

AYUB TEACHING HOSPITAL ABBOTTABAD.



TENDER DOCUMENTS

VOLUME-II

TECHNICAL SPECIFICATIONS OF HVAC WORKS OF OPERATION THEATERS AT AYUB TEACHING HOSPITAL

Design and Supervision Consultant:



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TECHNICAL SPECIFICATIONS

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SECTION AB010- BASIC MECHANICAL REQUIREMENTS

PART 1 – GENERAL

1.1 RELATED DOCUMENTS:

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

1.2 SUMMARY

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

Submittals.

Samples.

Record documents.

Maintenance manuals

Shop Drawings

Mechanical installations.

Cutting and patching.

1.3 SUBMITTALS

General: The Contractor shall submit the submittals 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

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

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 related to the product being installed at site.

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.

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

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

Contract Modifications, actual equipment and materials installed.

1.6 MAINTENANCE MANUALS

Prepare maintenance manuals in triplicate, these manuals shall be in properly binding form including all the information required for the maintenance of the equipment. These maintenance manuals shall include the followings:

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

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.

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

Servicing instructions and lubrication charts and schedules.

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

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

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

Verify all dimensions by field measurements.

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

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.

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

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

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

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

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.

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

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

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

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

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

Install equipment and materials in existing structure.

Uncover Work to provide for installation of ill-timed Work.

Remove and replace defective Work.

Remove and replace Work not conforming to requirements of the Contract Documents.

Provide suitable caps for exposed ends of pipes.

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

END OF SECTION AB010

SECTION AB050 - BASIC MECHANICAL MATERIALS AND METHODS PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

This Section includes the following:

Piping Materials and Installation to all piping systems.

Mechanical Seals for Sleeves.

Sleeves.

Escutcheons.

Equipment Installation Requirements.

Painting and finishing.

Concrete Foundations.

Grouting.

1.3 DEFINITIONS

- A. Finished Spaces: All the spaces other than mechanical, electrical rooms, piping and ducting shafts, spaces below roof, and spaces above false ceilings.
- B. Exposed, Interior Installations: Exposed to view from indoors. For examples include finished occupied spaces and mechanical, electrical equipment rooms etc.
- C. Exposed, Exterior Installations: Exposed to view from outdoors or exposed to outdoor ambient temperatures and weather conditions. For examples rooftop locations etc.
- D. Concealed, Interior Installations: Concealed from view and protected from physical contact by building occupants. For examples include above ceilings and in duct shafts etc.
- E. Concealed, Exterior Installations: Concealed from view and protected

from weather conditions and physical contact by building occupants but subject to outdoor ambient temperatures. For examples installations within unheated shelters area etc.

1.4 QUALITY ASSURANCE

Steel Support Welding: Qualify processes and operators according to AWS D1.1, "Structural Welding Code-Steel." or approved equivalent.

Steel Pipe Welding: Qualify processes and operators according to ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications."

Comply with provisions in ASME B31 Series, "Code for Pressure Piping."

Certify that each welder has passed AWS qualification tests for welding processes involved and that certification is current, or approved equivalent.

Electrical Characteristics for Mechanical Equipment: Equipment of higher electrical characteristics may be furnished provided such proposed equipment is approved in writing and connecting electrical services, circuit breakers, and conduit sizes are appropriately modified. If minimum energy ratings or efficiencies are specified, equipment shall comply with requirements.

All Division 15 work shall comply with the most recent codes of the American Society of Mechanical Engineers (ASME) and American Society of Heating, Refrigeration and Air Conditioning Engineers (ASHRAE).

All Division 15 work shall comply with the latest version of the International Mechanical Code,

Commissioning of all Division 15 work shall be performed in accordance with ASHRAE Guideline 1- "The HVAC Commissioning Process."

1.5 DELIVERY, STORAGE, AND HANDLING

Deliver pipes with factory installed end caps. Maintain these end caps through shipping, storage, and handling to prevent pipe end from damage and to prevent entrance of dirt, debris, and moisture.

Store pipes to prevent sagging and bending.

1.6 COORDINATION

- A. Arrange for pipe spaces, chases, slots, and openings in building structure during progress of construction, to allow for mechanical installations.

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

Coordinate requirements for access panels and doors for mechanical items requiring access that are concealed behind finished surfaces. Access panels and doors are specified in another Section "Access Doors and Frames."

PART 2 - PRODUCTS

2.1 PIPE AND FITTINGS

Refer to individual Division 15 piping Sections for pipe, tube, and fitting materials and joining methods.

Pipe Threads: ASME B 1.20.1 for factory-threaded pipe and pipe fittings.

2.2 JOINING MATERIALS

- A. Refer to individual Division 15 piping Sections for special joining materials not listed below.

2.3 MECHANICAL SEALS FOR SLEEVE

Description: Modular sealing element unit, designed for field assembly, to fill annular space between pipe and sleeve.

Sealing Elements: EPDM interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size of pipe.

Pressure Plates: Plastic. Include two for each sealing element.

Connecting Bolts and Nuts: Carbon steel with corrosion-resistant coating of length required to secure pressure plates to sealing elements. Include one for each sealing element.

2.4 SLEEVES

- A. Galvanized-Steel Sheet: 20 SWG minimum thickness; round tube

closed with welded longitudinal joint.

Steel Pipe: ASTM A 53, Type E, Grade B, Schedule 40, galvanized, plain ends.

Cast Iron: Cast or fabricated "wall pipe" equivalent to ductile-iron pressure pipe, with plain ends and integral water-stop, unless otherwise indicated.

2.5 ESCUTCHEONS

- A. Description: Manufactured wall and ceiling escutcheons and floor plates, with an ID to closely fit around pipe, tube, and insulation of insulated piping and an OD that completely covers opening.

One-Piece, Deep-Pattern Type: Deep-drawn, box-shaped brass with polished chrome-plated finish.

- D. One-Piece, Floor-Plate Type: Cast-iron floor plate.

2.6 GROUT

Description: ASTM C 1107, Grade B, non-shrink and nonmetallic, dry hydraulic- cement grout.

Characteristics: Post-hardening, volume-adjusting, non-staining, non-corrosive, nongaseous, and recommended for interior and exterior applications.

PART 3 - EXECUTION

3.1 PIPING SYSTEMS - BASIC REQUIREMENTS

Install piping according to the following requirements and Division 15 Sections specifying piping systems.

Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Indicated locations and arrangements were used to size pipe and calculate friction loss, expansion, pump sizing, and other design considerations. Install piping as indicated unless deviations to layout are approved on Coordination Drawings.

Install piping in concealed locations, unless otherwise indicated and except in equipment rooms and service areas.

Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.

- E. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.

Install piping to permit valve servicing.

Install piping at indicated slopes.

Install piping free of sags and bends.

Install fittings for changes in direction and branch connections.

Install piping to allow application of insulation.

Select system components with pressure rating equal to or greater than system operating pressure.

Install escutcheons for penetrations of walls, ceilings, and floors according to the following:

Piping:

Piping with Fitting or Sleeve Protruding from Wall: One-piece, deep-pattern type.

Chrome-Plated Piping: One-piece, cast-brass type with polished chrome-plated finish.

Insulated Piping: One-piece, cast-brass type with polished chrome-plated finish.

Bare Piping at Wall, Ceiling and Floor Penetrations in Finished Spaces: One-piece, cast-brass type with polished chrome-plated finish.

Sleeves are not required for core-drilled holes.

Install sleeves for pipes passing through concrete & masonry walls & concrete floor & roof slabs.

Install sleeves for pipes passing through concrete and masonry walls, gypsum-board partitions, and concrete floor and roof slabs.

1. Cut sleeves to length for mounting flush with both surfaces.
 - a. Exception: Extend sleeves installed in floors of mechanical equipment areas or other wet areas 2" above finished floor level. Extend cast-iron sleeve fittings below floor slab as required to secure clamping ring if ring is specified.

Install sleeves in walls and slabs as walls and slabs are constructed.

Install sleeves that are large enough to provide 1/8" annular clear space between sleeve and pipe or pipe insulation. Use the following sleeve materials:

Steel Pipe Sleeves: For pipes smaller than 6' in diameter.

Steel Sheet Sleeves: For pipes 6" and larger, penetrating gypsum-board partitions.

Except for underground wall penetrations, seal annular space between sleeve and pipe or pipe insulation, using joint sealants appropriate for size, depth, and location of joint.

Aboveground, Exterior-Wall Pipe Penetrations: Seal penetrations using sleeves and mechanical sleeve seals. Select sleeve size to allow for 1" annular clear space between pipe and sleeve for installing mechanical sleeve seals.

Install steel pipe for sleeves smaller than 6' in diameter.

Install cast-iron "wall pipes" for sleeves 6" and larger in diameter.

Mechanical Sleeve Seal Installation: Select type and number of sealing elements required for pipe material and size. Position pipe in center of sleeve. Assemble mechanical sleeve seals and install in annular space between pipe and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

Fire-Barrier Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with fire-stop materials.

Refer to equipment specifications in other Sections of these Specifications for roughing-in requirements.

No installation shall be permitted which blocks or otherwise impedes access to any existing machine or system. Except as otherwise indicated, emergency switches and alarms shall be installed in conspicuous locations. All indicators, to include gauges, meters, and alarms shall be mounted in order to be easily visible by people in the area.

3.2 PIPING JOINT CONSTRUCTION

- A. Join pipe and fittings according to the following requirements and Division 15 Sections specifying piping systems.

Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.

Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.

Flanged Joints: Select appropriate gasket material, size, type, and thickness for service application. Install gasket concentrically positioned. Use suitable lubricants on bolt threads.

3.3 PIPING CONNECTIONS

Make connections according to the following, unless otherwise indicated:

Install unions, in piping 2" and smaller, adjacent to each valve and at final connection to each piece of equipment.

Install flanges, in piping 2 1/2" and larger, adjacent to flanged valves and at final connection to each piece of equipment.

Wet Piping Systems: Install dielectric nipple fittings to connect piping materials of dissimilar metals.

3.4 EQUIPMENT INSTALLATION - BASIC REQUIREMENTS

Install equipment to allow maximum possible headroom unless specific mounting heights are not indicated.

Install equipment level and plumb, parallel and perpendicular to other building systems and components in exposed interior spaces, unless otherwise indicated.

Install mechanical equipment to facilitate service, maintenance, and repair or replacement of components. Connect equipment for ease of disconnecting, with minimum interference to other installations. Extend grease fittings to accessible locations.

Install equipment to allow right of way for piping installed at required slope.

3.5 PAINTING

- A. Painting of mechanical systems, equipment, and components is specified in another Section "Painting".

Damage and Touchup: Repair marred and damaged factory-painted finishes with materials and procedures to match original factory finish.

3.6 CONCRETE FOUNDATIONS

Concrete Foundations: Anchor equipment to concrete base according to equipment manufacturer's written instructions and according to seismic codes at Project.

Construct concrete bases of dimensions indicated, but not less than 4" larger in both directions than supported unit.

Install dowel rods to connect concrete base to concrete floor.
Unless otherwise indicated, install dowel rods on 18" centers around the full perimeter of the base.

Install epoxy-coated anchor bolts for supported equipment that extend through concrete base, and anchor into structural concrete floor.

Place and secure anchorage devices. Use supported equipment manufacturer's setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.

Install anchor bolts to elevations required for proper attachment to supported equipment.

Install anchor bolts according to anchor-bolt manufacturer's written instructions.

Equipment bases and foundations, when constructed of concrete or grout, shall cure a minimum of 28 days, or 14 days, as specified, before being loaded.

3.7 GROUTING

Mix and install grout for mechanical-equipment base bearing surfaces, pump and other equipment base plates, and anchors.

Clean surfaces that will come into contact with grout.

Provide forms as required for placement of grout.

Avoid air entrapment during placement of grout.

Place grout, completely filling equipment bases.

Place grout on concrete bases and provide smooth bearing surface for

equipment.

Place grout around anchors.

Cure placed grout.

END OF SECTION AB050

SECTION AB055 - MOTORS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

This Section includes basic requirements for factory-installed and field-installed motors.

Related Sections include the following:

Division 15 Sections for application of motors and reference to specific motor requirements for motor-driven equipment.

1.3 DEFINITIONS

- A. Factory-Installed Motor: A motor installed by motorized-equipment manufacturer as a component of equipment.

