

## Section 6 – Employer's Requirements

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## Specifications

### 6. GENERAL

**Interpretation:** - The Standard Specifications are extracted from Specifications for Building and Road Works – 2009 of Standard and Quality Control Authority. In the event of discrepancy in the laid specification the Specifications for Building and Road Works – 2012 of Department of Engineering Services, MoWHS should be referred to for interpreting the meaning of the laid specifications.

**Materials:** - All materials to be provided by the contractor shall be in conformity with the specification laid down in the contract document. The contractor shall ensure that the materials are suitable and to the satisfaction of the Engineer-in-charge and nothing shall be paid extra on this account. Wherever BIS marked material is available, such material will be used subject to fully satisfying other requirements of the specifications.

**Testing of materials:-** Samples whether submitted to govern bulk supplies or required for testing before use shall be provided free of charge by the contractor. Suitable packages to contain the samples shall also be supplied free of charge. Testing charges, if any, and all other expenditure required to be incurred for taking the samples, conveyance, packaging etc. shall be borne by the contractor himself. The time loss in the process shall be incorporated in the work programming and no additional time will be considered.

**Safety on works:** - Safety precautions pertaining to construction works such as excavation, trenching, blasting, demolition, provision of scaffolds, ladder, working platforms, gang ways, mixing of asphalt materials, electric arc and gas welding, use of hoisting and construction machinery shall be taken as directed by the Engineer.

**Antiquities and useful materials:** - Any finds at the time of excavation such as relics of antiquity, coins, fossils or other articles of value shall be delivered by the contractor to the Engineer and shall be the property of the Government. Any materials obtained from the excavation which in the opinion of the engineer are useful, shall be stacked separately in regular stacks as directed by the engineer and shall be the property of the Government.

**Bench marks:** - Temporary site bench mark shall be constructed at the construction site by the Contractor, where so required by the Engineer.

**Reference to I.S:** - Wherever I.S (Indian Standard) specifications issued by the Bureau of Indian Standards is referred to, it shall be taken as reference to the latest edition with all amendments issued thereto. However, in the event of any variation between the DES, MoWHS Specification and that in the I.S., the DES, MoWHS specification shall take precedence over the I.S.

## PARTICULAR SPECIFICATIONS

### 6.1 General

All the works unless otherwise specified hereinafter or permitted by Engineer-in-Charge shall be done in accordance with the latest editions of Department of Engineering Services, MoWHS Specifications, with up to date correction slips & relevant IS Codes as applicable, issued up to the date of issue of Tender.

Unless otherwise expressly stated the method of measurements and other guide lines as generally laid down in the IRC Specifications and Department of Engineering Services, MoWHS specifications shall equally be applicable for this contract.

### 6.2 Work Programme

Whereas the specific schedule and programme to be followed for the various work items comprising this project will be at the discretion of the Contractor, the impacts of the Works Restrictions and Specific Requirements must be considered and included in the Works Programme to be prepared by the Contractor.

The Works Programme must be prepared by the Contractor using Excel or Project software within 15 days of award of the Contract. The Works Programme must be approved by the client before all significant works commence. The Programme shall be detailed enough to give, in addition to construction activities, detailed network activities for the submission and approval of materials, procurement of critical materials, procurement/rental/leasing of equipment, progress milestones, fabrication of special products/equipments if any, and their installation and testing, and for all activities of the Contractor that are likely to affect the progress of work. It shall be prepared so as to permit revisions, inclusion of additional detail and regular updates as the work progresses. In all respects the Contractor shall pay particular attention to seasonal weather patterns including rainfall and the construction sequencing while preparing the Programme and executing the Works in accordance with this. Any proposal for night working shall also be stated in the Programme.

If the Contractor requests a change in the sequence and such change is approved by the Engineer, the Contractor shall have no claim for delay arising from such revisions to the Program.

The Contractor shall update all activities in accordance with the decisions taken at the periodic site review meetings, or as directed by the Engineer.

### 6.3 WORKS RESTRICTIONS

On a day to day basis, the Contractor must adhere to certain specific requirements and restrictions to ensure the continued and safe movement of aircraft on the **movement area** of the airport, namely:

- Discuss with the Works Supervisor, Airport Manager and ATC Controllers, on a daily basis any matters necessary to ensure the safe conduct of the works and the safe movement of aircraft on the airport.
- Ensure that vehicles, plant equipment and materials not directly in use on the Works, are parked or stored outside the **movement area**, and do not obstruct the approach, take off or transition OLS, or interfere with radio navigational and landing aids.
- Ensure that access routes to the work sites for the movement of staff, equipment and vehicles within the airport are well defined and communicated to all Contract staff.
- Ensure that the **movement area** is safe for normal aircraft operations following removal of markers, vehicles, plant equipment and personnel from the Works area.
- Avoid crossing of the runway at any time unless it is essential as part of the implementation of the works.

Note: (1) **Movement Area** is defined as “That part of an aerodrome to be used for the take-off, landing and taxiing of aircraft ... and the apron(s)”.

#### 6.4 Site Installation

(Facilities, tools, plant, equipment and so forth)

- 6.4.1 The contractor shall be deemed to have made himself fully acquainted with the full nature of work, the location and character of the site and means of access to the site, including any restrictions imposed.
- 6.4.2 All necessary accommodations, stores, workshops, etc. required for proper execution of the works shall be provided, built, maintained and removed by the contractor at his own costs and within the working time program. In this context, the following requirements are essential:
- all necessary safety measures and efforts to avoid accidents and damage to the property and people need be in place for the duration of the contract period.
  - a labor camp with sufficient and well maintained sanitary facilities, sufficient drinking water and an adequate supply of electric power needs to be provided at a site to be approved by the client. Sufficient drinking water has also to be available at the construction site.
  - proper waste management facilities and processes need to be provided at the site and labor camp.
- 6.4.3 The client shall inspect the contractor's site infrastructure and give instructions in terms of the operation and maintenance of this infrastructure. These instructions are binding and shall be strictly implemented by the contractor.
- 6.4.4 The contractor shall make his own connections for water and electric supply and energy whatsoever and pay for it. The contractor has to check for water and electricity availability at or around the work site, and if necessary to make his own connections and/or install generators to produce the level of electricity required. The client will not pay any costs to the contractor.
- 6.4.5 The contractor cannot use the existing infrastructure such as telephone, fax, photocopies, etc. from the client. The contractor has to set up his own equipment and necessary infrastructure.

## 6.5 Material and its protection

The construction materials for the works are to be deposited and stored well under constructed shed conditions to avoid quality drops and loss.

The contractor shall build sufficient shelter buildings, so that all material can be stored without being exposed to rain and hot sun. The material has to be protected from these elements. This is required for the materials of any kind. The crushed stones and gravel as required as aggregate for concrete have to be cleaned and washed. The contractor has to secure the site for the storage of these materials with an adequate fence and security system.

## 6.6 Tools, Plant and Facilities

6.6.1 The contractor shall supply and provide all materials, plants, equipment, spare parts, whatsoever, to execute the works in accordance with the contract and all descriptions in the Bill of Quantities.

6.6.2 The contractor has to provide sufficient spare parts and equipment so that the work can be executed without delay. The tools, materials and plants to erect all temporary building and scaffolding have to be on site. Tools, equipment and plant have to be provided in sufficient numbers and in good working condition. The contractor is responsible for the maintenance of all the equipment. The client reserves the right to stop on-going work in any situation where materials, tools or plants do not meet these requirements and/or are judged to be in an unsafe condition.

6.6.3 The contractor has to construct a separate office space for his own use and he will not be allowed to use the office provided to the client for any reason so as to maintain the confidentiality and safeguarding of office documents.

6.6.4 The contractor has to provide sufficient equipment, welding installation and so forth at the place to fulfill work execution and to cope up with the construction schedule. This consideration has to be put in the site Installation item.

6.6.5 **Field Office for the Engineer and his Staff and other facilities:** In addition to the office space required for his own use, the Contractor shall provide and maintain a furnished field office for the use of the Engineer and his staff. Requirements for the office, including overall size, number and size of individual rooms, construction and furniture are stated below;

6.6.6 The size of the Engineer's Field office will be 50 square meter plinth area having more than one rooms and meeting hall to meet the requirements for accommodating 10(ten) persons of the Client/Consultants Field staffs. The field office shall be maintained in a secure and watertight condition by the Contractor until completion of the Works or as otherwise instructed by the Engineer and shall be provided with electricity, continuously running water and sewerage. All doors shall be fitted with approved locks, and windows shall be provided with mosquito screens and shall have interior locking devices.

6.6.7 The Contractor shall arrange for the field office to be regularly and properly cleaned. All furnishings and fittings in the field office shall also be maintained by the Contractor in working condition and to the approval of the Engineer.

6.6.8 The Contractor shall provide adequate water-borne sanitation and refuse collection and disposal, complying with the Laws of Bhutan and all local By-Laws, and to the satisfaction of the Engineer, for all offices, laboratories, workshops, houses etc. erected on the Site.

6.6.9 The following standard quality equipment and furnisher shall be provided and fixed/installed by the contractor for the field office. All furniture are to be made from acceptable quality of hardwood.

6.6.10 List of Furniture and Equipment

Items of equipment/furniture	Number required
Computers	- 1
A3 mono Laser Printer	- 1
UPS	- 1
Mobile Telephone	- 2
Photocopier, A3	- 1
Electronic Digital Calculators	- 2
Engineer's Representative Desk (1.5mx0.9m)	- 1
Senior Site Engineer's Desk + plus site Engineer + Visiting official	- 4
Computer Table (1.5m x 0.8m)	- 1
Printer Desk	- 1
Photo Copier Desk	- 1
Armed Chairs for Desks	- 4
Armless cushioned chairs (meeting/visitors)	- 10
Computer Chairs	- 1
Steel Filing Cabinets with 4 drawers each(1.4m x1.2m x 0.8m)	- 1
White board (1.5m x 1.0m)	- 1
Pin-board (1.5m x 1.0m)	- 1
Conference Table 2.4mx1.2m	- 1
All stationery and Bathroom Consumables	: As directed by the Engineer

6.6.11 Monthly telephone bills for making call for project related communications shall be paid by the contractor and after completion of works the telephones shall be the property of the contractor.

6.6.12 One photocopy machine is capable of making A3 size photo copies.

6.6.13 Desktop computers shall be of the following specifications (minimum) networked to each other and all peripherals:-

- Pentium Core i-5 with original Intel Mother Board.
- 500 GB hard disk
- 4 GB RAM
- Combo DVD drive
- 17" LCD Monitor
- Complete with Windows 8/10, Microsoft Office, AutoCAD and the latest version of Microsoft Project & Anti-virus Software.

6.6.14 Laser Jet printer automatic sheet feeder taking up to paper size A3

6.6.15 Uninterruptable Power Supply (UPS) for use with computers and photocopiers

6.6.16 After completion of the construction works, field offices with all service facilities shall be the property of the Contractor all the furniture and equipment with its peripherals and associated software etc. will be formally handed over to the DoAT Airport Manager at Bumthang.

## 6.7 Providing and Maintaining Vehicles for the Engineer

6.7.1 Scope : The work covers providing and maintaining of pick-ups for use by the Engineer as described under Bill of Quantities.

6.7.2 Description: The pick –stroke–ups shall be diesel driven and shall be double-cabin type, Mahindra Bolero, NEF, 4WD or equivalent. The Contractor shall purchase and provide vehicle as indicated above, within four weeks from the date of order by the Engineer. The vehicles shall be purchased through DoAT with DoAT's support in the process of application and approval for import license. The vehicle will be registered in the name of DoAT. The Contractor will maintain and service the until the Taking over Certificate for the completed work has been issued. After taking over of site the vehicle will be handed over to DoAT/ Airport Manager, Gelephu. All necessary taxes for operating the vehicles shall be fully paid and all necessary papers shall be provided by the Contractor as required by prevailing laws and regulations in Bhutan. Comprehensive insurance cover shall be provided by the Contractor. The vehicle shall be provided day and night as required by the Engineer. The Contractor shall make available drivers for the pick-up who have a valid licence at such times and such duration as required by the Engineer. Contractors shall allow for the fact that use of the vehicle provided for the Supervising Engineer will include use to travel from Bumthang to destinations associated with project works for which the Supervising Engineer has responsibility, as well as duty visits to Paro/Thimphu.

6.7.3 Maintenance: The vehicles shall be maintained in a smooth running condition. All expenses required for keeping the vehicles in smooth running condition such as fuel, lubrication oil and other consumables, necessary service and maintenance, drivers, repairs and replacement etc. are to be met by the Contractor. In the event of any vehicle being off the road for maintenance or on account of breakdown, the Contractor shall provide substitute vehicle(s) immediately. If the Contractor at any time fails to provide vehicle(s) or substitute vehicle(s) as specified above, an amount of Nu. 2500 per day or part thereof for each vehicle (that the Contractor failed to provide) shall be debited to the Contractor's account. Also the number of days for which the vehicle(s) were not provided shall not be included for payment.

6.7.4 If the Contract Works are not completed within the stipulated period or within the granted extended time of completion, provision and maintenance of vehicles in accordance with clause 6.7.1 through 6.7.3 shall be carried out by the Contractor at his own cost and no payment shall be made for the same. In case of any failure by the Contractor to do so, an account of Nu. 2500 per day or part thereof per vehicle shall be debited to the Contractor's account.

6.7.5 Measurements for Payment: The measurement for payment for providing and maintaining of vehicles shall be on day basis for actual number of days the vehicles were provided in satisfactory working order. No payment shall be made for the period of withdrawal as per clause 6.7.3 above irrespective of the fact whether the vehicle was available or not.

6.7.6 Rates: The Contract unit rate for providing and maintaining vehicle for Engineer shall include all expenses towards providing and keeping the vehicles in smooth running condition including taxes etc.

**6.8 Project Sign Board** – The contractor shall provide a project Sign Board of 1.8m wide x 1.20m high which should be maintained at a prominent location/entrance to the site with project details such as funding source, client, contractor, project value and etc. in the format and wording as per the direction of the Engineer. The Project sign board shall be erected within 14 days after the contractor has been

given the Possession of Site. The contractor shall not erect any advertisement sign board on or along the work site without the written approval of the client. All sign boards shall be removed by the contractor by the end of the Defects Liability Period.

*Measurement and Payment* - No separate measurement and payment shall be made to the contractor for this work. The expenses in connection with the work specified herein shall be distributed/adjusted into other items of works specified within the Bill of Quantities.

## **6.9 Health and Safety**

6.9.1 The contractor shall take due care and ensure that medical staff, first aid room with first aid kit along with proper medical supplies are available at the camps, housing and on the jobsite at all times throughout the period of the contract and that suitable arrangements are made for the prevention of epidemics and for all necessary welfare and hygiene requirements. If imported laborers are required for construction, proper medical tests of the laborers shall be carried out to prevent the spread of diseases such as STD and HIV/AIDS amongst the communities near the construction sites.

6.9.2 The Contractor shall provide on-site such life-saving apparatus as may be appropriate and an adequate and easily accessible first aid outfit, or such outfits as may be required in any Government Ordinances, Factories, Acts as subsequently published and amended from time to time.

6.9.3 In addition an adequate number of persons permanently on the Site shall be instructed in their use, and the persons so designated shall be made known to all employees by the posting of their names and designations in a prominent position on Site.

