



**HVAC WORKS AT**

**LABORATORY BUILDING**

**GAMBAT INSTITUTE OF MEDICAL SCIENCES**

**TENDER DOCUMENTS**

**VOLUME-I**

**TECHNICAL SPECIFICATIONS**

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## **GENERAL PROVISIONS HVAC WORKS**

### **1.1 HVAC SYSTEM CONCEPT**

The building shall be air-conditioned by Variable Refrigerant Flow system (with R410A refrigerant), comprising of PV VRF All DC Inverter air-conditioning units with built-in photovoltaic inverter, which can be directly connected to photovoltaic panels to be installed at site depending upon the Solar panels installed capacity.

The system shall comprise of one or more outdoor units connected via inter-connecting refrigeration pipe work to multiple indoor units using branch pipe connectors. The system shall be complete with all the necessary electronic controls and associated control wiring to maintain the space design conditions.

### **1.2 DESIGN CONDITIONS**

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

#### **Summer outside Design Conditions**

- a) Summer Dry Bulb Temp: 125°F  
Wet Bulb Temp: 82°F

#### **Inside Design Conditions**

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

### **1.3 MATERIALS**

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

### **1.4 WORKMANSHIP**

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

## **1.5 EQUIPMENT**

- a) All equipment shall be manufactured by companies which have had at least ten years of previous experience in the design and manufacture of equipment of comparable type, capacity and operating conditions, unless otherwise approved by the Consultant.
- b) All equipment and materials supplied shall be from approved manufacturers who are adequately represented in Pakistan by an Agent capable of providing installation, commissioning and after sales service. All major equipment shall be imported directly from the manufacturers through their local agents. Import of this equipment through warehouses/Export Houses will not be accepted.
- c) All equipment shall be of latest manufacture, not older than the year in which this contract is awarded and shall bear year of manufacture stamped on the manufacturer's name plate duly certified by the manufacturer.
- d) When a manufacturer's product is specified by name, or equivalent, it shall be in the sole judgment of the Consultant as to acceptability of any product which is offered as equal to that specified.
- e) Where two or more units of the same class of equipment are furnished, product of the same manufacturer shall be used; component parts of entire system need not be product of same manufacturer.

## **1.6 CHASES AND OPENINGS**

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

## **1.7 PROTECTION**

The contractor shall keep pipe, duct and other openings closed to prevent entry of foreign matter. All fixtures, equipment and apparatus shall be covered and protected against dirt, water, chemical or mechanical damage, before and during the construction period. All fixtures, apparatus, or equipment damaged including damaged shop coats of paint shall be restored to original conditions prior to Commissioning and also again

prior to Final Acceptance. All bright finished shafts, bearing housings and similar items shall be protected until in service. No rust will be permitted.

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

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

## **1.9 LINES, LEVELS AND SPACES**

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

## **1.10 ACOUSTIC TREATMENT**

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

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

All equipment installed should not be audible inside the occupied areas and the Contractor must ensure that the equipment he is offering is quiet and supplied with all necessary silencers to ensure satisfactory sound levels. Where silencers are required, these must be incorporated into the price quoted for such equipment, if these are not specified separately.

## **1.11 SAMPLES**

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

1. G.I. sheet
2. Pipes and fittings. (Refrigerant)
3. Duct insulation and covering.
4. Pipe insulation and covering
5. Insulation adhesive and tapes
6. Diffusers, grilles and registers
7. OA/EA louvers
8. All types of dampers.
9. Power and control cables
10. Pipe hangers etc

#### **1.12 APPROVAL OF MATERIAL AND EQUIPMENT**

As soon as practicable after the award of contract, the contractor shall submit for approval of the Consultant specifications, drawing, catalogue diagrams and other descriptive data for all materials components and equipment which the contractor proposes for use under this contract. For certain materials and equipment, data may be required to be submitted in accordance with a detailed form furnished by the Consultant. Items submitted shall be properly labeled to indicate item number, and other data required by the Specifications. All items shall be submitted time to permit proper consideration and action thereon without delaying the construction schedule.