Field-Installed Motor: A motor installed at Project site and not factory installed as an integral component of motorized equipment.

1.4 QUALITY ASSURANCE

Testing Agency Qualifications: An independent agency, acceptable to authorities having jurisdiction, with the experience and capability to conduct the testing indicated, as documented according to ASTM E 548.

Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

1.5 COORDINATION

Coordinate features of motors, installed units, and accessory devices. Provide motors that are: and features that comply with the following:

Compatible with the following:

Magnetic controllers.

Multi-speed controllers.

Reduced-voltage controllers.

Variable Frequency Drive (VFD)

Designed and labeled for use with variable frequency controllers, and suitable for use throughout speed range without overheating.

Matched to torque and horsepower requirements of the load.

Matched to ratings and characteristics of supply circuit and required control sequence.

PART 2 - PRODUCTS

2.1 MOTOR REQUIREMENTS

Motor requirements apply to factory-installed motors except as follows:

Different ratings, performance, or characteristics for motor are specified in another Equipment Selection.

Manufacturer for a factory-installed motor requires ratings, performance, or characteristics, other than those specified in this Section, to meet performance specified.

2.2 MOTOR CHARACTERISTICS

- A. Voltage Rating: NEMA standard voltage selected to operate on nominal circuit voltage to which motor is connected.

Service Factor: 1.15 for open drip proof motors; 1.0 for totally enclosed motors.

Duty: Continuous duty at ambient temperature of 40 deg C and at same altitude as where the installation is to occur. In case of AHU motor the ambient temperature is 60 C if motor is installed inside the AHU.

Capacity and Torque Characteristics: Sufficient to start, accelerate, and operate connected loads at designated speeds, at installed altitude and environment, with indicated operating sequence, and without exceeding nameplate ratings or considering service factor.

Enclosure: Open drip proof.

2.3 POLYPHASE MOTORS

- A. Stator: Copper windings, unless otherwise indicated.

1. Multi-speed motors shall have separate winding for each speed.

Rotor: Squirrel cage, unless otherwise indicated.

Bearings: Double-shielded, pre-lubricated ball bearings suitable for radial and thrust loading.

Temperature Rise: Match insulation rating, unless otherwise indicated.

Code Letter Designation:

Motors 1.5 HP and Larger: NEMA starting Code F or Code G.

Motors Smaller Than 15 HP: Manufacturer's standard starting characteristic.

Enclosure: Cast iron for motors 7.5 hp and larger; rolled steel for motors smaller than 7.5 hp.

Finish: Gray enamel.

2.4 POLYPHASE MOTORS WITH ADDITIONAL REQUIREMENTS

Motors Used with Reduced-Inrush Controllers: Match wiring connection requirements for controller with required motor leads. Provide terminals in motor terminal box, suited to control method.

Motors Used with Variable Frequency Controllers: Ratings, characteristics, and features coordinated with and approved by controller manufacturer.

Designed with critical vibration frequencies outside operating range of controller output.

Temperature Rise: Matched to rating for Class B insulation.

Insulation: Class H.

Thermal Protection: Comply with NEMA MG 1 requirements for thermally protected motors.

Rugged-Duty Motors: Totally enclosed, with 1.25 minimum service factors, greased bearings, integral condensate drains, and capped relief vents. Windings insulated with non-hygroscopic material.

Source Quality Control for Field-Installed Motors: Perform the following tests on each motor according to NEMA MG 1:

Measure winding resistance.

Read no-load current and speed at rated voltage and frequency.

Measure locked rotor current at rated frequency.

Perform high-potential test.

Alignment.

2.5 SINGLE-PHASE MOTORS

Type: One of the following, to suit starting torque and requirements of specific motor application:

Permanent-split capacitor.

Split-phase start, capacitor run.

Capacitor start, capacitor run.

Shaded-Pole Motors: For motors 1/20 hp and smaller only.

Thermal Protection: Internal protection to automatically open power supply circuit to motor when winding temperature exceeds a safe value calibrated to temperature rating of motor insulation. Thermal-protection device shall automatically reset when motor temperature returns to normal range.

Bearings: Ball type for belt-connected motors and other motors with high radial forces on motor shaft; sealed, pre-lubricated-sleeve type for other single-phase motors.

Source Quality Control for Field-Installed Motors: Perform the following tests on each motor according to NEMA MG 1:

Measure winding resistance.

Read no-load current and speed at rated voltage and frequency.

Measure locked rotor current at rated frequency.

Perform high-potential test.

PART 3 – EXECUTION

3.1 FIELD QUALITY CONTROL FOR FIELD-INSTALLED MOTORS

A. Prepare for acceptance tests as follows:

Run each motor with its controller. Demonstrate correct rotation, alignment and speed at motor design load.

Test interlocks and control features for proper operation.

Verify that current in each phase is within nameplate rating.

Testing: Perform the following field quality-control testing:

Perform each electrical test and visual and mechanical inspection stated in NETAATS, Section 7.15.1. Certify compliance with test parameters.

Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.

3.2 ADJUSTING

Align motors, bases, shafts, pulleys and belts. Tension belts according to manufacturer's written instructions.

3.3 CLEANING

- A. After completing equipment installation, inspect unit components. Remove paint splatters and other spots, dirt, and debris. Repair damaged finish to match original finish.

END OF SECTION AB055

SECTION AB060 - HANGERS AND SUPPORTS PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

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

1.3 PERFORMANCE REQUIREMENTS

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

Design seismic restraint hangers and supports for piping and equipment.

PART 2 - EXECUTION

2.1 HANGER AND SUPPORT APPLICATIONS

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

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

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

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

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

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

2.2 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.

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.

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.

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

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

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.

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

2.3 EQUIPMENT SUPPORTS

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

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

2.4 METAL FABRICATION

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.

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

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

Obtain fusion without undercut or overlap.

Remove welding flux immediately.

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

2.5 ADJUSTING

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

END OF SECTION AB060

SECTION AB081 - DUCT INSULATION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

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

1.3 QUALITY ASSURANCE

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

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

1.4 DELIVERY, STORAGE, AND HANDLING

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

1.5 COORDINATION

- A. Coordinate clearance requirements with duct Installer for insulation application.

1.6 SCHEDULING

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

PART 2 - PRODUCTS

2.1 INSULATION MATERIALS

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

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

2.2 ACCESSORIES AND ATTACHMENTS

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

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

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

Nylon bands

Galvanized Steel: 0.13 mm thick.

Aluminum: 0.18 mm thick.

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

PART 3 - EXECUTION

3.1 EXAMINATION

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

Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

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

3.3 GENERAL APPLICATION REQUIREMENTS

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

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

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

Seal joints and seams with aluminum foil tape.

Keep insulation materials dry during application and finishing.

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

Apply insulation with the least number of joints practical.

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

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

Apply insulation with integral jackets as follows:

Pull jacket tight and smooth.

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

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

Install vapor-retarder mastic on ducts and plenums.

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

mastic to maintain vapor-retarder seal.

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

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

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

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

3.4 DUCT SYSTEM APPLICATIONS

Refer to insulation schedules on drawings for materials and thickness.

END OF SECTION AB081

SECTION AB083 - PIPE INSULATION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This Section includes preformed, rigid and flexible pipe insulation; insulating cements; field-applied jackets; accessories and attachments; and sealing compounds.

Related Sections include the following:

Division 15 Section "Duct Thermal Insulation" for insulation for ducts and plenums.

Division 15 Section "Equipment Insulation" for insulation materials and application for pumps, tanks, hydronic specialties, and other equipment.

Division 15 Section "Hangers and Supports" for pipe insulation shields and protection saddles.

1.3 QUALITY ASSURANCE

Energy Conservation: Hot and Chilled water piping shall be insulated to meet energy conservation requirements of 10 CFR 434.

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

1.4 DELIVERY, STORAGE, AND HANDLING

Packaging: Insulation shall be packed in cartons and shall be stored properly in an environment that it shall not be affected from water and sun. Proper stacking shall be made.

1.5 COORDINATION

- A. Coordinate size and location of supports, hangers, and insulation shields specified in Division 15 Section

Use wooden saddles of same thickness as of insulation at the place of hangers and supports. The minimum length of wooden sleeves shall be 4 inches for pipes up to 2 inch diameter and 6 inches for pipes above 2 inch diameter.

Coordinate clearance requirements with piping Installer for insulation application.

Coordinate installation and testing of electric heat tracing.

1.6 SCHEDULING

- A. Schedule insulation application after testing piping systems and, Insulation application may begin on segments of piping that have satisfactory test results.

PART 2 - PRODUCTS

2.1 INSULATION MATERIALS

For chilled hot water piping use preformed fiber glass insulation pipe, 64 kg/cu m density, bonded with reinforced aluminum foil jacket manufactured from kraft paper, reinforcing scrim, aluminum foil, and vinyl film.

For condensate drain piping use preformed polystyrene pipe or high density closed cell foam insulation, fire retardant type.

2.2 FIELD-APPLIED JACKETS

Apply 08 oz per sq yard canvas cloth over pipe insulation of all types with approved adhesive on 100% area of insulation.

Apply 02 coats of Foster USA sealant over canvas cloth.

Further cover all the insulation with GI sheet Cladding where ever insulated.

PART 3 – EXECUTION

- A. All piping shall be insulated with glass fibber insulation having a thermal conductivity not greater than 0.24 Btu/in/sq ft/°F in a mean temperature of 75°F. and minimum density of 64 kg/m³ all pipe

insulation shall have a factory applied all service jacket consisting of white Kraft paper on the outside and reinforced aluminum foil on the inside.

All above ground piping up to 2" diameter shall be insulated with 1" thick insulation, and piping above 2" in diameter shall be insulated with 2" thick insulation.

All longitudinal and transverse joints shall be covered with 3" wide aluminum foil tape. Tape shall be of same material as foil jacket over insulation. Insulation shall be continuous and there should be no gaps in insulation.

Insulation shall be further jacketed with 08 oz/sq yd. canvas cloth, to be applied with approved adhesive on 100% area. All joints shall be overlapped at least 3"

Over canvas jacket provide 2 coats of FOSTER USA sealant.

All insulated piping exposed shall be further cladded with 26 gauge GI sheet. At all flanges and valves cladding shall be open end type, valves shall be provided with clamps for quick opening.

No insulation shall be applied on piping unless all foreign materials have been removed, and same has been hydrostatically tested for leakages, and test reports have been signed by the Engineer.

All valves and fittings, except as noted below, shall be insulated with fabricated mitered segments of pipe insulation or pre-molded segments of a thickness equal to that of the insulation on the adjoining pipe. Fittings on any hot water piping may be insulated with insulation cement of thickness equal to the adjoining pipe insulation. Insulating cement shall be given a 1/4" smoothing coat. All valves and fittings shall be finished with a pre-sized glass cloth and coated with a fire resistant adhesive.

Except as otherwise specified, fittings, flanges and valves shall be insulated and finished in same manner and same thickness as piping in which installed.

For all fittings in vapour sealed piping, apply same vapour barrier finish as specified for fittings in exposed piping.

All drain piping shall be insulated with 1" thick preformed fire retardant closed cell foam insulation, with standard application practice.

Insulation shall be further jacketed with 08 oz/sq yd. canvas cloth, to be applied with approved adhesive on 100% area. All joints shall be overlapped at least 2”

3.1 PREPARATION

Surface Preparation: Clean and dry pipe and fitting surfaces. Remove materials that will adversely affect insulation application.

3.2 GENERAL APPLICATION REQUIREMENTS

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

Refer to schedules on the drawings for materials, forms, jackets, and thicknesses required for each piping system.

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

Apply insulation with longitudinal seams at top and bottom of horizontal pipe runs.

Do not weld brackets, clips, or other attachment devices to piping, fittings, and specialties.

Keep insulation materials dry during application and finishing.

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

Apply insulation with the least number of joints practical.

Apply insulation continuously through hangers and around anchor attachments.

3.3 PIPING SYSTEM APPLICATIONS

A. Insulation materials and thicknesses are specified on Insulation Schedule.

END OF SECTION AB083

SECTION AB122 – METERS AND GAUGES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

All instruments including thermometers pressure gauges, thermometer wells, gauge cocks, and all the items related to flow switches, shall cover supply and installation complete in all respects as approved by the Consultant.

