints are used, hard drawn tubing shall be used where no bending is required and silver- brazed joints are used, and for all tubing larger than 20 mm. Copper tube joints shall be brazed, except joints on lines 17 mm or smaller which may be flared. Fittings for flare joints shall be standard SF' forged brass flare-type with short shank flare units. Fittings for brazed joints shall be wrought copper or forge brass seat fittings. Cast seat type fittings will not be allowed for brazed joints.

### 3.2.1 INSTALLATION

It is imperative the method of installation and the materials used are also to high standards, to ensure trouble free operation and long-term reliability.

The interconnecting pipe work must be installed by a competent and trained engineer. Refrigeration quality copper tube must be used, soft copper coils or half-hard straight lengths. The refrigeration quality tube must be soft drawn seamless high grade copper pipe. The copper tube must be selected taking into account the higher operating pressures of refrigerant, and that high pressures will occur throughout the system because of the reverse cycle operation.

The supplied branch pipe kits, must be used to make connections to indoor units, and the supplied manifold kits must be used to make connections between outdoor units (where applicable); it is not permitted to use standard fittings such as elbows, tees etc. the branch pipes shall be installed in accordance with the manufacturer's instructions, allowing unrestricted flow of refrigerant. All brazed joints shall be made with dry nitrogen purge to ensure the prevention of oxidization to the internal surface of the copper pipes. The ingress of moisture, dirt and any other contaminants to the interior of the copper pipes, and air conditioning units, must be prevented during the installation procedure. After the installation of pipe work, prior to the connection of the outdoor units, and sealing of insulation joints, the pipe work must be pressure tested for leakage, using dry nitrogen.

Procedure for Copper Piping:

- a) Cleaning: All copper tubing shall be properly cleaned prior to use. The following cleaning procedure shall be adopted.
  - i) A clean lint less cloth shall be drawn through the tubing by means of a wire to remove all coarse particles of dirt and dust
  - ii) A clean lint less cloth saturated with trichloroethylene shall be pulled through pipe and the procedure. repeated till no further discoloration of the cloth is observed.
  - iii) A clean cloth saturated with compressor oil squeezed dry shall be drawn through pipe.'Finally, a clean cloth shall be drain through pipes.

**b) General Instructions:**

Pipes shall be cut accurately to measurements established at the job site and worked into place without springing or forcing, properly clearing all windows, doors and other openings. Excessive cutting or other weakening of the building structure to facilitate piping installation No installation will be permitted, without. Written approval. -Layout drawing, required under the title of "App-oval of Material and Equipment" shall show locations of all supports, the load imposed on each fastening or anchor, typical details for special anchorage, for suspended piping, valves, tank, pumps, converters, and other mechanical equipment. Where supports are required between structural framing members, suitable intermediate metal framing shall be provided and detailed. Pipe shall have burrs removed by reaming and shall be installed to permit free expansion and contraction-without damage to joints and hangers." Changes in direction shall be made with fittings, except that bending of pipe and smaller will be permitted provided a pipe bender is used and type-sweep bends are formed. The centerline radius of bends shall not be less than 6 diameters of the pipe. Bent pipe showing kinks wrinkles, flattening or other malformations will not be accepted. All piping shall be installed with sufficient pitch to ensure adequate drainage and venting. Piping connections to equipment shall be provided with unions or flanges. Open ends of pipelines or equipment shall be properly capped or plugged during installation to keep dirt and other foreign matters out of the system.

Tubing shall be cut so ends are perfectly square and will "bottom" in the fitting. There shall be no gaps left through which solder can run into the line. If possible, a pipe cutter shall be used. hacksaw must be used, it shall always be guided with a mitre-boxjto ensure a square, even cut. Tubing shall be reamed to remove burr being careful not to expand tubing while reaming.

The outside of the copper pipe and the inside of the fitting, where solder will be applied, shall be burnished. Fine crocus cloth or tight-fitting brushes especially made for his type of work shall be used. Surfaces shall be burnished until all dirt and oxide is removed. Cleaned surface shall not be touched with hands or gloves. A- light coat of brazing flux shall be applied to both pipe and: fittings. -An acid flux such as muriatic (hydrochloric acid) shall never be used as the resulting corrosion can seriously affect the pipe and composition for brazing.

Joint shall be heated to proper brazing temperature being sure that it hot so brazing material will flow to all parts of the joint. The brazing material shall be fed to the joint until uniform link of brazing material appears around the pipe at the end of the fitting.

95-5 solders which is an alloy of 95% tin and 5% antimony shall be used.

When solenoid stop valves are being installed, the coil shall be removed to prevent the heat of soldering from ruining the Insulation. When sight glass is being installed, the glass shall be Removed to prevent cracking. No heat shall be applied near the bulb of the expansion valve or any other place where an excessive temperature may cause damage. Pipe insulation shall not be installed nor the piping anchored until Testing is completed-and all leaks have been properly eliminated.



**Pipe Supports:**

- i) **General:** Pipe hangers, brackets, saddles, inserts, clamps, and pipe rolls including rods, bolts, shall conform to standard recommended practice. Design generally accepted, as exemplifying good engineering practice, using stock or production parts, shall be utilized wherever possible. Chain, wire, strap or other make shift devices will not be permitted as hangers or supports.
- ii) Hangers shall be supported from clamps, concrete inserts, Philips concrete fasteners, or Raw bolts. Concrete inserts when used, shall be installed in the exact location prior to the pouring of concrete.

**iii) Suspended Horizontal Piping:**

Shall be supported by adjustable hangers or supports, which shall provide means of vertical adjustment after erection. Unless otherwise indicated on drawings maximum spacing between copper pipes supports the straight runs of pipe and tubing shall be in accordance with recommended spacing shown in the table

**Maximum Spacing between Copper tubing Supports:**

<b>MIN. TUBING SIZE – INCHES</b>	1/2	5/8	7/8	1 1/8	1 3/8	1 5/8	2 1/8	2 5/8	3 1/8	3 5/8
<b>(Min) SPAN - FEET</b>	5	6	6	7	8	9	10	10	11	12

Pipe hangers and supports shall be spaced not over 5 feet apart at heavy fittings and valves. A hanger shall be installed not over 1 foot from each change in direction of piping. Vertical piping shall be guided or supported in the center of each riser but not over 8 feet of centers and shall be supported at the base of the riser, on a base elbow or tee, with pipe stand only where required. For un-insulated brass or copper tubing, the riser clamp shall be compatible non-ferrous or electrolytic ally coated steel as for hangers.

**Commissioning & Testing:**

The contractor shall be responsible for commission the air conditioning unit in accordance with manufacturer's recommendations.

All AC Units will have a guarantee/warranty period of 36 months from the date of commissioning the units, and should any defects arise during this period which can be attributed to poor workmanship, improper material, or defective manufacture of the air conditioning units, for which the Consultant shall be the project engineer & consultant judge,

the Contractor shall be required to replace or repair all defective parts, except compressors (burnt or otherwise) which shall be replaced with new compressors. All repairs and replacement shall be as directed by the Consultant. If the Noise Level from the unit \_ create any nuisance or-its NC level (50db) is not maintained then it is the responsibility of the contractor to meet the specification as stated in the schedule.

SUPPORTS & ANCHORS: (If applicable)

### **General:**

Pipe hangers, brackets, saddles, inserts, claps and pipe rolls including rods, bolts, turn buckles, bases and protection shields shall conform to standard recommended engineering practice. Design generally accepted as exemplifying good engineering practice, using stock or production parts, shall be utilized wherever possible. Chain, wire, strap or other make shift devices will not be permitted as hangers or supports. Pipe hangers shall be capable of supporting the pipe in all conditions of operations. Hangers shall be supported with beam-

Clamps, concrete inserts, Philips concrete fasteners, or raw-bolts. Concrete inserts when used shall be installed in the exact location prior to the pouring of the concrete.

Suspended Piping Supports :( If applicable)

- (a) Piping shall be supported by adjustable hangers or supports, which shall provide a means of vertical adjustment after erection.

### **Additional Refrigerant:**

Additional refrigerant only shall be used, and must be charged by weight only, using electronic scales. The amount of additional refrigerant must be accurately calculated from the manufacturer's data, based on the length and diameter of each section of the liquid refrigerant pipe work of the system.

## **3.3 CONDENSATE DRAIN PIPING:**

All condensate drains piping including fittings shall be of UPVC, Class E, as per BS 3505.

