

Part 1 General

1.1 SECTION INCLUDES

- .1 Single phase electric motors.

1.2 RELATED SECTIONS

- .1 Section 21 05 00 – Submittal Procedures.
- .2 Section 21 05 00 - Product Requirements.
- .3 Section 21 05 00 - Closeout Submittals.
- .4 Section 26 05 80 - Equipment Wiring: Electrical characteristics and wiring connections.

1.3 REFERENCES

- .1 AFBMA 9 - Load Ratings and Fatigue Life for Ball Bearings.
- .2 AFBMA 11 - Load Ratings and Fatigue Life for Roller Bearings.
- .3 IEEE 112 - Test Procedure for Polyphase Induction Motors and Generators.
- .4 NEMA MG 1 - Motors and Generators.

1.4 SUBMITTALS

- .1 Section 21 05 00: Procedures for submittals.
- .2 Product Data: Provide wiring diagrams with electrical characteristics and connection requirements.
- .3 Manufacturer's Installation Instructions: Indicate setting, mechanical connections, lubrication, and wiring instructions.

1.5 OPERATION AND MAINTENANCE DATA

- .1 Section 21 05 00: Submittals for project closeout.
- .2 Operation Data: Include instructions for safe operating procedures.
- .3 Maintenance Data: Include assembly drawings, bearing data including replacement sizes, and lubrication instructions.

1.6 QUALIFICATIONS

- .1 Manufacturer: Company specializing in manufacture of electric motors and their accessories, with minimum three years documented product development, testing, and manufacturing experience.

1.7 REGULATORY REQUIREMENTS

- .1 Conform to applicable electrical code.
- .2 Products Requiring Electrical Connection: Listed and classified by testing firm acceptable to the authority having jurisdiction as suitable for the purpose specified and indicated.

1.8 DELIVERY, STORAGE, AND HANDLING

- .1 Section 21 05 00: Transport, handle, store, and protect products.
- .2 Protect motors stored on site from weather and moisture by maintaining factory covers and suitable weather-proof covering. For extended outdoor storage, remove motors from equipment and store separately.

1.9 WARRANTY

- .1 Section 21 05 00: Submittals for project closeout.
- .2 Provide five year warranty.

Part 2 Products

2.1 GENERAL CONSTRUCTION AND REQUIREMENTS

- .1 Motors less than 250 Watts, for intermittent service: Equipment manufacturer's standard and need not conform to these specifications.
- .2 Electrical Service:
 - .1 The following are required electrical characteristics unless otherwise indicated in the drawings and schedules.
 - .2 Motors 0.5 kW (3/4 hp) and smaller: 115 volts, single phase, 60 Hz.
 - .3 Motors Larger than 0.5 kW (3/4 hp): 575 volts, three phase, 60 Hz.
 - .4 Motors Larger than 0.5 kW (3/4 hp): 208 volts, single phase, 60 Hz.
- .3 Type:
 - .1 Open drip-proof except where specifically noted otherwise.
 - .2 Motors: Design for continuous operation in 40 degrees C environment.
 - .3 Design for temperature rise to NEMA MG 1 limits for insulation class, service factor, and motor enclosure type.
 - .4 Motors with frame sizes 254T and larger: Energy Efficient Type.
- .4 Visible Nameplate: Indicating motor horsepower, voltage, phase, cycles, RPM, full load amps, locked rotor amps, frame size, manufacturer's name and model number, service factor, power factor, efficiency.
- .5 Wiring Terminations:

- .1 Provide terminal lugs to match branch circuit conductor quantities, sizes, and materials indicated. Enclose terminal lugs in terminal box sized to code, threaded for conduit.
- .2 For fractional horsepower motors where connection is made directly, provide conduit connection in end frame.

2.2 SINGLE PHASE POWER - SPLIT PHASE MOTORS

- .1 Starting Torque: Less than 150 percent of full load torque.
- .2 Starting Current: Up to seven times full load current.
- .3 Breakdown Torque: Approximately 200 percent of full load torque.
- .4 Drip-proof Enclosure: Class A (50 degrees C temperature rise) insulation, NEMA Service Factor, prelubricated sleeve or ball bearings.
- .5 Enclosed Motors: Class A (50 degrees C temperature rise) insulation, 1.0 Service Factor, prelubricated ball bearings.