1.3 PIPE THERMOMETERS

Pipe thermometers shall be adjustable angle type with 9” scale case. 3~5” insertion sensor lengths with ¾” separable brass sockets

Case shall be aluminum die cast type; window shall be clear acrylic plastic or double strength glass, held in place with removable stainless steel caps.

Tube shall be lens front with red appearing mercury tube

Scales shall be on white background with black embossed figures and markings, both in centigrade and Fahrenheit, of one degree graduation

Thermometer wells shall be suitable for mounting on pipelines. Wells on insulated pipe line shall be provided with extension sockets compatible with insulation thickness

Thermometers shall be installed wherever shown on the drawings. Installation shall be done as per manufacturer’s recommendations.

The range of these thermometers shall be suitable for fluid being served.

All thermometers, pressure gauges shall be made of Ashcroft, Weiss, Terrace USA or approved equal.

1.4 PRESSURE GAUGES

Dial of pressure gauge shall be at least 4” in diameter

Range should be double of operating pressure

Graduation shall be both in psi and kg/cm²

Each gauge shall be provided with gauge cock.

Case shall be of case aluminum black finish.

Chrome plated ring shall be close type.

Dial shall be white with embossed one degree graduation.

Pointer shall be black with red tip.

Bourdon tube shall be phosphor bronze type.

Socket shall be of forged brass.

Accuracy shall be 1% of scale range.

These shall be installed as shown on drawings.

Gauges shall be screwed that there shall be no leakage.

Dials shall be aligned for convenient reading.

END OF SECTION AB122

SECTION AB131 – ELECTRICALLY OPERATED AIR COOLED WATER CHILLER

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

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

Furnish all labour, materials, plant, and equipment and perform all necessary operations required to execute the work of this section.

Materials and equipment to be provided shall be from the specified manufacturer and shall conform the data provided in equipment schedule. The manufacturer shall be regularly engaged in the manufacturing such type of products since at least 10 years.

1.3 SUBMITTALS

After the award of contract the Contractor shall submit the technical submittal for Electrically Operated Air Cooled Chiller. In selection of Air Cooled Chiller Contractor shall ensure the proper installation of these Chillers in the allocated space.

1.4 QUALITY ASSURANCE:

Manufacturer's Qualifications: Firms regularly engaged in manufacture of Air Cooled Chiller, of types and capacities required, whose products have been in satisfactory use in similar service for not less than 10 years.

Codes and Standards:

Testing and rating of Air Cooled Chiller units shall be in accordance with ARI 360 "Standard for Commercial and Industrial Unitary Air-Conditioning Equipment".

Refrigerating system construction of Air Cooled Chiller units shall be in accordance with ASHRAE 15 "Safety Code for Mechanical Refrigeration".

Air Cooled Chiller units shall be designed, manufactured, and tested in accordance with UL requirements.

All air cooled chillers shall be inverter type

1.5 DELIVERY, STORAGE, AND HANDLING:

Handle Air Cooled Chiller units and components carefully to prevent damage. Replace damaged parts or components with new.

Air Cooled Chiller units and components in clean dry place, off the ground and protect from weather, water, and physical damage.

Rig Air Cooled Chiller units to comply with manufacturer's rigging and installation instructions for unloading rooftop units, and moving them to final location.

1.6 SCHEDULING AND SEQUENCING:

Coordinate installation of roof mounting with structure.

Coordinate locations and for mechanical and electrical connections.

PART 2 – PRODUCTS

2.1 AIR COOLED CHILLER

Electrically Operated Air Cooled Chiller shall be packaged type, fully equipped with all the accessories and shall be ready for operation while connecting water piping, and electric connections.

The selection of Air Cooled Chiller shall be carried out on the basis of technical specifications and data given in schedule, but not limited to the information given. Additional parameters shall also be considered in selection of the machine if found suitable in the opinion of the Consultant. Available Manufacturers: Subject to compliance with incorporated in the work include, but are limited to as specified in List of Approved manufacturers.

General Description; Units shall be factory-assembled and tested, designed for installation, and consisting of compressors, condensers, Shell & Tube type or Plate type evaporator, condenser fans, refrigeration and temperature controls. Chilled water re-circulating pump and expansion tank. Capacities and electrical characteristics are scheduled in the Equipment Selection Data.

Casing: manufacturer's standard casing construction, having corrosion protection coating, and exterior finish. Casings shall have removable panels or access doors for inspection and access to internal parts, a minimum of 40 mm thick thermal insulation, shall be provided on evaporator, knockouts for electrical and piping connections and an exterior condensate drain connection and lifting lugs.

Evaporator shall be shell and tube type or plate type, provided with insulation and cladding. It shall be tested at a pressure not less than

 Psig. It shall be provided with water inlet and outlet and drain connections.

Condenser fans: propeller-type, direct-driven fans with permanently lubricated bearings. Outdoor fans shall discharge upwards.

Coils:

 General: Aluminum plate fin and seamless copper tube type. Fins shall have collars drawn, belled and firmly bonded to the tubes by means of mechanical expansion of the tubes. No soldering or tinning shall be used in the bonding process. Coils shall have a galvanized steel casing. Coils shall be mounted in the coil casing with same end connections accessible for service. Coils shall be removable from the unit through the roof or through the piping enclosure. Coil section shall be completely insulated.

Compressors: serviceable, semi-hermetic, or fully hermetic compressors, Screw type or approved equal, complete with integral vibration isolators and crankcase heaters. Compressors shall be preferred of the same manufacture as unit. Compressor warranty shall be 5 Year (Free of Cost).

Safety controls: manual reset type for:

- Low pressure cut-out;
- High pressure cut-out;
- Compressor motor overload protection;
- Loss of charge.
- Anti-freeze thermostat
- Chilled water temperature controller

Control Panel: the air cooled chiller shall be provided with integral operational panel, including all safeties, indications lamps and controls.

Chilled Water Re-circulating Pump: Integral chilled water re-circulating pump shall be enclosed in casing. Pump shall be suitable to deliver the required amount of water at specified head. Pump shall be centrifugal

type with mechanical seals. Pump shall be complete with drive electric motor, starters and controls.

Expansion Tank: Chiller shall be provided with an integral expansion tank to accommodate the expansion and contraction of water. The size of expansion tank shall be sufficient to meet the requirements of water contained in connected piping and equipment's. Expansion tank shall be constructed with ASME standards and shall be suitable to operate at 100 psig working pressure and 150 test pressure. Expansion tank shall be provided with safety relief valve to provide safety against over pressure.

Capacity control: The unit should be provided automatic capacity control system, and could operate from 0% to 50% to 100% capacity, with optimum energy inputs.

PART 3 – EXECUTION

3.1 EXAMINATION:

Examine areas and conditions under which Air Cooled Chiller are to be installed. Do not proceed with work until unsatisfactory conditions have been corrected in manner acceptable to Installer. Prepare proper concrete foundations as indicated in the drawings.

3.2 INSTALLATION:

General: Install Air Cooled Chiller in accordance with manufacturer's installation instructions. Install units plumb and level, firmly anchored in locations indicated, and maintain manufacturer's recommended clearances.

FOUNDATIONS:

The Air Cooled Chiller units shall have spread type foundation, which shall be raised 6" above the floor and shall be made with reinforced concrete construction capable of bearing the load of machine. The top R.C.C footings to be at least 6" larger on each side

The unit shall be installed on a level foundation with spring type Isolation pad to avoid the transmission of vibration to the structure.

Electrical Connections: Refer to Section Electrical Works for final connections to equipment and installation of loose shipped electrical components.

3.3 DEMONSTRATION:

A, Start-Up Services:

Provide the services of a factory-authorized service representative to start-up air cooled chiller, in accordance with manufacturer's written start-up instructions. Test controls and demonstrate compliance with requirements. Replace damaged or malfunctioning controls and equipment.

Make the chilled water piping connections as recommended by the manufacturer and shown in the drawings.

Operating and Maintenance Training:

Provide services of manufacturer's service representative to instruct Owner's personnel in operation and maintenance of Air Cooled Chiller. Training shall include start-up and shut-down, servicing and preventative maintenance schedule and procedures, and troubleshooting procedures plus procedures for obtaining repair parts and technical assistance. Review operating and maintenance data contained in the Operating and Maintenance Manuals specified.

Pre-Shipment Inspection:

The Contractor shall make all the arrangements like visa, tickets, boarding and lodging conveyance etc for Client and consultant for the pre-shipment inspection. Contractor shall inform at least six weeks before the date of inspection. No separate payment shall be made to the Contractor for the Pre-shipment inspection; Contractor shall include its price in the quote of chillers

Following tests on full load shall be carried out at factory, and log sheets shall be verified by the Client and Consultant prior to the shipment of the equipment.

- Chilled Water Inlet temperature
- Chilled Water Outlet temperature
- Chilled Water Flow Rate
- Chilled Water pressure Drop
- Cooling Air Inlet temperature
- Cooling Air Outlet temperature
- Functioning of all Safeties and Controls etc.

Packing

Prior to the shipment of equipment the Air Cooled Chiller shall be packed in wooden box, before wooden packing it shall be covered with some suitable material to protect it from weather effects. The wooden crate shall be closed from all sides, and shall be constructed with heavy wooden rafters and planks. The crate shall be provided with

suitable arrangements for its lifting during shipment, loading and unloading

3.4 Commissioning:

Air Cooled Chiller shall be factory charged with refrigerant and shall be commissioned by the manufacturer's authorized representative. And all the commissioning reports shall be submitted to the Consultant.

END OF SECTION AB131

SECTION AB137 - CENTRIFUGAL FANS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This Section includes centrifugal fans of all types either used for ventilation or for the supply of fresh air.

1.3 PERFORMANCE REQUIREMENTS

Project Altitude: Base air ratings on actual site elevations.

Operating Limits: Classify according to AMCA 99.

All fans shall be suitable for outdoor installations.

Motors and other parts shall be provided with cover for protection against weather conditions

1.4 QUALITY ASSURANCE

- A. AMCA Compliance: Products shall comply with performance requirements AMCA-Certified Ratings.
- B. NEMA Compliance: Motors and electrical accessories shall comply with NEMA standards.

1.5 DELIVERY, STORAGE, AND HANDLING

- A. Deliver fans as complete factory-assembled units, to the extent allowable by transportation limitations, with protective crating and covering.

Disassemble and reassemble units, as required for moving to the final location, according to manufacturer's written instructions.

Lift and support units with manufacturer's designated lifting or supporting points.

1.6 COORDINATION

- A. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork as required.
- B. Coordinate installation of roof curbs, equipment supports, and roof penetrations with civil contractor and other services.

1.7 EXTRA MATERIALS

Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

Belts: One set for each belt-driven unit.
Vibration Isolators for each fan

PART 2 - PRODUCTS

2.1 MANUFACTURED UNITS

Description: Factory-fabricated, -assembled, -tested, and -finished, belt-driven centrifugal fans consisting of housing, wheel, fan shaft, Belts bearings, motor and disconnect switch, drive assembly, and support structure

Fan and motor balance shall conform to ISO Std. 1940/1 - (1986) Balance Quality Requirements of Rigid Rotors - Determination of Permissible Residual Unbalance unless otherwise noted. Motor vibration levels shall conform to NEMA MG-1, Motor and Generators, Part 7 unless otherwise noted.

Dynamically balance at the factory to ISO 1940/1 - 1986, G6.3, G2.4, or G1.0 as specified.

2.2 HOUSINGS

Materials and Fabrication: Formed and reinforced steel panels to make curved scroll housings with shaped cutoff, spun-metal inlet bell, and doors or panels to allow access to internal parts and components.

Panel Bracing: Steel angle- or channel-iron member supports for mounting and supporting fan scroll, wheel, motor, and accessories.

Horizontal Flanged Split Housing: Bolted construction.

Plug Fans: Fabricate without fan scroll and volute housing, with steel cabinet.

Tubular Centrifugal Fans: Fabricate tubular housing from formed and reinforced steel panels with welded seams and the following:

Outlet guide vanes.

Motor and disconnect switch.

Spun inlet cone with flange.

Outlet flange.

Brackets suitable for horizontal or vertical mounting.