### **6.9.4 Measurement and Payment**

No separate measurement and payment shall be made for the works described in this Clause. All costs in connection with the work specified herein shall be considered included in the related items of the work specified within the Bill of Quantities.

## **6.10 Public Utilities**

6.10.1 The contractor shall be responsible to coordinate and liaise with underground and over ground service provider / concerned authorities / local authorities for shifting of utilities and removal of encroachments etc. and for making the site unencumbered during the project construction period until the completion of work. This shall include initial and frequent follow-up meetings / actions / discussions with each involved service provider / concerned authorities. The contractor will not be entitled to any additional compensation for the delay in shifting of utilities, and removal of encroachments by the service provider / concerned authorities.

6.10.2 The contractor will make payments to the respective service provider/authorities for any costs required for the relocation of utilities, wherever required. The contractor will obtain the



necessary approvals from such authorities including cases where payments are not required to be made for such relocations.

Information on any utilities likely to be affected by the contractor's work shall be brought to the notice of the Engineer, and any work required shall be undertaken only after receiving written clearance from the Engineer/Client.

- 6.10.3 Arrangements shall be made for the continuity of all public services such as power lines, telephone lines, water mains, sewerage, drainage, etc., if the existing services are likely to be affected during the period of construction.

*6.10.4 Measurement and Payment*

No separate measurement and payment shall be made for the work of temporarily supporting; maintaining and protecting the government, public and privately owned services. All the expenses in connection with the work specified herein shall be distributed/adjusted into other items of works specified within the Bill of Quantities.

**6.11 Insurance**

- 6.11.1 The contractor shall provide and maintain the insurance cover in accordance with Clause 19 of the General Conditions of Contract from an approved insurance company from the commencement of project to the end of the Defects Liability Period.

*6.11.2 Measurement and Payment*

No separate measurement and payment shall be made for this item. All expenses in connection with Insurance coverage shall be distributed/adjusted into other items of works specified within the Bill of Quantities.

**6.12 Submittals**

**6.12.1 General Requirements**

- The contractor shall maintain an approved system of recording and tracking submissions, indicating dates, status (i.e. approved, not approved, approved subject to conditions), quantities, and other details as required.
- Copies of all approved submissions will be retained securely and properly filed on site, available for reference by the Engineer at any time.

**6.12.2 Contractor's Monthly Progress Report**

- The contractor shall report monthly progress to the Engineer showing actual work done superimposed upon copies of the program. He shall furnish an explanation of any deviation from the Programme stating his proposals for improving progress should this be lacking in any respect, and he shall furnish

the Engineer with his amended critical path analysis. The contractor shall comply with the reporting requirements on implementation of Environmental Management Plan and record this information in the monthly report following the guidelines provided by the Engineer.

- The contractor shall submit monthly Laboratory/Field test report including cumulative number of tests completed in the prescribed format. If required, the Engineer shall ask the contractor to submit quarterly Funds Expenditure Statement.

#### 6.12.3 Samples

- The Engineer may at his discretion request or take samples of any material or product intended for use in the Works. Where samples are requested in the Specifications they shall be submitted in the number requested or if not specified then as directed by the Engineer.
- Samples shall be of the type and size specified and fully representative of the materials proposed to be used.
- Samples shall be indelibly and clearly marked with the date of submission, material reference and any other data required to determine the source and kind of sample.
- The Engineer may reject any materials and goods which in his opinion are inferior to the samples thereof previously approved, and the contractor shall promptly remove such materials and goods from the Site.

#### 6.12.4 Copies of Orders

- The contractor shall provide the Engineer with one copy of all orders for the supply of materials and goods required in connection with the Works, as the Engineer may require.

#### 6.12.5 Site Trials

- In some cases site trials/mock-up of works as specified shall be prepared by the contractor for review and acceptance of the Engineer. They shall be in a location agreed with the Engineer, and if so specified, may be incorporated into the work in a clearly identified position upon approval of the Engineer. The Contractor shall carry out such changes or carry out field trials as required in obtaining the Engineer's approval. Approved field trials shall form the standard of acceptance of subsequent materials and workmanship.

#### 6.12.6 As Built Drawings

- The Contractor shall submit As Built Drawings prior to the final Handing over/completion date. It is advisable that the Contractor prepares the as-built drawings as the work is completed at the site to facilitate checking and verification.
- The drawings shall be prepared in the latest version of auto CAD and shall include all available information. The As Built Drawings shall include the informations according to the tender drawing pattern as directed by the Engineer.

#### 6.12.6 *Measurement and Payment*

No separate measurement and payment shall be made for all above items under 'Submittals'. All the expenses in connection with the work specified herein shall be distributed/adjusted into other items of works specified within the Bill of Quantities.

### 6.13 Environmental Protection Works

The environment has been defined to mean surrounding area in the vicinity of the construction site, including human and natural resources which should be affected by execution of the works and after completion of works.

The contractor shall take all precautions for safeguarding the environment during the execution of the contract. He shall abide by all prevailing laws, rules and regulations governing environmental protection. In particular, the Contractor shall fully comply with the Environmental Codes of Practice. The Contractor shall follow the requirements specified in the Environmental Management Plan for the environmental protection and management of the works carried under the contract. The Contractor shall be responsible for the implementation of the Environmental Management Plan (EMP) and compliance with it. As part to this requirement the contractor shall follow the guidelines and submit required information on a monthly basis for monitoring of the EMP implementation by the Engineer. The Contractor at all-times shall ensure that requirements of EMP are fulfilled.

The contractor shall prohibit employees from unauthorized use of explosives, poaching wildlife, fishing and cutting trees. Where possible the workers must be provided with kerosene for cooking. Where it is not possible to access kerosene, firewood must be provided by purchasing it through the local firewood contractor. Where there is no local firewood contractor, proper forestry permits must be obtained for collection of firewood. The Contractor shall be responsible for the actions of his employees at all times..

#### 6.13.1 Reinstatement of Environment

After completion of the works the contractor shall clear away and remove from the site all tools and plant, surplus materials, rubbish, garbage, temporary constructions, and temporary work of any kind and leave the whole site clean and to satisfaction of the client. The site area of the camp, storage area, access road and so forth shall be rebuilt and brought into the same shape, state and condition as before starting the work. The Contractor shall be required to carry out filling, removal and disposal works along with plantation of grass and trees as directed by the Engineer at his own costs at identified locations to reinstate environment.

#### 6.13.2 *Measurement and Payment*

No separate measurement and payment shall be made for the works described in this Clause. All costs in connection with the work specified herein shall be considered included in the related items of the work specified within the Bill of Quantities.

## **HEATING VENTILATION AND AIRCONDITIONING WORK**

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## **A. INSTRUCTION & SPECIAL CONDITIONS**

### **Air-Conditioning & Mechanical Ventilation System for Terminal Building at Bumthang Domestic Airport.**

#### **Equipment & Materials of HVAC System**

The HVAC System shall comprise of following Equipment's & Materials as specified in BOQ.

- A) VRV / VRF Outdoor Unit Cool / Heat Pump Type.
- B) Standard VRV / VRF Indoor Unit,
- C) Double Skinned VRV / VRF DX AHU.
- D) Fan.
- E) Under-deck insulation.
- F) G.S.S / AL Ducting, Duct Insulation, Grill / Diffusers etc.
- G) Insulated Copper refrigerant piping.
- H) Drain water piping duly insulated.
- I) All other items as detailed in **"Schedule of Quantities."**

#### **General**

The special conditions of contract given below shall be read in conjunction with the other documents forming part of the contract. In case of any variance, these conditions shall supersede any other conditions mentioned in any contract document.

The materials, design and workmanship shall satisfy the specifications contained herein and codes referred to. Where the technical specifications stipulate the requirement in addition to those contained in the Standard Codes and specifications those additional requirements shall also be satisfied. In the absence of any Standard / Specifications covering any part of the work covered in this tender document, the instructions / directions of engineer-in-charge will be binding on the contractor.

All HVAC installations shall be of high quality, complete and dully operational including all necessary items and accessories whether or not specified herein.

All HVAC work shall be completed in accordance with the regulations and standard to the satisfaction of the Engineer-in-charge.

#### **Shop Drawings**

On the award of the work, the Contractor shall immediately proceed with the preparation of detailed working drawings showing the detail of each equipment that are to be installed and the ancillary works that are to be carried out. All the works are deemed to be included in various items of bill of quantities as applicable.

Three sets of all such working drawings dully signed by the head of the planning & design department of the tenderer shall be submitted to the Engineer-in-charge for approval to ensure that the works will be carried out in accordance with the specifications and drawings, including such changes as may have been mutually agreed upon. All the drawings shall be received by the Engineer-in-charge for approval within 04 (Four) weeks from the date of award of work. The approval of the drawings by the Consultants / Engineer-in- charge shall in no way relieve the Contractor from his obligations to provide a complete and satisfactory plant installation, testing and commissioning as per intent and purpose as laid down in the specifications. It will be the responsibility of the AC contractor to ensure that laid down inside conditions are maintained at all times.

Any omissions and / or errors shall be made good or rectified whether or not the drawings are approved. Contractor shall obtain written approval for samples (like grills / diffusers) and other materials before placing the order.

Contractor shall guarantee the specified inside conditions at specified outside conditions. Prior to the erection of Equipments, the contractor shall furnish to the employer (2) two sets of a comprehensive manual for all equipments etc. describing all components furnishing a list of spare parts and setting forth in details the instructions for the operation and maintenance of the plant.

The Contractor shall also fix in the Operating / Maintenance Room, neatly typed and framed, instructions in details, for the starting and running of the plant.

The AC contractor for approval- shall prepare the following shop drawings

- a) AC Equipment Layout along with sectional drawings of each installed equipment.
- b) Schematic refrigerant piping layout with pipe size.
- c) HVAC layout plans of all floors with sections, support details, position of duct dampers / splitter dampers, insulation, etc.
- d) AC equipment foundation layout plans and load data.
- e) Electrical panel, power & control wiring drawings.
- f) Electrical power requirements on AC Layout Plans along with summary.
- g) Individual equipment drawings from equipment manufacturer along with technical data sheets.  
(For Engineer-in-Charge / Consultant's Approval)
- h) Any other shop drawings necessary for the project.



## As Built Drawings

The AC Contractor shall submit six sets of paper prints of the as-built drawings & one soft copy, showing accurate record of the work as installed to the Client for his reference. The contractor shall also submit three copies of an Operating Manuals in ring binder describing the brief write up on the system installed, operating instruction for all equipments, catalogues, maintenance of equipments etc

## Instruction / Maintenance Manual

The Contractor shall prepare and produce instruction, operation and maintenance manuals in English for use, operation and the maintenance of the supplied equipment and installations, and submit to the Engineer-in-charge in three copies at the time of handing over. The manual shall generally consist of the following:

- a) Description of the Project.
- b) Operating instructions.
- c) Maintenance instructions including procedures for preventive maintenance.
- d) Manufacturers catalog.
- e) Spare parts list.
- f) Trouble shooting charts.
- g) Drawings.
- h) Type and routine test certificates of major items.
- i) Six sets of as built drawings along with soft copy of drawings in CD.

## Discrepancies between Bill of Quantities, Specifications & Drawings

In case of conflicts between Bill of Quantities, Specification & Drawings **the Bill of Quantities shall take precedence over the Specification & Drawings, in keeping with the general intent of the scope of work in the contract document.** In all such cases, the Engineer-in-Charge / Consultant will interpret the requirements of the design intent & the Contract Documents & their decision shall be final & binding. The contractor shall not be entitled to any extension of time or any compensation due to such determination.

## Quiet Operation & Vibration Isolation of AC System

All HVAC equipments shall operate under all varying / part load conditions without any objectionable sound or vibration as specified in the section Noise & Vibration Control or in the opinion of the Department / consultant. In case of rotating machinery sound or vibration noticeable outside / inside the room in which it is installed shall be considered objectionable & shall be rectified by the contractor at his own expense up to the satisfaction of consultant / Department.

## Testing

All testing instruments, velocity meter, digital / electronic electric energy meter, digital thermometer, psychrometer, measuring steel tapes, tools, scaffolding and ladders etc., that may be required for taking measurements shall be arranged by air-conditioning contractor at his own cost.

All types of specified & routine tests of the equipments shall be carried out at the works of the Contractor or the manufacturers of the components. The Department shall be free to witness any or all tests, if they so desired. The Contractor has to inform to the Client before dispatch of any material / equipment.

On the completion of the installation the Contractor shall arrange to carry out various initial tests as detailed below, in the presence of and to the complete satisfaction of the Department / Engineer-in-Charge / Consultants, any defect or short-coming found during the tests shall be speedily rectified or made good by the Contractor at his own expenses. The initial tests shall include, but not be limited to the following:

- a) To operate and check proper functioning of all electrically operated components viz. Compressor motor, pumps, fan of air handling units etc. as well as other electrical motors.
- b) To test and check the proper functioning of electrical gears, safety and other controls to ensure their proper functioning.
- c) To check the air distribution system and to provide designed airflow in all areas by adjusting the grills, diffusers and dampers for air-conditioning.
- d) To check & balance / adjust the refrigerant / water in the circuit for smooth and noiseless flow.
- e) To check the systems against leaks in different circuits, alignment of motor, 'V' belt adjustments, control setting and all such other tests which are essential for smooth functioning of the plant.
- f) Contractor shall have to submit the capacity test of all equipment at site.
- g) On the satisfactory completion of all 'Initial' tests the plant shall be considered 'Virtually Complete' for the purpose of taking over by the Client & balance payment shall be released against BG.
- h) In addition to the 'Initial' test the Contractor shall also give summer, monsoon & winter tests of the plant, each of (3) three days duration, and each one during the full specified outside conditions (when the ambient conditions are close to the specified ambient conditions). The first running test may be taken on the completion of the initial test, provided the ambient temperature and humidity are near their peak. Inside condition as per the contract, performance of each equipment, Airflow etc. shall be as per the requirement of the contract during these tests.

**It is clarified that defect liability period shall start after successful completion of commissioning & handing over.**

### **System Balancing**

The contractor shall leave the system operating in complete balance with water and air quantities as shown on drawings. Set stops on all balancing valves and lock all damper quadrants in proper position. Secure all automatic damper and valve linkage in proper positions to provide correct operating ranges. Proper damper positions shall be marked on ducts with permanent indication.

### **Operation of Plant**

The Contractor shall arrange to operate the plant for a period of ONE MONTH from the date of commissioning of plant and successful completion of initial test free of cost.

### **Training of Personal**

The contractor shall impart training to the minimum three technical staffs appointed by the client free of cost during erection and commissioning of the plant.

### **Inspections & Testing**

All the major equipments may got inspected & tested before dispatch if desired by the client at the manufacturers work.

The AC Contractor shall intimate the client minimum 21 days in advance about the date of readiness of equipment for inspection & testing at a date to be mutually agreed upon by the client & the AC Contractor.

The manufacturer of these equipments must have a facility of testing the equipments at the test bed on full load at their works. All the test readings mutually taken shall be recorded & evaluated with the technical data furnished by the AC Contractor.

