# SUPPLY, INSTALLATION, TESTING & COMMISSIONING OF COOLING SYSTEM AT CMU WAREHOUSE, ISLAMABAD




## BIDDING DOCUMENTS

## TECHNICAL SPECIFICATION

## VOLUME II

**Developed and designed by**

**Pakistan Environmental Planning & Architectural Consultants Ltd.**

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# Contents

# 1. BASIC MECHANICAL REQUIREMENTS

## PART 1 – GENERAL

### 1.1 RELATED DOCUMENTS:

A. All Drawings and General Provisions, Special Provision of the Contract, including General and Special Conditions Technical Specification, Equipment Selection Sections, apply to this Section. The approved drawings or building layout plan shall be available for participating bidders for clarification and understanding.

### 1.2 SUMMARY

A. This Section includes general administrative and procedural requirements for mechanical installations. The following administrative and procedural requirements are included.

1. Submittals.
2. Samples.
3. Record documents.
4. Maintenance manuals
5. Shop Drawings
6. Mechanical installations.
7. Cutting and patching.

### 1.3 SUBMITTALS

A. General: The Contractor shall submit the submittals/broachers/manuals for all the equipment and material to be installed at site in triplicate. After review one copy shall be returned to the Contractor and 02 copies shall be retained by the Consultants. The Contractor shall provide all the information's in these submittals as required by the Consultants and found necessary to review the product. No additional payment shall be made for these submittals.

### 1.4 SAMPLES

A. General: The Contractor shall submit the samples for all the material to be installed at site. After review rejected samples shall be returned to the

Contractor and approved samples shall be retained by the Consultant. The Contractor shall submit the samples in a proper manner and shall be fixed on a sample board and all technical features shall be provided in triplicate with these samples, 02 copies technical features shall be retained by the Consultants and one copy shall be returned to the Contractor. The Contractor shall provide all the information's related to these samples as required by the Consultants and found necessary to review the product. No additional payment shall be made for these samples.

**1.5 RECORD DOCUMENTS:**

A. The Contractor shall prepare and furnish record documents of all the equipment and material. These documents shall include installation manual, operational instructions, technical literature, engineering data and other information's related to the product being installed at site.

1. Ductwork mains and branches, size and location, for both exterior and interior; locations of dampers and other control devices; filters, boxes, and terminal units requiring periodic maintenance or repair.

2. Equipment locations (exposed and concealed), dimensioned from prominent building lines.

3. Approved substitutions, Contract Modifications, and actual equipment and materials installed.

4. Contract Modifications, actual equipment and materials installed.

**1.6 OPERATIONS AND MAINTENANCE MANUALS**

A. Prepare/provide manufacturer recommended operations and maintenance manuals in triplicate, these manuals shall be in properly binding form including all the information's required for the operations and maintenance of the equipment. These manuals shall be translated into Urdu and English and include the followings:

1. Description of function, normal operating characteristics and limitations, performance curves, engineering data and tests, and complete nomenclature and commercial numbers of replacement parts.

2. Manufacturer's printed operating procedures to include start-up, break-in, and routine and normal operating instructions; regulation, control, stopping,

shutdown, and emergency instructions; and summer and winter operating instructions.

3. Maintenance procedures for routine preventative, curative maintenance and troubleshooting; disassembly, repair, and reassembly; aligning and adjusting instructions.

4. Servicing instructions and lubrication charts and schedules.

5. Quality control and assurances measures

## 1.7 SHOP DRAWINGS

General: Contractor shall prepare the shop drawings before execution of any job and these shop drawings shall be submitted to the Consultant for the approval, after approval of these shop drawings the Contractor shall carry out the work. These shop drawings shall be submitted by the Contractor in triplicate, 02 copies shall be retained by the Consultant and one copy shall be returned to the Contractor. These shop drawings shall be drawn on scale and shall be submitted on minimum A2 size paper. Contractor shall provide section and other details as necessary and directed by the Consultant.

## 1.8 MECHANICAL INSTALLATIONS

A. General: Sequence, coordinate, and integrate the various elements of mechanical systems, materials, and equipment. Comply with the following requirements:

1. Coordinate mechanical systems, equipment, and materials installation with other building components.

2. Verify all dimensions by field measurements.

3. Arrange for chases, slots, and openings in other building components during progress of construction, to allow for mechanical installations.

4. Coordinate the installation of required supporting devices and sleeves to be set in poured-in-place concrete and other structural components, as they are constructed.

5. Sequence, coordinate, and integrate installations of mechanical materials and equipment for efficient flow of the Work.

6. Where mounting heights are not detailed or dimensioned, install systems, materials, and equipment to provide the maximum headroom possible.

7. Install systems, materials, and equipment to conform with approved
   Submittal data, including coordination drawings, to greatest extent possible. Conform to arrangements indicated by the Contract Documents, recognizing that portions of the Work are shown only in diagrammatic form. Where coordination requirements conflict with individual system requirements, refer conflict to the Consultant

8. Install systems, materials, and equipment to conform with approved
   Conform to arrangements indicated by the Contract Documents, recognizing that portions of the Work are shown only in diagrammatic form. Where coordination requirements conflict with individual system requirements, refer conflict to the Consultant

9. Install systems, materials, and equipment level and plumb, parallel and perpendicular to other building systems and components, where installed exposed in finished spaces.

10. Install mechanical equipment to facilitate servicing, maintenance, and repair or replacement of equipment components. As much as practical, connect equipment for ease of disconnecting, with minimum of interference with other installations.

11. Install access panel or doors where units are concealed behind finished surfaces.

12. Install systems, materials, and equipment giving right-of-way priority to systems required to be installed at a specified slope.

1.9 **CUTTING AND PATCHING:**

A. General: Perform cutting and patching in accordance with requirements and co-ordinations with other services, the following requirements apply:

   1. Protection of Installed Work: During cutting and patching operations, protect adjacent installations.

B. Perform cutting, fitting, and patching of mechanical equipment and materials required to:

1. Install equipment and materials in existing structure.
2. Uncover Work to provide for installation of ill-timed Work.
3. Remove and replace defective Work.
4. Remove and replace Work not conforming to requirements of the Contract Documents.

C. Provide suitable caps for exposed ends of pipes.

D. Protect the structure, furnishings, finishes, and adjacent materials not indicated or scheduled to be removed.

END OF SECTION

## 2. GENERAL PROVISIONS

## PART 1 – GENERAL

### RELATED DOCUMENTS:

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

### COOLING SYSTEM WORKS

### 2.1 COOLIJG SYSTEM CONCEPT:

The building shall be air-conditioned by Variable Refrigerant Flow system (with R410A refrigerant), Multi Split air conditioning system with electronic expansion valves with indoor units.

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

### 2.2 VENTILATION:

All toilets shall be provided with mechanical ventilation by means of propeller type or inline exhaust fans as required and mentioned in schedule of equipment and shown in the drawings.

### 2.3 DESIGN CONDITIONS:

Cooling 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, but these temperature conditions must be authenticated from Metrological Authority

External Conditions for Design:
i) Summer Dry Bulb Temperature Range: 113$^{o}$ F-130$^{o}$ F
ii) Winter Dry Bulb Temperature Range: 30$^{o}$ F-35$^{o}$ F

Internal Conditions for Design:

a) Temperature Range: 70$^{o}$ F- 72$^{o}$ F
b) Humidity Range: 40-45 %

## 2.4 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.

## 2.5 WORKMANSHIP:

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

## 2.6 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, and renowned manufacturers who are adequately represented in Pakistan preferably by itself, if not then by an authorized Agent/Partner capable of providing installation, commissioning, spare parts and after sales services. 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 production, not older than one 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 offered , product of the same manufacturer shall be selected, component parts of entire system need not be product of same manufacturer.