2.3 SINGLE PHASE POWER - PERMANENT-SPLIT CAPACITOR MOTORS

- .1 Starting Torque: Exceeding one fourth of full load torque.
- .2 Starting Current: Up to six times full load current.
- .3 Multiple Speed: Through tapped windings.
- .4 Open Drip-proof or Enclosed Air Over Enclosure: Class A (50 degrees C temperature rise) insulation, minimum 1.0 Service Factor, prelubricated sleeve or ball bearings, automatic reset overload protector.

2.4 SINGLE PHASE POWER – ELECTRONIC COMMUTATED MOTORS (ECM)

- .1 Motor to be a DC electronic commutation type motor (ECM) specifically designed for fan applications.
- .2 Permanently lubricated with ball bearings.
- .3 Motor shall be a minimum of 85% efficient.
- .4 Internal motor circuitry shall convert AC power supplied to the fan to DC power.
- .5 Motor shall be speed controllable down to 20% of full speed.
- .6 Speed shall be controlled by either a potentiometer dial mounted at the motor or by a 0-10 VDC signal.

Part 3 **Execution**

3.1 APPLICATION

- .1 Single phase motors for direct drive fans: Split phase, Permanent split capacitor, Electronic Commutated.

3.2 INSTALLATION

- .1 Install to manufacturer's written instructions.
- .2 Install securely on firm foundation. Mount ball bearing motors with shaft in any position.
- .3 Check line voltage and phase and ensure agreement with nameplate.

END OF SECTION

Part 1 General

1.1 SECTION INCLUDES

- .1 Pipe and equipment hangers and supports.
- .2 Equipment bases and supports.

1.2 RELATED SECTIONS

- .1 Section 07 84 00 - Firestopping: Joint seals for piping and duct penetration of fire rated assemblies.
- .2 Section 09 91 23 - Painting.
- .3 Section 21 11 00 - Fire Protection Piping.

1.3 REFERENCES

- .1 ASME B31.9 - Building Services Piping.
- .2 ASTM F708 - Design and Installation of Rigid Pipe Hangers.
- .3 MSS SP58 - Pipe Hangers and Supports - Materials, Design and Manufacturer.
- .4 MSS SP69 - Pipe Hangers and Supports - Selection and Application.
- .5 MSS SP89 - Pipe Hangers and Supports - Fabrication and Installation Practices.
- .6 NFPA 13 (2016) - Installation of Sprinkler Systems.
- .7 UL 203 - Pipe Hanger Equipment for Fire protection Service.

1.4 SUBMITTALS

- .1 Section 21 05 00: Procedures for submittals.
- .2 Shop Drawings: Indicate system layout with location and detail of trapeze hangers.
- .3 Product Data: Provide manufacturers catalogue data including load capacity.
- .4 Design Data: Indicate load carrying capacity of trapeze, multiple pipe, and riser support hangers.
- .5 Manufacturer's Installation Instructions: Indicate special procedures and assembly of components.

1.5 REGULATORY REQUIREMENTS

- .1 Conform to applicable code for support of plumbing, hydronic, steam and steam condensate piping.
- .2 Supports for Sprinkler Piping: To NFPA 13 (2016).

Part 2 Products

2.1 PIPE HANGERS AND SUPPORTS

- .1 Fire Protection Piping:
 - .1 Conform to NFPA 13 (2016).
 - .2 Hangers for Pipe Sizes 13 to 38 mm (1/2 to 1-1/2 inch): Carbon steel, adjustable swivel, split ring.
 - .3 Hangers for Pipe Sizes 50 mm (2 inches) and over: Carbon steel, adjustable, clevis.
 - .4 Multiple or Trapeze Hangers: Steel channels with welded spacers and hanger rods.
 - .5 Wall Support for Pipe Sizes to 75 mm (3 inches): Cast iron hook.
 - .6 Wall Support for Pipe Sizes 100 mm (4 inches) and over: Welded steel bracket and wrought steel clamp.
 - .7 Vertical Support: Steel riser clamp.
 - .8 Floor Support: Cast iron adjustable pipe saddle, lock nut, nipple, floor flange, and concrete pier or steel support.
 - .9 Copper Pipe Support: Carbon steel ring, adjustable, copper plated.

2.2 ACCESSORIES

- .1 Hanger Rods: Mild steel threaded both ends, threaded one end, or continuous threaded.

2.3 INSERTS

- .1 Inserts: Malleable iron case of galvanized steel shell and expander plug for threaded connection with lateral adjustment, top slot for reinforcing rods, lugs for attaching to forms; size inserts to suit threaded hanger rods.

2.4 FLASHING

- .1 Metal Flashing: 0.5 mm thick (26 gauge) galvanized steel.
- .2 Metal Counterflashing: 0.8 mm thick (22gauge) galvanized steel.