#### **1.13 TIME FOR DELIVERY**

All equipment plant and machinery shall be delivered at site on such dates so as to ensure adherence to scheduled dates stated in programs of works submitted by the contractor and the Consultant informed of the progress of the shipment and notify them in advance, in writing, as to when the equipment will be ready for inspection at site by the Consultant and shall supply lists covering each consignment in sufficient detail to enable Consultant to check the contents of the package, if he so desires.

#### **1.14 STANDARDS AND CODE REQUIREMENTS**

All equipment and materials under HVAC Scope of works shall be furnished in conformity with the latest edition of applicable standards of ASME, ASHRAE, ARI, SMACNA, AMCA and applicable \Government and local Codes governing the same. In case of conflict, the stricter requirements shown/ specified shall govern.

Abbreviations for Codes and Standards referred in the Contract are as under:

1. ASME – American Society of Mechanical Engineers.
2. ASTM – American Society for Testing & Materials.
3. ASHRAE – American Society of heating, Refrigeration and Air conditioning Engineers.
4. NFPA—National Fire Protection Association, USA
5. ARI - Air-conditioning and Refrigeration Institute, USA.
6. SMACNA — Sheet Metal and Air-conditioning Contractors National Association.
7. GOVERNMENT - Government of Pakistan
8. LOCAL-Local authorities of the city where the Project is located
9. AMCA — Air Moving and Control Association inc. USA
10. P.S. - Pakistan Standards.
11. B.S. - British Standards.

## **1.15 ERECTION SUPERVISORS AND OPERATING STAFF**

### **General**

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

### **Work by Erection Supervisors**

- a) The Erection Supervisor shall direct the activities of Contractor's employees as they concern the installation, commissioning balancing and testing of the Equipment furnished under this contract. The Contractor through his Erection Supervisors shall cooperate with other Contractors to whatever extent is necessary to produce an installation satisfactory to the Consultant in accordance with the requirements of the time schedule, the Drawings and the Specifications.
- b) Erection Supervisor shall be present from the Commencement of Work and remain on Site until the substantial completion.

- c) Should a disagreement arise between other Contractors and the Erection Supervisor, the matter shall be submitted without delay to the Consultant for his decision. Upon such decision, the Erection Supervisor shall proceed with the work in accordance therewith, immediately.
- d) Erection Supervisor shall be a qualified HVAC/ Mechanical Associate Engineer, having at least 8-10 years experience in HVAC installation works of similar nature.
- e) If the Contractor fails to fulfill his obligations and also fails to provide the services of the erection supervisor having the minimum qualifications as stated in sub. Clause (d) of this Clause then the Contractor would be obligated to pay to the Employer an agreed penalty amount per day for the number of days when the services of such erection supervisor are not provided. The Employer would be entitled to deduct the amount due from the Contractor in this regard for his running bill/any payable sums.
- f) Provision of (e) above shall not apply when the Erection Supervisor is on authorized legal leave (casual), sick leave and official holidays only. His absence up to a period of ten (10) days will also be allowed when the contractor intends to replace the Erection Supervisor with the consent of the Consultant.

### **Operating Staff**

The Contractor shall provide staff to operate the HVAC system continuously for twelve (12) hours a day during the Defect Liability period and whenever the HVAC facilities required.

Operating supervisor shall be a 3 (three) years Diploma holder HVAC or Mechanical from Government College of Technology etc. And having 4 (Four) years experience of similar plants with automatic controls.

The Contractor shall also arrange to provide proper training to Employer's staff to operate the HVAC system to the entire satisfaction of the Employer. All costs incidental to providing operating staff including staff salaries shall be deemed to be included in relevant item of schedule of Prices. No separate payment shall be made to the Contractor for fulfillment of his obligations under this clause.

### **1.16AS BUILT DRAWINGS**

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

### **1.17MANUFACTURER'S DATA**



Manufacturer's performance data, certified factory drawings and/or curves of apparatus giving full information as to capacity, performance at different operating and ambient conditions, dimensions, materials electrical data and all information pertinent to the adequacy of the submitted equipment shall be submitted for approval. One original and 3copies of catalogues and other information shall be submitted.