## 2.7 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 Cooling system scope of works.

**2.8 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 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.

**2.9 CUTTING, PATCHING AND REPAIRING**:

Required for proper installation and completion of Cooling system 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.

**2.10 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 Cooling system equipment and any conflict observed shall immediately be reported to the Consultant.

**2.11 ACOUSTIC TREATMENT:**

The noise criterion (NC) < 35 is to be obtained.

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, air curtains 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 Cooling system 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.

## 2.12 SAMPLES:

Contractor shall provide at own 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

a) GI Sheet Metal
b) Fiber Glass Duct Insulation
c) Refrigerant Piping
d) Condensate drain piping
e) Pipe insulations
f) Adhesives and tapes
g) Air devices
h) Pipe hanger trays and supports
i) Cables and accessories

## 2.13 APPROVAL OF MATERIAL AND EQUIPMENT:

As soon as practicable after the award of contact, 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.

## 2.14 TIME FOR DELIVERY:

All equipment plant and machinery shall be delivered at site on such dates to ensure adherence to time scheduled given for the completion of project and dates stated in programs of works submitted by the contractor and approved by the Consultant. Contractor shall inform the progress of the shipment and notify them in advance, in writing, as to when the equipment will be ready for inspection at factory by the Consultant and client prior to shipment. All expanses for the pre-shipment inspection shall be borne by the contractor without any additional cost to the Employer. The contractor shall share a complete Gantt chart for project deliverables with specified timelines

## 2.15 STANDARDS AND CODE REQUIREMENTS:

All equipment and materials under Cooling System 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:

a) ASME – American Society of Mechanical Engineers.

b) ASTM – American Society for Testing & Materials.

c) ASHRAE – American Society of heating, Refrigeration and Air Conditioning Engineers.

d) NFPA—National Fire Protection Association, USA

e) ARI - Air-conditioning and Refrigeration Institute, USA.

f) SMACNA — Sheet Metal and Air-conditioning Contractors National Association.

g) GOVERNMENT - Government of Pakistan

h) LOCAL-Local authorities of the city where the Project is located

i) AMCA — Air Moving and Control Association inc. USA

j) P.S. - Pakistan Standards.

k) B.S. - British Standards.

## 2.16 AS BUILT DRAWINGS:

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

## 2.17 MANUFACTURER'S DATA:

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

END OF SECTION

## 3. HANGERS AND SUPPORTS:

1. PART 1 - GENERAL

### 3.1 RELATED DOCUMENTS:

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

### 3.2 SUMMARY:

A. This Section includes Hangers and Supports for mechanical system piping and equipment.

### 3.3 PERFORMANCE REQUIREMENTS:

A. Design channel support systems for piping to support multiple pipes capable of supporting combined weight of supported systems.

B. Design seismic restraint hangers and supports for piping and equipment.

PART 2 – **EXECUTION:**

### 3.4 HANGER AND SUPPORT APPLICATIONS:

A. Specific hanger requirements are specified in Sections specifying equipment and systems.

B. Horizontal-Piping Hangers and Supports: Unless otherwise indicated and except as specified in piping system Specification Sections, install the following types:

1. Adjustable Steel Clevis Hangers. For suspension of non-Insulated or insulated stationary pipes,

C. Vertical-Piping Clamps: Unless otherwise indicated and except as specified in piping system Specification Sections, install the following types;

1. Extension Pipe or Riser Clamps. For support of pipe risers, DN20 to DN500

C. Hanger-Rod Attachments: Unless otherwise indicated and except as specified in piping system Specification Sections, and detailed drawings

## 3.5 HANGER AND SUPPORT INSTALLATION:

A. Pipe Hanger and Support Installation: Install hangers, supports, clamps, and attachments as required to properly support piping from building structure.

B. Channel Support System Installation: Arrange for grouping of parallel runs of piping and support together on field-assembled channel systems.

1. Field assemble and install according to manufacturer's written instructions.

C. Install building attachments within concrete slabs. Install additional attachments at concentrated loads, including valves, flanges, guides, strainers, and expansion joints, and at changes in direction of piping. Install concrete inserts before concrete is placed; fasten inserts to forms and install reinforcing bars through openings at top of inserts.

D. Install mechanical-anchor fasteners in concrete after concrete is placed and completely cured. Install fasteners according to manufacturer's written instructions.

E. Install hangers and supports complete with necessary inserts, bolts, rods, nuts, washers, and other accessories.

F. Install hangers and supports to allow controlled thermal and seismic movement of piping systems, to permit freedom of movement between pipe anchors, and to facilitate action of expansion joints, expansion loops, expansion bends, and similar units.

G. Load Distribution: Install hangers and supports so that piping live and dead loads and stresses from movement will not be transmitted to connected equipment

## 3.6 EQUIPMENT SUPPORTS:

A. Fabricate structural-steel stands to suspend equipment from structure above or to support equipment above floor.

B. Grouting: Place grout under supports for equipment and make smooth bearing surface.

## 3.7 **METAL FABRICATION**:

A. Cut, drill, and fit miscellaneous metal fabrications for heavy-duty steel trapezes and equipment supports.

B. Fit exposed connections together to form hairline joints. Field-weld connections that cannot be shop-welded because of shipping size limitations.

C. Field Welding: Appearance and quality of welds, and methods used in correcting welding work, and with the following:

1. Use materials and methods that minimize distortion and develop strength and corrosion resistance of base metals.

2. Obtain fusion without undercut or overlap.

3. Remove welding flux immediately.

4. Finish welds at exposed connections so no roughness shows after finishing and contours of welded surfaces match adjacent contours.

## **3.8 ADJUSTING:**

A. Hanger Adjustment: Adjust hangers to distribute loads equally on attachments and to achieve indicated slope of pipe.

END OF SECTION

# 4. **MECHANICAL IDENTIFICATION:**

PART 1 - GENERAL

## 4.0 RELATED DOCUMENTS:

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

## 4.1 SUMMARY:

A. This Section describes the following Mechanical Identification materials and their installation:

1. Equipment Identification.
2. Piping Identification.
3. Duct Identification.
4. Warning Indications.

## 4.2 COORDINATION:

A. Coordinate installation of identifying devices with completion of covering and painting of surfaces where devices are to be applied.

B. Coordinate installation of identifying devices with location of access panels and doors.

C. Install identifying devices before installing false ceilings and similar concealment.

PART 2 – **PRODUCTS:**

## 4.3 EQUIPMENT IDENTIFICATION:

A. Paint names on all equipment in service color-letters 2” high. The painting and color coding shall be applied throughout the building except where concealed and not accessible through lay-in-ceiling, pipes and ducts shall be identified.

B. Mechanical equipment shall be stenciled with its appropriate designation in a place where the view is not obstructed to operating personnel.

## 4.4 PIPING IDENTIFICATION DEVICES:

A. Manufactured Pipe Markers, General: Preprinted, color-coded, with lettering indicating service, and showing direction of flow.

1. Colors: Comply with ASME A 13.1, unless otherwise indicated.

2. Lettering: Use piping system terms indicated and abbreviate only as necessary for each application length.

3. Pipes with OD, Including Insulation, Less Than 150 mm: Full-band pipe markers extending 360 degrees around pipe at each location.

4. Pipes with OD, Including Insulation, 150 mm and Larger. Either full band or strip-type pipe markers at least three times letter height and of length required for label.

5. Arrows: Integral with piping system service lettering to accommodate both directions; and as separate unit on each pipe marker to indicate direction of flow.

B. Pre-tensioned Pipe Markers: Pre-coiled semi-rigid plastic formed to cover mil circumference of pipe and to attach to pipe without adhesive.

## 4.5 DUCT IDENTIFICATION DEVICES:

A. Duct Markers: Engraved, colors-coded laminated plastic. Include direction and duct service (such as supply, return, and exhaust). Include contact-type, permanent adhesive.