Part 3 Execution

3.1 INSTALLATION

- .1 Install to manufacturer's written instructions.

3.2 INSERTS

- .1 Provide inserts for suspending hangers from reinforced concrete slabs and sides of reinforced concrete beams.
- .2 Provide hooked rod to concrete reinforcement section for inserts carrying pipe over 100 mm (4 inches).

- .3 Where inserts are omitted, drill through concrete slab from below and provide through-bolt with recessed square steel plate and nut flush with top of slab.

3.3 PIPE HANGERS AND SUPPORTS

- .1 Install to manufacturer's written instructions.
- .2 Perforated strap or wire hangers will not be permitted.
- .3 Support horizontal piping as scheduled.
- .4 Where hangers must be installed in existing concrete slabs, approved expansion type inserts shall be used, or if heavy weights must be supported, a hole shall be drilled through the slab and a 50 mm x 50 mm (2" x 2") washer and nut installed above rough slab before the floor finish is poured.
- .5 Where the structural system is open web steel joists, piping shall be supported by means of angles spanning the top chords of adjacent joists. The number of joists to be spanned in this way shall be determined by the incident load of piping.
- .6 In no case shall the hanging of piping directly from roof or ceiling decking be allowed, unless special permission is obtained from the Consultant.
- .7 Install hangers to provide minimum 13 mm (1/2 inch) space between finished covering and adjacent work.
- .8 Place hangers within 300 mm (12 inches) of each horizontal elbow.
- .9 Use hangers with 38 mm (1-1/2 inch) minimum vertical adjustment.
- .10 Support vertical piping at every floor. Support vertical cast iron pipe at each floor at hub or with pipe clamps on hubless pipe.
- .11 Where several pipes can be installed in parallel and at same elevation, provide multiple or trapeze hangers.
- .12 Support riser piping independently of connected horizontal piping.
- .13 Provide copper plated hangers and supports for copper piping.
- .14 Design hangers for pipe movement without disengagement of supported pipe.
- .15 All hanger rods shall have sufficient threaded length to allow for vertical adjustment of hangers after pipe is in place. Use 2 nuts on each rod, one above the clevis or angle iron and one below.
- .16 Where pipes or equipment are supported from floors or walls, structural steel supports shall be fabricated, using welded joints except where provision is made for adjustment. Where details of construction are not indicated, drawings shall be submitted to Consultant for approval before fabrication.

- .17 Clamps should be located immediately below a coupling if possible. Risers up to 50 mm (2") size shall be braced at intervals not over 2100 mm (7').
- .18 Vertical piping other than risers through floors shall be provided with suitable supports, sway braces, etc.
- .19 Vertical piping shall be supported at the base in an approved manner.
- .20 On insulated piping supported by roller supports or trapeze supports (angle iron) provide at each hanger or support a protection saddle of 16 ga. galvanized sheet steel, rolled to match the outside diameter of the insulation. The saddle shall cover approximately the bottom one third of the circumference of the insulation. The length shall be at least as long as that recommended by the insulation manufacturer as published in their data.
- .21 On insulated pipe up to and including 50 mm (2") pipe, clevis hangers shall be sized to suit the O.D. of the pipe. On insulated pipe of 63 mm (2½") and above, the hangers shall be sized to suit the O.D. of the insulation and protection saddles, as described above shall be installed.
- .22 Prime coat exposed steel hangers and supports. Refer to Section 09 91 23. Hangers and supports located in crawl spaces, pipe shafts, and suspended ceiling spaces are not considered exposed.

3.4 EQUIPMENT SUPPORTS

- .1 Provide templates, anchor bolts, and accessories for mounting and anchoring equipment.
- .2 Construct supports of steel members. Brace and fasten with flanges bolted to structure.
- .3 Provide rigid anchors for pipes after vibration isolation components are installed.

3.5 SCHEDULES

- .1 Maximum spacing between pipe supports:
 - .1 Hangers shall be installed not more than 12" (300mm) from each change in direction of pipes.
 - .2 Where there are concentrations of valves and fittings, closer spacing will be necessary.
 - .3 Steel Pipe:

.1	Up to 50mm (2")	2.4m (8 ft.)
.2	65mm (2½") to 150mm (6")	3.6m (12 ft.)
.3	200mm (8") to 300mm (12")	5.4m (18 ft.)
.4	350mm (14") to 450mm (18")	7.2m (24 ft.)
.5	500mm (20") to 600mm (24")	9.0m (30 ft.)