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

## **2.0 EQUIPMENT**

### **2.1 GENERAL:**

The contractor shall supply and install PV VRF All DCinverter system (outdoor & indoor units) of the capacity and rating as shown in the Bill of Quantities. PV VRF system shall have built-in photovoltaic inverter to be connected with Photovoltaic panels depending upon the installation capacity of Photovoltaic panels at site.

The units will have guarantee/warranty period of **1 year (12 months)** from the date of commissioning the units, and should any defects arise during this period which can be attributed to poor workmanship, improper materials, or defective manufacture of the air conditioning units, for which the consultant shall be the sole judge, the contractor shall be required to replace or repaired all defective parts, except compressors (burnt or otherwise) which shall be replaced with new compressors, all repairs and replacement shall be as desired by the consultant.

All equipment shall be of such overall dimensions, operating weights, service area requirements and configuration that it can be located where shown on the plans without any adverse effect on its performance and clearance requirements.

Provision for clearance and service spaces shall be made around all mechanical equipment as recommended by equipment manufacturers.

All equipment supplied under this section shall be brand new factory manufactured and factory assembled (unless otherwise specified) and complete in all respects. The type, characteristics, capacity ratings, component sections of all equipment shall be as specified /scheduled. All equipment shall be tested at factory for performance before shipment.

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

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

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

### **2.2.1 Overview**

#### **Photovoltaic VRF All DC InverterSystem:**

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

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

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

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

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

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

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

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

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

### **2.2.2 Features**

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

#### **Built-in Photovoltaic Inverter:**

VRF All DC inverter modules shall have built-in photovoltaic inverter which can directly be connected to photovoltaic panels depending upon the installed photovoltaic panels at site. Rest of the VRF system shall be without built-in photovoltaic inverter.

The VRF system shall be able to automatically switch between following 5 working modes.

- a) Photovoltaic air conditioning mode

- b) Photovoltaic air conditioning and power generation mode (2 way supply of power)
- c) Photovoltaic air conditioning and power consumption mode (Mixed supply of power)
- d) Photovoltaic power generation mode.
- e) Air conditioning mode

Variable-capacity compressors:

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

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

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

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

The condenser fan motors shall be DC Inverter type and shall have Step less speed regulation ranges from 5Hz to 65Hz. Compared with traditional inverter motors, it shall be more efficient. It shall have Sensor less control technology to guarantee low noise, less vibration and steadier operation.

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

System shall have automatic energy auto-allocation technology.

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

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

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

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

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

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

The outdoor unit shall be able to receive a power signal of electricity shortage. In some places like first-class hotels, diesel generator may sometimes be used to provide electricity. In this case, this signal will be received and only VIP rooms can be provided with air conditioning service.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

The system should offer 2HP increments of capacity range, which should meet customer needs accurately and the maximum capacity combination should be up to 64HP.

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

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

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

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

**Controls:**

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

The system shall have auto debugging features like:

Automatically allocate ODU and IDU addresses

Automatically calculate numbers of ODU and IDU

Automatically detects errors;

Automatically starts debugging.

PV VRF Central Controller shall have following features.

- a) Integrate solar power generation from Photovoltaic Panels with VRF power consumption.
- b) Real time display of power data.
- c) Adopt CAN communication technology.

### **2.2.3 Air Cooled Condensing Units (CU-Units)**

The condensing unit shall be of the vertical discharge, air cooled type, suitable for outdoor installation and sized to deliver the required capacity matched to relevant indoor units at specified ambient temperature. The condensing unit shall be of same manufacturer as that of Indoor A.C. Unit.

The condensing units shall be air-cooled type incorporating heat exchanger coils manufactured from copper tube copper fins or Aluminum Manganese anti rust alloy which should be coated with Golden protection Layer (Components: Epoxy Resin & Modified Acrylic, Silicon free), the anti-corrosive performance in salt-spray testing must be at-least 200% higher than normal blue/golden fins, factory treated to reduce the effect of atmospheric corrosion. The colour shall be manufacturer's standard. The air outlet grilles shall have plastic coated guards.

All outdoor units are to be permanently marked with an identification number. The removable access panels are also to be marked with the same number.

The outdoor units are to be Variable Refrigerant Flow (VRF) based centralized combination of multiple outdoor units of capacities given in schedules.