# PART 3 – EXECUTION:

## 4.6 APPLICATIONS, GENERAL:

A. Products specified are for applications referenced in other Division 15 Sections. If more than single-type material, device, or label is specified for listed applications, selection is Installer's option.

## 4.7 EQUIPMENT IDENTIFICATION:

A. Install equipment signs with screws and permanent adhesive on or near each major item of mechanical equipment. Locate signs where accessible and visible.

1. Identify mechanical equipment with equipment markers in the following color codes:

    a. Green: For cooling equipment and components.

    b. Yellow: For cooling equipment and components.

    c. Orange: For combination cooling and cooling equipment and components.

2. Letter Size: Minimum 6.4 mm for name of units if viewing distance is less than 600 mm, 13mm for viewing distances up to 1830 mm, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.

3. Data: Distinguish among multiple units, indicate operational requirements, indicate safety and emergency precautions, warn of hazards and improper operations, and identify units.

4. Include signs for the following general categories of equipment:

    a. Main control and operating valves, including safety devices and hazardous units.

    b. Fuel-burning units, including boilers.

    c. Pumps, compressors, chillers, condensers, and similar motor-driven units.

    d. Heat exchangers, coils, cooling towers and similar equipment

    e. Fans, blowers, primary balancing dampers, and mixing boxes.

    f. Packaged Cooling system central-station and zone-type units.

    g. Tanks and pressure vessels.

    h. Strainers, AHU filters section, humidifiers, water-treatment systems, and similar equipment.

## 4.8 PIPING IDENTIFICATION:

A. Install manufactured pipe markers indicating service on each piping system. Install with flow indication arrows showing direction of flow.

1. Use: Pre-tensioned pipe markers. Use size to ensure a tight fit.

B. Locate pipe markers and color bands where piping is exposed in finished spaces; machine rooms; accessible maintenance spaces such as shafts, tunnels, and plenums; and exterior non-concealed locations as follows:

1. Near each valve and control device.
2. Near each branch connection, excluding short takeoffs for fixtures and terminal units. Where flow pattern is not obvious, mark each pipe at branch.
3. Near penetrations through walls, floors, ceilings, and no accessible enclosures.
4. At access doors, manholes, and similar access points that permit view of concealed piping.
5. Near major equipment items and other points of origination and termination.
6. Spaced at maximum intervals of 15 m along each run. Reduce intervals to 7.6 m in areas of congested piping and equipment.
7. On piping above removable acoustical ceilings. Omit intermediately spaced markers.

## 4.9 DUCT IDENTIFICATION:

A. Install duct markers with permanent adhesive on air ducts in the following color codes:

1. Cyan: For cold-air supply ducts.
2. Blue: For hot-air supply ducts.
3. Orange: For exhaust-, outside-, relief-, return-, and mixed-air ducts.
4. ASME A13.1 Colors and Designs: For hazardous material exhaust.
5. Letter Size: Minimum 6.4 mm for name of units if viewing distance is less than 600 mm, 13 mm for viewing distances up to 1830 mm, and

proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.

B. Locate markers near points where ducts enter into concealed spaces and at maximum intervals of 15 m in each space where ducts are exposed or concealed by removable ceiling system.

## 4.10 WARNING-TAG INSTALLATION:

A. Write required message on, and attach warning tags to, equipment and other items where required.

## 4.11 ADJUSTING:

A. Relocate mechanical identification materials and devices that have become visually blocked by other work.

## 4.12 CLEANING:

A. Clean faces of mechanical identification devices and glass frames of valve schedules.

## 4.13 PAINTING:

All MS piping shall be painted with 02 coats of Red Oxide Primer. One coat shall be applied prior to installation and other coat shall be applied after installation. Final finish coats (02) of all piping shall be as per color codes specified by ASHRAE

END OF SECTION

5. VRF AIR HANDLING UNITS

PART 1 - GENERAL

## 5.1 RELATED DOCUMENTS:

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

## 5.2 SUMMARY:

The Contractor shall furnish all labor, materials, plant equipment and perform all necessary operations required to execute the work of this section. It is the responsibility of the Contractor to ensure that equipment, ductwork, piping etc shall fit into the spaces allocated and shall allow acceptable clearances, recommended by the manufacturer for entry, servicing and maintenance.

## 5.3 QUALITY ASSURANCE:

A. Source Limitations: Obtain all air-handling units for a single project through one source from a single manufacturer.

B. NFPA Compliance: Air-handling units and components shall be designed, fabricated, and installed in compliance with NFPA 90A, "Installation of Air Conditioning and Ventilating Systems."

C. ARI Certification: Air-handling units and their components shall be factory tested according to ARI 430, "Central-Station Air-Handling Units," and shall be listed and labeled by ARI. Or as approved by the Consultant

## 5.4 COORDINATION:

A. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements as specified

B. Coordinate installation of roof curbs, equipment supports, and roof penetrations.

## 5.5 SUBMITTALS:

After the award of contract, the Contractor shall submit the technical submittal for Air Handling Units. In selection of air handling units Contractor shall ensure the proper installation of these air handling units in the space allocated for air handling units.

PART 2 - PRODUCTS

## 5.6 VRF AIR HANDLING UNITS:

A. Furnish and install all central air handling units, complete of size, type and capacities as shown in the Drawings, Equipment Selection Data. The Air Handling Units (AHUs) shall be tested rated and certified as complete unit in accordance with ARI Standard 430-66 and shall bear the ARI seal, or equivalent certification as approved by the Consultant. And as approved by the consultant

B. All the Air Handling Units shall be manufactured at factory having ISO 9002 certified manufacturing facility; the manufacturer shall have at least 10 years of experience of manufacturing Air Handling Units. All the AHUs shall be complete with all the fittings, fixtures and accessories mentioned hereinafter.

C. The Air-handling units shall be factory assembled and basic units shall consist of main frame, casing, fan section, condensate drain-pan, cooling coils, filters section, fan, drive motor, vibration isolators, service lock, internal service light, controls and all the necessary accessories as required

D. Air Handling unit shall have refrigerant VRF coils, with refrigerant kit to make it suitable for operation of design conditions

E. Air Handling unit shall be supplied with matching all dc inverter VRF condensing unit

## 5.7 MAIN FRAME:

The main frame of all the air handling units shall be made of extruded aluminum profiles, these profiles shall be forming a structural frame to house all internal components, and these shall be joined at corners in such a manner that there shall be no heat leakage or sweating.
Thermal break and non-aging rubber seals shall be provided to eliminate the heat and air leakages.

## 5.8 CASING PANELS:

The outer casing panels shall be constructed with minimum of 0.8 mm thick galvanized steel sheets, with baked polyester powder coated on exterior walls and shall be filled with polyurethane with not less than 50 kg/cu m density, and the inner casing panels shall be stainless steel sheets for hygienic applications with round edges, the thickness of panels is 50 mm or as given in equipment selection data, and shall be provided with self-locking mechanism represented by a wedge and frame exerting pressure evenly onto the panel and seal attached to the frame for better air tight construction. The unit casing shall

be airtight at low and high pressure, units to be installed open to weather shall be weatherproof type. The casing shall be designed to meet Eurovent Casing Air Leakage class B. The casing strength shall meet the European Standard EN 1886:1998, Casing Strength Class 2A.

5.9 **FANS**:

A. Each Air Handling Unit shall be provided with direct driven plug fan, all fans shall be forward/back ward curved, as specified in equipment selection data, fans shall be dynamically and statically balanced according to air flow and speed and shall be tested in the factory. All fans shall be certified to AMCA 210 and AMCA 300 Standards.

B. All fans shall be provided with vibration isolators for 80 to 90% isolation efficiency at operating speed. Fan air suction and discharge arrangements shall be suitable for proper fixing or as indicated.