- a) Install drainpipes as and were shown on drawings.
- b) Provide support at every 1 meter and at every change in direction.
- c) Drainpipe shall be installed with proper slope.
- d) Do-not connect drain piping to draining system. Use in-direct connection.
- e) Insulate drain pipe with closed cell foam insulation.

## **3.4 PIPE SLEEVES:**

All pipes opening through walls, floor slabs shall have sleeves with internal diameter at least 50 mm larger than the outside diameter of the pipe of the insulation passing through the sleeve.

Pipes passing through walls shall be provided with UPVC sleeves

Space between pipe and sleeve shall be packed with fiber glass at least 1.5 lbf/ft<sup>3</sup> densities and sealed. All openings on roof shall be sealed water tight

## 2.0 AIR DISTRIBUTION SYSTEM

### 2.1 GENERAL

- a. Except as otherwise specified, all sheet metal ductwork, flexible ducts, flexible connections, dampers of all types and related items shall be in accordance with this section.
- b. Make every duct bent with centerline radius not less than its width. Make every change in size or shape of duct with taper not exceeding 1 in 5. Unless otherwise indicated, provide throats at all branches with throat velocity same as main duct velocity, Construct square throat elbows, indicated or required, with internal turning vans in accordance with detail indicated.
- c. Joints in all ductwork shall form smooth interior surface.
- d. Support horizontal ductwork on galvanized iron hangers not less than 1" X 1/8". Spaced not more than 8 ft. on center for ducts up to 8 sq. ft. in area and not more than 4 ft on centers for larger ductwork.
- e. Support vertical duct work at each floor with angles not less than 1 1/4" X 1 1/4" X 1/8", for ducts up to 30" wide 1-1/2" X 1-1/2" X 1/8", ducts from 31" to 60 "wide; provide minimum of two angles for each duct.
- f. Furnish dampers indicated or required to balance distribution of air through various parts of duct systems to obtain air deliveries indicated at all air inlets and outlets.
- g. For all ducts, dampers, access door, joints, stiffeners and hangers, "wide" is meant greatest dimension.
- h. All ductwork, UNLESS OTHERWISE SPECIFIED, in accordance with recommendation of ASHRAE.
- i. All the air plenums for linear grills shall be factory fabricated.
- j. During construction, where it is necessary for ductwork to be left open for extended period before completion, temporarily close any such openings with sheet metal covers where necessary or required to prevent debris from entering ducts and /or to maintain opening straight and square.
- k. All ducting measurements will be done after the installation.

## 2.2 DUCTWORK – MATERIAL

Unless otherwise specified or indicated.

1. Air Conditioning System: Galvanized steel sheet prime quality.
2. Ventilating System: Galvanized steel sheet prime quality.

### **GALVANISED STEEL DUCTWORK:**

3. All ductwork, prime quality galvanized sheet steel:
4. To 12 inches maximum dimension, #26 USSG
5. 13 to 30 inches maximum dimension, #24 USSG
6. 31 to 60 inches maximum dimension #22 USSG
1. 61 to 90 inches maximum dimension #20 USSG
2. Over 90 inches maximum dimension #18 USSG
3. Transverse joint connections and duct-work stiffening, except as otherwise, specified:
4. To 24 inches wide: “S” slip, drive slip, pocket slip or bar slip on 94-inch centers.
5. 25 to 30 inches wide: “S” slip, drive slip, pocket slip or bar slip on 94-inch centers with 1-inch angles on 48-inch centers.
6. 31 to 40 inches wide: Drive slip, 1 inch pocket slip or 1 inch bar slip on 94-inch centers with 1-inch angles on 48-inch centers.
7. 41 to 60 inches wide: 1-1/2” angle connections, 1-1/2-inch pocket slip or 1-1/2-inch bar slip on 94 centers with 1-1/2-inch angles on 48-inch centers.
  - a. 61 to 90 inches wide: 1-1/2-inch angle connections, 1-1/2-inch pocket slip or 1-1/2-inch bar slip on 45-inch centers, with 1-1/2-inch angles on 24-inch centers.
  - b. 91 inches and larger: 2-inch angle connections, 1-1/2-inch pocket slip or 1-1/2-inch bar slip on 45-inch centers, with 1-1/2-inch angles on 24-inch centers.
  - c. On ductwork up to 60” wide, 45 inches long duct sections may be used.

Ductwork for distance of 20 ft. from fan inlet and outlet: Stiffened as specified above, except angles spaced on centers not greater than 24 inches, both transverse and longitudinal.

Stiffing angles: Riveted or spot welded to ductwork, may be of black structural steel. Angles, total girth, on all four sides of ductwork. Angles may be omitted at joints if joints are equivalently reinforced.

Make longitudinal seams on all ductwork with Pittsburgh or double seams, locked and hammered tight, with smooth interior duct surface.

Cross-break all un-insulated ducts 18 inches wide and larger to prevent vibration or buckling.

### **2.3 FLEXIBLE DUCTS (If required)**

All main duct and linear diffuser plenums shall be connected through flexible ducts. The sizes of flexible ducts are indicated on drawings or as directed by the consultant. The flexible duct shall be 2 ply aluminum flexible ducts with high tensile steel wire reinforcement, and shall be insulated with 1 inch thick 16 kg/m<sup>3</sup> glass fiber insulation, covered with aluminum foil vapor barrier insulation.

### **2.4 DAMPERS**

#### **General:**

In all ductwork systems, furnish all dampers necessary for proper control and balancing of air distribution. Furnish dampers in all branches, with operating levers readily accessible. No damper greater than 48" long. For greater lengths provide dampers in equal sections as required. These shall be opposite blades configuration.

Same material as ductwork, except as otherwise specified, rigid 18g. Construction, free of all rattling and vibration, with edges crimped or creased for stiffness.

All dampers shall have through rods, not less than 3/8" diameter fastened to blade with 2 or more yokes with set screws, with steel washer at each end of damper rod.

Damper blades, two-gauge numbers heavier than ductwork, # 18 gauge and lighter shall have both edges double hemmed. Blades longer than 36 inches shall have "V" crease in middle to receive damper rod.

Dampers shall have through damper rod with #14 gauge bearing plate at one end and quadrant and lever with lock screw at other end; damper lever fastened to rod with set screws.

On insulated ductwork, mount guardant on metal saddles finishing flush with insulation surface.

Multi-Leaf Dampers: Shall comply with requirements for single leaf dampers. All damper rods, linked together to operate as a unit.

Splitter Dampers: Provide for air adjustment in throats at duct branches, Rigid construction, securely held in adjusted position with adjusting rod connected to leading edge of damper and protruding through duct; hinged connection at damper and lock screw fitting connection at duct face. On insulated ductwork mount lock-screw fitting so that lock-screw is located outside insulation. For each splitter damper provide sufficient number of adjusting rods to prevent vibration or loosening of adjusted position. Length of splitter, at least equal to width of branch throat served.

## 2.5 ACCESS DOORS IN DUCTWORK

1. Furnish as indicated and wherever necessary or required for proper access to all instruments, controls and equipment and for convenient inspection, maintenance and replacement, of the same. In general, provide access doors for each plenum, fire dampers, automatic dampers, fan bearing and as indicated.
2. Size of access doors:
3. In ducts, 20" X 14", unless otherwise indicated.
4. In plenums, 21" X 60" with bottom set 12" above finished floor.
5. Access doors smaller than sizes listed above will be permitted only where necessary due to space limitations. In all cases where smaller doors are provided, they shall be as large as space conditions permit.
  - a. In ductwork: Two-piece pan construction with outer side crimped over inner dished side and including frame and hardware. Dished portion filled with same insulations as used on duct or casing. Frame contact surface covered with continuous heavy dense fastened in place. Door contact surface, designed to close against felt to make door airtight. All hardware, brass construction. Provide not less than 2 hinges and not less than 2 heavy window type latches for each door where space conditions do not permit hinging of doors.
  - b. In casings: Similar to access doors in ductwork system except as follows:
    1. Door adequately braced with interior angles or as approved.
    2. 3 heavy brass hinges per door.
  - c. Latches: Operation either side of door, brass bronze construction, minimum 2 per door.

## 2.6 FLEXIBLE COLLARS

- d. Unless otherwise specified, make connections between ductwork and fans by means of approved coated fabric collars with sewed and cemented seams, fastened by bolted metal strap.
- e. Flexible connections – Flexible connections for air conditioning systems shall be at least 850 gr. 30-ounce glass fabric double coated with neoprene. Connections shall not be stretched tight but shall, after installation, be able to be moved in any direction at least 1 inch without stretching.