### **Storage of Materials / Equipments**

Store room if ready can be used for storage of materials / equipment brought to site by the contractors. Watch and ward of the same shall be the contractor's responsibility. In case the plant room space is not readily available, it shall be contractor's responsibility to make his own temporary structure at site with approved location from the department at his own cost.

## B. BASIS OF DESIGN

### Basis of Design.

#### 1. Site Location :Bumthang Domestic Airport, Bumthang.

#### 2. Introduction

A centralised HVAC system shall be designed, installed & commissioned to provide thermally controlled environment for the proposed complex. The HVAC systems shall be designed for automated round the clock year round operation to provide for the Inside environmental conditions as specified below and as per BOQ.

#### 3. Outside design conditions

##### DBT DEG C

##### RH%

Summer

25

40

Winter

5

35

#### 4. Inside Design Conditions

##### DBT DEG C

##### RH%

Summer

23± 2

50% to 60%

Winter

22± 2

50% to 60%

#### 5. Exposed Roof

All exposed roof / terraces shall be insulated as per BOQ or equivalent material by HVAC Contractor to get an overall heat transmission factor of 0.06 BTU/HR/SFT/°F.

#### 6. Power Supply

Stabilised three phase four wire AC supply i.e. 415 Volts ± 10 % & 50Hz ± 5 % with double earthing shall be made available near Sub Panels AHUs, Isolators of VRV / VRF Outdoor Unit etc & Single-phase power supply with earthing near each inline fan or wherever as required by electrical contractor.

#### 7. Fresh Air / Air Change Per Hour

Fresh Air / Air Change Per Hour in the various Air Conditioned areas shall be maintained as per the ASHRAE guidelines.

**8. Occupancy**

Occupancy in the various areas shall be as per provided Furniture Layout Plan.

**9. Light Power Density**

Average Light Power Density in the various areas shall be based on 0.50~1.00 Watt / SFT.

**10. Floor & Glass Height**

Floor to Floor & Glass Height taken shall be based on architectural drawings made available to us.

**11. Equipment Load**

Equipment Load in the various areas shall be as reflecting under in the Table under 'Parameters of AC Area'

**12. Thermostat**

Each AC Unit shall have provision of Thermostat to set the desired temperature.

**13. VRV / VRF System**

VRV / VRF System shall have all inverter compressors for variable speed of compressor for actual demand requirement. COP of VRV / VRF System shall better than the Green Building requirement (COP-4.00) at ARI parameters.

**14. Refrigerant**

Refrigerant used shall be R-134a / R-407C / R-410 / R-32.

**15. Mechanical Ventilation**

For Mechanical Ventilation designing, NBC 2005 (National Building Code of India) guidelines shall be followed.

**16. Building External Parameters**

Followings external parameters have been assumed while detailed working of the proposed building.

- a. Exposed Wall U Factor - 0.360 in BTU Unit
- b. Partition Wall U Factor - 0.320 in BTU Unit
- c. Floor / Ceiling U Factor - 0.380 in BTU Unit
- d. Exposed Insulated Roof U Factor - 0.120 in BTU Unit
- e. Exposed Glass U Factor- 0.560 in BTU Unit

**Design Parameters****A) Air-handlers / Indoor Unit**

- a) Maximum Face velocity across cooling coil MPM
- b) Maximum face velocity across filters MPM
- c) Maximum water pressure drop across the coil in Mt.

- d) Maximum water velocity through coil in MPS
- e) Maximum Fan outlet velocity MPS

## **B) Ducting Work**

- a) Method of Duct Design
- b) Maximum air velocity in supply duct (AC) MPM
- c) Maximum air velocity in return duct (AC) MPM
- d) Friction loss in duct (Maxm.) MM Wg in 100 Mt run.
- e) Maximum Velocity at supply air grill outlet (AC) MPM

## **C) For Air-cooled Outdoor Unit**

- a) Temperature of air to inlet of condenser °C

## **Noise & Vibration Control**

The air conditioning contractor must take all necessary precautions to have minimum noise generation and its transmission. Minimum vibration as permitted by IS relevant code shall be ensured. A few points for guidance only are given below:

### **a) Outdoor Unit**

The factory built outdoor unit should be complete with rubber pad of suitable thickness to absorb the vibration generated.

### **b) Indoor Unit / Other Equipment**

All indoor unit / other equipment shall have vibration isolation pads of suitable thickness in consultation with manufacturer for isolation of vibration. Double fire retardant flexible connections shall be provided between the outlet of indoor unit & the duct.

### **c) Duct, Pipes & other accessories**

All items suspended from ceiling shall be isolated on separate hangers. In case of ducts, conduits, pipes & tubes the annular space between construction and penetrating element shall be sealed suitably to isolate vibration transmission. The duct lining shall be provided as shown in the tender drawings to reduce the noise level.

## Parameters for Air Conditioned Area With AC Load- As per Summary of Heat Load.

### System Description

#### Scheme for Air Conditioning System

Based on the parameters given above, it proposed to install required capacity of VRV / VRF outdoor unit of cool / heat type in capacity of multiple combination to cater the above air conditioning load. Indoor unit shall be floor mounted / ceiling suspended VRV / VRF DX type AHU or VRV / VRF standard indoor unit as shown on the drawings. Indoor and outdoor unit shall be connected with the help of copper refrigerant piping of suitable sizes duly insulated.

Low side work such as ducting, duct lining, duct insulation, grilles / diffusers shall also be planned in coordination with architect, which shall be executed as per the shop drawings made by AC Contractor & approved by Consultant / Architect / Client.

Electrical work shall comprise isolators, power and control cabling, conduiting, earthing etc as detailed in Bill of Quantities.

VRV / VRF Outdoor Unit selected above shall not be capable of providing winter heating in Winter Season.

AC with Normal Hi Wall Split Unit have also been considered for the areas as tabulated under 'Parameters of Air Conditioned Area'.

#### Scheme for Ventilation of Toilets

Inline fan have been considered for toilet ventilation.

### SUMMARY OF HEAT LOAD

<u>BASIS OF DESIGN</u>		
MAX OUTSIDE TEMP - SUMMER	30	DEG C
MIN OUTSIDE TEMP - WINTER	-10	DEG C
INDOOR TEMP	23	DEG C
RH IN %	55-60	
<u>DOUBLE GLASS</u>		
CFM / PERSON	7.5	
ELECTRICAL LOAD	1 WATT/ SQ.FT.	

S.N.	DESCRIPTION	AREA	# Of Ppl	PART.	ACTUAL CFM	ACTUAL KW	ACTUAL TR	PROPOSED AHU-CFM	PROPOSED KW	PROPOSED TR	OUTDOOR UNIT OF VRF IN HP	VENTILATION FRESH AIR CFM	MAXIMUM DUCT SIZE IN MM	VELOCITY FOR DUCT DESIGN
1	<b>GROUND FLOOR</b>													
A	<b>BAGGAGE CLAIM</b>							7000	62	15.5	16		1600 X 300	1300 FPM
1	SUMMER	3861	75	595	4785		9.68					644		
2	WINTER	3861	20	595	6761	52.12	13.03					644		
B	<b>DEPARTURE LOUNGE</b>							8500	76	19	20		1750 X 350	1300 FPM
1	SUMMER	4589	75	1200	5538		11.2					765		
2	WINTER	4589	20	1200	8258	63.4	15.85					765		
C	<b>CHECK IN</b>							7000	62	15.5	16		1600 X 300	1300 FPM
1	SUMMER	2236	75	625	4330		8.86					563		
2	WINTER	2236	20	625	6820	50.58	12.645					373		
D	<b>CONCOURSE &amp; BAG CHECK IN</b>	2946	15	200	5000	55.81	15.86	5000	40	10	10	491		
THE ABOVE CFM N TR WILL BE ADDED AS 50% IN LEFT SIDE AHU AND 50% IN RIGHT SIDE AHU														
2	<b>FIRST FLOOR</b>													
A	<b>BAGGAGE CLAIM</b>							4500	40	10	10		1000 X 300	1300 FPM
1	SUMMER	2097	15	820	4476		7.65					350		
2	WINTER	2097	5	820	4013	30.52	7.63					350		
B	<b>DEPARTURE LOUNGE</b>							7000	62	15.5	16		1600 X 300	1300 FPM
1	SUMMER	3061	30	650	6557		12					510		
2	WINTER	3061	10	650	6323	47	11.75					510		
C	<b>CHECK IN</b>							5100	46	11.5	12		1200 X 300	1300 FPM
1	SUMMER	1270	16	0	5047		8.33					212		
2	WINTER	1270	10	0	4742	30.56	7.64					212		
1	SINGLE AHU FOR BAGGAGE CLAIM GF + FF & DEPARTURE AREA G.F.							20000						
2	SINGLE AHU FOR BAGGAGE CLAIM FF & CHECK IN AREA G.F. + FF							19100						

## C. TECHNICAL SPECIFICATION OF EQUIPMENTS.

### Double Skinned Air Handling Unit Scope of Work

The specification for Double Skin Air Handling Units covers the design requirement, constructional feature, supply, installation, testing & commissioning. The floor mounted horizontal / vertical type & ceiling suspended type air handlers shall be of double skin construction, draw through type comprising of various sections such as pre-filter section, cooling coil section, fan section etc as per details given in BOQ.



## **Double Skinned Air Handling Units**

### **a) Double Skinned Casing**

The casing shall be self-supporting type, factory fabricated & assembled made of extruded anodised aluminum hollow sections to make a rigid frame structure. The frame shall be assembled using pressure die cast aluminum joints. The self supporting unit shall consist of sandwiched panel made out of 0.6mm thick pre-plasticide / pre-coated GI sheet outside & 0.6mm GI sheet inside (0.6 mm polished stainless steel in case of AHU for Operation Theatre) duly factory fabricated insulated with 23 / 48 mm thick PU foam insulation in between as specified in Bill of Quantities. The insulated panels shall be bolted to mainframe with neoprene rubber gaskets held captive in the framed extrusion to make it leak proof. Suitable airtight access doors / panels with pressure die cast aluminum hinges & nylon handles and locks shall be provided for access to various sections for maintenance. The Entire housing shall be mounted on Extruded Aluminum channel framework having pressure die cast aluminum jointers or the framework shall be joined together with corner plates Condensate. Drain Pan shall be constructed of 22 gauge Stainless steel sheet with all corners welded with uniform slope from all sides leading to drain pan ensuring no stagnation of condensate water.

### **b) Motor & Drive**

The fan motors shall be suitable for  $415 \pm 10\%$  volts,  $50 \pm 5\%$  HZ, 3 phases TEFC SQ. Cage induction motor. The motor shall be specially designed for quiet operation & motor speed shall not exceed 1440 RPM. Drive to fan shall be provided through belt drive arrangement. Belts shall be of oil resistant type only.

### **c) Fan of Double Skinned Air Handling Units**

The casing shall have heavy gauge GI construction forward curved DIDW imported fan statically & dynamically balanced mounted on EN8 solid shaft or C 40 carbon steel. The supply air DIDW fan shall be forward / backward curved as per BOQ. The fan impeller shall be supported to housing with angle iron frame & pillow block heavy duty ball bearing. The fan shall be selected for a fan outlet velocity below 10 meter / sec. The fan housing with TEFC Sq.Cage motor shall be mounted on a common adjustable base frame on vibration isolators in case the impeller diameter is exceeding 450 mm & rubber turret mounts vibration isolators for fan diameter up to 450mm diameter. The fan motor shall be installed inside the housing of air handling unit to keep low noise level. The fan & motor assembly shall be of aluminum extruded section only.

### **d) DX Cooling / Heating Coils**

The Cooling coil should be at least 4 row deep or as per BOQ and shall have at least 4.7 fins/cm. The Cooling coil should have aluminium fins and copper tubes mechanically bonded. The unit shall be factory aligned, tested and complete with refrigerant piping connection port, charging valves, thermostatic expansion valve, distributor, liquid strainer, dehydrator, liquid line shut off valve etc. The cooling coil should be tested for leaks at a hydraulic pressure of at least 10 Kg / sq.cm. for a minimum period of 3 hours at works. The velocity across face should be limited to 152 metre / minute.

## **e)Filters**

Each unit shall be provided with a factory assembled pre-filter section containing washable synthetic tube air filters having extruded aluminum frame. The filtration efficiency shall be 90 % down to 10 micron particle size of MERV 5 rating. Filters shall fit so as to prevent by pass. Holding frames shall be provided for installing a number of filters cells in banks. These cells shall be held within the frames by sliding the cells between guiding channels. Face velocity across filters shall not exceed 152 MPM.

### **(i) Accessories**

The following accessories shall be provided with each air handlers

a)Vibration isolators shall be provided with all air handling units. Vibration isolators shall be cushy foot mountings, springs or approved equal type.

## **Ventilation Fans Scope of Work**

The specification for supplies & exhaust air blowers for mechanical ventilation covers the design requirement, constructional feature, supply, installation, testing & commissioning.

### **(ii) In-Line Fans**

Inline fans shall be complete with centrifugal impeller, casing, direct driven motor, vibration isolators, direction of discharge and rotation position shall be as per the job requirement and shall be marked on the fan assembly. Housing shall be constructed of hot rolled GSS sheet metal construction. Housing metal parts shall be either spot-welded or screwed or mounted together with rivets. Indication showing rotation arrow and make, model number and duty conditions of the fan shall be available on the housing. Fan wheel shall be forward curved type, statically and dynamically balanced. The fan shall be provided with ball bearings can be used in any mounting position at maximum indicated temperature.

## **Accessories**

All necessary accessories shall be provided for proper operation and shall also include as part of Unit Price.

- ☐ Dunlop cushy foot vibration isolators for the blowers
- ☐ Double canvas connections at the outlets of each fan
- ☐ Nuts, Bolts, Shims etc. as required for the grouting of the equipment
- ☐ Slide rails for mounting the motor and belt adjust
- ☐ Bird Screens in the Inlet
- ☐ Detachable and washable fresh air filters at the inlets

## **Performance Data**

All fans shall be selected for the lower operating noise level. Capacity ratings, power consumption, with operating points clearly indicated shall be submitted and verified at the time of testing and

commissioning of the installation. All the fans should be AMCA certified for sound and performance.

(iii) **Testing**

Capacity of all fans shall be measured by an anemometer. Measured airflow capacities shall conform to the specified capacities and quoted ratings. Power consumption shall be computed from measurements of incoming voltage and input current. Contractor has to carry out the field balancing, if required.

## **D. VRV / VRF UNITS**

### **1.0 VARIABLE REFRIGERANT VOLUME / FLOW SYSTEM (VRV/VRF)**

The scope of this section comprises the supply, erection testing and commissioning of inverter based Variable Refrigerant Volume System with 3D Scroll Inverter Compressor conforming to these specifications and in accordance with the requirements of Drawing and Schedule of Quantities

Window type/Split type air-conditioning units, water coolers / desert coolers and water softening plants for treatment of water are also excluded from the scope of these specifications.

These General Specifications cover the equipment and materials for the system, their testing and/ or inspection as may be necessary before their dispatch from their respective works, their delivery at site, all preparatory works, assembling, installation and adjustments, commissioning, final testing, putting into operation, equipment capacity computation and handling over of the complete system.

These General Specifications are subject to revision from time to time.