C. Direct Drive Plug Fans and drive shall be mounted on a framework isolated through vibration isolators and a flexible connection at fan discharge.

**5.10 FILTERS:**

The air handling units shall be provided with Pre-Filters and Bag Filters, as specified in schedule. The AHU shall have a separate filter section

**5.11 COOLING COIL:**

A. The Contractor shall ensure proper selection of coils for required heat transfer and capacities given in Equipment Selection Data. The Dx coils shall be removable without dismantling the unit. The Dx coils shall be constructed of seamless copper tubing with suitable non-ferrous fins securely bonded to the tubes. The coils shall be tested pneumatically and proved tight under gauge pressure of 30 bars and shall be designed for 15 bar working pressure. The wall thickness of copper tubes shall not be less than 0.80 mm. These coils shall be dehydrated and sealed at the factory after inspection. Tubes shall be round seamless of suitable outer diameter. Tabulators inside the coils shall not be acceptable. Coils shall be suitable for 32 to $220^0$F operating temperatures.

B. Unless otherwise specified the cooling coils shall have not more than 10 fins per inch and face velocity not to exceed 450 fpm. Fins should be flat and with full drawn collars so that no bare copper tube shall be visible between fins. Tube headers shall be made of extra heavy seamless copper tube. There shall be air vent on the top of the header and drain point at the bottom

**5.12 DRAIN PAN:**

The Units shall be equipped with condensate drain pan, the drain pan shall be made of stainless-steel sheet and shall be insulated with foam insulation. The drain pan shall be pitched for even flow of condensate and with side drain connection on both sides.

## 5.13 BASE FRAME:

A. The air handling unit sections shall be mounted on a 2 mm thick galvanized iron base frame to assure entire stability and for easy lifting, handling and positioning at site

B. Unit sections shall be provided with non-ageing gaskets and connection clamps to permit quickly and airtight assembly at site

C. Air Handling Units shall be installed by the Contractor complete in all respects as recommended by the manufacturer and to the entire satisfaction of the Consultant. All piping, ducting, electrical etc., connections shall be made as per specifications and drawings and standard engineering practices.

## 5.14 SERVICE LIGHT:

Each floor mounted air handling unit shall be provided with factory fitted weather resistant, inside the AHU and shall be provided with an ON-OFF switch box outside the unit. The light shall be single phase with PL lamp with ballast and reflector.

## 5.15 ACCESS & INSPECTION DOOR:

Access and inspection door shall be provided with same construction as of AHU panels. Door shall have durable rubber seal and rigid frame and shall not permit air leakage. The door shall be hinged and able to be lifted off or removed totally for easy access. This shall also incorporate the thermal break feature.

## 5.16 OUTDOOR UNIT:

The Variable Refrigerant Flow (VRF) System shall be Inverter type R410A refrigerant based Multi Split Unit System with high C.O.P. The systems shall comprise of one or several of outdoor units connected via interconnecting refrigeration pipe work to multiple indoor units using simple Y type branch pipe connectors. Y Connectors (as per drawings/manufacturer's recommendations) shall be supplied with A/C units. The systems shall be complete with all the necessary electronic controls board and control wiring to maintain the design room conditions without external controller.

The units shall be air-cooled type incorporating heat exchanger coils manufactured from copper tubes and aluminum fins, factory treated to reduce

the effect of atmospheric corrosion. The unit casing shall be manufactured with 50µm polyester powder coated baked enamel finish sheet steel and condenser fins should be coated with hydrophilic coating with 95µm in order to have a high corrosion resistance and to protect against salt laden environment close to where the units may be installed. VRF outdoor unit coil must be 168 Hours salt spray tested. The color shall be manufacturer's standard. The air outlets of outdoor units should have grills/guards for safety.

The outdoor units are to be Variable Refrigerant Flow (VRF) inverter based, combination of Multiple Outdoor Units of capacities given in schedules.

All VRF Outdoor units must be heat pump type and must have an ambient operating range of minimum 54 degree C without tripping.

The outdoor units shall have DC Inverter driven scroll compressors electronically controlled and capable of changing speed linearly to follow the variation in cooling requirements. Each compressor should have a standard crankcase heater.

All compressors used in the offered VRF system must be DC Inverter T3 type Scroll compressors must be made in Japan/Europe/Thailand or Korea only and must be high pressure chamber design type. Moreover, compressors must be performance tested, rain tested with minimum 6-Hours and salt spray tested with minimum 500-Hours.

Power modules of PCB cards must be made in Japan/Europe/Thailand or Korea only.

The capacity control of the outdoor units will be inverter controlled and shall be determined electronically by sensing operational temperatures and ambient temperature and monitoring requirements for the indoor units.

The units shall be complete with electronic expansion valve(s), oil separator(s), high pressure switches, fan motor safety devices, over current relay, inverter overload protection, fuses, necessary solenoid valves and all necessary sensors for a safe and trouble-free operation.

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

It shall be possible to connect up to 64 indoor units, capacity permitting, to one modular outdoor unit.

The outdoor unit shall have capacity control to meet the load fluctuation up to 130% and indoor unit individual control.

The outdoor fan must be axial type and must be capable of overcoming a minimum of 82 Pascal of external static pressure. The outdoor fan motor should be DC operated and capable of minimum 64-Stage speed adjustments. The outdoor fan motor must be 6-pole type and with minimum E class of insulation, I class of safety and protection class of IP44.

Outdoor Heat exchanger must be designed with corrosion and oxidation resistant grooved inner tubes of 8mm dia and hydrophilic coated coil fins. Each outdoor unit must have two pieces' heat-exchangers of 2-way each.

Outdoor unit casing cabinet must be made of hot zinc plate with 0.8mm thickness and should be salt spray test minimum 72 Hours. Casing should also have a powder coating of minimum 50um thickness.

The outdoor unit PCB card must be air-cooled type and each outdoor unit module should have two or more refrigerant circuits.

Outdoor unit should have two separate chambers design as upper and lower chambers and there must be a drain pan between both the chambers. Upper chamber contains the heat-exchanger and fan, and lower chamber contains the compressor and other electronic components. This is subjected to better service experience.

2-Stage oil separation technology must be used and minimum 4-solinoid valve technology must be used for oil balancing of VRF outdoor units.

All the outdoor unit modules should be of same footprint dimensions for ease of installation works. The dimension of all outdoor unit modules should be (WXD): 1350×720mm as footprints, rest the height of the outdoor units can be varied according to the manufacturers design.

END OF SECTION

# 6. METAL DUCT WORK:

PART 1 - GENERAL

## 6.1 RELATED DOCUMENTS:

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

## 6.2 SUMMARY:

A. This Section includes rectangular and round metal ducts for Cooling Systems in pressure classes, from minus 2 inches to plus 4 inches' water gage.

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

1. Section 15050, "Basic Materials and Methods" for fire-resistant sealants for use around duct penetrations and fire damper installations in fire rated floors, partitions, and walls.

2. Section 15010, "Basic Mechanical Requirements"

3. Section 15147 "Duct Insulation" for exterior duct and plenum insulation.

4. Section 15892 "Duct Accessories" for flexible duct materials, dampers, duct-mounted access panels and doors, and turning vanes.

5. Division 15 Section "Diffusers, Registers, and Grilles."

6. Division 15 Section "Testing, Adjusting, and Balancing,"

## 6.3 DEFINITIONS:

A. Sealing Requirements Definitions: For the purposes of duct systems sealing requirements specified in this Section, the following definitions apply:'

1. Seams: A seam is defined as joining of two longitudinally (in the direction of airflow) oriented edges of duct surface material occurring between two joints. All other duct surface connections made on the perimeter are deemed to be joints.