## 2.7 DUCT TEST HOLES

- f. Duct test holes shall be required at different places for the purpose of air balancing. These shall be provided in main as well as branch ducts, for the insertion of Pitot tube. The diameter, constructions and spacing of these test holes shall be as shown in the drawings.

## 2.8 LEAKAGE AND PREVENTION

- g. Duct leakage tests shall be carried out as recommended and test reports shall be submitted to the consultant for approval.
- h. To this end, the contractor shall, in the construction of his work, use appropriate joint, seam, and connection caulking and sealers, to insure air tightness of the ductwork. In addition, he

shall apply a 3-inch-wide frame resistant duct tape to all joints and seams that are not welded, soldered or otherwise air tight. Tape shall be applied in a continuous and even strip on and around the joints.

- i. For exposed ductwork, contractor shall confer with the Consultant as to the appropriate method of sealing to affect the most aesthetic appearance while maintaining an efficient seal.

## 2.9 ADJUSTMENT OF SYSTEMS AND TESTS

- j. Upon completion of installation, balance air distribution by adjustment of dampers and apparatus so that actual air delivery of each diffuser, grille and register does not vary more than  $\pm 5\%$  from air quantities indicated. Adjust all registers and diffusers so that there are no drafts.
- k. After balancing air distribution, test ventilating and air conditioning systems to certify compliance with Code requirements for ventilation and proper functioning of all operating devices.
- l. Submit certification and test report as specified.

## 2.10 DUCT WORK INSULATION

### a. Insulation:

All supply air ducting and return air-ducting shall be insulated with insulation. Panels shall be cut to size to fit duct being insulated, and shall be fixed to the duct with approved adhesive. Adhesive shall cover at least 75 % of cut area. Sheet metal hooks will not be allowed. The insulation is to be installed flush with the duct, but so as not to 'lessen the thickness of the insulation. Insulation shall be continuous, and no gaps, crevices, or other discontinuities shall be acceptable. The insulation shall be held in place additionally by using polyethylene-packaging bands, 10 mm wide.

### b. Jacket:

To provide mechanical protection to the insulating shall be provided in mechanical rooms, on duct, which are installed at, or below 2m or below 2m heights. Jacket shall be as indicated under INSULATION SCHEDULE (Section-3), pasted to insulation using approved adhesive. All circumferential and longitudinal joints shall be over-lapped at least 40mm.

### a. Cladding:

All insulated ducting exposed to the atmosphere shall be provided with a cladding of 24 gage (0.70 mm) GI sheet over the insulation. All joints shall be sealed with "Silicon Sealant", so that the cladding becomes completely waterproof. Cladding shall also be installed at all other locations shown on the drawings.

### 3.0 DUCT INSULATION

- **PART 1 – GENERAL**
- **RELATED DOCUMENTS**

A. All Drawings and General Provisions, Special Provision of the Contract, including General and Special Conditions Technical Specification, Equipment Selection Sections, apply to this Section.

#### **SUMMARY**

B. This Section includes insulation over GI sheet metal duct, and plenums, sound lining inside the duct work, field-applied jackets; accessories and attachments; and sealing compounds.

- **QUALITY ASSURANCE**

C. Fire-Test-Response Characteristics: As determined by testing materials identical to those specified in this Section according to ASTM E 84, by a testing and inspecting agency acceptable to authorities having jurisdiction. Factory label insulation and jacket materials and sealer containers with appropriate markings of applicable testing and inspecting agency.

D. Insulation: Flame-spread rating of 25 or less and smoke-developed rating of 50 or less.

- **DELIVERY, STORAGE, AND HANDLING**

E. Packaging: insulation rolls shall be properly packed in water resistant bags marked by manufacturer with appropriate ASTM specification designation, type thickness, thermal conductivity and density.

- **COORDINATION**

F. Coordinate clearance requirements with duct Installer for insulation application.

- **SCHEDULING**

G. Schedule insulation application after testing duct systems. Insulation application may begin on segments of ducts that have satisfactory test results.



- **PART 2 - PRODUCTS**
- **INSULATION MATERIALS**

- A. Fiber Glass Thermal Insulation: Glass fibers insulation blanket of specified thickness, bonded with all-service jacket manufactured from Kraft paper, reinforcing scrim, aluminum foil, and vinyl film.
- B. The duct insulation shall be further covered with 08 oz per sq yard canvas cloth, where specified

Sound liner shall be of 1-inch-thick fiber glass with thermosetting resin with facing.

- **ACCESSORIES AND ATTACHMENTS**

Aluminum Foil Tape: 3-inch-wide aluminum foil tape shall be used to join the insulation, facing of aluminum foil tape shall be same as of duct insulation.

Water based glue for the application of insulation on 100% area of duct to be insulated.

Bands: 19 mm wide, in one of the following materials compatible with jacket: Nylon bands

Galvanized Steel: 0.13 mm thick. Aluminum: 0.18 mm thick.

Self-Adhesive Anchor Pins and Speed Washers: Galvanized steel plate, pin, and washer manufactured for attachment to duct and plenum with adhesive: Pin length sufficient for insulation thickness indicated.

- **PART 3 - EXECUTION**
- **EXAMINATION**

Examine substrates and conditions for compliance with requirements for installation and other conditions affecting performance of insulation application. Proceed with installation only after unsatisfactory conditions have been corrected.

- **PREPARATION**

- A. Surface Preparation: Clean and dry surfaces to receive insulation. Remove materials that will adversely affect insulation application.

- **GENERAL APPLICATION REQUIREMENTS**

Apply insulation materials, accessories, and finishes according to the manufacturer's written instructions; with smooth, straight, and even surfaces; and free of voids throughout the length of ducts and fittings.

Refer to schedules on drawings for material, jackets, and thickness required for each system.

Use accessories compatible with insulation materials and suitable for the service. Use accessories that do not corrode, soften, or otherwise attack insulation or jacket in either wet or dry state.

Seal joints and seams with aluminum foil tape.

Keep insulation materials dry during application and finishing.

Apply insulation with tight longitudinal seams and end joints. Bond seams and joints with adhesive recommended by the insulation material manufacturer, or as specified.

Apply insulation with the least number of joints practical.

Apply insulation over fittings and specialties, with continuous thermal and vapor-retarded integrity.

Hangers and Anchors: Seal penetrations in insulation at hangers, supports, anchors, and other projections with vapor-retarder mastic. Apply insulation continuously through hangers and around anchor attachments.

Apply insulation with integral jackets as follows: Pull jacket tight and smooth. Joints and Seams: Cover with tape and vapor as recommended by insulation material manufacturer to maintain vapor seal.

Cut insulation according to manufacturer's written instructions to prevent compressing insulation to less than 75 percent of its nominal thickness.

Install vapor-retarder mastic on ducts and plenums.

Ducts: Overlap insulation facing at seams and seal with vapor-retarder mastic and pressure-sensitive tape having same facing as insulation. Repair punctures, tears, and penetrations with tape or mastic to maintain vapor-retarder seal.

M. Interior Wall and Partition Penetrations: Apply insulation continuously through walls and partitions, except fire-rated walls and partitions.

N. Fire-Rated Wall and Partition Penetrations: Terminate insulation at fire/smoke damper sleeves for fire-rated wall and partition penetrations.

Floor Penetrations: Terminate insulation at underside of floor assembly and at floor support at top of floor.

Insulation shall not impede access to duct covers/doors used for duct cleaning and/or maintenance.

- **DUCT SYSTEM APPLICATIONS**  
Refer to insulation schedules on drawings for materials and thickness.
- **DUCT INSULATION**
- **PART 1 – GENERAL**
- **RELATED DOCUMENTS**

All Drawings and General Provisions, Special Provision of the Contract, including General and Special Conditions Technical Specification, Equipment Selection Sections, apply to this Section.

- **SUMMARY**

This Section includes insulation over GI sheet metal duct, and plenums, sound lining inside the duct work, field-applied jackets; accessories and attachments; and sealing compounds.

- **QUALITY ASSURANCE**

Fire-Test-Response Characteristics: As determined by testing materials identical to those specified in this Section according to ASTM E 84, by a testing and inspecting agency acceptable to authorities having jurisdiction. Factory label insulation and jacket materials and sealer containers with appropriate markings of applicable testing and inspecting agency.