Each air-conditioning work has its own particular requirements. These General Specifications shall be supplemented with tender specifications as may be required for a particular work. The tender specification, wherever they differ from these General Specifications, shall have overriding value and shall be followed for that particular work. A specimen NIT for central air conditioning work is appended at Appendix 'L' for general guidance.

#### **General**

The air-conditioning system shall exhibit 'Capacity control' operating features providing very efficient energy and maximum comfort to the users. The VRF system shall be air-cooled, variable refrigerant system consisting of modular outdoor units and multiple indoor units, each having capability to cool independently and serving the different requirements of the room and users.

#### **Scope**

The scope of this section comprises the supply, erection testing and commissioning of Variable Refrigerant Volume System conforming to these specifications and in accordance with the requirements of Drawings and Schedule of Quantities.

#### **Type**

Units shall be air cooled, variable refrigerant volume air conditioner consisting of one outdoor unit and multiple indoor units. Each indoor units having capability to cool or heat independently for the requirement of the specified area/ rooms.

It shall be possible to connect minimum 10 indoor units on one refrigerant circuit. The indoor units on any circuit can be of different type and also controlled individually. Following type of indoor units shall be connected to the system:

Ceiling mounted cassette type (Multiflow) Ceiling mounted Ductable type  
Hi-Wall mounted type

Compressor installed in outdoor unit shall be equipped with all inverter compressor. The system shall be capable of changing the rotating speed of inverter compressor by inverter controller to follow variations in cooling and heating load.

Outdoor unit shall be suitable for mix match connection of all type of indoor units.

The refrigerant piping between indoor units and outdoor unit shall be extended up to 160m with maximum 50m level difference without any oil traps.

Both indoor units and outdoor unit shall be factory assembled and should be 100% imported, tested and filled with first charge of refrigerant before delivering at site.

#### **1.1 Outdoor Condensing Unit**

The outdoor unit shall be factory assembled, weather proof casing constructed from heavy gauge mild steel panels and coated with baked enamel finish. The unit should be completely factory wired.

All outdoor units shall have all Inverter Scroll Compressors.

It shall also be provided with duty cycling for multiple inverter compressors switching starting sequence of multiple outdoor units in case of 18 HP and above.

The outdoor unit shall be modular in design and should be allowed for side by side installation. The unit shall be provided with its own microprocessor control panel.

The outdoor units shall have anti-corrosion paint.

The outdoor unit shall be fitted with low noise, aero spiral design fan with grill for spiral discharge airflow to reduce pressure loss and should be fitted with DC fan motor to better efficiency. The ductable unit shall be capable to deliver 150mm external static pressure to meet long duct connection requirement.

##### **Compressor**

The compressor shall be highly efficient scroll type and capable of inverter control. It shall change the speed in accordance to the variation in cooling or heating load requirement:

All outdoor units shall have multiple steps of capacity control to meet load fluctuation and indoor unit individual control. All parts of compressor shall be sufficiently lubricated stock. Forced lubrication shall also be employed.

Oil heater shall be provided in the compressor casing.

**Heat Exchange**

The heat exchanger shall be constructed with copper tubes mechanically bonded to aluminium fins to form a cross fin coil.

The aluminum fins shall be covered with anti-corrosion resin film.

The unit shall be provided with necessary number of direct driven low noise level propeller type fans arranged for vertical discharge. Each fan shall have a safety guard.

**Refrigerant Circuit**

The refrigerant circuit shall include liquid (refrigerant R-410A) & gas shut-off valves and a solenoid valves at condenser end.

All necessary safety devices shall be provided to ensure the safe operation of the system.

**Oil Recovery System**

Unit shall be equipped with an oil recovery system to ensure stable operation with long refrigeration piping lengths.

**1.2 Indoor Units:**

This section deals with supply, installation, testing, commissioning of various type of indoor units conforming to general specification and suitable for the duty selected. The type, capacity and size of indoor units shall be as specified in detailed Schedule of Quantities.

Indoor units shall be either **ceiling mounted cassette type, or ceiling mounted ductable type or Hi-wall mounted type** as specified in Schedule of Quantities. These units shall have electronic control valve to control refrigerant flow rate respond to load variations of the rooms.

The address of the indoor unit shall be set automatically in case of individual and group control.

In case of centralized control, it shall be set to be liquid crystal remote controller.

The fan shall be dual suction, aerodynamically designed turbo, multi blade type, statically & dynamically balanced to ensure low noise and vibration free operation of the system. The fan shall be direct driven type, mounted directly on motor shaft having support from housing.

The cooling coil shall be made out of seamless copper tubes and have continuous aluminium fins. The fins shall be spaced by collars forming an integral part. The tubes shall be staggered in the direction of airflow. The tubes shall be hydraulically/ mechanically expanded for minimum thermal contact resistance with fans. Each coil shall be factory tested at 21kg/sqm air pressure under water.

Unit shall have cleanable type synthetic non woven type filter fixed to an integrally moulded plastic frame. The filter shall be slide away type and neatly inserted.

Each indoor unit shall have computerized PID control for maintaining design room temperature. Each unit shall be provided with microprocessor thermostat for cooling and heating.

Each unit shall be with wired LCD type remote controller. The remote controller shall memorize the through its touch screen, icon display and color LCD display.

It shall be able to control up to 64 groups of indoor units with the following functions:-

Starting/ stopping of Air conditioners as a zone or group or individual unit.

**Temperature settling for each indoor unit or zone.**

Switching between temperature control modes, switching of fan speed and direction of airflow, enabling/ disabling of individual remote controller operation.

Monitoring of operation status such as operation mode & temperature setting of individual indoor units, maintenance information, trouble shooting information.

Display of air conditioner operation history.

Daily management automation through yearly schedule function with possibility of various schedules.

The controller shall have wide screen user friendly color LCD display and can be wired by a non polar 2 wire transmission cable to a distance of 1 km. away from indoor unit.

**1.2.1 Ceiling Mounted Ductable Type Unit (Multi Flow Type)**

The Unit shall be suitable for ceiling mounted ductable type. The unit shall include pre filter, fan section & DX coil section .The body of unit shall be light weight powder coated galvanized steel. The unit shall have high static fan for ducting arrangement as required.

Units regardless of their difference in capacity should have same decorative panel size for harmonious aesthetic point of view. It should have provision of connecting branch ducts.

**1.2.2 Hi-Wall Mounted Type Unit**

The unit shall be wall mounted type. The unit shall include synthetic non-woven type filter, fan section and DX-coil section. The body of the unit shall be powder coated galvanized steel. The unit vertical auto swing realizes efficiency of air distribution. The louver closes automatically when the unit stops. The drain pipe can be fitted to from either left of right side.

**1.2.3 Ceiling Mounted Duct Type TFA Unit**

The Unit shall be suitable for ceiling mounted duct type for fresh air. The unit shall include, fan section.The body of unit shall be light weight powder coated galvanized steel. The unit shall have ducting arrangement.

This unit is intended for the treatment of outside air only. It is not be used for maintaining indoor air temperature.

**1.2.4 Thermostat Sensor**

Temperature sensors line provides economical solutions for a wide variety of temperature sensing needs. Like all of our HVAC sensors, they are designed with your needs in mind, with easy installation, energy efficiency and cost-effectiveness being top priorities.

The temperature sensors is packaged with the necessary mounting accessories to increase installation ease and reduce commissioning time and cost.

## **2.0 DX SYSTEM (INDOOR & OUTDOOR)**

The scope of this section comprises the supply, erection testing and commissioning of inverter based DX System with 3D Scroll Compressor conforming to these specifications and in accordance with the requirements.

It must be reliable and should maintain consistent temperature. The DX system outdoor units shall be located on the terrace of the building or suitable as site location and refrigerant pipes shall be laid vertically to feed all the indoor units. This system consist separate outdoor unit for each indoor unit.

## **E. TECHNICAL SPECIFICATION FOR ELECTRICAL ITEMS**

### **Electrical Motors**

#### **Scope of Work**

The scope of this section comprises the supply, installation, testing & commissioning of all types of motors used for HVAC Units conforming to these specifications and in accordance with Schedule of Quantities. The motor installation, wiring & its control shall be carried out in accordance with the specifications as detailed below.

#### **Motors**

The motor shall be of the following design and should run at all loads without any appreciable noise or hum.

#### **Totally enclosed fan cooled Sq. Cage.**

Enclosure and type of motor shall depend upon duty and usage unless otherwise specified. a) The winding of motors shall be class 'B' insulation and suitable for local conditions.

b) The insulation of motors shall confirm to IS:325/1978

c) All motors shall comply with IS:325, IEC-34.1 or BS – 2313, IEC-72.1 for foot mounted motors.

d) The rating of the motor shall be as indicated in the Schedule of Quantities. The motors shall be selected on the basis of ambient temperatures and allowable maximum

temperature rise. Motor above 1HP shall be three phase unless otherwise specified. All motors shall be rated for continuous duty as per IS:325. Motor shall be suitable for operation on 415 volts  $\pm$  10% volts, 50

$\pm$  5% Hz three phase AC supply (or 230  $\pm$  10% volts, 50  $\pm$  5% Hz for single phase AC supply)

- e). Motors shall be provided with cable box to receive Aluminum conductors, PVC insulated, PVC sheathed and armored cables.
- f) All motors shall be provided with combination of 'Ball and Roller Bearing'. Suitable grease nipples for regressing the bearing shall be provided.
- g) Motors above 0.25 HP shall be provided with overload protection.
- h) Motors above 100 HP shall be provided with thermal protection and thermistor detector in the stator winding.
- i) The starter current and the type of starter to be used shall be as follows (unless otherwise specified)

Type of motor	Starting Current	Starting Method
a) Sq. Cage motor upto 7.5 HP	600% of full load current	D.O.L
b) Above 7.5 HP upto 60 hp	250% of full load current	Star/Delta
c) 75 HP & above	200% of full load current	Closed transition star/ Delta of Double star

### Motor Starters

- a) All starter shall conform to IS: 13947. The starter shall be enclosed in sheet metal enclosure, which would be dust vermin proof.
- b) All starter should have suitable range of voltage and frequency.
- c) All starter shall have integral stop/start push button of international colour code.
- d) Contactor shall have number of poles as required for appropriate duty.
- e) Contacts should be made of solid silver faced & shall be suitable for at least 40 contacts per hours. In event of power failure, the starter should automatically disconnect.
- f) All starters shall be provided with thermal over load relay.



- g) All-star delta starters shall have adjustable timers.
- h) Terminal blocks with integral insulating barrier shall be provided for each starter.
- i) All starters shall be provided as specified in Schedule of Quantities. All starter shall be compatible to the drive and driven equipment.
- j) Extra contact for interlocking purpose shall be provided in the starter.
- k) All starter shall be compatible for Auto / Manual operation (BMS Compatible)
- l) All starter shall have separate single phasing preventer.

### **Installation of Motors**

- a) The motor and drive machine shall be fixed on slide rails to facilitate belt and other adjustments.
- b) Vibration isolation arrangement shall be provided.
- c) The installation of motor shall be carried out as per IS:900
- d) The motor with driving equipment shall be mounted on foundation and connected to each other with flexible coupling with guard in condenser & chilled water pumps.
- e) All motor shall be wired as per specifications. Earthing of motor frame shall be done with GI strips as specified in 'Schedule of Quantities'.
- f) All motors shall be tested at manufacturer's works as per I.S. standard and test certificates shall be furnished.
- g) All motors after AC contractor shall test installation at site for vibrations, heating and electrical insulation resistance.

## Motor Control Centre, Ventilation Sub Panel, Power & Control Cabling, Earthing etc.

### Scope of Work

The scope of this section comprises the supply, installation, testing & commissioning of Motor Control Centre, Ventilation Panels, AHU Sub Panel, power / control cabling & earthing work shall be carried out as per the specification given below and in accordance with Schedule of Quantities. All work shall conform to Indian Electricity Act (amended up to date), I.S. code of practices, local rules and regulations etc. The codes & standard to be followed shall be as given below:-

- |   |   |
|---|---|
| <input type="checkbox"/> BIS 13947 (Part 4) | - AC contactors up to 1000V   |
| <input type="checkbox"/> BIS 13947          | - AC Circuit Breakers   |
| <input type="checkbox"/> BIS 2705           | - Current Transformers  |
| <input type="checkbox"/> BIS 3156 & 4146    | - Potential Transformers  |
| <input type="checkbox"/> BIS 4064           | - Air break switches for voltage not exceeding 1000V                                      |
| <input type="checkbox"/> BIS 13947          | - Control switches  |
| <input type="checkbox"/> BIS 1822           | - Motor duty Switches   |
| <input type="checkbox"/> BIS 12021          | - Specification for control transformer   |
| <input type="checkbox"/> BIS 8623           | - Factory built assembly of switchgear & control gear                                     |
| <input type="checkbox"/> BIS 13947 (Part I) | - Degree of protection for enclosure  |
| <input type="checkbox"/> BIS 3842           | - Specification for electrical relays for AC system                                       |
| <input type="checkbox"/> BIS 13707          | - Specification for HRC fuses   |
| <input type="checkbox"/> BIS 5082           | - Wrought Al. and Aluminium alloys, bars, rods, tube and sections for electrical purposes |
| <input type="checkbox"/> BIS 13947 (Part 1) | - General requirement for switchgear & control gear for voltage not exceeding 1000V       |
| <input type="checkbox"/> BIS 3231           | - Electrical relays for power system protection   |

### Motor Control Centre / Ventilation Sub-Panel

Motor control centre shall be floor mounted extendable type bolted construction & Ventilation sub-panel shall be wall mounted type. The sheet steel (CRCA) used for fabrication shall be of 2.0mm for load bearing members and 1.6mm for non-load bearing members. The panels shall be supplied with required base channels. These panels shall be cubical sectionalized type, totally enclosed dust & vermin proof. Gaskets shall be provided in all joints to prevent dust to reach the internals of the panels to make it completely dust proof. The degree of protections for panels shall be IP 52 for indoor applications and IP 65 for outdoor applications as per IS:2147.

These panel (MV) shall be suitable for voltages up to 500 volts, three phase 50 Hz, 4 wire supply capable of functioning satisfactorily in temperature ranging up to 45 to 50 degree centigrade and rupturing capacity suitable for connected load & design should be type tested for 42 KA fault level.

All joints of panels shall be welded and braced as necessary to provide a rigid support for all components. The base channel provided in the floor mounted MV panel shall be 100mm x 50mm x 6mm & a clear space of 200mm between the floor and the bottom most part of the unit shall be provided. The panel shall be correctly positioned. Self- threading screws shall not be used in the construction of control panels. Appropriate knock-out holes of proper sizes shall be provided for incoming and outgoing cables. The facility for bottom or top entry of cables in the panels shall be provided. Necessary cables clamps shall provided for holding the cables in position. All power/control wiring inside the panel shall be colour coded and control wiring ferruled for identification purpose. All labeling shall be provided in engraved anodized aluminum strips on the front face of the panel. Each circuit breaker shall be housed in separate compartments. It shall have steel sheets on top and bottom of compartment. The steel sheet hinged door shall be interlocked with the circuit breaker on the "ON" position. When the breaker is on the

"ON" position, suitable preventive measures shall be provided, such as interlocks, to prevent the breaker from being drawn out. When the breaker is in "ON" position steel sheet shall be provided between the tiers in the vertical section. The door of this compartment shall not form part of the draw out arrangements.