2. Joints: Joints include girth joints; branch and subbranch intersections; so-called duct collar tap-ins; fitting subsections; louver and air terminal connections to ducts; access door and access panel frames and jambs; duct, plenum, and casing abutments to building structures.

## 6.4 SYSTEM PERFORMANCE REQUIREMENTS:

A. The duct system design, as indicated, has been used to select and size air moving and distribution equipment and other components of the air system. Changes or alterations to the layout or configuration of the duct system must be specifically approved in writing. Accompany requests for layout modifications with calculations showing that the proposed layout will provide the original design results without increasing the system total pressure.

## 6.5 SUBMITTALS:

A. General: Submit the following in accordance with Conditions of Contract and Division 15 Specification Sections.

B. Product data including details of construction relative to materials, dimensions of individual components, profiles, and finishes for the following items:

1. Duct Liner.

2. Sealing Materials.

C. Shop drawings from duct fabrication shop, drawn to a scale not smaller than 1:50 scale, on drawing sheets same size as the Contract Drawings, detailing:

1. Fabrication, assembly, and installation details, including plans, elevations, sections, details of components, and attachments to other work.

2. Duct layout, indicating pressure classifications and sizes in plan view. For exhaust ducts systems, indicate the classification of the materials handled as defined in this Section.

3. Fittings.

4. Reinforcing details and spacing.

5. Seam and joint construction details.

6. Penetrations through fire-rated and other partitions.

7. Terminal unit installation.

8. Hangers and supports, including methods for building attachment, vibration isolation, and duct attachment.

9. Dimensions shall be in IP units.

D. Coordination drawings for ductwork installation in accordance with Division 15 Section "Basic Mechanical Requirements." In addition to the requirements specified in "Basic Mechanical Requirements" show the following:

1. Coordination with ceiling suspension members.

2. Spatial coordination with other systems installed in the same space with the duct systems.

3. Coordination of ceiling- and wall-mounted access doors and panels required to provide access to dampers and other operating devices.

4. Coordination with ceiling-mounted lighting fixtures and air outlets and inlets.

## 6.6 DELIVERY, STORAGE, AND HANDLING:

A. Deliver sealant materials to site in original unopened containers or bundles with labels informing about manufacturer, product name and designation, color, expiration period for use, pot life, curing time, and mixing instructions for multi-component materials.

B. Store and handle sealant in compliance with manufacturers' recommendations to prevent their deterioration or damage due to moisture, high or low temperatures, contaminants, or other causes.

# PART 2 – **PRODUCTS:**

## 6.7 SHEET METAL MATERIALS:

A. Sheet Metal, General: Provide sheet metal in thicknesses indicated, packaged and marked as specified in ASTM A 700.

B. Galvanized Sheet Steel: Lock-forming quality, ASTM A653, Coating Designation G90. Provide mill phosphatized finish for exposed surfaces of ducts exposed to view.

C. Reinforcement Shapes and Plates: Unless otherwise indicated, provide galvanized steel reinforcing where installed on galvanized sheet metal ducts.

## 6.8 DUCT LINER:

A. General: Comply with NFPA Standard 90A and TTMA Standard AHC-101.

B. Materials: ASTM C 1071, Type II, with coated surface exposed to airstreams to prevent erosion of glass fibers,

1. Thickness: 25 mm.

2. Density: 7,32 kg/$m^2$.

3. Thermal Performance: "K-Factor" equal to 0.107 [kcal.m/h.$m^2$°C} or better, at a mean temperature of 24°C.

4. Fire Hazard Classification: Flame spread rating of not more than 25 without evidence of continued progressive combustion and a smoke developed rating of no higher than 50, when tested in accordance with ASTM C 411.

5. Liner Adhesive: Comply with NFPA Standard 90A and ASTM C 916.

6. Mechanical Fasteners: Galvanized steel, suitable for adhesive attachment, mechanical attachment, or welding attachment to duct. Provide fasteners that do not damage the liner when applied as recommended by the manufacturer, that do not cause leakage in the duct, and will indefinitely sustain a 23-kilogram tensile dead load test perpendicular to the duct wall.

a. Fastener Pin Length: As required for thickness of insulation, and without projecting more than 6 mm into the airstreams.

b. Adhesive for Attachment of Mechanical Fasteners: Comply with the "Fire Hazard Classification" of duct liner system.

## 6.9 JOINT SEALANT:

A. Apply joint sealant to all transverse joints as recommended by the manufacturer.

B. Joint sealant is specified in the list of approved manufacturers.

## 6.10 **HANGERS AND SUPPORTS**:

A. Building Attachments: Concrete inserts or structural steel fasteners appropriate for building materials.

B. Hangers: Galvanized steel round rods on minimum 10 mm diameter

C. Duct Attachments: Sheet metal screws, blind rivets, or self-tapping metal screws; compatible with duct materials.

## 6.11 **RECTANGULAR DUCT FABRICATION**:

A. General: Except as otherwise indicated, fabricate rectangular ducts with galvanized sheet steel, in accordance with SMACNA "Cooling system Duct Construction Standards," Tables 1-3 through 1-19, including their associated details. Conform to the requirements in the referenced standard for metal thickness, reinforcing types and intervals, tie rod applications, and joint types and intervals.

1. Fabricate rectangular ducts in lengths appropriate to reinforcement and rigidity class required for pressure classification.

2. Provide materials that are free from visual imperfections such as pitting, seam marks, roller marks, stains, and discolorations.

B. Static Pressure Classifications: Except where otherwise indicated, Construct duct systems to the following pressure classifications:

1. Supply Ducts: 75 mm water gage.

2. Return Ducts: 50 mm water gage, negative pressure.

3. Exhaust Ducts: 50 mm inches' water gage, negative pressure.

C. Cross breaking or Cross Beading: Cross break or bead duct sides that are 48 cm and larger and are 20 gage or less, with more than 1 square meter of unbraced panel area, as indicated in SMACNA "HVAC / cooling system Duct Construction Standard," Figure 1-4, unless they are lined or are externally insulated.

## 6.12 **RECTANGULAR DUCT FITTINGS**:

A. Fabricate elbows, transitions, offsets, branch connections, and other duct construction in accordance with SMACNA "HVAC / cooling system Metal Duct Construction Standard," 1985 Edition, Figures 2-1 through 2-10.

## 6.13 SHOP APPLICATION OF LINER IN RECTANGULAR DUCTS:

A. Adhere a single layer of indicated thickness of duct liner with 90 percent coverage of adhesive at liner contact surface area. Multiple layers of insulation to achieve indicated thickness is prohibited.

B. Apply a coat of adhesive to liner facing in direction of airflow not receiving metal hosing.

C. Butt transverse joints without gaps and coat joint with adhesive.

D. Fold and compress liner in corners of rectangular ducts or cut and fit to assure butted edge overlapping.

E. Longitudinal joints in rectangular ducts shall not occur except at corners of ducts, unless the size of the duct and standard liner product dimensions make longitudinal joints necessary.

1. Apply an adhesive coating on longitudinal seams in ducts exceeding 12.7 m/s air velocity.

F. Secure liner with mechanical fasteners 10 cm from corners and at intervals not exceeding 30 cm transversely around perimeter; at 7.5 cm from transverse joints and at intervals not exceeding 45 cm longitudinally.

G. Secure transversely oriented liner edges facing the airstreams with metal nosing that are either channel or "Z" profile or are integrally formed from the duct wall at the following locations:

1. Fan discharge.

2. Intervals of lined duct preceding unlined duct.

3. Upstream edges of transverse joints in ducts.

## 6.14 ROUND DUCT FABRICATION:

A. General: "Basic Round Diameter" as used in this article is the diameter of the size of round duct that has a circumference equal to the perimeter of a given sized of flat oval duct. Except where interrupted by fittings, provide round ducts in lengths not less than 3.5 meters.