Insulation: Flame-spread rating of 25 or less and smoke-developed rating of 50 or less.

- **DELIVERY, STORAGE, AND HANDLING**

Packaging: insulation rolls shall be properly packed in water resistant bags marked by manufacturer with appropriate ASTM specification designation, type thickness, thermal conductivity and density.

## **COORDINATION**

H. Coordinate clearance requirements with duct Installer for insulation application.

- **SCHEDULING**

I. Schedule insulation application after testing duct systems. Insulation application may begin on segments of ducts that have satisfactory test results.

## **PART 2 - PRODUCTS**

- **INSULATION MATERIALS**

- A. Fiber Glass Thermal Insulation: Glass fibers insulation blanket of specified thickness, bonded with all-service jacket manufactured from Kraft paper, reinforcing scrim, aluminum foil, and vinyl film.
- B. The duct insulation shall be further covered with 08 oz per sq yard canvas cloth, where specified

Sound liner shall be of 1-inch-thick fiber glass with thermosetting resin with facing.

- **ACCESSORIES AND ATTACHMENTS**

Aluminum Foil Tape: 3-inch-wide aluminum foil tape shall be used to join the insulation, facing of aluminum foil tape shall be same as of duct insulation.

Water based glue for the application of insulation on 100% area of duct to be insulated.

Bands: 19 mm wide, in one of the following materials compatible with jacket:

- A. Nylon bands
- B. Galvanized Steel: 0.13 mm thick. Aluminum: 0.18 mm thick.

Self-Adhesive Anchor Pins and Speed Washers: Galvanized steel plate, pin, and washer manufactured for attachment to duct and plenum with adhesive: Pin length sufficient for insulation thickness indicated.

## **PART 3 - EXECUTION**

- **EXAMINATION**

Examine substrates and conditions for compliance with requirements for installation and other conditions affecting performance of insulation application.

Proceed with installation only after unsatisfactory conditions have been corrected.

### **PREPARATION**

- A. Surface Preparation: Clean and dry surfaces to receive insulation. Remove materials that will adversely affect insulation application.

## GENERAL APPLICATION REQUIREMENTS

Apply insulation materials, accessories, and finishes according to the manufacturer's written instructions; with smooth, straight, and even surfaces; and free of voids throughout the length of ducts and fittings.

Refer to schedules on drawings for material, jackets, and thickness required for each system.

Use accessories compatible with insulation materials and suitable for the service. Use accessories that do not corrode, soften, or otherwise attack insulation or jacket in either wet or dry state.

Seal joints and seams with aluminum foil tape.

Keep insulation materials dry during application and finishing.

Apply insulation with tight longitudinal seams and end joints. Bond seams and joints with adhesive recommended by the insulation material manufacturer, or as specified.

Apply insulation with the least number of joints practical.

Apply insulation over fittings and specialties, with continuous thermal and vapor-retarded integrity.

Hangers and Anchors: Seal penetrations in insulation at hangers, supports, anchors, and other projections with vapor-retarder mastic. Apply insulation continuously through hangers and around anchor attachments.

Apply insulation with integral jackets as follows: Pull jacket tight and smooth.

Joints and Seams: Cover with tape and vapor as recommended by insulation material manufacturer to maintain vapor seal.

Cut insulation according to manufacturer's written instructions to prevent compressing insulation to less than 75 percent of its nominal thickness.

Install vapor-retarder mastic on ducts and plenums.

Ducts: Overlap insulation facing at seams and seal with vapor-retarder mastic and pressure-sensitive tape having same facing as insulation. Repair punctures, tears, and penetrations with tape or mastic to maintain vapor-retarder seal.

M. Interior Wall and Partition Penetrations: Apply insulation continuously through walls and partitions, except fire-rated walls and partitions.

N. Fire-Rated Wall and Partition Penetrations: Terminate insulation at fire/smoke damper sleeves for fire-rated wall and partition penetrations.

Floor Penetrations: Terminate insulation at underside of floor assembly and at floor support at top of floor.

Insulation shall not impede access to duct covers/doors used for duct cleaning and/or maintenance.

## DUCT SYSTEM APPLICATIONS

Refer to insulation schedules on drawings for materials and thickness.

### 4.01 AIR DEVICES

#### - DIFFUSERS, REGISTERS, AND GRILL'S PART 1 – GENERAL

- **RELATED DOCUMENTS**

All Drawings and General Provisions, Special Provision of the Contract, including General and Special Conditions Technical Specification, Equipment Selection Sections, apply to this Section.

- **SUMMARY**

This Section includes ceiling- and wall-mounted diffusers, registers, and grilles, Louvers and linear grills etc.

Related Sections include the following:

This Section includes rectangular and round metal ducts for heating, ventilating, and air conditioning systems in pressure classes, from minus 2 inches to plus 4 inches water gage.

Related Sections: The following sections contain requirements that relate to this Section:

Section AB055, "Basic Materials and Methods" for fire-resistant sealants for use around duct penetrations and fire damper installations in fire rated floors, partitions, and walls.

Section 15010, "Basic Mechanical Requirements"

Division 15 Section "Duct Insulation" for exterior duct and plenum insulation.

Division 15 Section "Duct Accessories" for flexible duct materials, dampers, duct-mounted access panels and doors, and turning vanes. Division 15 Section "Testing, Adjusting, and Balancing,"

- **QUALITY ASSURANCE**

A. Product Options: Drawings and schedules indicate specific requirements of diffusers, registers, Louvers, linear grills and grilles and are based on the specific requirements of the systems indicated. Other manufacturer's products with equal performance characteristics may be considered.

B. NFPA Compliance: Install diffusers, registers, and grilles according to NFPA 90A, "Standard for the Installation of Air Conditioning and Ventilating Systems."

## **PART 2 – PRODUCTS**

- **GRILLES AND REGISTERS**

Adjustable Bar Grille or Register:

Material: Aluminum.

Finish: Baked enamel, white.

Damper Type: Adjustable opposed-blade assembly.

- **CEILING DIFFUSER OUTLETS**

Rectangular and Square Ceiling Diffusers:

A. Material: Aluminum.

B. Finish: Baked enamel, white.

C. Face Size: See schedule on drawings.

D. Dampers: Radial opposed blade.

- **CEILING DIFFUSER DISC TYPE**

Round Ceiling Diffusers:

Material: Aluminum.

Finish: Baked enamel, white.

Face Size: See schedule on drawings. Face Style: Disc type.

- **LINEAR GRILL**

Linear Grill Series 6000 T &B: or Imperial Line Series Material: Aluminum. Finish: Baked enamel, white.

Face Size: See schedule on drawings.

- **LOUVERS**

Rectangular and Square Louvers:

Material: Aluminum.

Finish: Baked enamel, white.

Face Size: See schedule on drawings.

- **SOURCE QUALITY CONTROL**

Verification of Performance: Rate diffusers, registers, linear grills, Louvers and grilles according to ASHRAE 70, "Method of Testing for Rating the Performance of Air Outlets and Inlets."

### **PART 3 - EXECUTION**

- **EXAMINATION**

- A. Examine areas where diffusers, registers, and grilles are to be installed for compliance with requirements for installation tolerances and other conditions affecting performance of equipment.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

- **INSTALLATION**

Install diffusers, registers, linear grill, louvers and grilles level and plumb.

Ceiling-Mounted Outlets and Inlets: Drawings indicate general arrangement of ducts, fittings, and accessories. Air outlet and inlet locations have been indicated to achieve design requirements for air volume, noise criteria, airflow pattern, throw, and pressure drop. Make final locations where indicated, as much as practicable. For units installed in lay-in ceiling panels, locate units in the center of panel. Where architectural features or other items conflict with installation, notify Architect for a determination of final location.

Install diffusers, registers, and grilles with airtight connections to ducts and to allow service and maintenance of dampers, air extractors, and fire dampers.

- **ADJUSTING**

- A. After installation, adjust diffusers, registers, and grilles to air patterns indicated, or as directed, before starting air balancing

- **4.12 AIR BALANCING**

The contractor shall provide a third party for air balancing on the cost of contractor. The consultant will approve third party for air balancing.



## **5.01 INSTALLATION**

### **5.1 REQUIREMENTS**

The contractor shall obtain the approval and perform necessary inspections to the national, local and corporate codes and standards involved in the system used, and provide the Employer with the written documents required expressly by the acceptance, inspections and codes before the execution on site.