The outdoor units shall have allDC inverter compressors electronically controlled and capable of varying refrigerant flow with variation in

cooling/heating requirements.

The capacity control of the outdoor units will be digitally controlled and shall be determined electronically by sensing operational temperatures, pressures, and ambient temperature etc

The access to the internal components for maintenance purposes shall be by removable panels.

It shall be possible to connect up to 80 indoor units, capacity permitting, to one modular outdoor unit.

The outdoor unit shall have full capacity control to meet the load fluctuation up to 135%.

#### **2.2.4 Indoor Units**

Direct Expansion type Air conditioning units each carrying its own thermo-static expansion valve, shall be ceiling recessed (Cassette type) reversible, (Heat pump) type or ceiling concealed ducted type or Decorative Wall Mounted. All necessary components/parts shall be selected manufactured and assembled by the same manufacturer as for outdoor condensing units with Scroll Compressors.

The Indoor units shall include following items

- 1) DX.- Type coil
- 2) Washable filters
- 3) Supply air fan with Step less DC Inverter motor
- 4) Automatic air swing facility. (Wherever required with the unit)
- 5) Drain arrangement.

The following type of indoor units may be used for this type of system.

##### **Four way discharge cassette**

The unit casing shall be manufactured from galvanized steel plate and shall be fully insulated. Facility shall be provided for duct connection for introduction of fresh air in the unit.

The fan shall be of propeller type, statically and dynamically balanced to ensure low noise and vibration free operation.

The heat exchanger coils shall be manufactured from copper tubes and aluminum fins. It shall have electronic expansion valve to control refrigerant flow rate in response to the load variation in the conditioned space. The expansion valve shall be controlled by an integral computerized control system to maintain the desired room temperature.



The low profile dedicated decoration panel shall be provided for each unit. The decorative panel shall incorporate the return air grille and supply air louvers. A facility shall be provided to automatically swing the supply air louvers or lock them at a desired angle to ensure even distribution of the airflow.

A condensate drain pump shall be provided with the unit. The condensate shall be drained from the unit using thermally insulated u PVC piping and run directly to the nearest drain piping mains.

The air filters shall be incorporated within the unit and shall be mould resistant washable type.

#### **Ceiling concealed Duct type**

The unit casing shall be manufactured from galvanized steel plate. Facility shall be provided for duct connection for introduction of fresh air in the unit and branch ductwork from the unit. The return air to the unit shall be through the bottom/back of the unit as per manufacturer's standard.

The heat exchanger coils shall be manufactured from copper tubes and aluminum fins. It shall have electronic expansion valve to control refrigerant flow rate in response to the load variation in the conditioned space. The expansion valve shall be controlled by an integral computerized control system to maintain the desired room temperature.

The condensate shall be drained from the unit using thermally insulated u PVC piping and run directly to the nearest drain piping mains.

#### **Wall mounted type**

The unit casing shall be manufactured from heat resistant plastic. The casing color shall be manufacturer's standard. The fan shall be cross-flow centrifugal type, statically and dynamically balanced to ensure low noise and vibration free operation.

The heat exchanger coils shall be manufactured from copper tubes and aluminum fins. It shall have electronic expansion valve to control refrigerant flow rate in response to the load variation in the conditioned space. The expansion valve shall be controlled by an integral computerized control system to maintain the desired room temperature.

The condensate shall be drained from the unit using thermally insulated u PVC piping and run directly to the nearest drain piping mains.



### **3.0 REFRIGERANT PIPING AND SPECIALITIES**

#### **3.1 GENERAL**

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

All piping shall be grouped wherever practicable and shall be erected to present a neat appearance. Pipes shall be parallel to each other and parallel or at right angles to structural members of the building and shall give maximum possible headroom.

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

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

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

Approved pipe fittings shall be used and bending of pipes will not normally be allowed.

All 90° elbows used shall be of long radius type, except where space limitations restrict the use of long radius.