B. Round Ducts: Fabricate round supply ducts with spiral lock seam construction. Comply with SMACNA "HVAC/cooling system Duct Construction Standards/ Table 3-2 for galvanized steel gages.

## 6.15 ROUND SUPPLY AND EXHAUST FITTINGS FABRICATION:

A. Elbows: Fabricate in die-formed, gored, or pleated construction. Fabricate the bend radius of die-formed, gored, and pleated elbows 1.5 times the elbow diameter. Unless elbow construction type is indicated, provide elbows meeting the following requirements:

1. Round Elbows - 20 cm and Smaller: Die-formed elbows for 45- and 90-degree elbows and pleated elbows for 30, 45, 60, and 90 degrees only.

2. Round Elbows - 22 cm Through 36 cm: Gored or pleated elbows for 30, 45, 60, and 90 degrees, except where space restrictions require a mitered elbow.

PART 3 – **EXECUTION:**

## 6.16 DUCT INSTALLATION, GENERAL:

A. Duct System Pressure Class: Construct and install each duct system for the specific duct pressure classification indicated.

B. Install ducts with the fewest possible joints.

C. Use fabricated fittings for all changes in directions, changes in size and shape, and connections.

D. Install couplings tight to duct wall surface with projections into duct at connections kept to a minimum.

E. Locate ducts, except as otherwise indicated, vertically and horizontally, parallel and perpendicular to building lines; avoid diagonal runs. Install duct systems in shortest route that does not obstruct useable space or block access for servicing building and its equipment.

F. Install ducts close to walls, overhead construction, columns, and other structural and permanent enclosure elements of building.

G. Provide clearance of 25 mm where furring is shown for enclosure or concealment of ducts, plus allowance for insulation thickness, if any.

H. Install insulated ducts with 25 mm clearance outside of insulation.

I. Conceal ducts from view in finished and occupied spaces by locating in mechanical shafts, hollow wall construction, or above suspended ceilings. Do not encase horizontal runs in solid partitions, except as specifically shown.

J. Coordinate layout with suspended ceiling and lighting layouts and similar finished work.

K. Non-Fire-Rated Partition Penetrations: Where ducts pass interior partitions and exterior walls, and are exposed to view, conceal space between construction opening and duct or duct insulation with sheet metal flanges of same gage as duct. Overlap opening on 4 sides by at least 4 cm.

## 6.17 SEAM AND JOINT SEALING:

A. General: Seal duct seams and joints as follows:

B. Pressure Classification 50 and 75 mm Water Gage: All transverse joints and longitudinal seams.

C. Seal externally insulated ducts prior to insulation installation.

## 6.18 DUCT LINING:

Provide duct lining on ductwork within 4 meters of the Air Handling Units, both supply and return ducts. Duct sizes shown on drawing shall be the net free dimensions inside the duct.

## 6.19 HANGING AND SUPPORTING:

A. Install rigid round, rectangular, and flat oval metal duct with support systems indicated in SMACNA "HVAC/cooling system Duct Construction Standards," Tables 4-1 through 4-3 and Figures 4-1 through 4-8.

B. Support horizontal ducts within 60 cm of each elbow and within 120 cm of each branch intersection.

C. Support vertical ducts at a, maximum interval of 4 M and at each floor.

D. Upper attachments to structures shall have an allowable load not exceeding 1/4 of the failure (proof test) load but are not limited to the specific methods indicated.

E. Install concrete insert prior to placing concrete.

6.20 **CONNECTIONS**:

A. Equipment -Connections: Connect equipment with flexible connectors in accordance with Division 15 Section "Duct Accessories."

B. Branch Connections: Comply with SMACNA "HVAC/cooling system Duct Construction Standards," Figures 2-7 and 2-8.

C. Outlet and Inlet Connections: Comply with SMACNA "HVAC/cooling system Duct Construction Standards," Figures 2-16 through 2-18.

D. Terminal Units Connections: Comply with SMACNA "HVAC/cooling Duct Construction Standards," Figure 2-19.

**6.21 FIELD QUALITY CONTROL:**

A. Disassemble, reassemble, and seal segments of the systems as required to accommodate leakage testing, and as required for compliance with test requirements.

B. Conduct tests, in the presence of the Consultant, at static pressures equal to the maximum design pressure of the system or the section being tested. If pressure classifications are not indicated, test entire system at the maximum system design pressure. Do not pressurize systems above the maximum design operating pressure. Give 7 days' advanced notice for testing.

C. Determine leakage from entire system or section of the system by relating leakage to the surface area of the test section.

D. Maximum Allowable Leakage: As described in ASHRAE 1989 Handbook, "Fundamentals" Volume, Chapter 32, Table 6 and Figure 10. Comply with requirements for leakage classification 3 for round and flat oval ducts, leakage classification 12 for rectangular ducts in pressure classifications less than and equal to 50 mm water gage (both positive and negative pressures), and leakage classification 6 for pressure classifications greater than 50 mm water gage and less than and equal to 250 mm water gage.

E. Remake leaking joints as required and apply sealants to achieve specified maximum allowable leakage.

F. Leakage Test: Perform volumetric measurements and adjust air systems as described in ASHRAE 1987 "HVAC/Cooling Systems and Applications" Volume, Chapter 57 and ASHRAE 1989 "Fundamentals" Volume, Chapter 13, and Division 15 Section "TESTING, ADJUSTING, AND BALANCING."

## 6.22 ADJUSTING AND CLEANING:

A. Adjust volume control devices as required by the testing and balancing procedures to achieve required air flow. Refer to Division 15 Section "TESTING, ADJUSTING, AND BALANCING" for requirements and procedures for adjusting and balancing air systems.

END OF SECTION

## 7. DUCT WORK & ACCESSORIES:

PART 1 – GENERAL

### 7.1 RELATED DOCUMENTS:

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

### 7.2 **DESCRIPTION OF WORK**:

A. Extent of ductwork and accessories work is indicated on drawings and in schedules, and by requirements of this section.

B. Types of ductwork accessories required for project include the following:

1. Dampers.

a. Manual Dampers.

b. Motor-Operated Dampers.

2. Turning Vanes.

3. Duct Hardware.

4. Duct Access Doors.

5. Flexible Ducts.

6. Screens.

### 7.3 **QUALITY ASSURANCE**:

A. Manufacturer's Qualifications: Firms regularly engaged in manufacture of ductwork accessories, of types and sizes required, whose products have been in satisfactory use in similar service for not less than 10 years.

B. Codes and Standards:

1. SMACNA. Compliance: Comply with applicable portions of SMACNA "HVAC/Cooling system Duct Construction Standards, Metal and Flexible."

2. Industry Standards: Comply with ASHRAE recommendations pertaining to construction of ductwork accessories, except as otherwise indicated.

**7.4 SUBMITTALS:**

A. Product Data: Submit manufacturer's technical product data for each type of ductwork accessory, including dimensions, capacities, and materials of construction; and installation instructions.

B. Shop Drawings: Submit manufacturer's assembly-type shop drawings for each type of ductwork accessory showing interfacing requirements with ductwork, method of fastening or support, and methods of assembly of components.

C. Maintenance Data: Submit manufacturer's maintenance data including parts lists for each type of duct accessory. Include this data, product data, and shop drawings in maintenance manual; in accordance with requirements of Division 15.

**PART 2 – PRODUCTS:**

**7.5 DUCT WORK:**

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 center line 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 ductworks shall form smooth interior surface.

d. Support horizontal ductwork on galvanized iron hangers not less than 1” X 1/8”. Spaced not more than 8 ft. on center for ducts up to 8 sq. ft. in area and not more than 4 ft on center for larger ductwork.

e. Support vertical duct work at each floor with angles not less than 1 ¼” X 1 ¼” 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 SMACNA & 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.