The manufacturer shall provide conformity certificates for products and the following information that comes with each piece of equipment:

A/C schematics, installation charts and specification (incl. standards for installation, commissioning and acceptance, requirements for installation of indoor and outdoor units, installation of refrigerant circuits, condensate circuits and electrical circuits, thermal insulation for refrigerant, and acceptance of concealed works);

Electrical schematics and wiring diagram

Operating specification and maintenance and commissioning manual (indicating fault, causes and method for trouble-shooting)

List of maintenance tools for accessories and spare parts, and instruments and apparatus;

Other necessary information on design, installation, commissioning, operation and maintenance;

The manufacturer shall provide the construction and performance of the unit as per the design scheme, which includes but not limited to the following:

Performance parameters of the unit like air volume, refrigerating output, heating output, power, weight, dimensions and more (included in a list); and

Performance description of main parts like, compressor, oil circuit, control system, refrigerant and more.

The manufacturer shall provide all particular test and inspection reports for A/C equipment, and assume responsibility for the accuracy and completeness of the test reports.

## **5.2 GENERAL**

### **5.3 INSTALLATION OF OUTDOOR UNIT**

The outdoor unit shall be so installed that the other services and the façade effect of the building will not be affected.

The outdoor unit will be mounted at the spot designated for A/C on the building drawing. Access for maintenance to the outdoor unit shall be made available.

The outdoor unit shall allow fast maintenance like fast replacement of the compressor.

The unit shall have vibration damping device, allow easy maintenance and provide good condition during operation. During the operation, abnormal sound and vibration shall not happen, and the unit shall run in quiet operational mode.

### **SUPPORTING AND SECURING**

Hangers shall be fabricated and installed in line with the diagrams for supports and hangers provided by the designer or equipment manufacturer and approved by the supervisor.

Use screws. Generally, use hot dip galvanized steel wood screws to secure concrete, brick or block wall. In wet and exposed cases, use lubricated wood screws.

Use drilling machine of proper size and length, and fit for structure. Never use flame to bore in metal products.

All fasteners and securing methods shall comply with the rules from the manufacturer.

### **THERMAL INSULATION**

Condensate tubes are to be thermally insulated to prevent condensation.

### **CLEANING**

The surface of the unit shall be free of scratches, stains and impression. It should be smooth, even in the coating, consistent in color and free of peeling-off, curls, cracks, bubbles, dripping marks etc.

### **COMMISSIONING AND TRIAL RUN**

When the system is installed, conduct the test before trial run under the supervision of the purchaser and Consultant to prove it is ready for trial run.

Participants for the trial run include technical support personnel from the manufacturer, installing people, supervisor and Employer.

The manufacturer winning the contract shall conduct commissioning and trial run of the equipment on site to verify the design, fabrication, operability and functions.

The technical staff from the manufacturer winning the contract shall make available the special tools, consumables and special instruments and apparatus required for the installation and commissioning. Commissioning and trial run shall take place only after satisfactory results are available for the system purging, air-tightness test, evacuation, filling refrigerant, condensate tube connection test, and test for control line and power line, and checked and signed by supervisor and project management people. Commissioning and trial run shall take place to the equipment piece by piece, and the record for commissioning shall be submitted to the user. The A/C condensate tubes have to be subject to water-tightness test.

## **CONTROL SYSTEM**

The control line will run in conduit. Power line and control line shall be routed separately and spaced as required by the standards.

The control system of the unit shall allow self-regulation, automatically regulating the operational state of the compressor in line with the set indoor temperature and the operational condition of the indoor unit.

Each indoor unit will be equipped with a standard wired remote controller which is secured to the wall. The control panel of the screen displays all operational conditions, provides temperature setting, cooling/heating mode setting, air volume regulation, self-diagnosis of faults, fault display, and prompt for cleaning filtering screen, and allows easy enquiry of faults and system inspection.

The control system shall centrally control all the indoor units and allow separate control of each indoor unit. The control panel shall enable simple operation and correct operation and judgment by the operator via instructions.

Intelligent central control will be used for the A/C and the following functions shall be available:

- Central control: allowing uniform setting of On/Off, temperature and operational modes for A/Cs in different zones, and operating authority of the remote controller.

### **Motor Control Centers (MCC's):**

- The MCC shall be of 16 SWG sheet-steel, floor-mounted cubicle type, totally enclosed, splash- proof, dust tight and vermin proof to IP54. It shall be factory tested and complete in all respect with components, material and accessories, and finished according to the specifications

6.0 List of Approved Manufactures for AIR CONDITIONING WORK

<b><u>S.No.</u></b>	<b><u>Equipment/Material</u></b>	<b><u>Recommended Manufactured</u></b>
1	DX coil AHU With Matching Condensing Units	Daiken, Mitsubishi, Clivet, Boreas Korea, Japan, USA, Western Europe.
2	Air Cooled Packaged Outdoor Condensing Inverter type variable refrigerant flow	Daiken, LG, Mitsubishi, Samsung Korea, Japan, USA & Western Europe.
3	Ducted Concealed Fan Coil Units	Daiken, Mitsubishi, LG, Samsung Korea, Japan, USA & Western Europe.
4	PVC Pipes	Beta, Dadex, Plasco, Alpha, Polo or approved equal
5	Duct Insulation & Sound Liner	Afico, Kimmco, Owens Corning
6	GI Sheets	ISL or any other imported make available locally
8	Electrical Panels	Siemens, electrech, Electromech, South Asian HumProtect or approved Eq.
9	Refrigerant Pipe Insulation	ISO Pipe, Aero duct, Aero flex
10	Electric Cables/Control/Comm... cable	Pakistan Cable, Pioneer, Allied Cable, Newage,
11	Hepa Filters	AAF, Trox, Eco Air, GEA
12	Flexible Round Duct	Atco, Frantechm, Thermaflex
13	Air Curtain	Teco, Fast, Theodor or approved equal
14	Copper Pipe	Imported GD approved or approved equal

15	Exhaust Fans	Aerotech, Sasa, Air Mech (Pakistan)
16	Reheat Electrical coil	Local Made Approved by the engineer
17	Hanger and Support System	Mungo, link, Index, Fisher or approved equal
18	All equipment/ Materials other stated above	Make approved by the Employer

**NOTE:**

1. All Equipment/Material Must Be Supplied from Authorized/Sole Distributors.
2. Manufacturers Authorization Certificate in Original Must Be Provided.
3. Compliance to The Mentioned Country (Origin, Manufacturing, Assembly, Testing & Supply) For Offered/Supplied Equipment Is Mandatory
4. Any Approved Equal Brand Other Than the Above-Mentioned Recommended Manufacturer, the bidder shall submit the Following Additional Information in Addition to Prequalification Information with The Technical Bid.
  - A. Compliance of Equipment Parts and Their Origin as Mentioned in Technical Specification.
  - B. Compliance Statement of Technical Specification/ Standards from the Equipment Manufacturer.
  - C. Comparison of Each Part/System of Proposed Brand with One of the Brands Provided in Suggested Manufacturer's List Along with The Test Reports.
  - D. Approved Equal Brand Shall Clearly Be Mentioned in The Technical Bid Along with Above Said Information.

## **7.0 ELECTRICAL WORKS**

### **PART 1 – GENERAL**

#### **1.1 RELATED DOCUMENTS**

All Drawings and General Provisions, Special Provision of the Contract, including General and Special Conditions Technical Specification, Equipment Selection Sections, apply to this Section.

#### **1.2 SUMMARY**

The Contractor shall furnish all labour, materials/plant equipment and perform all necessary operations required to execute the work of this section.

It is the responsibility of the Contractor to ensure that equipment, Main Control panel, MCC's etc shall fit into the spaces allocated and shall allow acceptable clearances, recommended by the manufacturer for entry, servicing and maintenance.

This Section includes all Electrical works related to HVAC.

#### **1.3 QUALITY ASSURANCE**

Product Options: Drawings indicate requirements of electrical and are based on the specific requirements of the systems indicated.

Pakistan Electricity Rules & Regulations Compliance: Install all the components, panels, MCCs, SPs, and local Isolation panels according to "Pakistan Electricity Act 1910 and the Electricity Rules 1937"

### **1.4 PART 2 - PRODUCTS**

#### **2.1 GENERAL**

Scope: The electrical works included in the scope of Mechanical Contract are shown on the drawings and given in these specifications. It shall include but not be limited to the following:

Motor Control Centers (MCCs) & Starter Panels (SP's) & Apparatus Control Panels (ACP) for HVAC equipment.