B. Coatings: Powder-baked enamel or as approved by Consultant.

2.3 WHEELS

Backward-Inclined Fan Wheels: Steel construction with curved inlet flange, back plate, backward-inclined blades welded or riveted to flange and back plate; cast-iron or cast-steel hub riveted to back plate and fastened to shaft with set screws. All fans above 10,000 CFM shall be backward curved.

Forward-Curved Fan Wheels: Black-enameled or galvanized steel construction with inlet flange, back plate, shallow blades with inlet and tip curved forward in direction of airflow, mechanically secured to flange and back plate; cast-steel hub swaged to back plate and fastened to shaft with set screws.

Wheel shall be statically and dynamically balanced to ISO 1940/1-1986, G6.3, G2.5, or G1.0 as specified.

2.4 SHAFTS

A. Statically and dynamically balanced and selected for continuous operation at maximum rated fan speed and motor horsepower, with final alignment and belt adjustment made after installation.

Turned, ground, and polished hot-rolled steel with keyway. Ship with a protective coating of lubricating oil.

Designed to operate at no more than 70 percent of first critical speed at top of fan's speed range.

2.5 BEARINGS

Pre-lubricated and Sealed Shaft Bearings: Self-aligning, pillow-block-type ball bearings.

Ball-Bearing Rating Life: ABMA 9, L of 50,000 hours.

Roller-Bearing Rating Life: ABMA 11, L of 50,000 hours.

When possible, the use of sealed bearings is encouraged. Bearings shall have a certified AFBMA 9 or AFBMA 11, L minimum life expectancy rating of 30,000, 40,000, 50,000 or 80,000 hours as specified under load conditions the service will impose.

2.6 BELT DRIVES

Description: Factory mounted, with final alignment and belt adjustment made after installation.

Service Factor Based on Fan Motor: 1.5.

Fan Pulleys: Cast iron or cast steel with split tapered bushing; dynamically balanced at factory.

Motor Pulleys: Variable pitch.

Belts: Oil resistant, non-sparking, and non-static; matched sets for multiple belt drives.

Belt Guards: Fabricate to comply with OSHA and SMACNA requirements; 2.7-mm-thick, 20-mm diamond-mesh wire screen welded to steel angle frame or equivalent, prime coated. Secure to fan or fan supports without short circuiting vibration isolation. Include provisions for adjustment of belt tension, lubrication, and use of tachometer with guard in place.

Motor Mount: Adjustable for belt tensioning.

2.7 ACCESSORIES

Scroll Access Doors: Shaped to conform to scroll, with quick-opening latches and gaskets.

Companion Flanges: Galvanized steel, for duct connections.

Inlet Screens: Galvanized steel welded grid screen.

Scroll Drain Connection: DN 25 steel pipe coupling welded to low point of fan scroll.

Shaft Cooler: Metal disk between bearings and fan wheel, designed to dissipate heat from shaft.

Shaft Seals: Airtight seals installed around shaft on drive side of single-

width fans.

2.8 MOTORS

- A. Refer to Division 15 Section "Motors" for general requirements for factory-installed motors.

Motor Construction: NEMA MG 1, general purpose, continuous duty, high efficiency, Design B.

Enclosure Type: Open drip-proof.

Electrical Requirements: Ability to open and/or remove access covers is required for maintenance activities.

2.9 SOURCE QUALITY CONTROL

Sound-Power Level Ratings: Comply with AMCA 301, "Methods for Calculating Fan Sound Ratings from Laboratory Test Data." Factory test fans according to AMCA 300, "Reverberant Room Method for Sound Testing of Fans." Label fans with the AMCA-Certified Ratings Seal.

Fan Performance Ratings: Establish flow rate, pressure, power, air density, speed of rotation, and efficiency by factory tests and ratings according to AMCA 210, "Laboratory Methods of Testing Fans for Rating."

PART 3 - EXECUTION

3.1 INSTALLATION

Install centrifugal fans level and plumb.

Secure vibration controls to concrete bases using anchor bolts cast in concrete base Support floor-mounting units.

Install floor-mounting units on concrete bases designed to withstand, without damage to equipment, Concrete, reinforcement, and formwork requirements as specified by the Consultant.

Support suspended units from structure using threaded steel rods and spring hangers. Vibration-control devices are specified by the Consultant.

Install units with clearances for service and maintenance.

Install vibrations isolators on all grouting points to avoid the transmission of vibration to the structure.

3.2 CONNECTIONS

Duct installation and connection requirements are specified in other Division 15 Sections. Drawings indicate general arrangement of ducts and duct accessories. Make final duct connections with flexible connectors. Flexible connectors are specified in Division 15 Section "Duct Accessories."

Install ducts adjacent to fans to allow service and maintenance.

Ground equipment.

Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.

3.3 FIELD QUALITY CONTROL

Field Quality Control: Provide the services of a factory-authorized service representative to supervise the field assembly of components and installation of fans, including duct and electrical connections, alignment of fan shaft and motor shaft, alignment of pulleys, belt adjustments, and lubrication, and to report results in writing.

Acceptance Tests: Specifies the type and characteristics of the vibration analyzer the Contractor shall use. Final test reports shall be provided to the Consultant.

Equipment Startup Checks:

Verify that shipping, blocking, and bracing are removed.

Verify that unit is secure on mountings and supporting devices and that connection to ducts and electrical components are complete. Verify that proper thermal-overload protection is installed in motors, starters, and disconnect switches.

Verify that cleaning and adjusting are complete.

Disconnect fan drive from motor, verify proper motor rotation direction, and verify fan wheel free rotation and smooth bearing operation. Reconnect fan drive system, align and adjust belts, and install belt guards.

Verify lubrication for bearings and other moving parts.

Verify that manual and automatic volume control and fire and smoke dampers in connected ductwork systems are in fully open

position.

Starting Procedures:

Energize motor and adjust fan to indicated rpm.

Measure and record motor voltage and amperage.

Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation. Remove malfunctioning units, replace with new units, and retest.

Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

Shut unit down and reconnect automatic temperature-control operators.

Refer to Division 15 Section "Testing, Adjusting, and balancing" for testing, adjusting, and balancing procedures.

Replace fan and motor pulleys as required to achieve design airflow.

Repair or replace malfunctioning units. Retest as specified above after repairs or replacements are made.

3.4 ADJUSTING

Adjust damper linkages for proper damper operation.

Adjust belt tension.

Lubricate bearings.

3.5 CLEANING

- A. On completion of installation, internally clean fans according to manufacturer's written instructions. Remove foreign material and construction debris. Vacuum fan wheel and cabinet.

After completing system installation, including outlet fitting and devices, inspect exposed finish. Remove burrs, dirt, and construction debris and repair damaged finishes.

3.6 DEMONSTRATION

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

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

END OF SECTION AB137

SECTION AB150 - AIR HANDLING UNITS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

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

1.3 QUALITY ASSURANCE

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

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."

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.

Comply with NFPA 70.

The Air Handling Units shall be designed for hygienic applications for hospitals

1.4 COORDINATION

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

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

1.5 EXTRA MATERIALS (SPARES)

A. Furnish extra materials described below that match products installed

and that are packaged with protective covering for storage and identified with labels describing contents.

Fan Drive Belts: one set for each AHU

1.6 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

2.1 AIR HANDLING UNITS

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.

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.

The basic units shall consist of main frame, casing, fan section, condensate drain-pan, cooling-heating coils, filter section, fan, drive motor and pulleys, vibration isolators, service lock, internal service light, sight glass, controls and all the necessary accessories as required

Air-handling units shall be factory assembled and consist of fans, high efficiency VFD motor and drive assembly, coils, damper, plenums, filters, stainless steel condensate pans, and accessories as specified.

2.2 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.

2.3 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, 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 air tight at low and high pressure, units to be installed open to weather shall be weather proof 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.

2.4 FANS

Each Air handling Unit shall be provided with centrifugal type fan(s), all fans shall be full width, double inlet, 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, fans above 10,000 cfm shall be backward curved type. Fan inlets shall be aerodynamically designed having bell mouth type inlet nozzles. The impeller blades shall be galvanized steel finish for forward curved fans and epoxy painted steel for backward curved, and shall be securely fixed to the straight shaft. Fan shafts shall be made with carbon steel (C45) grade. Fans shall not pass through their first critical speed at any catalogue RPM. The fans shall be suitable to operate with in temperature limits from -20°C to 85°C

All fans shall be provided with spring type 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.

Fans and drive shall be mounted on a framework isolated through vibration isolators and a flexible connection at fan discharge. V-belt drives shall be designed for 50 percent over-load capacity. All fan drive shall be provided with variable pitch, suitable for an adjustment of +/-5% of specified rpm.

The Fan bearings shall be block type self-aligning ball journals and split block with grease points provided outside the unit, and permanently sealed and pre-lubricated. The bearings shall have an average life L-50, of up to 200,000 hrs. Fan shall be selected for quiet operation, fan

outlet velocity not to exceed 1800 fpm in any case, to be connected to the ducting with short flexible collars as specified. All the fans shall be so selected that fan speed shall not exceed from 1000 rpm

2.5 FAN DRIVE MOTOR

The fan drive motors shall be mounted integral to an isolated fan assembly furnished by the unit manufacturer. Motors shall be mounted on a sliding base inside the unit casing to permit adjustment of drive belts tension. The unit shall be provided with electric motor and starter, V-belt drive and variable pitch pulley to adjust fan speed. Motors up to and including ½ hp shall be 230/1/50 motors larger than ½ hp shall be 400/3/50. The electric motor shall be induction motor, squirrel cage, totally enclosed fan cooled with IP54 protection with class F insulation and suitable for operation at an ambient temperature of not less than the hot water supply temperature to the AHU, otherwise the motors to be fitted outside the AHU casing. Electric motors shall conform to the current characteristics as required and shall be provided with thermal overload protection. All AHU motors shall be VFD compatible and shall not overheat at any frequency as specified.

2.6 FILTERS

The air handling units shall be provided with Pre Filters and Bag Filters, and shall be capable of providing 90% air filtrations. The pre-filter shall be cleanable type, the AHU shall have a separate filter section. Filters shall be accessible from both sides.

2.7 COOLING/HEATING COILS

The Contractor shall ensure proper selection of coils for required heat transfer and capacities given in Equipment Selection Data. The coils shall be removable without dismantling the unit. The water 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 5/8" outer diameter. Tabulators inside the coils shall not be acceptable. Coils shall be suitable for 32 to 220°F operating temperatures.

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, steel headers with flanges independent of size,

for connections at site. There shall be air vent on the top of the header and drain point at the bottom

2.8 DRAIN PAN

The Units shall be equipped with condensate drain pan, to discharge condensate quickly in order to reduce microbiological growth; 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.

2.8 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 air tight assembly at site

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.

2.10 SERVICE LIGHT

Each floor mounted air handling unit shall be provided with factory fitted weather resistant, vapour tight light 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.

2.11 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.

PART 3 - EXECUTION

3.1 EXAMINATION

Examine ducts, plenums, and units to receive air coils for compliance with requirements for installation tolerances and other conditions affecting coil performance.

Examine roughing-in for piping systems to verify actual locations of piping connections before coil installation.

Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

Install air handling units in level and plumb.

Install metal ducts and casings constructed according to the latest edition of SMACNA's "HVAC Duct Construction Standards, Metal and Flexible."

Concrete Bases: Install floor mounting units on 100-mm- high concrete bases. See Division 15 Section "Basic Mechanical Materials and Methods" for concrete base materials and fabrication requirements.

Install air-handling units with the vibration isolators. Floor-Mounted Units: Support on concrete bases using housed-spring isolators. Secure units to anchor bolts installed in concrete bases.

Arrange installation of units to provide access space around air-handling units for service and maintenance.

Make electrical, duct and pipe connections as specified in different sections.

3.3 CONNECTIONS

Piping installation requirements are specified in other Piping Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

Install piping adjacent to machine to allow service and maintenance.

Connect piping to air-handling units mounted on vibration isolators with flexible connectors.

Connect condensate drain pans using drain piping. Extend to nearest equipment or floor drain. Construct deep trap at connection to drain pan and install cleanouts at changes in direction.

Hot-and Chilled-Water Piping: Comply with applicable requirements in Piping Section. Connect to supply and return coil tapings with valves and union or flange at each connection as specified.