## 7.6 DUCTWORK – MATERIAL

### GALVANISED STEEL DUCTWORK:

a. All ductwork, prime quality galvanized sheet steel:

1. To 12 inches’ maximum dimension, #24 USSG

2. 13 to 27 inches’ maximum dimension, #24 USSG

3. 28 to 50 inches’ maximum dimension #22 USSG

4. 51 to 80 inches’ maximum dimension #20 USSG

5. Over 80 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 centers.

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 centers.

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 centers.

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 centers.

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 centers.

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 it joints ate 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.

**DAMPERS:**

A. Manual Dampers: Provide dampers of single blade type or multi-blade type, constructed in accordance with SMACNA "HVAC / cooling system Duct Construction Standards."

B. Motor-Operated Dampers: Provide automatic dampers, as indicated, with damper frames not less than formed 13-gauge galvanized steel. Provide mounting holes for enclosed duct mounting. Provide damper blades not less than formed 16-gauge galvanized steel, with maximum blade width of 8”. Equip dampers with motors, with proper rating for each application. Dampers shall be spring return to closed.

1. Secure blades to ½” diameter zinc-plated axles using zinc-plated hardware. Seal off against spring stainless steel blade bearings. Provide blade bearings of nylon and provide thrust bearings are each end of every blade. Construct blade linkage hardware of

zinc-plated steel and brass. Submit leakage and flow characteristics, plus size schedule for controlled dampers.

2. Operating Temperature Range: From -30ªC to 95°C.

**7.7 TURNING VANES:**

A. Fabricated Turning Vanes: Provide fabricated turning vanes and vane runners, constructed in accordance with SMACNA "HVAC /cooling system Duct Construction Standards."

**7.8 DUCT HARDWARE:**

A. Test Holes: Provide in ductwork at fan outlet, and elsewhere as indicated, duct test holes, consisting of slot and cover, for instrument tests.

B. Quadrant Locks: Provide for each damper, quadrant lock device on one end of shaft; and end bearing plate on other end for damper lengths over 300 mm. Provide extended quadrant locks and end extended bearing plates for externally insulated ductwork.

7.9 **DUCT ACCESS DOORS**:

A. General: Provide where indicated, duct access doors of size indicated.

B. Construction: Construct of same or greater gage as ductwork served, provide insulated doors for insulated ductwork. Provide extended frames for externally insulated duct. Provide one size hinged other side with one handle-type latch for doors 12” high and smaller, 2 handle type latches for larger doors.

**7.10 FLEXIBLE CONNECTORS:**

A. General: Provide flexible duct connections wherever ductwork connects to the air conditioning unit and to other vibration isolated equipment. Construct flexible connections of neoprene-coated flameproof fabric crimped into duct flanges for attachment to duct and equipment. Make airtight joint. Provide adequate joint flexibility to allow for thermal, axial, transverse, and tensional movement, and capable of absorbing vibration of connected equipment.

7.11 FLEXIBLE DUCTS

A. General: Provide flexible duct connects to plenums with main ducts. Flexible ducts shall be as short as possible and shall be a single continuous piece.

B. Construction: Flexible ducts shall be UL 181 Class 1 labelled composed of a flexible, resin bonded fiberglass helix wrapped with several layers of glass fibber insulation. Ducts shall be covered with a tough, seamless, vapor barrier jacket.

**7.12 SCREENS:**

A. General: Provide 2" clear, 1/8" diameter galvanized wire screens in a 1/16" (minimum) galvanized steel frame where shown on the drawings.

PART 3 – **EXECUTION:**

**7.13 INSPECTION:**

A. Examine areas and conditions under which ductwork accessories will be installed. Do not proceed with work until unsatisfactory conditions have been corrected in manner acceptable to Consultant.

7.14 **INSTALLATION OF DUCTWORK ACCESSORIES**:

A. Install ductwork accessories in accordance with manufacturer's installation instructions, with applicable portions of details of construction as shown in SMACNA standards, and in accordance with recognized industry practices to ensure that products serve intended function.

B. Install turning vanes in square or rectangular 90-degree elbows in supply and exhaust air systems, and elsewhere as indicated.

C. Install access doors to open against system air pressure, with latches operable from either side, except outside only where duct is too small for person to enter.

D. Coordinate with other work, including ductwork, as necessary to interface installation of ductwork accessories properly with other work.

**7.15 FIELD QUALITY CONTROL:**

A. Operate installed ductwork accessories to demonstrate compliance with requirements. Test for air leakage while system is operating. Repair or replace faulty accessories, as required to obtain proper operation and leak proof performance.

7.16 **ADJUSTING AND CLEANING**:

i). Adjusting: Adjust ductwork accessories for proper settings, install fusible links in fire dampers and adjust for proper action.

ii)Final positioning of manual dampers is specified in Division- 15 section "Testing, Adjusting, and Balancing."

iii). Cleaning: Clean factory-finished surfaces. Repair any marred or scratched surfaces with manufacturer's touch-up paint.

7.17 **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 otherwise airtight. 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.

7.18 **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 □ 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.

END OF SECTION

# 8. DIFFUSERS, REGISTERS, AND GRILLES

## PART 1 – GENERAL

### 8.1 RELATED DOCUMENTS:

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

### 8.2 SUMMARY:

A. This Section includes ceiling- and wall-mounted diffusers, registers, and grilles, Louvers and linear grills etc. B. Related Sections include the following:

1. This Section includes rectangular and round metal ducts for cooling systems in pressure classes, from minus 2 inches to plus 4 inches' water gage.
2. Related Sections: The following sections contain requirements that relate to this Section:
3. Section 15055, "Basic Materials and Methods" for fire-resistant sealants for use around duct penetrations and fire damper installations in fire rated floors, partitions, and walls.
4. Section 15010, "Basic Mechanical Requirements"
5. Division 15 Section "Duct Insulation" for exterior duct and plenum insulation.
6. Division 15 Section "Duct Accessories" for flexible duct materials, dampers, duct-mounted access panels and doors, and turning vanes.
7. Division 15 Section "Testing, Adjusting, and Balancing,"

### 8.3 QUALITY ASSURANCE:

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

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

Conditioning and Ventilating Systems."

## PART 2 – PRODUCTS:

### 8.4 GRILLES AND REGISTERS:

A. Adjustable Bar Grille or Register:

1 Material: Aluminum.
2 Finish: Baked enamel, white.
3 Damper Type: Adjustable opposed-blade assembly.

### 8.5 CEILING DIFFUSER OUTLETS:

A. Rectangular and Square Ceiling Diffusers:

1. Material: Aluminum.
2. Finish: Baked enamel, white.
3. Face Size: See schedule on drawings.
4. Dampers: Radial opposed blade.

### 8.6 JET DIFFUSERS:

1 Round Ceiling Diffusers:
2 Material: Aluminum.
3 Finish: Baked enamel, white.
4 Face Size: See schedule on drawings.

### 8.7 CEILING DIFFUSER DISC TYPE:

A. Round Ceiling Diffusers:

1. Material: Aluminum.
2. Finish: Baked enamel, white.
3. Face Size: See schedule on drawings.
4. Face Style: Disc type.

### 8.8 LINEAR GRILL:

A. Linear Grill Series 6000 T &B: or Imperial Line Series

1. Material: Aluminum.
2. Finish: Baked enamel, white.
3. Face Size: See schedule on drawings.

### 8.9 LOUVERS:

A. Rectangular and Square Louvers:

1. Material: Aluminum.
2. Finish: Baked enamel, white.
3. Face Size: See schedule on drawings.

### 8.10 SOURCE QUALITY CONTROL:

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

## PART 3 - EXECUTION

### 8.11 EXAMINATION:

A. Examine areas where diffusers, registers, and grilles are to be installed for compliance with requirements for installation tolerances and other conditions affecting quality and performance of equipment.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

### 8.12 INSTALLATION:

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

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

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

### 8.13 ADJUSTING:

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

END OF SECTION

# 9. OPERATION AND MAINTENANCE OF COOLING SYSTEM

## 9.1 RELATED DOCUMENTS:

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

## 9.2 SUMMARY:

This Section includes the following:

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

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

## 9.3 OPERATION:

A. The entire Cooling System (VRF & Split type) would be operated wholly by the Contractor without any assistance of Owner's staff. The operation timings shall be designated by the Owner, however 10 hrs. a day without any break (No leave throughout the year except gazette holidays) operation is to be carried out by the Contractor.