### **Bus-Bars**

The bus-bar and its connections shall be aluminum Electrolytic grade E-91 as per IS: 5082 and shall be of rectangular section. These should be suitable for full load current for phase bus-bar and neutral bus-bar shall be of half rated current capacity. The bus-bar should have provision on either side for extension. The bus-bar should be sleeved with colour coded heat shrinkable PVC sleeve. Bus-bar supports shall be of fibre glass reinforced thermosetting polyester having in built and tracking barriers to break the path of conducting dust through moulded ribs. In panels bus-bar connections shall be done by drilling holes with cadmium coated bolts and nuts. Extra cross section shall be provided to compensate drilling of the holes. Insulated aluminum strips of suitable size of full rated current capacity shall be used for interconnecting bus-bar and breaker. A horizontal / vertical wire way shall be provided for interconnecting control wiring between different vertical sections. The terminal blocks shall be used for outgoing terminals and neutral link at a suitable located place in the control panel. Separate compartments for outgoing and incoming cable shall be provided. The current transformers of all instruments shall be mounted with terminal blocks. All live parts including incoming and outgoing link / terminals should be

### **Air Circuit Breakers**

The circuit breaker shall be capable of making and breaking the specified fault currents without straining or damaging any part of the switchgear. The breakers shall be air break, motorized / manually operated as specified in BOQ and draw out type. All feeders of rating 800A and above shall be ACB and of fully draw out type. The circuit breaker shall be stored energy closing type, manual/electrically operated with tripping mechanism. The circuit breaker shall be provided with 4 NO + 4 NC of auxiliary potential free contacts required for indication, control, interlocking and other purposes. All contacts shall be wired to a terminal block. Circuit breakers with stored energy closing mechanism shall be capable of making the rated short-circuit current, when the stored

energy is suitably charged by a spring. It shall also be capable of closing on no-load without suffering undue mechanical deterioration. The maximum make- time shall also not be exceeded.

The direction of motion of the handle, for manual spring charging shall be marked. A device indicating when the spring is charged fully shall also be provided. Motors and their electrically operated auxiliary equipment for charging a spring shall operate satisfactorily between 85% and 110% of the rated supply voltage. The breaker operating mechanism should store energy for O-C-O operation and shall not, in any case, get stuck in closed position during this cycle. After failure of power supply to the motor, at least one open-close-open operation of the circuit breaker shall be possible. The breaker operating mechanism shall be electrically and mechanically trip-free in all positions.

All ACBs shall be provided with microprocessor based trip unit for protection against overload, short circuit and earth faults. The releases shall be communicable to other systems on an open communication protocol. The Communication Port shall be provided in front/back. The circuit breakers shall be suitable for locking in fully isolated condition. Following interlocks and features shall be provided so that Truck can be moved within panel only when CB is off.

- a) CB can be closed only when the test (or) service limit switches permits
- b) Breaker compartment door cannot be opened when the CB is in Service/test position.
- c) Breaker cannot be put in to service position with compartment door open.
- d) Earth slide beyond the test position till trolley is drawn out.
- e) Closing and tripping coil shall operate satisfactorily under the following conditions of supply voltage variation:
  - a) Closing coils – 85% to 110% of rated voltage.
  - b) Trip coils – 70% to 110% of rated voltage.

### **Moulded Case Circuit Breakers**

The MCCBs shall conform to the latest applicable standards. MCCBs in AC circuits shall be of four pole construction arranged for simultaneous four pole manual closing and opening. Operating mechanism shall be quick-make, quick-break and trip free type. The ON, OFF and TRIP positions of the MCCB shall be clearly indicated and visible to the operator. Operating handle for operating MCCBs from door of board shall be provided. MCCB terminals shall be shrouded and designed to receive cable lugs for cable sizes relevant to circuit ratings. MCCBs shall incorporate time delay devices to ensure that it will tolerate harmless transient overload unless this is well in excess of 25% of its rated value for a sustained period. The circuit breaker shall be provided with 2 NO + 2 NC of auxiliary potential free contacts required for indication, control, interlocking and other purposes. All contacts shall be wired to a terminal block. The breaking capacity of MCCB's shall be as per the design requirements.

**Miniature Circuit Breakers**

Miniature Circuit Breaker shall comply with IS-8828-1996/IEC898-1995. Miniature circuit breakers shall be quick make and break type for 230/415 VAC 50 Hz applications with magnetic thermal release for over current and short circuit protection. The breaking capacity shall not be less than 10 KA at 415 VAC. MCBs shall be DIN mounted. The MCB shall be Current Limiting be type (Class-3). MCBs shall be classified (B,C,D ref IS standard) as per their Tripping Characteristic curves defined by the manufacturer. The MCB shall have the minimum power loss (Watts) per pole defined as per the IS/IEC and the manufacturer shall publish the values. The housing shall be heat resistant and having a high impact strength. The terminals shall be protected against finger contact to IP20 Degree of protection. All DP, TP and TPN miniature circuit breakers shall have a common trip bar.

**Rotary Switch / Selector Switch / Switches / HRC Fuses / Starters /****Single Phase Preventers / Toggle Switch**

These shall be of approved make and conforming to relevant ISI standard. The rupturing capacity of HRC fuses should not less than 80 KA and in case of switches it should be 60 Amps maximum.

**Current Transformer**

The current transformers shall have accuracy of class I and 5P10 / 10P10 and suitable VA burden for operation of the connected meters and relays.

**Overload Relays**

All the motors shall have overload relay protections conforming to relevant IS.

**Time Delay Relays**

These shall be adjustable type with time delay adjustments of 0-180 or as per manufacturers standards.

**Indicating Lamps And Metering**

These shall confirm to BS37 & BS39. All meters shall be flush mounted and draw-out type. The indicating lamp shall be filament type and with very low burden & economy resistor.

**Voltmeter And Ammeters**

Motor Control Centre (MV Panel) shall have flush type voltmeter & ammeter of size 96 x 96 mm.

#### Push Button Stations

These shall be suitable for panel mounting and accessible from front without opening. These shall be provided for manual starting and stopping of motors/equipments as per normal practices. The contacts shall be suitable for 6AMP current capacity.

#### Name Plate

Suitable anodized Aluminium name plate of 1.2 mm thick shall be provided on all the switchboards and individual compartments.

#### Conduits

These shall be preferable made of mild steel, stove enameled from inside and outside with minimum wall thickness of 1.6 mm for conduits up to dia of 25mm and 2 mm for conduits above 25 mm diameter.

#### Cables

Cable shall be supplied inspected, laid, tested and commissioned in accordance with drawings, specifications, relevant Indian Standards Specifications and cable manufacturer's instructions. The cable shall be delivered at site in original drums with manufacturer's name clearly written on the drum. The cables shall comply with the latest edition of the following standards

- ☐ BIS: 7098 (PART-I) - XLPE Cables - LT
- ☐ BIS: 8130 - Conductors for insulated electric cables & flexible cords.
- ☐ BIS: 3975 - Mild steel wires, strips & tapes for armouring of cables
- ☐ BIS: 10418 - Wooden drums for electric cables
- ☐ BIS: 10810 (PART 58) - Oxygen Index test

.

The material of cable shall be as follows:-

- a) The MV power cable of 660/1100 V. grade shall be XLPE insulated Aluminium conductor armoured cable.
- b) The MV control cables shall be PVC insulated copper conductor armoured stranded cable.

- c) The HT power cable of 415 V grade shall be XLPE insulated Aluminium conductor armoured cable.

### Laying of Cables

These shall be laid as Indian Standard code of practice. All cables shall be laid on 16G GI Perforated U shaped Channel 40mm x 20mm cable trays. In case more than one cable is running, then proper space in between the two cables shall be provided to avoid loss of current carrying capacity. While cables are running on walls, proper saddles must be provided.

### Wire Sizes

Single stand PVC-copper conductor wires shall be used inside the control panel for interconnecting different components. All wires shall be neatly dressed and coloured beads shall be provided for easy identification in control wiring. The minimum size of control wiring shall be 1.5sq.mm. Testing of panels as per code of practice shall be done at works by Employer / Architect before inspection & dispatch to site.

### Drawings

Necessary drawings of all control panels and wiring of equipment etc., shall be submitted by the contractor for approval of the Engineer in Charge. On final completion of job and before handing over of AC System As Built Drawings shall be submitted to the Department.

### Testing

All equipment and components supplied may be subjected to inspection and tests by the client / consultant or his authorized representatives during manufacture, erection / installation and after completion. No tolerances shall be allowed other than the tolerances specified or permitted in the relevant approved Standards, unless otherwise stated. If the guaranteed performance of any item of equipment is not met and / or if any item fails to comply with the specification requirement in any respect whatsoever at any stage of manufacture, test or erection, the client / consultant may reject the item, or defective component thereof, whichever he considers necessary. The complete electrical installation shall be tested in accordance with relevant IS codes in resence of Electrical Supervisor of the client before commissioning of plant.

### Painting of Panels

All sheet metal enclosures shall be powder coated only after de-rusting & hot-dip phosphating degreasing etc. at works only.

**NOTE:** Rubber mats of 1100 volts shall be laid in front of all switch boards.

### Sizes of Power Cabling

The following size of power cabling shall be used only or as per BOQ.

<b>HP of Motors</b>	<b>Cable size</b>
Up to 5 HP	3c x 4sq.mm aluminium conductor armoured cable.
5 to 7.5 HP	3c x 6sq.mm aluminium conductor armoured cable.
10 to 15 HP	3c x 6sq.mm aluminum conductor armoured cable
20 to 25 HP	3 x 16sq.mm aluminum conductor armoured Cable
30 to 35 HP	3c x 25sq.mm aluminum conductor armoured Cable
40 to 50 HP	3c x 35sq.mm aluminum conductor armoured Cable
60 HP	3c x 50sq.mm aluminum conductor armoured Cable
75 HP	3cx 70sq.mm aluminum conductor armoured Cable
100 HP	3cx 95sq.mm aluminum conductor armoured Cable
125 HP	3cx 120sq.mm aluminum conductor armoured Cable

### Earthing

The earthing of all equipments shall be carried out by Copper strips / wires as mentioned in Bill of Quantities. All panels / three phase motors shall be earthed with two number distinct and Dependent Copper strips / wires of the following sizes or as per BOQ.

1. Motor upto 5.5 KW	3 sq. mm Copper Wire	4 mm dia GI Wire
2. Motor 7.5 to 18.75 KW	4 sq. mm Copper Wire	6 mm dia GI Wire
3. Motor 18.75 to 50 KW	25x3 mm Copper Strip	25x6 mm GI Strip
4. Motor 51 to 89 KW	25x6 mm Copper Strip	32x6 mm GI Strip

The earthing connections shall be connected to main earth station or main earth grid. The earth connections shall be connected to equipments after removal of paint, grease etc.

## F. SPECIFICATION FOR AIR DISTRIBUTION

### Scope of Works



## SERVICES SPECIFICATION

The scope of this section comprises supply, fabrication, installation & testing of all sheet metal GI ducts as well as supply, installation, testing & balancing of all grills, diffusers & other accessories in accordance with these specification & Schedule of Quantities.

### 2. DUCT MATERIALS

#### 2.1 RAW MATERIALS

Galvanizing shall be Class VIII – light coating of zinc, nominal 120gm/sq.m surface area and Lock Forming Quality prime material alongwith mill test certificates. In addition, if deemed necessary, samples of raw material, selected at random by owner's site representatives shall be subject to approval and tested for thickness and zinc coating at contractor's expense.

#### 2.2 GAUGES, BRACING BY SIZE OF DUCTS (MACHINE FABRICATED)

All ducts shall be fabricated from galvanized steel/aluminum of the following thickness, as indicated as below :

For Ducts with external SP upto 250 Pa (25mmWg)

#### AS PER SMACANA

Rectangular Ducts G. S.	Pressure 25 MM		
	Duct Section Length 1.2m (4 ft)		
Maximum Duct Size	Gauge		Bracing Spacing
1–450 mm	26	C&S/TDF	Nil
451 – 750 mm	26	C&S/TDF	Nil
751 – 1000 mm	26	TDF	Nil
1001 – 1500 mm	24	TDF	Nil
1501 – 1800 mm	22	SLIP ON	Nil
1800 – 2100 mm	20	SLIP ON	Zeebar stiffener 1-S
Greater than 2100 mm	18	SLIP ON	Zeebar stiffener 1-S

#### FOR ROUND DUCTS

Duct diameter mm	Upto 50 mm Wg static pressure (+ve)		51–250 mm Wg static pressure		Upto 50 mm Wg static pressure (-ve)	
	Spiral seam gauge	Longitudinal seam gauge	Spiral seam gauge	Longitudinal seam gauge	Spiral seam gauge	Longitudinal seam gauge
Upto 650	26	24	24	22	24	22
651–900	24	22	22	20	22	20
901–1250	22	20	20	20	20	18
1251–1500	20	18	18	18	18	16
1501–2100	18	16	18	16	16	14

### **FABRICATION STANDARDS & EQUIPMENT**

All duct construction and installation shall be in accordance with SMACNA standards. In addition ducts shall be factory fabricated utilizing the following machines to provide the requisite quality of ducts.

1. Coil (Sheet metal in Roll Form) line to facilitate location of longitudinal seams at corners/folded edges only, for required duct rigidity and leakage free characteristics. No longitudinal seams permitted along any face side of the duct.
2. All ducts, transformation pieces and fittings to be made on CNC profile cutter for requisite accuracy of dimensions, location and dimensions of notches at the folding lines.
3. All edges to be machine treated using lockformers, flangers and rollers for turning up edges.
4. Kitchen exhaust ducting shall be with 16 G MS. Suitable access doors shall be provided at every 3m. Provision shall be made for firefighting agency to install duct mounted sprinklers at every 3m. Generally exhaust ducts shall have slope towards kitchen hood.

### **DUCT CONSTRUCTION**

All ducts shall be fabricated and installed in workmanlike manner, conforming to relevant SMACNA codes.

- a) Ducts so identified on the Drawings shall be acoustically lined and insulated from outside as described in the section "Insulation" and as indicated in schedule of Quantities. Duct dimensions shown on drawings, are overall sheet metal dimensions inclusive of the acoustic lining where required and indicated in Schedule of quantities. The fabricated duct dimensions should be as per approved drawings and care should be taken to ensure that all connecting sections are dimensionally matched to avoid any gaps.
- b) Ducts shall be straight and smooth on the inside with longitudinal seams shall be airtight and at corners only which shall be either Pittsburgh or snap button as per SMACNA practice, to ensure air tightness.
- c) All ducts up to 75cms width within conditioned spaces shall have slip and drive (C & S/SS) joints. The internal ends of slip joints shall be in the direction of airflow. Care should be taken to ensure that S/SS Cleats are mounted on the longer side of the duct and Cleats on the shorter side. Ducts and accessories within ceiling spaces, visible from air-conditioned areas shall be provided with two coats of mat black finish paint.
- d) Changes in dimensions and shape of ducts shall be gradual (between 1:4 and 1:7). Air-turns (vanes) shall be installed in all bends and duct collars designed to permit the air to make the turn without appreciable turbulence.
- e) Ducts shall be fabricated as per details shown on Drawings. All ducts shall be rigid and shall be adequately supported and braced where required with standing seams, tees, or angles, of ample size to keep the ducts true to shape and to prevent buckling, vibration or breathing.
- f) All sheet metal connection, partitions and plenums, required to confine the flow of air to and through the filters and fans, shall be constructed of 18 gauge GSS/ 16 gauge aluminum, thoroughly stiffened with 25mm x 25mm x 3mm galvanized steel angle braces and fitted with all necessary inspection doors as required, to give access to all parts of the apparatus. Access doors shall be not less than 45cm x 45cm in size.
- g) Plenums shall be shop/factory fabricated panel type and assembled at site. Fixing of galvanized angle flanges on duct pieces shall be with rivets heads inside i.e. towards GS sheet and riveting shall be done from outside.
- h) Self-adhesive Neoprene rubber/UV resistant PVC foam lining 5mm nominal thickness instead of felt shall be used between duct flanges and between duct supports in all ducting installation.