Duct installation and connection requirements are specified in other Sections. Drawings indicate general arrangement of ducts and duct

accessories. Make final duct connections with flexible connections.

Electrical: Comply with applicable requirements in Electrical Sections for power wiring, switches, and motor controls.

Ground equipment according to Electrical Section "Grounding and Bonding."

3.4 ADJUSTING

Adjust initial temperature and humidity set points.

Straighten bent fins on each air coil.

Verify condensate pan drainage and remove any obstructions in the drain line to insure proper drainage.

3.5 CLEANING

Clean air-handling units internally, on completion of installation, according to manufacturer's written instructions. Clean fan interiors to remove foreign material and construction dirt and dust. Vacuum clean fan wheels, cabinets, and coils entering air face.

After completing system installation and testing, adjusting, and balancing air-handling and air-distribution systems, clean filter housings and install new filters at commissioning for occupancy.

Clean coils using materials and methods recommended in writing by manufacturers, and clean inside of casings and enclosures to remove dust and debris.

3.6 STARTUP SERVICE

Engage a factory-authorized service representative to perform startup service.

Final Checks before Startup: Perform the following:

Verify that shipping, blocking, and bracing are removed.

Verify that unit is secure on mountings and supporting devices and that connection to piping, ducts, and electrical systems are complete. Verify that proper thermal-overload protection is installed in motors, starters, and disconnect switches.

Perform cleaning and adjusting specified in this Section.

Disconnect fan drive from motor, verify proper motor rotation direction, and verify free fan wheel rotation and smooth bearing

operations. Reconnect fan drive system, align belts, and install belt guards.

Lubricate bearings, pulleys, belts, and other moving parts with factory-recommended lubricants.

Set zone dampers to fully open position for each zone.

Set face-and-bypass dampers to full face flow.

Set outside- and return-air mixing dampers to minimum outside-air setting.

Comb coil fins for parallel orientation.

Install clean filters.

Verify that manual and automatic volume control and fire and smoke dampers in connected duct systems are in fully open position.

Starting procedures for air-handling units include the following:

Energize motor; verify proper operation of motor, drive system, and fan wheel. Adjust fan to indicated rpm (Not required if VFD installed). Replace fan and motor pulleys as required to achieve design conditions.

Measure and record motor electrical values for voltage and amperage.

Manually operate dampers from fully closed to fully open position and record fan performance.

Refer to Division 15 Section "Testing, Adjusting, and balancing" for air-handling system testing, adjusting, and balancing.

END OF SECTION AB150

SECTION AB151 - FAN-COIL UNITS

PART 1 – GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

This Section includes Fan Coil Units and accessories.

1.2 SUBMITTALS

Product Data: Include rated capacities, operating characteristics, furnished specialties, and accessories.

Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.

Wiring Diagrams: Power, signal, and control wiring.

Coordination Drawings: Floor plans, reflected ceiling plans, and other details, drawn to scale, on which the following items are shown and coordinated with each other, based on input from installers of the items involved:

Ceiling suspension components.

Structural members to which fan-coil units will be attached.

Method of attaching hangers to building structure.

Size and location of initial access modules for acoustical tile.

Items penetrating finished ceiling, including the following:

Lighting fixtures.

Air outlets and inlets.

Speakers.

Sprinklers.

Access panels.

Operation and Maintenance Data: For fan-coil units to include operation, and maintenance manuals. Maintenance schedules and repair part lists for motors, coils, integral controls, and filters.

1.3 QUALITY ASSURANCE

Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

Manufacturer Qualifications: Engage a firm experiences in manufacturing fan-coil units similar to those indicated for this Project and that have a record of successful in-service performance.

Comply with ASRHAE 440 for testing and rating units.

Comply with ASHRE 33 for testing coils.

1.4 COORDINATION

Coordinate layout and installation of fan-coil units and suspension system components with other construction that penetrates ceilings or is supported by them, including light fixtures, HVAC equipment, fire-suppression-system components, and partition assemblies.

PART 2 - PRODUCTS

2.1 CONFIGURATION

Horizontal Units: An assembly including cabinet, filter, chassis, coil, drain pan, fan, and motor in blow-through configuration with hydronic cooling/heating coil. Decorative 04 way cassettes with decorative plastic grills and condensate pump suitable for minimum 1 meter head

Fan and motor balance shall conform to ISO Std. 1940/1 – (1986) Balance Quality Requirements of Rigid Rotors – Determination of Permissible Residual Unbalance unless otherwise noted. Motor vibration levels shall conform to NEMA Specification MG-1, Motors and Generators, Part 7, unless otherwise noted.

Bearings: When possible the use of sealed bearings is encouraged.

2.2 MATERIALS

Chassis: Galvanized steel, with flanged edges.

Fire-Hazard Classification: Duct liner and adhesive shall have a maximum flame-spread rating of 25 and smoke-developed rating of 50 when tested according to ASTM E 84.

Drain Pans: Galvanized steel, with connection for drain. Drain pan shall have a removable plastic liner and be insulated with polystyrene, closed cell foam or polyurethane insulation. Drain pan and liner shall be formed to slope from all directions to drain connection.

Cabinet: Decorative plastic body as approved, if specified.

Horizontal Unit Bottom Panels: Fastened to unit with cam fasteners and hinge and attached with safety chain; with integral stamped grilles.

2.3 WATER COILS

Primary Coil: Copper tube, with mechanically bonded copper fins spaced no closer than 2.5 mm and with manual air vent. Coils shall be rated for a minimum working pressure of 250 psig and a maximum entering water temperature of 135° C.

All cooling coils must be piped counter-flow: the cooler water supplied on leaving airside; and warmer water on entering airside. The air velocity over the cooling coil not exceed 2.5 m/sec. Moisture carry over shall not be permitted. Stacked coils shall be provided with intermediate drain pans and separate drains to carry condensate to the main drain pan. Coil water flow velocity shall be sufficiently high enough to prevent laminar flow. Drain pans shall be of Galvanized steel and sloped to the drain.

2.4 FAN

Centrifugal, with forward-curved, double-width wheels and fan scrolls made of galvanized steel or thermoplastic material; directly connected to or V-belt driven from motor.

Fan shall be balanced dynamically and statically to ISO Std. 1940/1 at the factory, after assembly in unit.

The sound power level data values for all Fan Coil units shall be obtained in accordance with the test procedure specified in ARI Standard 443 based on ASHRAE Standard 36. The power sound values apply to these units provided with factory fabricated cabinet enclosures and standard size grilles.

2.5 FILTERS

Filters shall be provided for each unit and shall be of expanded aluminum permanent washable type, 0.5 inch (13mm) nominal thickness. Filter shall be removable without the use of tools.

2.6 FAN MOTORS

Motors for Direct-Drive Units: Shaded-pole or permanent-split capacitor, multi-speed (3-speed) motor with integral thermal-overload protection and resilient mounts.

Motors for Belt-Drive Units: Open drip proof with hinged mount and adjustable motor pulley.

Wiring Terminations: Match conductor materials and sizes of connecting power circuit. Connect motor to chassis wiring with plug connection.

2.7 CONTROL SYSTEMS

Two-Pipe, Valve Cycle with Cool/Heat: Wall-mounted thermostat, with hand-off-auto switch, and manual three fan-speed switch, thermometer and thermostat knob with setting point scale.

Cordless remote and thermostat provided by the manufacturer

Fan coil shall be provided with a junction box. The fan motor, electric valve, thermostat, OFF-HIGH-MEDIUM-LOW switch shall all be wired to the junction box, which shall be easily accessible

PART 3 - EXECUTION

3.1 EXAMINATION

Examine areas to receive fan-coil units for compliance with requirements for installation tolerances and other conditions affecting performance.

Examine roughing-in for piping and electrical connections to verify actual locations before fan-coil unit installation.

Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

Install fan-coil units in level and plumb.

Install fan-coil units to comply with NFPA 90A.

Suspend fan-coil units from structure with rubber-in-shear vibration isolators (rubber hangers). Vibration isolators are specified

Install wall-mounting thermostats and switch controls in electrical outlet boxes at heights to match lighting controls.

3.3 CONNECTIONS

Piping installation requirements are specified in other Piping Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

Unless otherwise indicated, install shutoff valve and union or flange at each connection.

Install piping adjacent to machine to allow service and maintenance.

Ground equipment.

Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.

3.4 FIELD QUALITY CONTROL

Testing: Perform the following field quality-control testing and report results in writing:

After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.

Test and adjust controls and safeties.

Repair or replace malfunctioning units. Retest as specified above after repairs or replacements are made.

4.0 COMMISSIONING & TESTING:

The unit shall be commissioned and tested as per the manufacturers recommendations. Drives shall be adjusted for the proper air flows, etc. The Contractor shall be required to carry out tests, on forms to be supplied later by the Consultant, and obtain approval.

END OF SECTION AB151

SECTION AB155 – CENTRIFUGAL

PUMPS PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

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

1.3 SUBMITTALS

After the award of contract the Contractor shall submit the technical submittal for pumps and approved pumps shall be tested at manufacturing facility before shipment. In selection of pumps Contractor shall ensure the proper installation of these pumps in the space allocated for pumps. This section shall cover all type of centrifugal pumps, like end suction top discharge, In-line and Booster Pumps.

1.4 CHILLED/HOT WATER PUMPS

Standard product Materials and equipment to be provided shall be the standard catalogue products of manufacturers regularly engaged in the manufacture of products conforming to these specifications, and shall essentially duplicate materials and equipment that have been in satisfactory use at least 10 years.

Prior to placement of purchase order for pumps the Contractor shall ensure the total required water flow and head is compatible with the other equipment's, being offered for installation.

No additional amount shall be paid to the Contractor for any increase/decrease in flow or head of the Chilled/Hot and Cooling water pumps in case if there is an increased capacity is required after the finalization of chillers air handling units and piping layout.

All Chilled/Hot and Cooling water Pumps shall be end-suction vertical discharge or split casing centrifugal type with casings designed for working pressure at least one and a half times the total pressure but not less than 150 psig for condenser water and Chilled Water Pumps. Flange connections shall correspond to casing working pressure.

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

Each pump shall be driven by a constant/variable speed motor through a flexible coupling. Motor horsepower shall be selected in a way that the motor shall not be overloaded at any point on the characteristic curves when operating at peak design speed. For variable speed application, the motor shall be suitable for operation with frequency converter without overheating.

Each pump shall be guaranteed to circulate not less than the quantity of water against the required circulating head when operating continuously, without overheating the motor or bearings, etc.

When more than one pump are required to operate in parallel, the pumps performance curves when operating in parallel shall be provided to show that required flow at the specified head will be obtained and electric motor will not be overloaded.

Pumps shall not transmit vibration to the building and shall operate without producing noise. Flexible connection shall be provided at pump suction and discharge.

All the pumps shall have cast iron casing, bronze impellers, stainless steel shaft and mechanical seals. These shall be directly connected by a flexible coupling to motor and integrally therewith on a common cast iron or steel base.

Pumps shall be designed for indicated capacities and head. There should be simple interchange of mechanical seal. Pumps shall have bronze renewable impeller and case wearing rings and closed impellers. Maximum impeller size shall not be more than 85% as large as the largest impeller that can be fitted in the pump casing.

Shaft shall be made of stainless steel and shall be provided with water slingers to protect motors.

The pump shall be suitable for circulation of water from 35 to 200 °F at safe working pressures.

The pump motor shall not over load in any condition shown in the performance curves.

Secondary chilled water pumps shall be variable frequency drive and shall operate at desired frequency.

For electric motors with pumps refer to section of AB055

1.5 FOUNDATIONS

Pump shall have block foundation with the block weight to be about 4 ½ times of pump assembly weight. The foundation shall be made of solid concrete placed on cork sheet for vibration elimination, details shown in the drawings.

1.6 ELECTRICAL INTERLOCK

Cooling Tower fans and pumps shall be interlocked with chillers so that Chiller shall not start unless condenser water pumps are in operation, similarly chillers shall be interlocked with chilled/hot water pumps so that chillers shall not start unless these water pumps are in operation. Furnish all required controls, relays and accessories.

1.7 INSTALLATION

- A. Pumps shall be installed on concrete foundations with cork sheet inside, as shown in drawings

Pumps shall be grouted on these concrete foundations as indicated in drawings

Pumps and motors shall be mounted on common base frame and shall have been factory aligned.