All outgoing power cables and earthing from MCC's and SP's to equipment.

All control cables for the control system specified herein between MCCs, ACPs, SP's, remote starters, push buttons, control devices, alarms, metering, relays, etc.

Conduits/Pipes and Cable Tray

Installation Materials and Accessories. Testing and commissioning of system. Getting system approval by Electric Inspector.

The Contractor shall be responsible for providing within his bid price any additional equipment and/or make modifications in the electrical equipment/material to suit the requirement of the equipment offered by him for ensuring proper operation of the system as approved by the Consultant. Where stated on the drawings, the electrical power supply shall be provided by electrical contractor up to the incoming termination point in the MCC.

The Contractor shall ensure all necessary co-ordination with the works of other Contractor and shall be responsible for any loss or damage caused due to his fault or negligence, and shall rectify the same at his own cost.

Standard Conditions: All equipment shall be designed to operate satisfactorily and continuously under the following conditions:

- ☐ Supply Voltage - 400/230 volts ±10%  
three  
Phase, four wires
- ☐ Supply Voltage - 230 volts ±10% single  
Phase, two wires
- ☐ Supply Frequency - 50 Hertz
- ☐ Ambient Temperature - 113 °F (45 °C) max.

Standards

British Standard Specifications and Code of Practices Pakistan Standard Institution IEE  
UK "Wiring Regulation for Electrical Installations"

- ☐ Ingress Protection Class - Indoor: IP 40  
Outdoor: IP 54

Rules & Regulations: The entire electrical installation works shall be carried out by a licensed Contractor, authorized to undertake such work under the provisions of the Electricity Act 1910 and the Electricity Rules 1937 as adopted and modified up to date by the Government of Pakistan.

The Contractor shall be responsible for submitting test certificates and having the installation passed by the Government Electric Inspector. All requirements of the Electric Inspector and the Electric Supply Company shall be complied with.

Equipment and Materials: In the specifications, certain types and makes of equipment material have been specified only for the purpose of reference and guidance. Prior to procurement of the materials the Contractor shall submit to the Consultants for approval, the names of the manufacturers and other technical data as required to satisfy as to the suitability, durability, quality and usefulness of the material intended to be purchased. When advised by the Consultant, samples of material shall be

provided free of cost for approval. If the material or equipment offered under this provision is, in the opinion of the Consultant, equal to or better than specified, it will be given consideration.

**Drawings & Data to be furnished By the Contractor:** The Drawings and data to be furnished by the Contractor for all electrical equipment's and shall include the following as applicable:

Shop drawings of MCCs and SP's showing dimensional plans, elevations, sections, line and wiring diagrams, foundation details, along with the relevant technical literature and manufacturer's characteristic data of proposed components. The Contractor shall also supply three copies of manufacturer's instruction manuals for the installation, operation and maintenance of the specified equipment including manuals of spare parts and tools of the equipment. Shop drawings, coordinated with other works shall be prepared by the Contractor and submitted to the Consultant for approval at least four weeks prior to commencement of that work.

**Markings:** The Contractor shall provide "Danger Boards" on all panels and "Shock Charts" wherever required to comply with the requirements of Electricity Rules at no cost to Owner.

**Associated Civil Works:** The cost of all civil works associated with any item of electrical works, shall be included in the bid price for electrical works. No separate payment for such works will be made.

## 1.5 PART 3 – EXECUTION

### 1.6 INSTALLATION

**General Installation Instructions:** The Contractor shall furnish all labour and materials, tools and equipment required to install, connect, test and commission all electrical equipment specified herein, whether or not such equipment is furnished by him or others.

For all equipment to be installed by the Contractor, the Contractor shall supply and install all installation materials such as foundation bolts, levelling steel, clamps, cable sockets, lugs, glands solder, wall plugs, raw bolts, washers, nuts, etc. as required and without any additional cost. In general, the manufacturer's instructions for installation shall be followed.

For any major departures from the working drawings that are deemed necessary by the Contractor due to site conditions, he shall submit the details and obtain the Consultants approval before starting such work.



**Motor Earthing:** The body of the motors shall be properly earthed as per local authority rules. Two number of standard HDBC CPC's of appropriate size from motor shall be terminated in MCC panel earth bus.

## TESTS

**Factory Test:** All routine tests on equipment shall be performed at the manufacturer's works in the presence of the Consultant or his representative prior to delivery of equipment. Test results and certificate shall be supplied in triplicate.

**Field Test:** Upon completion of the installation, the Contractor shall perform field tests on all equipment, materials and systems. All tests shall be conducted in the presence of the Consultant for the purpose of demonstrating equipment or system compliance with specifications.

All tests shall be made with proper regard for the protection of the equipment and the Contractor shall be responsible for adequate protection of all personnel during such tests.

The Contractor shall record test values of the tests made on all equipment. Three copies of all test data shall be given to the Consultant for record purposes.

The witnessing of any tests by the Consultant does not relieve the Contractor of his guarantees for materials/equipment

**Insulation Resistance Tests:** Insulation Resistance tests shall be made on all electrical equipment by using a meggar of 1000 volts.

Before making connections at the ends of each cable run, the insulation resistance measurement tests of each cable shall be made. All switch gear and control equipment shall be given an insulation resistance measurement test after installation, but before any wiring is connected. Insulation test shall be made between open contacts of circuit breakers, switches and between each phase and earth.

If the insulation resistance of the circuit under test is less than the specified value, the cause of the low reading shall be determined and removed. After all tests have been made, the equipment shall be reconnected as required.

**Earth Resistance Test:** Earth Loop Resistance and Earth Continuity tests shall be made by the Contractor on each section of earthing system separately.

**Control System:** The Control System shall be tested for correct operation by trial run and simulation of all operating and fault condition.

- **MATERIAL SPECIFICATIONS & INSTALLATION**

**INSTRUCTIONS Conduits & Pipes:**

**Steel Conduits:** All steel conduits and accessories such as bends, sockets, junction box, etc. shall be of heavy gauge 16 SWG steel, manufactured and tested in accordance with BS 31. Brass metal bushes shall be used at conduit termination to prevent cable from damage during pulling operation.

**Galvanized Iron (GI) and Accessories:** GI pipes and fittings shall be to BS 1387, light quality.

**Flexible Conduit:** All flexible conduits shall be of galvanized steel strip with plastic covering for water-tight installation. The flexible conduits (maximum 600mm length) shall be provided for protecting cable at all motor termination and at equipment subject to vibration during operation. Flexible conduit shall be terminated at both ends using appropriate brass fittings/clamps.

**Installation Requirements:**

**Steel Conduits:** In general conduits shall be installed on the surface by means of hospital type heavy-gauge steel saddles and clamps of approved design. Where advised by the Consultant, the conduits shall be concealed. These shall be fixed at a maximum of 1000mm spacing along horizontal and vertical runs of conduit. The exposed conduits, along with accessories shall be painted with enamel paint, to BS 1710, after completion of installation.

Under floor conduit installation shall be at a minimum depth of 50mm below the finished floor level when measured from the top of conduit. The conduits shall be installed empty before finishing of floor. Conduit ends pointing upwards or downwards shall be properly plugged, in order to prevent the entry of foreign materials.

The entire conduit system shall be installed and checked before wiring is carried out. The conduits at each termination point shall be connected to earth, and shall be continuous for the entire length to ensure earth continuity. Pull boxes and adapter boxes shall be of 16 SWG (1.5mm) and provided in conduit runs wherever required to facilitate pulling operation. The boxes shall be painted inside and outside with enamel paint, after base treatment. Wherever the conduit lengths cross the expansion joint along the column or slab, suitable arrangement shall be provided by means of field-fabricated expansion joints.

G.I. pipes shall be installed where power and control cables are running underground in paved areas, at crossing with other services, cable entry into buildings and where cables are running exposed to weather.

G.I. pipes installed on surface shall conform to the general requirements stated for steel conduits except that clamps saddles and installation accessories shall be galvanized type, and pipes shall be painted with zinc paint for all exposed runs.

### **Cables:**

**General:** All cables for power, control and earthing shall be PVC insulated, of specified voltage grade, complying with BS 6346 and BS 6004.

All power cables shall be 600/1000-volt grade, and control cables 300/500 volts grade for multi-core un-armored installation and 450/750-volt grade for single core installation.