- i) Guiding/Turning Vanes shall be provided where ever required and shall be securely fastened to prevent noise & vibration.
- j) Splitter Dampers will be provided where ever required.
- k) Ducts shall be suspended from the ceiling with dash fasteners.

#### DUCTING (MANUAL SITE FABRICATED)

All ducts manually fabricated shall be as per the details given below:

Maximum Side	Thickness of GI / AL Sheet	Type of Transverse Joint Connections	Bracing
(1) MM	(2) MM	(3)	(4)
Up to 300	0.63 / 0.80	S-drive, pocket or bar slips, on 2.5m centers	None
301 to 600 601 to 750	0.63 / 0.80	S-drive, pocket or bar slips, on 2.5m centres S-drive, 25mm pocket or 25mm bar slips on 2.5m centers	None 25 x 25 x 3mm angles 1.2m from joint
751 to 1000	0.80 / 1.00	Drive, 25-mm pocket or 25mm bar slips, on 2.5 m centres 40 x 40 mm angle connections,	25 x 25 x 3 mm angles, 1.2 m from joint
1001 to 1500		Or 40-mm bar slips, with 35 x 3 mm bar reinforcing on 2.5m centres.	40 x 40 x 3 mm angles, 1.2 m from joint
1501 to 2250	1.00/1.25	40 x 40 mm angle conn sections, or 40mm bar slips, 1M maximum centres with 35 x 3mm bar reinforcing.	40 x 40 x 3mm diagonal angles, or 40x40 x 3 mm angle 60 cm from joint
2250 to above*	1.25/1.50	50 x 50 mm angle, connections, or 40mm pocket or 40 mm bar slips, 1m max. Centres with 35x3mm bar reinforcing.	40 x 40 x 4 mm diagonal angles, or 40 x 40 x 3 mm angles, 60 cm From joint

- \* Ducts 2250 mm and larger require special field study for hanging and supporting methods.

In addition to above the following points should be also taken into account while fabrication of ducts.

- a) All ducts of size larger than 450mm shall be cross broken.
- b) All ductwork shall be independently supported from building construction. All horizontal ducts shall be rigidly and securely supported, in an approved manner, with hangers formed of galvanized steel wireropes (as per clause 5.2) and galvanized steel angle/channel or a pair of brackets, connected by galvanized steel wire hangers under ducts, rigid supports may be provided at certain interval if need be. The spacing between supports should be not greater than 2.4 meter. All vertical ductwork shall be supported by structural members on each floor slab. Duct supports may be through galvanized steel insert plates or Toggle end wirefixing left in slab at the time of slab casting. Galvanized steel cleat with a hole for passing the wire rope hanger shall be welded to the plates. Trapeze hanger formed of galvanized steel wire rope using self-grip double channel lock shall be hung through these cleats. Wherever use of metal insert plates is not feasible, duct support shall be through dash/anchor fastener driven into the concrete slab by electrically operated gun. Wire rope supports shall hang through the cleats or wire rope threaded studs can be screwed into the anchor fasteners.
- c) The vanes shall be provided wherever required and shall be securely fastened to prevent noise & vibration.
- d) The rubber gasket shall be installed between duct flanges in all connections and joints.
- e) All flanges and supports should be primer coated.
- f) All horizontal ducts shall be adequately secured and supported. In an approved manner, with trapeze Hangers formed of galvanized steel wire rope in a cradle support method (refer to typical drawings) under ducts at no greater than 3000mm centre, for 3001mm- above appropriate size angle along with neoprene pad in between the duct & C Channel/MS angle (as per clause 5.2) should be used with prior approval. All vertical ductwork shall be supported by structural members on each floor slab. Hanger wires shall

then hang around the ducting. Rigid supports shall be used in conjunction with wire rope hangers to assist with alignment of services where recommended for by the manufacturer. Rigid support must also be used in conjunction with wire rope hangers with duct work at each change of direction or connection. Support ducting in accordance with Schedule I at the end of this Section. In cases of Spiral ducting the wire can be wrapped directly around the ducting without the need for a spiral ducting clamp for sizes above 1100 a cradle support should be provided refer to manufacturer's recommendations.

### **INSTALLATION PRACTICE**

All ducts shall be installed generally as per tender drawings, and in strict accordance with approved shop drawings to be prepared by the Contractor:

- a. The Contractor shall provide and neatly erect all sheet metal work as may be required to carry out the intent of these Specifications and Drawings. The work shall meet with the approval of Owner's site representative in all its parts and details.
- b. All necessary allowances and provisions shall be made by the Contractor for beams, pipes, or other obstructions in the building, whether or not the same are shown on the drawings. Where necessary to avoid beams or other structural work, plumbing or other pipes, and conduits, the ducts shall be transformed, divided or curved to one side (the required area being maintained) all as per the site requirements.
- c. If a duct cannot be run as shown on the drawings, the contractor shall install the duct between the required points by any path available in accordance with other services and as per approval of owner's site representative.
- d. All duct work shall be independently supported from building construction. All horizontal ducts shall be rigidly and securely supported, in an approved manner, with hangers formed of galvanized steel wire ropes and galvanized steel angle/channel or a pair of brackets, connected by galvanized steel wire hangers under ducts, rigid supports may be provided at certain interval if need be. The spacing between supports should be not greater than 2.4 meter. All vertical ductwork shall be supported by structural members on each floor slab. Duct supports may be through galvanized steel insert plates or Toggle end wire fixing left in slab at the time of slab casting. Galvanized steel cleat with a hole for passing the wire rope hanger shall be welded to the plates. Trapeze hanger formed of galvanized steel wire rope using self-grip double channel lock shall be hung through these cleats. Wherever use of metal insert plates is not feasible, duct support shall be through dash/anchor fastener driven into the concrete slab by electrically operated gun. Wire rope supports shall hang through the cleats or wire rope threaded studs can be screwed into the anchor fasteners. In case of PEB structure Loop and Catenary system can be used based on the site conditions as per approved suspension system drawings.

- e. Ducting over furred ceiling shall be supported from the slab above or from beams after obtaining approval of Owner's site representative. In no case shall any duct be supported from false ceiling hangers or be permitted to rest on false ceiling. All metal work in dead or furred down spaces shall be erected in time to occasion no delay to other contractor's work in the building.
- f. Where ducts pass through brick or masonry openings, it shall be provided with 25mm thick TF quality expanded polystyrene around the duct and totally covered with fire barrier mortar for complete sealing.
- g. All ducts shall be totally free from vibration under all conditions of operation. Whenever duct work is connected to fans, air handling units or blower coil units that may cause vibration in the ducts, ducts shall be provided with a flexible connection, located at the unit discharge. Flexible connections shall be constructed of fire retarding flexible heavy canvas sleeve at least 10cm long securely bonded and bolted on both sides. Sleeve shall be made smooth and the connecting ductwork rigidly held by independent supports on both sides of the flexible connection. The flexible connection shall be suitable for pressure at the point of installation.
- h. Duct shall not rest on false ceiling and shall be in level from bottom. Taper pieces shall taper from top.
- i. All horizontal ducts shall be adequately secured and supported. In an approved manner, with trapeze Hangers formed of galvanized steel wire rope in a cradle support method (refer to typical drawings) under ducts at no greater than 3000mm centre, for 3001mm-above appropriate size angle along with neoprene pad in between the duct & C Channel/MS angle (as per clause 5.2) should be used with prior approval. All vertical duct work shall be supported by structural members on each floor slab. Hanger wires shall then hang around the ducting. Rigid supports shall be used in conjunction with wire rope hangers to assist with alignment of services where recommended for by the manufacturer. Rigid support must also be used in conjunction with wire rope hangers with duct work at each change of direction or connection. Support ducting in accordance with Schedule I at the end of this Section. In cases of Spiral ducting the wire can be wrapped directly around the ducting without the need for a spiral ducting clamp for sizes above 1100 a cradle support should be provided refer to manufacturer's recommendations.

### **Box Type Dampers & Splitters**

These dampers shall be provided in the ducting work for proper control and balancing of air distribution. All dampers shall be louver type robust construction. These dampers shall be fitted with easily accessible operating mechanism, complete with links, levers, quadrant for proper control and setting in a desired position. The position of the handle of the damper operating mechanism shall be clearly visible and shall indicate the position of the damper in the duct. All dampers, splitters shall be fabricated out of G.S.sheet of two gauges higher than the duct piece having these fittings. Dampers shall be installed in duct at all required locations. No extra payment shall be made separately since these form part of Air Circulation System.

**NOTE:** In case angle iron supports are not feasible to be installed for supporting the ducts due to height constraint then the contractor shall support the ducts with M.S flats of at least double the thickness of the angle iron supports.

### **Supply And Return Air Grills and Ceiling Diffusers**

The supply and return air grills and ceiling diffusers shall be made of powder coated extruded aluminum sections. The supply air grills / diffusers shall be provided with screw operated opposed blade volume control device made of MS duly black painted. All grills / diffusers shall have soft continuous rubber / foam gasket between the periphery of the grills / diffusers and surface on which it has to be mounted. The colour of grills / diffuser shall be as per the approval of the Engineer in Charge.

### **Linear Supply and Return Grills**

The linear continuous supply / return air grills shall be made of powder coated extruded aluminum construction with fixed horizontal bars. The thickness of fixed bar louvers shall be 5mm in front and the flange shall be 20mm wide with round edges. The register shall be suitable for concealed fixing and horizontal bars of the grills shall mechanically crimped from the back to hold them. The colour of grills shall be as per the approval of the Engineer in Charge.

### **Front Fixed Bar Rear Adjustable Louvered Grills**

The grills shall be made of powder coated extruded aluminum construction with front fixed horizontal bar at 0 degree inclination with one way or two way deflection with rear vertical individually adjustable louvers in black shade mounted on Nylon bushes to hold deflection setting under all conditions of velocity and pressure. The colour of grills shall be as per the approval of the Engineer in Charge.

### **Square / Rectangular Ceiling Diffusers**

The square / rectangular ceiling diffusers shall be made of powder coated extruded aluminum construction with flush fixed pattern. The diffusers shall have Anti-Smudge ring and spring loaded removable central core in various pattern for air flow direction. The diffusers shall be mounted by concealed screw fixing arrangement. The colour of diffuser shall be as per the approval of the Engineer in Charge.

### **Volume Control Device**

The opposed blade volume control device shall be made of MS duly black painted. Specially designed blade shall have an overlapping lip, which shall ensure a tight closure

### **Fresh Air Intake Louvers with Bird Screen**

The fresh air intake louvers at least 50mm deep will be made of powder coated extruded aluminum construction. Bird / insect screen will be provided with the intake louvers. The blades shall be inclined at 45 degree on a 40mm blade pitch to minimize water ingress. The lowest blade of the assembly shall be extended out slightly to facilitate disposal of rain water without falling on door /



wall on which it is mounted. The intake louvers shall be provided with factory fitted volume control dampers in black finish.

#### Painting

All ducts collar / shoot behind the grills / diffuser shall be given at least two coats oil black enamel paints.

#### Testing

The complete duct system shall be tested for air leakage & complete air distribution system shall be balanced in accordance with air quantities indicated on the approved drawing.

### **G. FIRE DAMPERS**

#### **Scope of Work**

The scope of this section comprises the supply, installation, testing & commissioning of fire dampers conforming to these specifications and in accordance with Schedule of Quantities.

#### **Motorized Combined Smoke & Fire Dampers - Spring Return Type**

a) All supply air Ducts in AHU room crossing shall be provided with approved make fire and smoke dampers of at least 90 minutes fire rating certified by CBRI, Roorkee as per UL555:1973.

b) The fire damper blades & outer frame shall be formed of 1.6 mm galvanized steel sheet. The damper blade shall be pivoted on both ends using chrome-plated spindles in self-lubricating bushes. Stop seals shall be provided on top & bottom of the damper housing made of 16G Galvanized steel sheet. For preventing smoke leakage side seals will be provided. In normal operating conditions damper blade shall be held in open position with the help of a 24 V operated electric actuators thereby providing maximum air passage without creating any noise or chatter.

c) The damper shall be actuated through electric actuator. The actuator shall be energized with the help of a signal from smoke detector installed in AHU Room / R. A. Duct. The fire damper shall close due to temperature rise in S. A. Ducts through the electric temperature sensor, which is factory set at 165 °F.

d) Each motorized smoke cum fire damper shall have its own panel which will incorporate necessary circuit required to step down voltage available from UPS or emergency power supply to show status of the damper (open or close), to allow remote testing of damper, indication in event of damper closure due to signal from smoke sensor / temp. sensor & reset button. Additional terminal will be provided to have audio cum video signal in Central Control Room.

e) Damper actuator shall be such that it should close the damper in the event of power failure automatically and open in the same in case of Power being restored.

f) The fire Damper shall be mounted in fire rated wall with a duct sleeve 600 MM long. The sleeve shall be factory fitted on fire damper. The joints at sleeve end shall be slip on type. Minimum thickness of GI Sheet shall be 18G.

g) The damper shall be installed in accordance with the installation method recommended by the manufacturer. Hinged access doors of suitable size complete with airtight gaskets shall be provided in all fire dampers & plenums.

## H. INSULATION

### Scope of Works

The scope of this section comprises supply & fixing of thermal / acoustic insulation of ducts, pipes etc. as per the specification given below & in accordance with Schedule of Quantities.

#### Material & Process of Acoustic Insulation of Duct / AHU Room

a) Resin Bonded Fibre Glass Wool

The Thermal conductivity values in W/m.K of fibre glass shall confirm to following: **Mean Temperature °C**

250C

#### Acoustic Lining of Duct

The material to be used for duct lining shall be 15mm thick open cell nitrile rubber insulation.

#### Material & Process of Thermal Insulation of Pipes / AC Equipments

##### Material

- ☐ Insulation material shall be Closed Cell Elastomeric Nitrile Rubber.
- ☐ Density of Material shall be between 60+/-10% Kg/m<sub>3</sub>.
- ☐ Thermal conductivity of elastomeric nitrile rubber shall not exceed 0.035

□ W/m<sub>0</sub>K at an average temperature of 0<sub>0</sub>C.

□ The insulation shall have fire performance such that it passes Class 1 as per BS476 Part 7 for surface spread of flame as per BS 476 and also pass Fire Propagation requirement as per BS476 Part 6 to meet the Class 'O'Fire category as per 1991 Building Regulations (England & Wales) and the Building Standards (Scotland) Regulations 1990. Water vapour permeability shall not exceed 0.017 Perm inch (2.48 x 10<sup>-14</sup> Kg/m.s.Pa), i.e. Moisture Diffusion Resistance Factor or 'μ' value should be minimum 7000. Thickness of the insulation shall be as specified for the individual application.