1.8 TESTS

After complete installation of the equipment and at the time directed by the Consultant, the Contractor shall conduct tests to demonstrate that operating and installation requirements of this specification have been met. Certified test curves of pump performance shall be furnished for approval, showing horsepower, total dynamic head, and efficiency versus GPM.

No pump motor shall be overloaded at any point on the characteristic curve. All the pumps and motors shall operate 1400 rpm speed.

Contractor shall furnish certified test curves for the performance of pumps, showing horsepower, total head, efficiency etc

END OF SECTION - AB155

SECTION AB172 – CLOSED EXPANSION TANK

Article I. 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.

1.2 SUMMARY

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

1.3 SUBMITTALS

After the award of contract the Contractor shall submit the technical submittal for closed Expansion tank within 02 months. In selection of closed Expansion tank Contractor shall ensure the proper installation of the closed Expansion tank in the space allocated.

1.4 CLOSED TYPE EXPANSION TANK

Closed type expansion tank shall be provided for the chilled/hot water system at the location shown in the drawing. The tank shall be constructed of carbon steel according to ASME Code for pressure Vessel and shall be tested for 150 psig. The capacity of the tank shall be suitable for the system water volume. Tank shall be externally sand blasted, and painted with two coats of primer and two coats of finished paint.

The tank shall be complete with all necessary control accessories and fittings for proper working, such as: relief valves, high and low alarms, pump operating control and drain fittings

The tank shall be of the suitable size for the function to be performed and shall have all threaded rods attaching to structure in an approved manner. The tank shall be provided with all necessary connections.

The tank shall be provided with expansion inlet connection from the water system, makeup water connection with a strainer, quick fill by pass connection and drain valve.

Tank shall be painted inside with one coat of red lead and linseed oil paint and a heavy finish coat of black asphalt paint.

The tank shall be insulated similar to air separator as specified hereinafter.

02 Centrifugal pumps shall be provided to maintain the desired pressure inside the tank. These pumps shall be internally piped and provided with electric connections.

Pressure switches shall be provided to get the desired operating pressure

Complete unit shall be packaged type and skid mounted and shall be ready for operation by giving electric and water connections.

Unit shall have its own electric operating panel provided with pressure gauges to monitor the operating pressure of the system.

Unit shall be installed on concrete foundation as indicated on the drawings

Unit shall be commissioned by the factory authorized representative,

END OF SECTION AB172

SECTION AB411 – WATER PIPING AND FLOW DEVICES**PART 1 – GENERAL****1.1 RELATED DOCUMENTS:**

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

1.2 SUMMARY:

- A. This Section specifies piping materials and installation methods common to more than one section of Division 15 and includes joining materials, piping specialties, and basic piping installation instructions.

1.3 DELIVERY, STORAGE, AND HANDLING:

Provide factory-applied plastic end-caps on each length of pipe and tube. Maintain end-caps through shipping, storage and handling to prevent pipe-end damage and prevent entrance of dirt, debris, and moisture.

Protect stored pipes and tubes. Elevate above grade and enclose with durable, waterproof wrapping. When stored inside, do not exceed structural capacity of the floor.

Protect flanges, fittings, and specialties from moisture and dirt by inside storage and enclosure, or by packaging with durable, waterproof wrapping.

1.4 INSTALLATIONS:

- A. General Locations and Arrangements: Drawings (plans, schematics, and diagrams) indicate the general location and arrangement of the piping systems. Location and arrangement of piping layout take into consideration pipe sizing and friction loss, expansion, pump sizing, and other design considerations. So far as practical, install piping as indicated. Refer to individual system specifications for requirements for coordination drawing submittals.

Install piping free of sags or bends and with ample space between piping to permit proper insulation applications.

Install exposed piping at right angles or parallel to building walls. Diagonal runs are not permitted, unless expressly indicated on the Drawings.

The Contractor shall furnish and install all the piping complete in all respects including all labour material and accessories like fittings, flanges, unions, hangers, supports etc., as indicated in drawings, Technical Specifications, Equipment schedule Data and Bill of Quantities.

Except as otherwise specified under various sections, all piping shall be in accordance with this "PIPING"

Piping shall conform to applicable standards of current specification of ASTM, ASME and reference of specification of recognized authorities, to establish basis of quality, shall mean current edition at date of bidding.

Furnish all piping required to make apparatus connected, complete and ready for regular operation. Unless otherwise noted, connect all apparatus and equipment in accordance with manufacturer's standard details, as approved.

Consult drawings and specification to determine number and requirements of all items of equipment requiring piping connections. Furnish accessory piping, such as vent, drain, relief, etc., wherever equipment is provided with connections for such piping.

Ends of all pipes shall be properly capped; Contractor shall ensure that no open end pipes are lying at site.

Unless otherwise specified or indicated, water mains shall have minimum pitch to insure adequate venting and drainage.

Drainage piping: Pitch $\frac{1}{4}$ inch per ft. wherever possible, but not less than $\frac{1}{8}$ inch per ft.

Chilled or hot water piping, provide pitch $\frac{1}{8}$ inch per ft. in direction of flow, and provide dirt pockets at change in directions

Provide valves and capped connection at all low points in piping system necessary for drainage of the system.

During construction, temporarily close all open ends of pipes with sheet metal/plastic caps in order to prevent debris from entering in the piping systems

Furnish, at bottom of each riser and where required or indicated. Not smaller than full size of riser and approximately 12" long.

In piping, provide in each dirt pocket $\frac{3}{4}$ " hose gate valve, with hose cap.

- Q. Automatic Air Vent Valves: Automatic float operated, furnish where indicated or required, to expel air from system and prevent air binding. Each provided with inlet gate valve, and outlet overflow extend to nearest open drain or slop sink

1.5 WELDING

Except as otherwise specified, MS Schedule 40 piping of size 2 inches diameter and smaller shall be screw joined, and all piping of size above 2 inches in diameter shall be joined by welding.

In welded piping use only flanged joints for valves and specialties, and all the flanges shall be of same standard and size as of valves.

Mitering of pipe or use of field fabricated welding fittings shall not be permitted, only factory made fittings shall be allowed.

Welded pipe bevels: Mill beveled or machine beveled on both ends

Before being welded. Bevel: 35 to 40 degrees. On odd lengths of steel pipe, beveling may be accomplished by means of angle grinder using grinding disc.

All piping shall be cut through pipe cutter only, if cutting torch is used then all scale and dust shall be removed by grinding.

Ream all the pipes after cutting prior to threading or welding.

Weld metal shall be thoroughly fused with base metal at all sections of weld and penetration of weld shall include un-beveled portion and extend to inside walls of pipe.

Welding shall be carried out by a qualified welder, through standard engineering practices.

Remove foreign matter from ends of pipe lengths before tacking and welding. Align pipe lengths straight with abutting pipe ends concentric. Space and tack weld pipe to prevent lapping or miss-alignment during welding.

Welding shall be carried out in passes, after each pass joint shall be cleaned for flux etc., single lap welding shall not be acceptable

Perform welding in accordance with latest accepted practice applicable to particular service, by welders tested and qualified under USA Code for Welding. Submit certificate for each welder.

1.6 STEEL PIPE

Black or Galvanized seamless, schedule 40, conforming to ASTM, A-53 Grade B or approved equivalent pipes shall be used for Chilled/Hot water, Cooling water, and natural gas. All welded fittings shall be seamless welding type compatible to the schedule of pipes and equal in weight. Flanges shall be welded neck or slip on type suitable and compatible with the fitting being used for

1.7 GALVANISED IRON PIPE

All galvanized iron pipe shall be welded type, medium series conforming to BSS 1387 of 1957. Fittings shall be of galvanized malleable iron. All galvanized fittings shall be screwed, banded or collar type.

1.8 MISCELLANEOUS PIPING

Where no class of pipes is specified for any particular system, it shall be informed to the Consultant and pipes used shall be as directed by the Consultant.

1.9 GASKETS

Unless otherwise specified, make up flanged joints with one piece gaskets, ring or full face as required, gaskets shall be non-asbestos, compressed material, with high strength aramid fibre bonded with high grade nitrile synthetic rubber

1.10 EXPANSION

Make proper provision for expansion and contraction in all parts of piping systems wherever possible by means of pipe bends, pipe loops, swing connection, or changes in direction of piping. Provide guides where necessary or required to confine lateral movement of piping, and on both sides of all expansion loops.

1.11 HANGERS AND ANCHORS

- A. All pipe hangers, brackets, saddles, inserts, clamps and pipe rollers including rods bolts, turn buckles; base and protection shields shall conform to the latest engineering standards. Supports of wire, rope, wood, chain, strip, perforated bar or any other make-shift device, not permitted.

Contractor shall be responsible for furnishing and properly locating all concrete inserts and anchor rods. Furnish any additional structural steel that may be required for proper installation of hangers, anchors, guides and supports.

- C. For locations where piping is parallel and close to piping of other trades, submit for approval composite drawing showing location and elevation of all such piping before erecting any hangers
- D. Furnish approved rollers for hangers, supports for horizontal pipes having straight run of 100 feet and more and guides for all piping where expansion joints are used.
- E. Where necessary, because of vibration or to prevent lifting due to expansion, furnish spring suspension hangers of approved design.
- F. All hangers and supports shall provide for 2 inches of vertical adjustments
- G. Provide approved wooden sleeves of wall thickness equal to the insulation with minimum 8 inch length, for all the supports and hangers for insulated piping
- H. For insulated piping #18 USWG galvanized steel shields, minimum 120□ are 8” long or pipe covering protective saddles

Anchor horizontal piping where indicated and whenever necessary to localize expansion or prevent undue strain on branches. Approved anchors of heavy forged construction, shall be entirely separated from supports

Furnish supports for horizontal piping at intervals given in following table. Provide hanger/support at 1 foot distance at every change in direction

Furnish supports for horizontal piping at intervals given in following table, in addition to these provide hanger/support at 1 foot distance at every change in direction.

Pipe Size From	½”	1”	1 ½”	2”	3”	4”	5”	6”	8”and above
Max. Span ft	5	6	7	8	9	10	12	14	14

2.0 VALVES

The Contractor shall furnish and install all type of valves and fittings complete in all respects, including all labor material and accessories like flanges, nut & bolts, gaskets, supports etc, as indicated in drawings, Technical Specifications, Equipment schedule Data and Bill of Quantities.

Furnish all gate valves, balancing valves, non-return valves and check valves, strainers, air vents etc as indicated in drawings, technical specifications, equipment schedule data and bill of quantities or required for satisfactory operation and complete control of apparatus specified or connected to.

All type of valves strainers etc shall be of same manufacture, and of same class, with minimum working pressure of 125 pounds per square inch and operating temperature not less than 120 °C

All type of valves 2 inch in diameter and below shall be of bronze and screwed type and above 2 inches in diameter shall be flanged type

All valves of larger than 2 inches in diameter shall be of cast iron with flanged connections

Gate Valve up to 2": Bronze gate solid wedge, inside screw, travelling spindle, union bonnet

Gate Valve 2 ½ inch and above shall be solid wedge, and rising spindle type

All valves installed above 6 feet high from floor shall be provided with chain operated handles.

2.1 GATE VALVES

All gate valves up to 2 inches in diameter shall be with threaded ends, body shall be made with bronze, with union type bonnet, non-rising stem and wedge disc. Stuffing box packed with PTFE. Stem, gland nut and gland shall be made of copper alloy, hand wheel shall be made of cast iron

All gate valves 2 ½" and larger shall be flanged type, body and bonnet shall be made of cast iron, wedge shall be of cast iron with bronze wedge facing ring and body seating ring. Stem shall be made of copper alloy or stain less steel, and stuffing box shall have graphite packing rings. Hand wheel shall be made of cast steel. All valves shall be rising stem type.

2.2 CHECK VALVES

- A. General requirements, same as for Gate valves. Furnish where specified or indicated, and unless otherwise specified, at discharge of every pump. Same manufacture as of Gate valves
- B. Water piping: Swing check valves:

- C. Provide of pump discharge of all pumps silent spring loaded check valve, iron body, bronze trim; 125 psi WSP class.

Wafer check valves shall also be acceptable of same class with duo-disc type, of stainless steel disc and bronze seat.