**Underground Cables:** shall be PVC insulated, PVC sheathed and armored with galvanized steel wire.

**Surface Cables:** Cables for distribution system on surface or cable trays shall be multi-core, PVC insulated and PVC sheathed.

**Cables in Conduits:** All cables/wiring in conduit shall be single core PVC insulated.

**Phase Identification:** All cables shall have phase identification. The colour coding shall be red, yellow and blue for the phase conductors and black for neutral conductor, but the Contractor shall co-ordinate with the manufacturer to ensure uniform coding.

Single phase circuits shall have red and black for phase and neutral conductor respectively & green earthing conductor.

Control cables shall be colour coded uniformly, scheme for which shall be submitted by the Contractor for approval of the Consultant.

Earth conductors shall have green insulation conforming to the same grade as associated power cable.

**Cable Accessories:** shall be provided for the complete cabling and wiring systems. These accessories are to include all items for satisfactory installation and operation, such as, saddles, connectors, dips, dampers, compression lugs, brass glands/tapes, trunking, identification tags, etc.

**Conduit Wiring Installation:** The wiring through conduit or pipe shall be started only after the pipe or conduit system is completely installed and all outlet boxes, junction boxes etc. are fixed in position, and the raceway is dry.

The wire shall be pulled in conduit with care, without the use of lubricant

Where several cables are to be in the same pipe or conduit, they shall be pulled together along with the earth conductor by means of fish-wire.

The wires shall not be bent to a radius less than ten times the overall diameter of the wire, unless otherwise recommended by the manufacturer.

The wiring shall be continuous between terminations. Any joint in wires within the race way or in pull boxes will not be allowed. A minimum of 300mm extra length of cable/wire shall be left at each termination to facilitate repairs in future.

**Surface Wiring:** The cables installed on surface shall be by means of steel or phenolic moulded clamps installed at a maximum distance of 500mm.

Wiring on Cable Trays: shall be strapped for securing in position. For power cables minimum clearance equal to the diameter of larger cable shall be provided. Cable trays shall be of 16 SWG (1.6mm) perforated (40% free area) hot-dip galvanized (after fabrication) steel/ of adequate size and design to carry the required number of cables, also ensuring specified clearances between cables. The cable trays shall be fabricated in sections, two sections to be connected by bolted joints. Cable trays on surface or in cable trench shall have suitable fixing/supporting arrangement. All installation material and accessories shall be galvanized and/or corrosion-proof type. Shop drawing of cable tray shall be submitted to the Consultants for approval prior to commencement of fabrication of work.

**Underground Cable:** The cable shall be laid direct in ground or in protective RCC/GI pipes. A minimum clearance of 1m shall be provided with fuel/gas lines. Cable markers shall be provided at bends and along straight length of underground cable trench at intervals of 30m.

Sufficient loop length (maximum 5% of total length) shall be provided near termination and at bends. Before installation of cable, a coordinated plan of other underground services in the vicinity of cables shall be prepared by the Contractor and submitted for approval to the Consultant.

## CONTROL AND PROTECTION EQUIPMENT

**Motor Control Centers (MCC's):** The MCC shall be of 16 SWG sheet-steel, floor-mounted cubicle type, totally enclosed, splash-proof, dust tight and vermin proof to IP54. It shall be factory tested and complete in all respect with components, material and accessories, and finished according to the specifications.

### **The MCC Shall:**

Have components with short circuit ratings to I EC 947-2, Icu/lcs at 415v (as noted on the MCC Schedule).

Be designed for flush mounting of all instruments on the front side.

Be designed for incoming and outgoing connections from the bottom or top as required, with removable top & bottom cover plates.

Have the components mounted in a logical sequence and arranged so as to facilitate operation and maintenance from the front only.

Have a separate cubed for installation of digital temperature indicators and controllers required for automatic control.

Have 30.5mm push-button & lights, with 250V bulbs, 96mm x 96mm meters, class 1.5 CTs, HRC control fuses.

Have engraved plastic nameplates for all circuits.

The cabling inside the MCC shall be properly tagged (harnessed by means of straps or cords). All indicating, and control equipment shall be suitably arranged and clearly labelled with indelible labels indicating the ratings, circuit number, etc. All internal wiring shall have numbered ferrules at both ends for identification. Wiring to components on the door shall be made with flexible wires in flexible PVC pipe.

All metal work shall be cleaned down to bare shining metal, degreased, and then spray-painted with:

Two base coats of anti-corrosive paint (zinc chromate/red-oxide).

Two finish enamel coat in approved color - inside and outside, Stove enameled. Be provided with ventilation ports suitably vermin proof.

A power and controls circuit diagram shall be provided at a suitable location inside the MCC.

**Outdoor Starter Panels:** shall be totally enclosed, weatherproof type. These shall be suitable for mounting on a galvanized steel or RCC pedestal. The front door shall be lockable hinged and gasketed for weather-proof and water tight design (IP 54). The unit shall be suitable for outdoor duty under all local weather conditions and designed to allow for ventilation and cooling of the equipment.

All cable connections shall be from the bottom. Suitable cable gland with weather-proof sleeve for PVC insulated, PVC sheathed armoured or un-armoured cables for sizes shown on the drawing shall be provided. All live parts of the switch board shall be protected from the front to avoid any accidental contacts during operation. All indication lamps shall be visible from outside, while the operating switches and push buttons shall be accessible after opening of door. All internal wiring shall have numbered ferrules and shall be suitably strapped and supported.

Where bus bars are provided, these shall be of high conductivity electrolytic copper insulated by PVC covering for protection against weather.

The outdoor panels shall be minimum 14 SWG, 2.0mm sheet steel painted with two base coats of zinochromate/red-oxide paint and finished in two coats of heavy enamel paint stove enameled inside and outside in colour as approved by the Consultants.

The approved danger sign, switch board designation, supply source, etc., shall be written on the front door in conspicuous letters, in red colour over white background. A power controls circuit diagram shall be provided inside the panel.

**Indoor Starter Panels:** shall be wall or pedestal mounted depending on the location. These shall be fabricated from 14 SWG 2.0mm sheet steel, having hinged lockable door and finished in a manner as specified for MCC. All indication and control components shall be accessible from outside. The panels shall meet the other general requirements as stated for MCC.

Where pedestal is provided it shall be fabricated from galvanized steel members having all galvanized accessories. The mounting height of the panels shall be 1200mm when measured from the floor level to the bottom of the panel.

**Controls:** to be provided for the various equipment are described below or in the MCC Schedule. These controls are the specific operational requirements of particular equipment, and shall be in addition to any other controls specified elsewhere, and shown on the drawings and/or normally required for proper operation and performance. All wiring, control equipment shall be furnished by the Contractor.

"ON", "OFF" and "TRIP" indication lamps shall be provided for all motors (AHUs & EFs) on the Motor Control Centre.

For all motors connectors to the MCC provision shall be made for Hand-Off-Auto selector switch for selecting mode of operation of motors. Hand operation shall be through ON-OFF push buttons. For auto operation, the circuit shall be arranged for connection to external circuits for receiving switching command from a Building Management System (BMS).

An audible alarm shall be provided on the MCC which shall operate in case of tripping of motors or other alarm conditions related to the electrical system. Alarm "test, accept and reset" facilities shall be provided.

Lamp "push-to-test" facility shall be provided on MCC two spare changeover contacts shall be provided on each starter for Employees use.

Motors with winding embedded thermistor protection shall be provided with suitable relays in the MCC to trips starter if the motor over- heating.

**Components:** The MCC's, indoor and outdoor panels shall be provided with all components as specified and shown on the drawings and as necessary for the satisfactory operation. Typical component specifications are given below.

Bus Bars shall be made of high conductivity electrolytic copper. The phase identification on bus bars shall be red, yellow and blue for phase, black for neutral and green for earth. The phase bus bars shall be of HDHC finned copper (99.9% purity) and insulated or properly painted with red, yellow, or blue and black colour coding identification sequence, if copper purity is less than 99.9% (up to 98.5%), then the correct density to be used shall be maximum 1.5A/mm<sup>2</sup> for loads up to 1000 A, maximum 1.2A/mm<sup>2</sup> for loads above 1000 A.

**Circuit Breakers:** shall be single/triple pole, air break, manually operated with front drive. ON-OFF-TRIPPED indication shall be provided on all circuit breakers. The circuit breakers shall have the following protections:

Three poles, temperature compensated thermal overload release, fixed type for starter panels and adjustable for all other circuits.