### **Pipe Insulation**

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

□ Insulating material in tube form shall be sleeved on the pipes

□ On existing piping, slit opened tube of the insulating material (slit with a very sharp knife in a straight line) shall be placed over the pipe and adhesive shall be applied as suggested by the manufacturer.

□ Adhesive must be allowed to tack dry and then press surface firmly together starting from butt ends and working towards centre

Wherever flat sheets shall be used it shall be cut out in correct dimension. All longitudinal and transverse joints shall be sealed as per manufacturer recommendations. The insulation shall be continuous over the entire run of piping, fittings and valves. All valves, fittings, joints, strainers, etc. in chilled water piping shall be insulated to the same thickness as specified for the main run of piping and application shall be same as above. Valves bonnet, yokes and spindles shall be insulated in such a manner as not to cause damage to insulation when the valve is used or serviced.

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

### **Recommended Adhesive**

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

### **Installation Exposed Directly to Sunlight**

For installations exposed to sunlight, after giving 36 hours curing time for the adhesive apply manufacturer's recommended UV/Mechanical Protection. Please refer the separate detailed

guidelines on UV/Mechanical Protection. FRP coating should be provided for protection from sun light.

### **Parameters for Selection of Thickness**

- a) Design Basis: Condensation Control
- b) Region: Non Coastal Area
- c) Application: Outdoor & Indoor

### **Thickness of Insulation**

- a) Drain Water Pipe Line Temperature 15.0 Deg. C Up To 50 mm Pipe Size - 9 mm Thick Insulation
- b) Refrigerant Pipe Line as per BOQ but stringent one shall be followed.

Mechanical Protection for Piping (with Adhesive and Glass Cloth /CSM) It's a two component composite system of woven glass cloth and manufacturer approved adhesive.

- a) Mechanical Protection should be applied after 36 hours of Curing of adhesive. It is the minimum time required for complete curing of adhesive.
- b) For UV protection apply two coats of special UV resistant paint after the above process. Apply adhesive liberally on Insulation. Immediately spread the 7 mil woven glass cloth on insulation without allowing adhesive to dry. Immediately apply another coat of adhesive liberally on woven glass cloth. Even out with brush and allow it to dry for 2-3 hours.

### **Material & Process of Thermal Insulation of Ducts**

**Duct insulation:** Chemically Cross Linked Closed Cell Polyethylene FR-XPE Fire Retardant grade in roll form density not less than  $33 \pm 3 \text{ kg/cum}$  and thermal conductivity  $0.0319 \text{ w/mk}$  at mean temperature of  $0^\circ\text{C}$ . Supply and Return air ducts shall be insulated as shown in the drawing/as specified in the bill of quantities

### **CASE-1**

Supply Air (SA) Duct. (When Return Air is being taken through the False-Ceiling)

Supply Air - 10 mm thick

Supply Air (SA) & Return Air (RA) Duct (When both are in the Non-Conditioned area) Supply Air – 18 mm thick-----Return Air – 13 mm thick

Supply Air (SA) & Return Air (RA) Duct (When both the Ducts are above False Ceiling of Airconditioned Area)

Supply Air – 13 mm thick-----Return Air – 9 mm thick

**Or as per BOQ but stringent one shall be followed.**

**Under deck Insulation with Expanded Polystyrene with Overlap Edge**

Ceiling of exposed roof shall be provided with under deck insulation as per following specifications & as specified in the Schedule of Quantities.

- a) Clean the surface & apply the adhesive on it.
- b) Fix 75 mm Expanded Polystyrene with Overlap Edge of density 20 Kg/CMT with the help of adhesive
- c) Apply adhesive between all longitudinal and transverse joints of Expanded Polystyrene.
- d) Fix the Expanded Polystyrene finally with the help of rawl plug & dash fasteners in ceiling

## **I. PIPING**

### **Condensate Drain Piping Work**

#### **Scope of Works**

The scope of this section comprises supply, installation, testing & commissioning of drain water pipes, pipe fittings and valves etc. as detailed below in specifications. All pipes, fittings and valves etc. shall conform to relevant Indian standards.

### Drain Water Piping

The pipes, fittings and valves shall be of approved make given in the tender. Drain water / make up water pipes shall be "B" Class GI Pipe & shall Conform to IS: 4736 or threaded PPR or Hard PVC pipe as per BOQ.

The pipes shall be sized for individual liquid flow & shall ensure smooth noiseless balanced circulation of fluid. All piping and their steel supports shall be thoroughly cleaned and primer coated before installation.

### Pipe Fittings

The pipe fittings for screwed piping shall be malleable iron and for piping with welded joints shall of weldable quality. Also the fittings shall be suitable for same pressure ratings as for the piping system. All bends up to sizes 150 mm dia shall be ready made of heavy duty wrought steel of appropriate class. All bends in sizes 200 mm and above shall be fabricated from the same dia and thickness of pipe in at least four sections and having a center in radius of at least 1.5 times diameter of pipes. Fittings such as tees, reducers etc. shall be fabricated from the same pipe and its length shall be at least twice the diameter of the pipe. The dead ends shall be formed with flanged joints & shall have 6mm thick blank between flange pair for 150 mm and over.

### Flanges

All flanges shall be of mild steel as per IS : 6392 / 71 (with latest amendments) & shall be slip on type welded to the pipes. Flanged thickness shall be to suit Class II pressure. 3 mm thick gasket shall be used in between the flanges. Flanged pair shall be used on all such equipments which are required to be isolated or removed for service for example condenser / chilled water pumps, chilling m/c, AHU etc.

### Installation of Water Piping

- a) All pipes shall be securely supported or suspended on stands, hangers, clamps etc. as required. The Air-conditioning contractor shall design all brackets, saddles, anchors, clamps etc. & shall be responsible for structural adequacy.
- b) All pipe supports shall be of steel, coated with two coats of anti-corrosive paint and finally finished with paint.
- c) The pipe spacing shall be as follows :

Dia of Pipe	Spacing supports	between
Up to 25mm	1.5 mt	
30 mm to 50 mm	2.0 mt	
65 mm to 75 mm	2.5 mt	
100 mm to 125 mm	3.0 mt	
150 mm	3.5 mt	

200 mm & above                      4.0 mt

d) The vertical rises shall run parallel to walls and should be straight to wall duly checked with plumb line.

e) In case pipes with/ without insulation while passing through the wall / slab, shall be provided with sleeve 50mm higher in size than the pipe with / without insulation.

f) Wherever insulated pipes are running, it should be supported in such away that no undue pressure is exerted on the insulated pipe.

g) The expansion-joints or expansion-loops shall be provided to take care of the expansion and contraction in pipes due to temperature rises.

### **Testing of Pipe System**

a) All tools, tackles, labours etc. shall be arranged by A/C Contractor.

b) All pipes shall be tested hydraulically at 1.5 times the maximum operating pressure for a period of 24 hours. All leaks occurring during testing shall be rectified to the satisfaction of the Engineer in Charge. After repairs of leak it shall be tested again at the same pressure.

c) In case piping is tested in parts, these sections shall be securely sealed and capped during testing.

d) The A/C Contractor should ensure that there should be minimum vibration / noise in the chilled water / condenser water circuit due to water turbulence.

### **VRV / VRF Refrigerant Piping**

#### **Scope of Works**

The scope of this section comprises supply, installation, testing & commissioning of refrigerant piping as detailed below in specifications.

#### **Refrigerant Piping**

All refrigerant piping for the air conditioning system shall be constructed from soft seamless up to 19.1mm and hard drawn copper refrigerant pipes for above 19.1mm with copper fittings and silver-soldered joints. The refrigerant piping arrangements shall be in accordance with good practice within the air conditioning industry, and are to include charging connections, suction line insulation and all other items normally forming part of proper refrigerant circuits. All joints in copper piping

shall be sweat joints using low temperature brazing and or silver solder. Before jointing any copper pipe or fittings, its interiors shall be thoroughly cleaned by passing a clean cloth via wire or cable through its entire length. The piping shall be continuously kept clean of dirt etc. while constructing the joints. Subsequently, it shall be thoroughly blown out using nitrogen. After the refrigerant piping installation has been completed, the refrigerant piping system shall be pressure tested using nitrogen at pressure of 20Kg per sq.cm and 10 Kg per sq.cm (low side). Pressure shall be maintained in the system for 24 hours. The system shall then be evacuated to minimum vacuum if 700mm hg and held for 24 hours.

The air-conditioning system supplier shall be design sizes and erect proper interconnections of the complete refrigerant circuit. The thickness of copper piping shall not be less than 20gauge for pipes up to 19.1mm and 18 gauge for bigger sizes. The suction line pipe size and the liquid line pipe size shall be selected according to the manufacturers specified outside diameter. All refrigerant pipes shall be properly supported and anchored to the building structure using

steel hangers, anchors, brackets and supports which shall be fixed to the building structure by means of inserts or expansion shields of adequate size and number to support the load imposed thereon.

The OD & wall thickness size of copper refrigerant piping shall be as per VRV/ VRF manufacturer standard.

**The Following are for guidance only.**

<b>Outside Diameter (mm)</b>	<b>Wall Thickness (G)</b>
a) 41.3	18
b) 34.9	18
c) 19.1	20
d) 15.90	20
e) 12.70	20
f) 9.5	20
g) 6.4	20



## J. NOISE & VIBRATION CONTROL

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

### General

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

All moving plant / equipment shall be statically and dynamically balanced at manufacturers works and certificates issued. The isolation of moving plant, machinery and apparatus including lines equipment from the building structure. Methods of Test of Silencers for Air Distribution Systems Laboratory and Field Measurement of Airborne Sound Insulation of Various Building Elements Recommendations for Field Laboratory Measurement of Airborne and Impact Sound Transmission in Buildings Methods of Measurement of Sound Adsorption in a Reverberation Room Acoustic Testing. Acoustic performance without additional ducting of forced fan convection equipment.

Acoustic performance with additional ducting of forced fan convection equipment Acoustic

Testing and Rating of High Pressure Terminal Reheat Units. Acoustic Testing and Rating of

Induction Units. 1984 Glossary of Refrigeration, Heating, Ventilating and Air Conditioning Terms Where duct work and pipe work services pass through walls, floors and ceilings, or wherever supported shall be surrounded with a resilient acoustic absorbing material to prevent contact with the structure and minimise the outbreak of noise from plant rooms. The reduction of noise breakout from plant rooms and the selection of externally mounted equipment and plant to meet ambient noise level requirements of the Specifications.

Electrical conduits and connections to all moving plant and equipment shall be carried out in flexible conduit and cables to prevent the transmission of vibration to the structure and nullify the provisions of anti-vibration mountings. All duct connections to fans shall incorporate flexible connections, except in cases where these are fitted integral within air handling units. All resilient acoustic absorbing materials shall be non flammable, vermin and rot proof and shall not tend to break up or compress sufficiently to transmit vibration or noise from the equipment to the structure.

Where practicable, attenuators shall be built into walls and floors to prevent the flanking of noise the duct work systems and their penetrations sealed in the manner previously described. Where this is not feasible, the exposed surface of the duct work between the attenuators and the wall subjected to noise infiltration shall be acoustically clad as specified. Ambient noise from cooling tower also shall be assessed to determine the suitable attenuators that can reduce the noise so as not affecting the adjoining public area.

### **Anti-vibration Mountings**

All items of rotating and reciprocating plant and equipment shall be isolated from the structure by the use of anti-vibration materials, mountings or spring loaded supports fixed to either concrete bases, inertia blocks or support steels.

Centrifugal fans and motors within air handling units shall be isolated from the frame of the air handling unit by suitable anti-vibration mountings. Fan discharge air connections shall be fitted with approved flexible connections.

Axial flow fans shall be mounted on steel legs as diaphragm plates supported on neoprene in shear anti-vibration mountings, or suspended using spring loaded hangers to suite the application.

The construction of the anti-vibration mountings shall generally comply with the following: -

#### **Enclosed Spring Mounting (Caged or Restrained Springs)**

Each mounting shall consist of cast or fabricated telescopic top and bottom housing enclosing one or more helical steel springs as the principle isolation elements, and shall incorporate a built-in leveling device. The springs shall have an outside diameter of not less than 75% of the operating height, and be selected to have at least 50% overload capacity before becoming coil bound. The bottom plate of each mounting shall have bonded to it a neoprene pad designed to attenuate any high frequency energy transmitted by the springs. Mountings incorporating snobbery of restraining devices shall be designed so that the snubbing damping or restraining mechanism, is capable of being adjusted to have no significant effect during the normal running of the isolated machine.

The manufacturers shall provide restrained isolator on chillers subject to approval.

### **Open Spring Mountings**

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

### **Neoprene-in-Shear Mountings**

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

**K. MODE OF MEASUREMENT**

Mode of Measurement.

The following measurement code shall apply to the Contract:

**Sheet Metal Work****Ducting**

The final finished sheet area in sq. mt shall be measured only.

- a) Vanes, splitters, flanges, access doors etc. shall not be separately measured. These shall be treated as part of duct work
- b) Bends, Elbows, Transformation, pieces etc. shall be measured along the centre line and measured as per duct work.
- c) Canvas connections, Duct Supports, Stiffening members, frames etc. shall not be measured separately and shall form part of duct work /equipment.

**Grills / Diffusers / Fire Dampers**

All Grills / Diffusers / Fire Damper areas will be measured in terms of effective area (Neck Area). Any Extruded aluminum grill / diffusers having an area less than 0.1 sq.mt shall be accounted as 0.1 sq.mt.

**Box Dampers**

- a) Duct dampers shall be measured in Sq. Mt. in terms of effective area
- b) Fresh air dampers shall be measured as effective areas only. No separate measurements for bird screen inlet / outlet louvers shall be done.

**Piping Work**

- a) The length of piping accessories & fittings shall be measured along its centre line in meters and no measurements for bends, elbows, tees etc. shall be made.
- b) All such fittings / accessories shall be treated as part of the piping work.
- c) Flanges shall not be measured, as they form part of piping work.
- d) For thermometer wells & pressure gauge sockets no measurement shall be done separately.

e) All kinds of supports, hangers etc shall be part of piping work & no extra measurements shall be done.

## **Insulation**

### **Insulation of Duct**

This shall be measured on the basis over the insulated duct surface area.

### **Insulation of Chilled Water / Drain Water Pipes.**

i) Insulation of pipes shall be measured in terms of linear length of pipe for each size.

ii) For insulation of bends, elbows, tees etc. it shall be measured along with the center line of insulation and shall be measured in meters.

iii) Insulation of valves shall be separately accounted as per bill of quantities.

### **Insulation of Chiller / Expansion Tank / Suction Line**

The insulation of the above equipments shall be deemed to form part of equipment and no separate measurements for insulation of such items will be accounted for.

### **Acoustic Lining of Duct & Plenum**

This shall be measured on the basis of bare duct surface area i.e. the area of duct lining & area of duct shall be same.

### **Electrical Cabling Work**

a) All power cables / controls cables shall be measured on linear basis in meters

b) No extra price shall be paid on account of end termination of cables which includes thimble, gland etc.