B. During this period of operation and maintenance the Contractor shall train the operating staff for the operation and maintenance of Cooling System's equipment

C. The Contractor shall provide qualified, experienced and competent staff for the operation of the complete Cooling System's equipment and systems and comply with the applicable Codes and Regulations.

D. The Contractor shall submit the biodata of operational staff to the Consultant, Consultant shall evaluate their qualification and experience, after satisfactory evaluation the Contractor shall appoint them.

E. Following minimum operating staff shall be employed by the Contractor

i. Operator/Mechanic 01

ii. Electrician 01

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

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

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

**9.4 MAINTENANCE:**

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

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

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

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

9.5 **TRAINING**:

During the period of operation and maintenance, the Contractor shall submit the "Training Schedule" to the Consultant for approval, after approval the Contractor shall impart regular training to the Owner's staff in operation and maintenance so that the Owner's staff should become competent to take independent charge of operation and maintenance of cooling system after two years.

**9.6 OPERATION AND MAINTENANCE MANUALS AND CHARTS:**

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

**9.7 AS-BUILT DRAWINGS:**

Contractor shall submit five (5) sets of as-built drawings in hard copy and its soft copy (DWG Format) including drawings of complete electrical and control circuits, duly approved by the Consultant. The drawings shall be prepared in a neat and accurate manner (on computer CAD) showing the completed work in detail as installed. Identification marks and colors on the drawings shall be shown corresponding to those marked on the installation.

**9.8 SPECIAL TOOLS AND INSTRUMENTS:**

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

**9.9 SUPPLEMENTARY SPARE PARTS:**

In addition to the maintenance stock recommended for two years' maintenance by the manufacturers of the equipment and approved by the Consultant, the Contractor shall provide supplementary spare parts as mentioned in Equipment schedule data and Bill of Quantities as part of contract before the commencement of testing and commissioning phase.

## 9.10 **COMPLETION OF OPERATION**:

After two-year successful completion of operation and maintenance of entire Cooling system, the Contractor shall handover the entire system to the Owner with each thing intact to the entire satisfaction of the Consultant and Owner, and if anything found damaged during this period the Contractor shall repair or replace it without any extra charges to the Owner before handing it over to the Owner.

END OF SECTION

## 10. TESTING, ADJUSTING, AND BALANCING

PART 1 – GENERAL

### 10.1 RELATED DOCUMENTS:

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

### 10.2 SUMMARY:

A. This Section includes Testing, and Commissioning, (Adjusting, and Balancing) of all Cooling Systems to produce design objectives, mainly as following:

1. Balancing air flow within distribution systems, including mains, all branches, and Terminal, to indicated quantities.

2. Measuring electrical performance of Cooling System's equipment

3. Verifying that automatic control devices are functioning properly

4. Measuring sound and vibration

### 10.3 DEFINITIONS:

A. Adjust: To regulate fluid flow rate and air patterns at the air outlet/inlet, such as to reduce fan speed or adjust a damper.

B. Balance: To set the proportional flows within the distribution system, including sub-mains, branches, and terminal, according to the design quantities.

C. Procedure: An approach to and execution of and sequence of work to obtain the results.

D. Test Reports: Test data sheets for recording test data in logical order.

E. Terminal: A point where the controlled medium, such as fluid or energy, enters or leaves the distribution system.

F. Test: A procedure to determine quantitative performance of a system or equipment.

## 10.4 QUALITY ASSURANCE:

A. Testing, Adjusting, and Balancing Reports: Use standard forms from for Testing, Adjusting, and Balancing" or as directed by the Consultant.

B. Instrumentation Type, Quantity, and Accuracy: All the instruments used for testing adjusting and balancing shall be calibrated by a approved agency.

## 10.5 COORDINATION:

A. Obtain all shop drawings of systems to be tested, adjusted and balanced in order to become familiar with installation prior to the day when testing, adjusting and balancing is performed.

B. Perform testing, adjusting, and balancing after leakage and pressure tests on air distribution systems have been satisfactorily completed.

PART 2 – **EXECUTION:**

A. Examine approved submittal data of Cooling Systems and equipment.

B. Examine project record documents.

C. Examine Consultant's design data, including Cooling System descriptions, statements of design assumptions for environmental conditions and systems' output.

D. Examine system and equipment installations to verify that they are complete and that testing, cleaning, adjusting, and commissioning specified in individual Specification Sections have been performed.

E. Examine system and equipment test reports.

F. Examine cooling system and equipment installations to verify that indicated balancing devices, such as test ports, gage cocks, thermometer wells, flow-control devices, balancing valves and fittings, and manual volume dampers, are properly installed, and their locations are accessible and appropriate for effective balancing and for efficient system and equipment operation.

G. Examine systems for functional deficiencies that cannot be corrected by adjusting and balancing.

H. Examine air-handling equipment to ensure clean filters have been installed, bearings are greased, belts are aligned and tight, and equipment with functioning controls is ready for operation.

I. Examine plenum ceilings, utilized for supply air, to verify that they are airtight. Verify that pipe penetrations and other holes are sealed.

J. Examine equipment for installation and for properly operating safety interlocks and controls.

K. Examine automatic temperature system components to verify the following:

1. Dampers, valves, and other controlled devices operate by the intended controller.

2. Dampers and valves are in the position indicated by the controller.

3. Thermostats are located to avoid adverse effects of sunlight, drafts, and cold walls.

4. Sensors are located to sense only the intended conditions.

5. Sequence of operation for control modes is according to the Contract Documents.

6. Controller set points are set at design values. Observe and record system reactions to changes in conditions. Record default set points if different from design values.

7. Interlocked systems are operating.

8. Changeover from normal to cooling mode occurs according to design values.

L. Report deficiencies discovered before and during performance of testing, adjusting, and balancing procedures.

## 10.6 PREPARATION:

A. Prepare a testing, adjusting, and balancing plan that includes strategies and step-by-step procedures.

B. Complete system readiness checks and prepare system readiness reports. Verify the following:

Permanent electrical power wiring is complete.

Automatic temperature-control systems are operational.

Equipment and duct access doors are securely closed.

Windows and doors can be closed so design conditions for system operations can be met.

10.7 **FUNDAMENTAL PROCEDURES FOR HYDRONIC SYSTEMS**:

A. Prepare test reports with pertinent design data and number in sequence starting at pump to end of system. Check the sum of branch circuit flows against approved flow rate. Correct variations that exceed plus or minus 5 percent.

**10.8 FINAL REPORT:**

A. Final test reports shall be provided to the Consultant.

B. General: Typewritten, or computer printout in letter-quality font, on standard bond paper, in 3-ring binder, tabulated and divided into sections by tested and balanced systems.

**SPECIAL NOTE**

Apart from other Documentation, Contractor is liable to provide the following information along with their evidences

1. List of Plant Machinery and Tools for the above project, the contractor must attach list of the main plant and machinery to be used at site
2. The description and location of the main fabrication shop of the contractor with address and facilities and design office location
3. List of engineers, technicians with qualification and membership like PEC for the engineers
4. Project plan and completion time with bar chart
5. Sub-contracting is not allowed for Cooling system
6. Performance and testing period and its cost either to be borne by the contractor or client

END OF SECTION