Indicating lamps also provided as shown on the MCC schedule and also for control system as stated in the specifications. The incoming circuit breaker on MCC's shall be provided with under voltage/shunt relays. Suitable connections shall also be made to disconnect electric supply to HVAC system in case the Fire Alarm panel is activated. The circuit breakers (with magnetic only trips for short-circuit protection of motor-starters) shall have suitable characteristics so as to avoid false tripping due to motor starting current. They shall be used as short-circuit protection devices for motor starters to EC 947 & BS4941 Part 1 (Category MC").

All circuit breakers shall be rated for I EC 947-2, Icu/lcs at 415v.

**Ammeters and Voltmeters:** All meters shall be flush mounted moving iron, spring controlled. The front dimensions shall be 96 x 96mm. The meters shall have accuracy Class 1.5 fed through a current transformer. The ammeters and voltmeters shall have measured range as indicated on the drawings. Ammeters installed on motor circuits shall have appropriate over-range (600% for DOL starters, and 200% for star-delta starters) for the motor starting current.

**Current Transformers:** Air cooled; ring type transformers (CT) shall be provided having transformation ratio as indicated on the drawings. The CTs shall be of suitable burden, saturation factor, and have accuracy class 1.0.

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

AUTO-OFF-MANUAL and pump priority selector switches shall be of similar design with suitable nameplate.

**vi) Load Break Switch:** Triple pole (AC23) load-break switches of Current rating as specified shall be provided complete with front drive grip handle and front plate.

These shall also be provided in water-proof boxes near equipment when motor is remotely located from the MCC, as a means of safety isolation.

**HRC Fuses:** HRC link-type (NH) fuses with time-lag characteristics of current ratings as specified shall be provided complete with fuse bases fuses etc. The fuses shall have a fusing factor as specified for class Q1 in accordance with BS 88.

**Indicating Lamps & Push Buttons:** Indicating lamps shall be suitable for flush mounting complete with bases, 250 volt incandescent lamps and shall have rosettes of suitable colour. Push buttons shall be of the momentary contact type, suitably colour coded. Diameter of these components shall be 30.5mm

**Line up terminals:** Line-up terminal units (SIEMENS 8WA type or approved equal) wherever provided for control or power circuits shall be suitable for voltage and size of conductors as indicated on the drawing.

**Three phase outlets:** Socket outlet for three phase circuit shall be five pin (three phase, neutral and earth) and provided with matching plug. Interlocking shall prevent wrong connection between plug and socket.



**Motor starters:** Suitable starters shall be provided for motors as shown on the drawings. The rating of each starter component shall be selected keeping in view motor rating, starting current, operating characteristics, etc. All starters shall have a minimum life of 0.5 million operations (ACS). Each starter shall be wired for manual and/or automatic operation depending on the operational requirements. The over-load relays shall have protections against phase-failure/ single phasing.

**Direct-on-line Starter (DOL):** These shall be provided with momentary contact ON-OFF push buttons, and lights, magnetic contactors, manual/auto-reset, differential type thermal/electronic overload release, trip indication lamp and other circuit components and accessories.

**Star-Delta Starters (S.D.):** These shall be automatic-timer controlled, three- contactor type, and meeting the requirements as stated above for DOL starters.

**Two/Three Speed Motor Starters:** The starters shall be designed for two speed motors, having provision for starting at high or low speed, and meeting the requirements as stated above for DOL starters.

## **SCHEDULE OF MCC's & SP's**

The schedule of MCC's & SP's is provided on the drawings.

## **DEMONSTRATION**

Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain units.

Train Owner's maintenance personnel on procedures and schedules for starting and stopping, troubleshooting, servicing, and maintaining units.

Review data in maintenance manuals.

Schedule training with Owner, through Architect, with at least seven days' advance notice.

## 8.0 OPERATION AND MAINTENANCE OF HVAC SYSTEM

- **RELATED DOCUMENTS**

All Drawings and General Provisions, Special Provision of the Contract, including General and Special Conditions Technical Specification, Equipment Selection Sections, apply to this Section.

- **SUMMARY**

This Section includes the following:

After satisfactory completion, testing commissioning adjustment and balancing of all HVAC equipment's and systems to the entire satisfaction of Consultant "Completion Certificate" shall be issued to the Contractor. After obtaining the completion certificate the Contractor shall operate and maintain the entire HVAC system through his own manpower for a period of one year starting after the issuance of completion certificate. Contractor shall provide training to the Owner's staff in operation and maintenance of HVAC systems during this period of operation and maintenance.

The Contractor shall submit operation and maintenance program to the Consultant for approval, after approval of Consultant the Contractor shall operate, maintain the entire HVAC equipment and systems through his manpower in accordance with the operation & maintenance program approved by the Consultant.

### **OPERATION**

The plant would be operated wholly by the Contractor without any assistance of Owner's staff. The operation timings shall be designated by the Owner, however 24 hrs. a day, 07 days a week and 365 days a year without any break (No leave throughout the year) operation is to be carried out by the Contractor.

During this period of operation and maintenance the Contractor shall train the operating staff for the operation and maintenance of HVAC equipment

The Contractor shall provide qualified, experienced and competent staff for the operation of the complete HVAC equipment and systems and comply with the applicable Codes and Regulations.

The Contractor shall submit the bio-data of operational staff to the Consultant, Consultant shall evaluate their qualification and experience, after satisfactory evaluation the Contractor shall appoint them. Following minimum operating staff shall be employed by the Contractor

<b>i. Mechanical/HVAC Engineer</b>	<b>01</b>
<b>ii. Technical Helpers</b>	<b>02</b>

Contractor shall maintain proper log sheet as directed by the Consultant, all necessary records of temperature, humidity, water, fuel and electricity consumption etc., shall be kept during the operation period. These shall conform to the figures and efficiency rating as per contract requirement.

The Contractor shall be responsible to maintain inside design conditions during the operating period.

The Contractor prepares daily log sheets of equipment as directed by the Consultant, and shall submit to the Consultant on weekly basis or as directed by the Consultant.

**MAINTENANCE**

The HVAC system shall be maintained by the Contractor during period of operation & maintenance stated above. This shall include routine maintenance including preventive maintenance of the plant, regular servicing and cleaning and periodical overhauling according to the maintenance program prepared on basis of manufacturer’s recommendations and approved by the Engineer.

Maintenance shall also include inspection, monitoring and troubleshooting of the plant. Complete maintenance record of all the equipment’s shall be kept in the form of a daily diary and log sheets. Maintenance record shall also be kept up to date on a log card shall be attached to each equipment. The operation & maintenance (O&M) record shall be reviewed and jointly signed by the Contractor’s Chief O&M and Owner’s representative daily.

All the consumable, non-consumable material, parts etc. involved during the one year operation and maintenance shall be provided by the Contractor, and no extra cost will be paid for these items to the Contractor, and if any part or spares are used from the maintenance stock, then Contractor is responsible to provide that part/material without any additional cost to the Owner.

D. During the Operation & Maintenance period if anything, part, machinery, equipment damages, Contractor shall replace/repair it, to the entire satisfaction of consultant without any additional cost to the Owner.

- **TRAINING**

During the period of operation and maintenance, the Contractor shall submit the “Training Schedule” to the Consultant for approval, after approval the Contractor shall impart regular training to the Owner’s staff in operation and maintenance so that the Owner’s staff should become competent to take independent charge of operation and maintenance of HVAC system.

- **OPERATION AND MAINTENANCE MANUALS AND CHARTS**

Before requesting acceptance of work, Contractor shall submit to the Engineer five (5) printed and bonded sets of complete operation and maintenance manuals together with technical data catalogs, and spare parts list for each piece of all the equipment's. The operation and maintenance manual shall include wiring diagrams and control diagrams of each equipment and of the whole system.

- **AS-BUILT DRAWINGS**

Contractor shall submit five (5) sets of as-built drawings including drawings of complete electrical and control circuits with one set consisting of reproducible plastic films, duly approved by the Consultant. The drawings shall be prepared in a neat and accurate manner (on computer CAD) showing the completed work in details as installed. Identification marks and colors on the drawings shall be shown corresponding to those marked on the installation.

- **SPECIAL TOOLS AND INSTRUMENTS**

Provide special tools and instruments as listed in the Equipment Schedule Data and Bill of Quantities for testing, operation and maintenance of HVAC systems as part of the contract, before commencement of testing and commissioning phase.  
(If, Specified)