2.3 STRAINERS

General requirements same as for Gate Valves, for 2 inch and smaller diameter body shall be made of gunmetal, screen shall be made of stainless steel with 0.75 mm diameter holes and 50 holes per square centimeter. Total area of perforation should be at least six times of inside area of pipe. Cap gasket shall be asbestos free non-stick type.

2 ½ “ diameter and larger valves shall be with above specifications except the bodies shall be flanged and made of cast iron, and these strainers shall be provided with blow off valves

Furnish strainers where specified or indicated, and unless otherwise specified at every inlet of equipment.

All strainers shall be „Y“ type and installed in right position in and convenient location for easy cleaning of dust and replacement of strainer screen bucket without dismantling the main piping.

2.4 DOUBLE BALANCING VALVES

- A. General requirements for balancing valves are same as for gate valves, stated above. Balancing valves shall be used for the balancing of water flow. These shall be adjusted through microcomputer on pressure differential readings. These valves shall have a locking arrangement at balanced condition, so when used as a shut off valve it will not open more than set position. These shall have calibrated scale for determination of valve position. The maximum pressure differential for the selection of balancing valve shall not be more than 6 kpa. These valves shall be furnished and installed where indicated on drawings.

The meters for balancing valves shall consist of programmable microcomputer and differential pressure gauge to indicate the pressure differential, flow rate, velocity and temperature of the fluid. These should be complete in all respects and suitable to operate battery and at 220 volts, single phase power supply. The Contractor shall arrange complete sets of balancing meters which shall be suitable for all types of balancing valves installed at project.

2.5 FLEXIBLE CONNECTORS

Flexible connectors shall be constructed with rubber, tetra-fluro-ethylene resin, stainless steel, or galvanized steel flanges. The material shall be suitable for working pressure and temperature stated above (125 psig at 120°C). The end connections shall be same as for valves, and flange assembly shall be provided with limit bolts to restrict travel beyond limits as approved by the manufacturer. The flexible connections shall be installed where indicated on drawings, and installation shall be as recommended by the manufacturer.

2.6 AUTOMATIC AIR VENTS

Automatic air vent shall be suitable for liquid system. The body shall be made of malleable iron, float and seat shall be made of stainless steel, operating pressure and temperature range shall be same as for gate valves. Air vents shall be provided at all highest points on all water coils, risers or as indicated in drawings.

2.7 BUTTERFLY VALVES

General requirements are same as for gate valves, the body of butterfly valve shall be made of ductile iron, shaft and disc shall be made of stainless steel, O ring and liner shall be made with EPDM rubber, these shall be suitable for manual or motorized operation. These shall be installed where indicated on the drawings. All butterfly valves shall be gear operated.

2.8 BALL VALVES

General requirements for ball valves are same as for gate valves. The body and seat retainer of screwed ball valves shall be made of gunmetal; ball shall be made of copper alloy with hard chrome plating or stainless steel stem seal should be of PTFE, stem shall be of copper alloy, and handle lever shall be made of galvanized steel. These shall be installed where indicated on drawings, or as directed by the Engineer.

2.9 FLOAT VALVE

These shall be installed where indicated, these shall have at least 6" diameter floating ball made of stainless steel. These shall be suitable for same operating conditions as of other valves.

2.10 EXPANSION

Make proper provision for expansion and contraction in all parts of piping systems wherever possible by means of pipe bends, pipe loops, swing connection, or changes in direction of piping. Provide guides where necessary or required to confine lateral movement of piping, and on both sides of all expansion loops.

3.0 ANCHORS

Anchors shall be provided where necessary, indicated on drawings or as directed by the Engineer to localize expansion or to prevent undue strain in piping. These shall consist of steel collars with lugs and bolts for clamping and attaching anchors braces. Anchors supports shall be attached in a place where it will not injure the construction during expansion and it shall be capable to hold the entire weight and stresses.

4.0 UNIONS & FLANGES

Make final connections to all equipment and automatic control valves with unions. Up to 2", screwed; 2-1/2" and larger, flanged.

Screw unions on steel pipe, 300 psi WSP class, and malleable iron with bronze seat rings; on brass pipe, copper pipe and copper tubing, 200 psi WSP class, all bronze with ground joints.

5.0 PIPING SLEEVES

- A. Furnish sleeves built into place for all pipes passing through walls, floors, or building construction. Sleeves, not less than 1/2 inch larger in diameter than piping and its covering, if any, and extending full depth of construction pierced. Pack sleeves through fire walls in accordance with underwriters requirements. All floor sleeves shall be 2 inches above from floor.

Sleeves piercing exterior walls, integral water proofed walls, footings, beams or floors of machinery rooms containing heating ventilating or air conditioning equipment: Standard weight steel pipe.

Extend sleeves in machinery room floors not less than 2 inches above finished floor. Furnish welded center flange buried in construction for sleeves through exterior wall below grade and floors of machinery rooms. At exterior walls make pipes watertight in sleeves with oakum packing and caulked lead joints on both sides of wall.

All other sleeves: Galvanized sheet steel with lock seam joints, not less than #18 USSG. Sleeves for piping 4 inches and larger, #16 USSG.

For pipes passing through interior membrane water-proofed floors, furnish cast iron flashing sleeve, with integral flashing flange and clamping ring; Adjust sleeves to floor construction with steel or wrought iron pipe nipples top and bottom, extending 2 inches above finished floor.

Protect piping run in floor fill with # 16 USSG galvanized iron U-shaped covers of sufficient size to allow for expansion and contraction of pipe.

Where insulated piping passes through masonry walls, floors, or roof slabs the Contractor shall furnish and install pipe sleeves and shall be responsible for locating them and coordinating installation with the building construction schedule and with other trades.

Insulation shall pass through the sleeves without a break. Unless specifically approved by the Consultant, otherwise piping and sleeve shall not pass through building footings.

6.0 FLOOR, WALL AND CEILING PLATES

Exposed pipe passing through floors, finished walls or finished ceilings shall be fitted with chromium plated or nickel plated steel escutcheon plates. Plates shall be large enough to close the hole around pipe completely and shall be round or rectangular with the least dimension not less than 1-1/2 inches larger than the diameter of the pipe. Plates shall be secured in a manner approved by the Consultant.

Roof cones shall be installed and shall be of 3/16 inch MS sheet for welding to pipe. Cones shall be continuously welded to pipe circumference at the top and extend down to the roof at a 15 degree angle from vertical. Base of the cone shall have a radius 6 inches larger than the pipe extending through the roof.

Vent Flashing – Flashing for vents through the roof shall be 3 lb. Lead or 8 oz copper. Base of the flashing shall have a diameter 8 inches larger than the vent pipe. Flashing shall extend up against the vent and turn down into the vent at least 1/2 inches. All joints shall be tightly soldered to prevent moisture infiltration.

Where sleeves or fittings project slightly from wall, partitions, floor, or ceiling, provide special deep type escutcheons to cover each case

7.0 CLEANING AND PAINTING

- A. Operate piping systems at maximum operating pressure and run to waste until system is thoroughly free of dirt oil, cuttings, etc. additional requirements, as specified hereinafter.
- B. Repair or replace, without additional cost to the Owner, all control valves and other system components which do not function properly because of imperfect cleaning of pipe system.

Prior to use, or prior to insulation or painting, all surfaces of equipment and materials shall be thoroughly cleaned.

- D. Except for copper and galvanized surfaces and surfaces to be insulated, concealed exterior metal surfaces on all equipment and materials shall be painted with one prime coat and one finish coat of Rust oleum damp-proof red primer or equal.

Final painting of exposed piping, ductwork, equipment, and insulation shall be completed as specified in Section: "PAINTING AND SPECIFICATIONS" and as directed by the Architect.

8.0 TESTING

Furnish all materials, supplies, labour, and power required for testing. Make preliminary tests and prove work satisfactory.

The piping system shall operate without any noise or vibration whatsoever. Notify Consultant and all authorities having justification in ample time to be present for final testing of all piping.

Test before insulating or concealing any piping. Repair defects disclosed by tests, or if required by Consultant, replace defective work with new without any additional cost to Owner.

Make tests in stages if so ordered by Consultant to facilitate work of others. Use of wicking in tightening leaking joints, not permitted.

Contractor shall be responsible for work of other trades disturbed or damaged by tests and/or repair and replacement of his work, and shall cause work so disturbed or damaged to be restored to its original condition at his own expenses.

Unless otherwise specified, all piping: Hydro-statically tested to 250 psi for four hours duration, during which time piping shall not leak and during which time no sealing of leaks will be permitted

END OF SECTION – AB411

SECTION AB780 - ELECTRICAL WORKS

PART 1 – GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

The Contractor shall furnish all labour, materials/plant equipment and perform all necessary operations required to execute the work of this section. It is the responsibility of the Contractor to ensure that equipment, Main Control panel, MCC's etc shall fit into the spaces allocated and shall allow acceptable clearances, recommended by the manufacturer for entry, servicing and maintenance.

This Section includes all Electrical works related to HVAC.

1.3 QUALITY ASSURANCE

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

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

PART 2 - PRODUCTS

2.1 GENERAL

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

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

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

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

Conduits/Pipes and Cable Trays.

Installation Materials and Accessories.

Testing and commissioning of system.

Getting system approval by Electric Inspector.

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

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

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

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

Standards

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

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

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

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

Company shall be complied with.

Equipment and Materials: In the specifications, certain types and makes of equipment material have been specified only for the purpose of reference and guidance. Prior to procurement of the materials the Contractor shall submit to the Consultants for approval, the names of the manufacturers and other technical data as required to satisfy as to the suitability, durability, quality and usefulness of the material intended to be purchased. When advised by the Consultant, samples of material shall be provided free of cost for approval. If the material or equipment offered under this provision is, in the opinion of the Consultant, equal to or better than specified, it will be given consideration.

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

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

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

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

PART 3 – EXECUTION

3.1 INSTALLATION

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

For all equipment to be installed by the Contractor, the Contractor shall supply and install all installation materials such as foundation bolts, levelling steel, clamps, cable sockets, lugs, glands solder, wall

plugs, raw bolts, washers, nuts, etc. as required and without any additional cost. In general, the manufacturer's instructions for installation shall be followed.

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

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

3.2 TESTS

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

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

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

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

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

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

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

If the insulation resistance of the circuit under test is less than the specified value, the cause of the low reading shall be determined

and removed. After all tests have been made, the equipment shall be reconnected as required.

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

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

3.3 MATERIAL SPECIFICATIONS & INSTALLATION INSTRUCTIONS

Conduits & Pipes:

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

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

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

Installation Requirements:

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

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

The entire conduit system shall be installed and checked before wiring is carried out. The conduits at each termination point shall be connected to earth, and shall be continuous for the entire length to

ensure earth continuity. Pull boxes and adapter boxes shall be of 16 SWG (1.5mm) and provided in conduit runs wherever required to facilitate pulling operation. The boxes shall be painted inside and outside with enamel paint, after base treatment. Wherever the conduit lengths cross the expansion joint along the column or slab, suitable arrangement shall be provided by means of field-fabricated expansion joints.

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

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

Cables:

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

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

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

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

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

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

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

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

Earth conductors shall have green insulation conforming to the same

grade as associated power cable.

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

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

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

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

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

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

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

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

Underground Cable: The cable shall be laid direct in ground or in protective RCC/GI pipes. A minimum clearance of 1m shall be

provided with fuel/gas lines. Cable markers shall be provided at bends and along straight length of underground cable trench at intervals of 30m.

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

3.4 CONTROL AND PROTECTION EQUIPMENT

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

The MCC Shall:

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

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

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

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

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

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

Have engraved plastic nameplates for all circuits.

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

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

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

Two finish enamel coat in approved colour - inside and outside, Stove enameled.

Be provided with ventilation ports suitably vermin proof.

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

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

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

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

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

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

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

general requirements as stated for MCC.

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

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

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

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

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

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

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

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

Bus Bars shall be made of high conductivity electrolytic copper. The phase identification on bus bars shall be red, yellow and blue for phase, black for neutral and green for earth. The phase bus bars shall be of HDHC finned copper (99.9% purity) and insulated or properly painted with red, yellow, or blue and black colour coding identification sequence, if copper purity is less than 99.9% (up to

98.5%), then the correct density to be used shall be maximum $1.5\text{A}/\text{mm}^2$ for loads up to 1000 A, maximum $1.2\text{A}/\text{mm}^2$ for loads above 1000 A.