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

#### **3.2 REFRIGERANT PIPING AND SPECIALITIES**

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

### 3.2.1 INSTALLATION

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

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

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

Procedure for Copper Piping:

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

b) General Instructions:

Pipes shall be cut accurately to measurements established at the job site and worked into place without springing or forcing, properly clearing all windows, doors and other openings. Excessive cutting or other weakening of the building structure to facilitate piping installation No installation will be permitted,

without written approval. Layout drawing, required under the title of "Approval of Material and Equipment" shall show locations of all supports, the load imposed on each fastening or anchor, typical details for special anchorage, for suspended piping, valves, tanks, pumps, converters, and other mechanical equipment. Where supports are required between structural framing members, suitable intermediate metal framing shall be provided and detailed. Pipe shall have burrs removed by reaming and shall be installed to permit free expansion and contraction without damage to joints and hangers." Changes in direction shall be made with fittings, except that bending of pipe and smaller will be permitted provided a pipe bender is used and type-sweep bends are formed. The centerline radius of bends shall not be less than 6 diameters of the pipe. Bent pipe showing kinks, wrinkles, flattening or other malformations will not be accepted. All piping shall be installed with sufficient pitch to ensure adequate drainage and venting. Piping connections to equipment shall be provided with unions or flanges. Open ends of pipelines or equipment shall be properly capped or plugged during installation to keep dirt and other foreign matters out of the system.

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

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

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

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

When solenoid stop valves are being installed, the coil shall be removed to prevent the heat of soldering from ruining the insulation. When sight glass is being installed, the glass shall be removed to prevent cracking. No heat shall be applied near the bulb of the expansion valve or any other place where an excessive temperature may cause damage.

Pipe insulation shall not be installed nor the piping anchored until testing is completed and all leaks have been properly eliminated.

**Pipe Supports:**

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

**iii)Suspended Horizontal Piping:**

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

**Maximum Spacing Between Copper tubing Supports:**

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

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

**Commissioning & Testing:**

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

All AC Units will have a guarantee/warranty period of 12 months from the date of commissioning the units, and should any defects arise during this period which can be attributed to poor workmanship, improper material, or defective manufacture of the air conditioning units, for which the Consultant shall be the

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

#### **SUPPORTS & ANCHORS: *(If applicable)***

##### **General:**

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

##### **Suspended Piping Supports:(If applicable)**

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

##### **Additional Refrigerant:**

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

### **3.3 CONDENSATE DRAIN PIPING:**

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

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

### **3.4 PIPE SLEEVES:**

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

Pipes passing through walls shall be provided with UPVC sleeves

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

## **4.0 AIR DISTRIBUTION SYSTEM**

### **4.1 GENERAL**

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

## 4.2 DUCTWORK – MATERIAL

Unless otherwise specified or indicated.

- a. Air Conditioning System: Galvanised steel sheet prime quality.
- b. Ventilating System: Galvanised steel sheet prime quality.

### GALVANISED STEEL DUCTWORK:

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



- d. Ductwork for distance of 20 ft. from fan inlet and outlet: Stiffened as specified above, except angles spaced on centers not greater than 24 inches, both transverse and longitudinal.
- e. Stiffing angles: Riveted or spot welded to ductwork, may be of black structural steel. Angles, total girth, on all four sides of ductwork. Angles may be omitted at joints if joints are equivalently reinforced.
- f. Make longitudinal seams on all ductwork with Pittsburgh or double seams, locked and hammered tight, with smooth interior duct surface.
- g. Cross-break all un-insulated ducts 18 inches wide and larger to prevent vibration or buckling.

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

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

#### **4.4 DAMPERS**

##### **General:**

- 1. In all ductwork systems, furnish all dampers necessary for proper control and balancing of air distribution. Furnish dampers in all branches, with operating levers readily accessible. No damper greater than 48" long. For greater lengths provide dampers in equal sections as required. These shall be opposite blades configuration.
- 2. Same material as ductwork, except as otherwise specified, rigid 18g. Construction, free of all rattling and vibration, with edges crimped or creased for stiffness.
- 3. All dampers shall have through rods, not less than 3/8" diameter fastened to blade with 2 or more yokes with set screws, with steel washer at each end of damper rod.
- 4. Damper blades, two gauge numbers heavier than ductwork, # 18 gauge and lighter shall have both edges double hemmed. Blades longer than 36 inches shall have "V" crease in middle to receive damper rod.
- 5. Dampers shall have through damper rod with #14 gauge bearing plate at one end and quadrant and lever with lock screw at other end; damper lever fastened to rod with set screws.