## **L. LIST OF ACCEPTABLE MAKES OF EQUIPMENTS / MATERIALS**

1.	VRF EQUIPMENT INDOOR & OUTDOOR		O-GENERAL / TOSHIBA / MITSUBISHI-HEAVY
2.	VRF THERMOSTATS / CCM		O-GENERAL / TOSHIBA / MITSUBISHI-HEAVY

3.	THERMOSTAT SENSOR		JOHNSON CONTROL / SIEMENS / HONEYWELL
4.	DX SYSETEM (INDOOR & OUTDOOR)		O-GENERAL / TOSHIBA / MITSUBISHI-HEAVY
5.	INLINE FAN		CARYAIRE / OSTERBERG / HUMIDIN.
6.	REFRIGERANT PIPES		MANDEV / MAXFLOW / TOTALINE
7.	REFRIGERANT PIPE INSULATION		ARMACELL / A-FLEX / K- FLEX.
8.	THERMAL INSULATION		PARAMOUNT / K FLEX. / ARMACELL
9.	AIR HANDLING UNITS.		EDGETECH / VTS / FLAKTWOOD
10.	AHU FANS		KRUGER / NICOTRA (IMPORTED)
11.	AHU KITS		O-GENERAL / TOSHIBA / MITSUBISHI-HEAVY
12.	Y JOINTS / T JOINTS		O-GENERAL / TOSHIBA / MITSUBISHI-HEAVY
13.	FACTORY FABRICATED DUCTING		ROLLASTAR / DUCTOFAB / DUSTECH
14.	FIRE DAMPERS		SUVIDHA / DYNAMIC / CARYAIRE
15.	GRILLS / DIFFUSERS		SUVIDHA / DYNAMIC / CARYAIRE
16.	VOLUME CONTROL DAMPERS		SUVIDHA / DYNAMIC / CARYAIRE
17.	COLLAR DAMPERS		SUVIDHA / DYNAMIC / CARYAIRE
18.	DRAIN PIPES		SUPREME / PRAKASH / POLYPACK.
19.	ELECTRICAL PANELS.		APPLICATION / POWER CONSULTANTS.
20.	ELECTRICAL CABLES		POLYCAB / GRANDLAY / GLOSTER / HAVELLS

**APPROVAL OF MAKE FROM THE CONSULTANT NEEDS TO BE TAKEN FOR ANY OTHER ITEM NOT MENTIONED IN THE LIST OF MAKES**

**M. EXCLUDED ITEMS FROM THE SCOPE OF HVAC CONTRACTOR**

- a. Housing of equipments.
- b. Foundations of all equipments, supporting structure etc.

- c. Main incoming stabilised power supply with double earthing in the Main Panel  
i.e.  $415 \pm 10$  % volts, 50 Hz  $\pm 5$ % AC supply.
- d. Any kind of false ceiling work, return air boxing, wooden / aluminium frames for fixing grills / diffuser.
- e. Any kind of masonry work such as openings in walls/slabs and making good thereof.
- f. Water softening plant if required.
- g. Makeup water connections with fittings and valves to make up & expansion Tank if required.
- h. Drain points in near each indoor unit.
- i. Power and water for erection, testing and commissioning of the HVAC System.
- j. Any kind of masonry shafts & trenches for laying pipes / cables / ducts etc.

**Diesel Generator Set -- P250H2/P275HE2**



www.FGWilson.com

## P250H 2/P275HE2

Output Ratings		
Generating Set Model	Prime*	Standby*
380-415V, 50Hz	250.0 kVA / 200.0 kW	275.0 kVA / 220.0 kW
220/127V, 60 Hz	- / -	- / -

Ratings at 0.8 power factor.

### Prime Rating

These ratings are applicable for supplying continuous electrical power (at variable load) in lieu of commercially purchased power. There is no limitation to the annual hours of operation and this model can supply 10% overload power for 1 hour in 12 hours.

### Standby Rating

These ratings are applicable for supplying continuous electrical power (at variable load) in the event of a utility power failure. No overload is permitted on these ratings. The alternator on this model is peak continuous rated (as defined in ISO 8528-3).

### Standard Reference Conditions

Note: Standard reference conditions 25°C (77°F) Air Inlet Temp, 100m (328 ft) A.S.L. 30% relative humidity. Fuel consumption data at full load with diesel fuel with specific gravity of 0.85 and conforming to BS2869: 1998, Class A2.

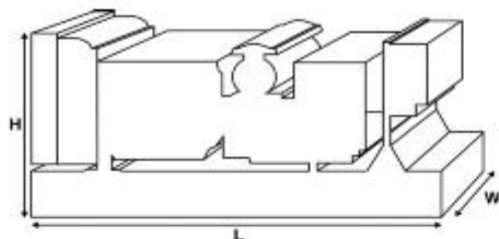


Image for illustration purposes only.

Ratings and Performance Data		
Engine Make & Model:	Perkins 1306C-E87TAG6	
Alternator manufactured for FG Wilson by:	Leroy Somer	
Alternator Model:	LL5014J	
Control Panel:	PowerWizard 1	
Base Frame:	Heavy Duty Fabricated Steel	
Circuit Breaker Type:	3 Pole MCCB	
Frequency:	50 Hz	60 Hz
Engine Speed: RPM	1500	-
Fuel Tank Capacity: litres (US gal)	350 (92.5)	
Fuel Consumption: l/hr (US gal/hr)		
(100% Load)	- Prime	58.9 (15.6)
	- Standby	63.3 (16.7)

### Available Options

FG Wilson offer a range of optional features to tailor our generating sets to meet your power needs. Options include:

- Upgrade to CE Certification
- A wide range of Sound Attenuated Enclosures
- A variety of generating set control and synchronising panels
- Additional alarms and shutdowns
- A selection of exhaust silencer noise levels

For further information on all of the standard and optional features accompanying this product please contact your local Dealer or visit: [www.FGWilson.com](http://www.FGWilson.com)

### Dimensions and Weights

Length (L) mm (in)	Width (W) mm (in)	Height (H) mm (in)	Dry kg (lb)	Wet kg (lb)
2960 (116.5)	1003 (39.5)	1718 (67.6)	2215 (488.3)	2252 (496.5)

Dry = With Lube Oil

Wet = With Lube Oil and Coolant

Ratings in accordance with ISO 8528, ISO 3046, IEC 60034, BS5000 and NEMA MG-1/22. Generating set pictured may include optional accessories.

FG Wilson has manufacturing facilities in the following locations:

Northern Ireland • Brazil • China • India • USA

With headquarters in Northern Ireland, FG Wilson operates through a Global Dealer Network.

To contact your local Sales Office please visit the FG Wilson website at [www.FGWilson.com](http://www.FGWilson.com)



Engine Technical Data		
No. of Cylinders / Alignment:		6 / In Line
Cycle:		4 Stroke
Bore / Stroke: mm (in)		116.6 (4.6)/135.9 (5.4)
Induction:		Turbocharged Air To Air Charge Cooled
Cooling Method:		Water
Governing Type:		Electronic
Governing Class:		ISO 8528 G2
Compression Ratio:		16.9:1
Displacement: l (cu. in)		8.7 (530.9)
Moment of Inertia: kg m (lb/in )		1.54 (5266)
Engine Electrical System:		
- Voltage / Ground		24/Negative
- Battery Charger Amps		45
Weight: kg (lb)	- Dry	671 (1479)
	- Wet	698 (1539)

Performance	50 Hz	60 Hz
Engine Speed: rpm	1500	-
Gross Engine Power: kW (hp)		
- Prime	228.5 (306.0)	-
- Standby	250.9 (336.0)	-
BMEP: kPa (psi)		
- Prime	2099.0 (304.5)	-
- Standby	2306.0 (334.4)	-

Fuel System				
Fuel Filter Type:	Replaceable Element			
Recommended Fuel:	Class A2 Diesel			
Fuel Consumption:	(l/hr (US gal/hr))			
	110%	100%	75%	50%
Prime	Load	Load	Load	Load
50 Hz	63.3 (16.7)	58.9 (15.6)	46.1 (12.2)	31.1 (8.2)
60 Hz	-	-	-	-
	110%	100%	75%	50%
Standby	Load	Load	Load	Load
50 Hz		63.3 (16.7)	50.2 (13.3)	34.3 (9.1)
60 Hz		-	-	-

(Based on diesel fuel with a specific gravity of 0.84 and conforming to BS2869, Class A2)

Air Systems	50 Hz	60 Hz
Air Filter Type:	Paper Element	
Combustion Air Flow: m <sup>3</sup> /min (cfm)		
- Prime	16.4 (579)	-
- Standby	16.4 (579)	-
Max. Combustion Air Intake Restriction: kPa (in H <sub>2</sub> O)	6.2 (25.0)	-

Cooling System	50 Hz	60 Hz
Cooling System Capacity: l (US gal)	45.3 (12.0)	-
Water Pump Type: Centrifugal		
Heat Rejected to Water & Lube Oil:		
kW (Btu/min)	- Prime	103.0 (5858)
	- Standby	110.0 (6256)
Heat Radiation to Room: Heat radiated from engine and alternator		
kW (Btu/min)	- Prime	40.0 (2275)
	- Standby	44.0 (2502)
Radiator Fan Load: kW (hp)	10.3 (13.8)	-
Radiator Cooling Airflow: m <sup>3</sup> /min (cfm)	424.2 (14980)	-
External Restriction to Cooling Airflow: Pa (in H <sub>2</sub> O)	125 (0.5)	-

Cooling system designed to operate in ambient conditions up to 50°C (122°F). Contact your local FG Wilson Dealer for power ratings at specific site conditions.

Lubrication System	
Oil Filter Type:	Spin-On, Full Flow
Total Oil Capacity: l (US gal)	26.4 (7.0)
Oil Pan: l (US gal)	22.7 (6.0)
Oil Type:	API-CI-4
Oil Cooling Method:	Water

Exhaust System	50 Hz	60 Hz
Silencer Type:	Level 1	
Silencer Model & Quantity:	SD100 (0)	
Pressure Drop Across Silencer System: kPa (in Hg)	8.70 (2.569)	-
Silencer Noise Reduction Level: dB	12	-
Maximum Allowable Back Pressure: kPa (in Hg)	10.7 (3.2)	-
Exhaust Gas Flow: m <sup>3</sup> /min (cfm)		
- Prime	44.5 (1572)	-
- Standby	44.5 (1572)	-
Exhaust Gas Temperature: °C (°F)		
- Prime	500 (932)	-
- Standby	528 (982)	-

Alternator Physical Data	
Manufactured for FG Wilson by:	Leroy Somer
Model:	LL5014J
No. of Bearings:	1
Insulation Class:	H
Winding Pitch Code:	2/3 - 6
Wires:	12
Ingress Protection Rating:	IP23
Excitation System:	SHUNT
AVR Model:	R450M

Alternator Operating Data	
Overspeed:	rpm 2250
Voltage Regulation: (Steady state)	+/- 0.5
Wave Form NEMA = TIF:	50
Wave Form IEC = THF:	2.0%
Total Harmonic content LL/LN:	4.0%
Radio Interference:	Suppression is in line with European Standard EN61000-6
Radiant Heat: kW (Btu/min)	
- 50 Hz	16.3 (927)
- 60 Hz	-

Alternator Performance Data:		50 Hz				60 Hz			
Data Item		415/240V	400/230V	380/220V	220/127V				
		230/115V	230/115V	220/110V					
		200/115V							
Motor Starting Capability* kVA		623	585	536	686				
Short Circuit Capacity** %		300	300	300	300				
Reactances: Per Unit									
	Xd	2.446	2.633	2.917	2.176				
	X'd	0.112	0.120	0.133	0.100				
	X''d	0.067	0.072	0.080	0.059				

Reactances shown are applicable to prime ratings.

\*Based on 30% voltage dip at 0.8 power factor.

\*\*With optional permanent magnet generator or AREP excitation.

Voltage Technical Data 50 Hz				
Voltage	Prime:		Standby:	
	kVA	kW	kVA	kW
415/240V	250.0	200.0	275.0	220.0
400/230V	250.0	200.0	275.0	220.0
380/220V	250.0	200.0	275.0	220.0
230/115V	250.0	200.0	275.0	220.0
220/127V	250.0	200.0	275.0	220.0
220/110V	250.0	200.0	275.0	220.0
200/115V	250.0	200.0	275.0	220.0

Voltage Technical Data 60 Hz				
Voltage	Prime:		Standby:	
	kVA	kW	kVA	kW

**General Information****Documentation**

A full set of operation and maintenance manuals and circuit wiring diagrams.

**Generating Set Standards**

The equipment meets the following standards: BS5000, ISO 8528, ISO 3046, IEC 60034, NEMA MG-1.22.

FG Wilson is a fully accredited ISO 9001 company.

EU Stage II Emissions Compliant.

**Warranty**

All prime equipment carries a one year manufacturer's warranty. Standby equipment, limited to 500 running hours per year, has a two year manufacturer's warranty. For details on warranty cover please contact your local Dealer, or visit our website: [FGWilson.com](http://FGWilson.com).

**Dealer contact details:****FG Wilson has manufacturing facilities in the following locations:**

Northern Ireland • Brazil • China • India • USA

With headquarters in Northern Ireland, FG Wilson operates through a Global Dealer Network.

To contact your local Sales Office please visit the FG Wilson website at [www.FGWilson.com](http://www.FGWilson.com)



**For general civil and Electrical works Specifications with BSR reference numbers**

Please refer

**SPECIFICATIONS FOR BUILDING AND ROAD WORKS (CIVIL) -2015**

and

**SPECIFICATION FOR ELECTRICAL MATERIALS AND WORKS (ELECTRICAL) 2015**

of

DEPARTMENT OF ENGINEERING SERVICES,  
MINISTRY OF WORKS AND HUMAN SETTLEMENT,  
ROYAL GOVERNMENT OF BHUTAN



# **Drawings**

(Provided in Separate Volume)

## **Supplementary Information Regarding Works to Be Procured**

(None)





## Personnel Requirements

Using Form PER-1 and PER-2 in Section 4 (Bidding Forms), the Bidder must demonstrate that it has personnel who meet the following requirements:

No.	Position	Total Work Experience [years]	Experience In Similar Work [years]
1	<i>Project Manager – 1 No, Degree in Civil Engineering</i>	10	5
2	<i>Project Engineer – 1 No, Degree/Diploma in Civil Engineering</i>	7/10	3/5
3	<i>Site Engineer – 1 No, Diploma in Civil</i>	7	3
4	<i>Site Supervisors – 2 No, Vocational Training Institute graduate</i>	5	5
5			



## Equipment Requirements

Using Form EQU in Section 4 (Bidding Forms), the Bidder must demonstrate that it has the key equipment listed below:

No.	Equipment Type and Characteristics	Minimum Number Required
1	Backhoe (bucket capacity of 0.6 cum or more)	1
2	TATA tipper 1612SE or equivalent	2
3	Compactor, plate type	2
4	Mixer Machine 10/7	4
5	Concrete Vibrator (5.5hp & 3600rpm)	8
6	Road Cutting & Bending machine	1
7	Wood cutting and planning machine	1
8	Survey Equipment (Total Station)	1
9	Mosaic Grinding machine	1