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

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

Indicating lamps also provided as shown on the MCC schedule and also for control system as stated in the specifications. The incoming circuit breaker on MCC's shall be provided with under voltage/shunt relays. Suitable connections shall also be made to disconnect electric supply to HVAC system in case the Fire Alarm panel is activated.

The circuit breakers (with magnetic only trips for short-circuit protection of motor-starters) shall have suitable characteristics so as to avoid false tripping due to motor starting current. They shall be used as short-circuit protection devices for motor starters to EC 947 & BS4941 Part 1 (Category ^MC").

All circuit breakers shall be rated for I EC 947-2, I_{cu}/I_{cs} at 415v.

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

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

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

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

vi) Load Break Switch: Triple pole (AC23) load-break switches of

Current rating as specified shall be provided complete with front drive grip handle and front plate.

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

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

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

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

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

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

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

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

Two/Three Speed Motor Starters: The starters shall be designed for two speed motors, having provision for starting at high or low

speed, and meeting the requirements as stated above for DOL starters.

3.5 SCHEDULE OF MCC's & SP's

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

3.6 DEMONSTRATION

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

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

Review data in maintenance manuals.

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

END OF SECTION AB780

SECTION AB891 – METAL DUCT WORK

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

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

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

Section 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.

Section 15010, "Basic Mechanical Requirements"

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

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

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

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

1.3 DEFINITIONS

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

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.

Joints: Joints include girth joints; branch and sub branch 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.

1.4 SYSTEM PERFORMANCE REQUIREMENTS

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.

1.5 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:

Duct Liner.

Sealing Materials.

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:

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

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.

Fittings.

Reinforcing details and spacing.

Seam and joint construction details.

Penetrations through fire-rated and other partitions.

Terminal unit installation.

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

Dimensions shall be in IP units.

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:

Coordination with ceiling suspension members.

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

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

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

1.6 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, colour, 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

2.1 SHEET METAL MATERIALS

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

Galvanized Sheet Steel: Lock-forming quality, ASTM A 527, Coating Designation G 90. Provide mill phosphatized finish for exposed surfaces of ducts exposed to view,

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

2.2 DUCT LINER

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

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

Thickness: 25 mm.

Density: 7.32 kg/m².

Thermal Performance: "K-Factor" equal to 0.107 [kcal.m/h.m².°C} or better, at a mean temperature of 24°C.

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.

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

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.

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

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

2.3 JOINT SEALANT

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

Joint sealant is specified in the list of approved manufacturers.

2.4 HANGERS AND SUPPORTS

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

Hangers: Galvanized steel round rods on minimum 10 mm diameter

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

2.6 RECTANGULAR DUCT FABRICATION

- A. General: Except as otherwise indicated, fabricate rectangular ducts with galvanized sheet steel, in accordance with SMACNA "HVAC 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.

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

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

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

Supply Ducts: 75 mm water gage.

Return Ducts: 50 mm water gage, negative pressure.

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

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 Duct Construction Standard," Figure 1-4, unless they are lined or are externally insulated.

2.7 RECTANGULAR DUCT FITTINGS

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

2.8 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.

Butt transverse joints without gaps and coat joint with adhesive.

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

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.

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

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.

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

Fan discharge.

Intervals of lined duct preceding unlined duct.

Upstream edges of transverse joints in ducts.

2.9 ROUND DUCT FABRICATION

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.

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

2.10 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:

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.

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

3.1 DUCT INSTALLATION, GENERAL

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

Install ducts with the fewest possible joints.

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

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

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.

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

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

Install insulated ducts with 25 mm clearance outside of insulation.

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.

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

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.

3.2 SEAM AND JOINT SEALING

General: Seal duct seams and joints as follows:

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

Seal externally insulated ducts prior to insulation installation.

3.3 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.

3.4 HANGING AND SUPPORTING

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

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

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

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.

Install concrete insert prior to placing concrete.

3.5 CONNECTIONS

- A. Equipment Connections: Connect equipment with flexible Connectors in accordance with Division 15 Section "Duct Accessories."
- B. Branch Connections: Comply with SMACNA "HVAC Duct Construction Standards," Figures 2-7 and 2-8.
- C. Outlet and Inlet Connections: Comply with SMACNA "HVAC Duct Construction Standards," Figures 2-16 through 2-18.
- D. Terminal Units Connections: Comply with SMACNA "HVAC Duct Construction Standards," Figure 2-19.

3.6 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.

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.

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

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.

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

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

3.8 ADJUSTING AND CLEANING

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 AB891

SECTION AB892 – DUCT WORK

ACCESSORIES PART 1 – GENERAL

1.1 RELATED DOCUMENTS

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

1.2 DESCRIPTION OF WORK

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

Types of ductwork accessories required for project include the following:

Dampers.

- Manual Dampers.
- Motor-Operated Dampers.

Turning Vanes.

Duct Hardware.

Duct Access Doors.

Flexible Ducts.

Screens.

1.3 QUALITY ASSURANCE

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 5 years.

Codes and Standards:

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

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

1.4 SUBMITTALS

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

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.

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

2.1 DAMPERS

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

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.

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.

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

2.2 TURNING VANES

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

2.3 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.

2.4 DUCT ACCESS DOORS

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

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.

2.5 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 also capable of absorbing vibration of connected equipment.

2.6 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 fiber insulation. Ducts shall be covered with a tough, seamless, vapour barrier jacket.

2.7 SCREENS

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

3.1 INSPECTION

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.

3.2 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.

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.

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

3.3 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.

3.4 ADJUSTING AND CLEANING

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

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

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

END OF SECTION AB892

SECTION AB893 - DIFFUSERS, REGISTERS, AND GRILLS

PART 1 – GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

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

Related Sections include the following:

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

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

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

Section 15010, "Basic Mechanical Requirements"

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

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

1.3 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

2.1 GRILLES AND REGISTERS

Adjustable Bar Grille or Register:

Material: Aluminum.

Finish: Baked enamel, white.

Damper Type: Adjustable opposed-blade assembly.

2.2 CEILING DIFFUSER OUTLETS

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.

2.3 CEILING DIFFUSER DISC TYPE

Round Ceiling Diffusers:

Material: Aluminum.

Finish: Baked enamel, white.

Face Size: See schedule on drawings.

Face Style: Disc type.

2.4 LINEAR GRILL

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

Material: Aluminum.

Finish: Baked enamel, white.

Face Size: See schedule on drawings.

2.5 LOUVERS

Rectangular and Square Louvers:

Material: Aluminum.

Finish: Baked enamel, white.

Face Size: See schedule on drawings.

2.6 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

3.1 EXAMINATION

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

3.2 INSTALLATION

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

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

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

3.3 ADJUSTING

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

END OF SECTION AB893

SECTION AB940 – OPERATION AND MAINTENANCE OF HVAC SYSTEM

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

This Section includes the following:

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

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

1.3 OPERATION

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

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

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

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

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

i. Mechanical/HVAC Engineer	01
ii. Chiller Operator/Mechanic	02
iii. Electrician cum Plumber	01
iv. Technical Helpers	03

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

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.

1.4 MAINTENANCE

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

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

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

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

1.5 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 HVAC system.

1.6 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 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.

1.7 AS-BUILT DRAWINGS

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

1.8 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 HVAC systems as part of the contract, before commencement of testing and commissioning phase.(if Specified)

1.9 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.
(if Specified)

1.10 COMPLETION OF OPERATION

After **One** year successful completion of operation and maintenance of entire HVAC system, the Contractor shall handover the entire system to the Owner with each and every 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 AB940

SECTION AB990 - TESTING, ADJUSTING, AND

BALANCING PART 1 – GENERAL

1.1 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.

1.2 SUMMARY

- A. This Section includes Testing, Adjusting, and Balancing of all HVAC systems to produce design objectives, mainly as following:

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

Measuring electrical performance of HVAC equipment

Verifying that automatic control devices are functioning properly

Measuring sound and vibration

1.3 DEFINITIONS

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

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

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

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

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

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

1.4 QUALITY ASSURANCE

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

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

1.5 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.

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

PART 2 – EXECUTION

Examine approved submittal data of HVAC systems and equipment.

Examine project record documents.

Examine Consultant's design data, including HVAC system descriptions, statements of design assumptions for environmental conditions and systems' output.

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.

Examine system and equipment test reports.

Examine HVAC 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.

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

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.

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

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

Examine automatic temperature system components to verify the

Following:

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

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

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

Sensors are located to sense only the intended conditions.

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

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.

Interlocked systems are operating.

Changeover from heating to cooling mode occurs according to design values.

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

2.0 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.

3.0 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.

6.0 FINAL REPORT

Final test reports shall be provided to the Consultant.

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.

END OF SECTION AB990

BOQ PREAMBLE

INSTRUCTIONS TO TENDERERS FOR FILLING OF BILL OF QUANTITIES

The tenderers shall fill in all the sections of the Bill of Quantities, (BOQ) otherwise Tenders may be considered liable to rejection.

All items mentioned in the Bill of Quantities (BOQ) consist of supply of all equipment, installation, material labour, plant, appliances, and consumables required for completing in all respects the items/works, in strict accordance with relevant specifications Contract Documents and Drawings

The quantities mentioned in the BOQ are the estimated quantities of the work and they are not to be taken as the actual and correct quantities of the work to be executed by the Contractor in fulfillment of the Contract. These quantities can vary in actual.

In all cases where the Bill of Quantities items are not fully specific in respect of description or in respect of recommended manufacturers or suppliers, the tenderers attention are drawn to all the other tender documents including Specifications and Drawings and Conditions of the Contract.

All equipment proposed to be supplied shall be supported by suitable manufacturer's catalogue/literature etc., with the model selected with make, origin and performance data clearly marked.

This Bill of Quantities is to be read in conjunction with the Drawings and Specifications prepared by the Consultants, as being mutually explanatory.

All tenderers are advised to quote strictly as per specifications. Any alternative or deviations from specifications proposed shall be provided in the form of a separate quotation. Any tender not quoting as per specifications may be considered liable to rejection.

Except as otherwise specifically provided for, all items in the Bill of Quantities are measured net, as fixed in place in accordance with the Drawings, and any allowance made for waste shall be included in the price rate for that item. No separate payment shall be made for any wastage etc,

Generally the following shall be deemed to be included in the prices submitted with all items herein:

Labour and all cost in connection therewith, materials, goods and all costs in connection therewith including but not limited to, transportation to site, delivery, unloading, unpacking, returning packing, handling, hoisting to any height, lowering, octroi charges etc.

Erection, dismantling and removal on completion contractor's site offices, stores, accommodation.

General and other requirements of Specifications.

Installing, fitting and fixing goods and materials in positions.

Use of tools, plant and equipment.

Waste of materials.

All necessary cutting and repairing

All overheads and profits including Income Tax , Sales Tax and all other taxes and duties

Testing & Pre-shipment Inspection and other miscellaneous Charges

Any discrepancies noticed by the tenderers between the Bill of Quantities, the intent of the Drawings and Specifications and the scope work, shall be brought to the attention of the Consultant/Engineer prior to submitting the tenders who shall notify their clarifications/decision to all the tenderers. No claims of whatsoever nature shall be admissible during or after the contract period for any misunderstandings, ambiguities due to above, which have not been notified to the Consultant/Engineer prior to submission of his priced tenders.

The Contract shall be on item rate contract for the accepted tendered price within which the contractor is required to supply & install, operate & maintain the system as specified.

The Employer has right to entirely delete or make changes in quantities for any item specified in BOQs, and no payment shall be made to the Contractor for deleted items. Payments against change in quantities shall be made only against executed and accepted items.

If the Contractor does not perform any work in conformance to specification or contract documents. The Employer may deduct or stop the payment against substandard work.

If Contractor fails to perform any work within specified time, the Employer has right to execute the same work on the Contractor's risk and cost.

AYUB TEACHING HOSPITAL ABBOTTABAD.



TENDER DOCUMENTS

VOLUME-II

**TECHNICAL SPECIFICATIONS OF HVAC WORKS OF OPERATION
THEATERS AT AYUB TEACHING HOSPITAL**

Design and Supervision Consultant:

PEPAC
Pakistan
Environmental
& Planning
Architectural
Consultants