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

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

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

#### **4.5 ACCESS DOORS IN DUCTWORK**

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

3. Latches: Operation either side of door, brass bronze construction, minimum 2 per door.

#### **4.6 FLEXIBLE COLLARS**

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

#### **4.7 DUCT TEST HOLES**

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

#### **4.8 LEAKAGE AND PREVENTION**

- a. Duct leakage tests shall be carried out as recommended and test reports shall be submitted to the consultant for approval.
- b. To this end, the contractor shall, in the construction of his work, use appropriate joint, seam, and connection caulking and sealers, to insure air tightness of the ductwork. In addition he shall apply a 3 inch wide frame resistant duct tape to all joints and seams that are not welded, soldered or other wise air tight. Tape shall be applied in a continuous and even strip on and around the joints.
- c. For exposed ductwork, contractor shall confer with the Consultant as to the appropriate method of sealing to affect the most aesthetic appearance while maintaining an efficient seal.

#### **4.9 ADJUSTMENT OF SYSTEMS AND TESTS**

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

- c. Submit certification and test report as specified.

#### 4.10 DUCT WORK INSULATION

- a. **Insulation:**

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

- b. **Jacket:**

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

- c. **Cladding:**

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

- d. **Insulation Tapes:**

At all insulation joints use. 75mm wide self-adhesive tape consisting of reinforced aluminum foil and white Kraft paper. Also applicable for Copper joints.

- e. **Adhesive:**

Adhesive shall be rubber reinforced co-polymeric compound or approved equal.

#### 4.11 AIR DEVICES

- a. **General:**

These shall be factory-fabricated of powder coated or anodized aluminum and of color as approved and shall distribute the specified quantity of air evenly over the space intended, without causing noticeable drafts, or dead spots anywhere in the conditioned area. The Contractor shall be responsible for diffusion, spread, drop and throw. If according to the certified data of the manufacturer of the proposed-units, the sizes indicated on the drawings will not perform satisfactorily, the units

shall be re-selected to perform quietly and effectively in accordance with the manufacturer's recommendations as approved by the Consultant. A schedule of all air inlets and outlets shall be submitted to the Consultant, indicating location, types, specified air quantity, neck or face velocity, sound power level values, pressure drop, throw and drop for registers and maximum and minimum diffusion range, prior to ordering.

**b. Diffusers:**

Shall be round, half round, square, rectangular, slot, strip shaped or perforated type with fixed or adjustable air discharge pattern, as indicated on the drawings. Ceiling mounted units shall be furnished with anti-smudge device, unless the diffuser unit minimizes ceiling smudging through design features. Diffusers shall be provided with air deflectors specified herein. Ceiling mounted units shall be installed with trims tight against ceiling whether flush, recessed or surface mounted. Rubber gasket shall be provided between ceiling and surface mounted diffusers. Duct collar connecting the duct to diffuser shall be airtight and will not interfere with the volume controller. Return or exhaust units, when indicated, shall be similar to supply diffusers. Diffusers shall be provided with opposed blade volume controller with accessible key operator.

**c. Registers:**

Shall be of the type and size shown on the drawings as approved. Registers shall be provided with rubber gaskets between flanges and walls or ceilings. Wall supply registers shall be installed at least 6 inch (150mm) below the ceiling unless otherwise indicated. Registers shall be provided with opposed blade volume controllers with accessible key operator.

**d. Grilles:**

Shall be of sizes and type shown on the drawings. All grills shall be provided with control dampers unless otherwise indicated on drawings.

**e. Installation:**

Shall ensure that all lines are perpendicular and parallel to the building walls and other surfaces, flush with the ceiling and properly centered so that complete symmetry is obtained.

All diffusers shall be installed directly to the supply air ducting, so that the weight of the diffusers is not transferred to the false ceiling. Diffuser shall be so installed that the collar is flush with the ceiling. Gaskets shall be used to prevent leakage.

Registers and grills on sidewalls shall be fixed on wooden frames. Frame thickness shall be 6mm less than the register / grill collar and shall cover the full depth of the wall. Perfect alignment and symmetry shall be maintained.

After the system is in operation, if drafts, dead spots, or excessive noise are noticeable in the conditioned areas due to improper selection or construction of the air outlet, the air-outlet shall be changed to the proper type to remove the defect, without additional cost to the Employer.

## **5.0 INSTALLATION**

### **5.1 REQUIREMENTS**

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

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

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

Electrical schematics and wiring diagram

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

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

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

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

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

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

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

### **5.2 GENERAL**

The PV VRF All DC Inverter system equipment has to be designed, manufactured, tested and accepted in compliance with the following



requirements.

Conduct detailed design, installation and commissioning of the equipment, piping and automation control system as recommended by the manufacturer.

After signing the contract, the bidder shall appoint his representative of the project who will coordinate all works throughout the project like drawing confirmation, packaging, shipment, field installation, commissioning and acceptance.

The manufacturer winning the contract shall complete the detailed design within 30 days after signing the contract. Before installation, related drawings and technical agreement shall be submitted complete, and approved by the client's representative. The unit shall be installed strictly to the approved drawings. In case of any change, prior approval from the Employer and confirmation by the designer shall be obtained.

Before installation, properly perform unpacking for inspection and all other necessary works, inform the purchaser and supervisor to be present, properly keep records and provide information feedback.

During the installation, strictly respect the rules for safety protection and fire safety. Take full account of the safety of installing and operating people, and take precautions against any accident. Avoid problems like sharp corner angles, burrs and cracking. Materials shall be fire-retardant, low-smoke and free of toxin. All exposed pipes shall be neatly arranged and in parallel with other pipes and buildings. Make sure that all vertical pipes are plumb and arranged along the lines of the building.

Take precautions to prevent the refrigerant gas from discharging into the atmosphere.

For the unit, ensure the safe reliable run, easy operation and maintenance, and low cost of maintenance.

The system shall be of simple installation with economical and rational dimensions for the tubes, low cost in installation and optimized tubing.

All key components and devices shall have protective system available.

The surface of the unit and tubing shall not drip condensate.

Participants for the test include Employer or his representative, contractor, technical support personnel from the manufacturer, installing people and supervisor



### **5.3 INSTALLATION OF INDOOR UNIT**

Indoor unit shall be installed/suspended in the ceiling. Strictly follow the standard for installation. Never have any part of the equipment damaged and make sure that it does not fall.

Before installing the indoor unit, make inspection and calibration. It shall be mounted firm and level with accurate position and elevation.

The indoor unit shall be so installed that the other services of the building will not be affected.

### **5.4 INSTALLATION OF OUTDOOR UNIT**

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

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

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

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

### **5.5 REFRIGERANT PIPING**

Before installation, the copper tube shall be kept from ingress by moisture. The tube shall be purged and vacuum dried.

The interior of the tube shall be kept clean at work.

For welding, the tube shall be filled with nitrogen for protection against oxidation of the copper tube.

Copper tubes shall be purged before connection with the main unit.

Refrigerant tubes shall be subject to air-tightness test and the air-tightness maintained.

## **5.6 SUPPORTING AND SECURING**

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

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

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

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

## **5.7 DISCHARGE OF CONDENSATE**

Condensate shall be centrally drained, which shall be smooth without overflow and leakage.

If sloping is impracticable, provide a condensate lift pump.

## **5.8 THERMAL INSULATION**

Condensate tubes are to be thermally insulated to prevent condensation.

## **5.9 CLEANING**

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

## **5.10 COMMISSIONING AND TRIAL RUN**

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

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

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

The technical staff from the manufacturer winning the contract shall make available the special tools, consumables and special instruments and apparatus required for the installation and commissioning.

Commissioning and trial run shall take place only after satisfactory results are available for the system purging, air-tightness test, evacuation, filling refrigerant, condensate tube connection test, and test for control line and power line, and checked and signed by supervisor and project management people.

Commissioning and trial run shall take place to the equipment piece by piece, and the record for commissioning shall be submitted to the user.

The A/C condensate tubes have to be subject to water-tightness test.

## **5.11 CONTROL SYSTEM**

The control mode for PV VRF ALL DC inverter system will be defined by the manufacturer via consultation with the Employer and approved by the designer.

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

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

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

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

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

- Central control: allowing uniform setting of On/Off, temperature and operational modes for A/Cs in different zones, and operating authority of the remote controller.
- VRF Central Controller shall have following features.
  - d) Integrate solar power generation from Photovoltaic Panels with VRF power consumption.
  - e) Real time display of power data.
  - f) Adopt CAN communication technology.

<b>LIST OF APPROVED MANUFACTURERS FOR AIR CONDITIONING WORK OF GIMS</b>		
<b>S. #</b>	<b>Equipment/Material</b>	<b>Recommended Manufacturer</b>
1-	Photovoltaic VRF All DC Inverter System	LG, Gree, York, Hitachi or approved equal
2-	Building management System	Same Brand
3-	Refrigerant Copper Piping & Fittings	Muller or Approved Imported equivalent
4-	PVC Condensate Drain Piping (D-Class)	Popular, Beta or Approved Equivalent
5-	Duct Insulation	Afico, Kimco, Owens corning
6-	Refrigerant Pipe Closed Cell Foam Insulation	Aero flex, Atco, Aero duct or approved equal
7-	GI Sheets (Hot Dip Galvanized)	AISL, Pak Steel Mills or Imported
8-	Fans	SasaMetel, Catkin, Shan Industries
9-	Air Devices	Shan Industries, Mehran, Steel Craft, Pak Premier
10-	Electrical Panels	Electrech, South Asian, ECS, Bilal Engg., Talha Electronics
11-	Cables	Pakistan Cables, A.G.E Cable, Pioneer Cables, Fast Cable
12-	All Equipment/Materials other than stated above.	Makes approved by the Engineer-in-charge/ Consultant

### **Equipment Compliance Sheet**

**Brand Name:****Country of Origin:**

S/N	Item Description		Vendor Remarks
1	Offered Model		
2	Compressor type and quantity in each condenser module	Fixed frequency	
		DC Inverter	
3	Built-in Photovoltaic inverter (YES/NO)		
4	Photovoltaic VRF All DC Inverter System direct connectivity with Photovoltaic panels (YES/NO)		
5	<p>The Photovoltaic VRF system shall be able to automatically switch between following 5 working modes.</p> <p>a) Photovoltaic air conditioning mode</p> <p>b) Photovoltaic air conditioning and power generation mode (2 way supply of power)</p> <p>c) Photovoltaic air conditioning and power consumption mode (Mixed supply of power)</p> <p>d) Photovoltaic power generation mode.</p> <p>e) Air conditioning mode</p>		
6	Outdoor Fan Motor Type		
7	Indoor Fan Motor Type		
8	Maximum Modular Combination Capacity of Condenser (in HP)		
9	Voltage operating range		
10	Operating Range for Cooling in °C		
11	Operating Range for Heating in °C		
12	IPLV Cooling (Maximum)		
13	Total Pipe Length limitation (in meters)		
14	Maximum Piping Length limitation between outdoor unit and farthest indoor unit (in meters)		

15	Maximum Piping Length limitation after first branch joint to farthest indoor unit (in meters)		
16	Maximum Height difference limitation between IDU & ODU (in meters)		
17	Sub Cooling Design (YES/NO)		
18	Auto refrigerant recovery function (YES/NO)		
19	Condenser Fan Static Pressure (Pa)		
20	Night Silent Mode (YES/NO)		
21	Automatic Addressing during commissioning (YES/NO)		
22	Inspection Window on ODU (YES/NO)		
23	Non Polar communication wire (YES/NO)		
24	Error display & Self diagnostics system (YES/NO)		
25	Maximum Indoor Units (connectable to one ODU)		
26	Anti-corrosion protection with "Golden Fin" on condenser coil (YES/NO)		
27	Link with Fire alarm signal, for protection against accidental fire.(YES/NO)		
28	Electricity shortage Identification (YES/NO)		
29	Dual Electronic expansion valves (YES/NO)		
30	Intelligent Debugging (YES/NO)		
31	Any Reference project of Photovoltaic VRF All DC Inverter System installation in Pakistan		