END OF SECTION

Part 1 General

1.1 SECTION INCLUDES

- .1 Vibration isolation.

1.2 RELATED SECTIONS

- .1 Section 23 05 16 - Piping Expansion Compensation.
- .2 Section 23 05 29 - Supports And Anchors.
- .3 Section 26 05 80 - Equipment Wiring: Electrical characteristics and wiring connections.

1.3 PERFORMANCE REQUIREMENTS

- .1 Provide vibration isolation on motor driven equipment over 0.35 kW (0.5 hp), plus connected piping and ductwork.
- .2 Provide minimum static deflection of isolators for equipment as indicated.
 - .1 Upper Floors, Normal
 - .1 Under 400 rpm: 90 mm (3.5 inch)
 - .2 400 - 600 rpm: 90 mm (3.5 inch)
 - .3 600 - 800 rpm: 50 mm (2 inch)
 - .4 800 - 900 rpm: 25 mm (1 inch)
 - .5 1100 - 1500 rpm: 12 mm (0.5 inch)
 - .6 Over 1500 rpm: 5 mm (0.2 inch)
 - .2 Upper Floors, Critical
 - .1 400 - 600 rpm: 90 mm (3.5 inch)
 - .2 600 - 800 rpm: 90 mm (3.5 inch)
 - .3 800 - 900 rpm: 50 mm (2 inch)
 - .4 1100 - 1500 rpm: 25 mm (1 inch)
 - .5 Over 1500 rpm: 12 mm (0.5 inch)
- .3 Consider upper floor locations critical unless otherwise indicated.

1.4 SUBMITTALS

- .1 Section 21 05 00: Procedures for submittals.
- .2 Shop Drawings: Indicate inertia bases and locate vibration isolators, with static and dynamic load on each.
- .3 Product Data: Provide schedule of vibration isolator type with location and load on each.
- .4 Manufacturer's Installation Instructions: Indicate special procedures and setting dimensions.

- .5 Manufacturer's Certificate: Certify that isolators are properly installed and adjusted to meet or exceed specified requirements.

1.5 PROJECT RECORD DOCUMENTS

- .1 Section 21 05 00: Submittals for project closeout.
- .2 Record actual locations of hangers including attachment points.

Part 2 Products

2.1 VIBRATION ISOLATORS

- .1 Open Spring Isolators:
 - .1 Spring Isolators:
 - .1 For Exterior and Humid Areas: Provide hot dipped galvanized housings and neoprene coated springs.
 - .2 Code: Colour code springs for load carrying capacity.
 - .2 Springs: Minimum horizontal stiffness equal to 75 percent vertical stiffness, with working deflection between 0.3 and 0.6 of maximum deflection.
 - .3 Spring Mounts: Provide with levelling devices, minimum 6 mm (0.25 inch) thick neoprene sound pads, and zinc chromate plated hardware.
 - .4 Sound Pads: Size for minimum deflection of 1.2 mm (0.05 inch); meet requirements for neoprene pad isolators.
- .2 Restrained Spring Isolators:
 - .1 Spring Isolators:
 - .1 For Exterior and Humid Areas: Provide hot dipped galvanized housings and neoprene coated springs.
 - .2 Code: Colour code springs for load carrying capacity.
 - .2 Springs: Minimum horizontal stiffness equal to 75 percent vertical stiffness, with working deflection between 0.3 and 0.6 of maximum deflection.
 - .3 Spring Mounts: Provide with levelling devices, minimum 6 mm (0.25 inch) thick neoprene sound pads, and zinc chromate plated hardware.
 - .4 Sound Pads: Size for minimum deflection of 1.2 mm (0.05 inch); meet requirements for neoprene pad isolators.
 - .5 Restraint: Provide heavy mounting frame and limit stops.
- .3 Closed Spring Isolators:
 - .1 Spring Isolators:
 - .1 For Exterior and Humid Areas: Provide hot dipped galvanized housings and neoprene coated springs.
 - .2 Code: Colour code springs for load carrying capacity.
 - .2 Type : Closed spring mount with top and bottom housing separated with neoprene rubber stabilizers.

- .3 Springs: Minimum horizontal stiffness equal to 75 percent vertical stiffness, with working deflection between 0.3 and 0.6 of maximum deflection.
- .4 Housings: Incorporate neoprene isolation pad meeting requirements for neoprene pad isolators, and neoprene side stabilizers with minimum 7 mm (0.25 inch) clearance.
- .4 Restrained Closed Spring Isolators:
 - .1 Spring Isolators:
 - .1 For Exterior and Humid Areas: Provide hot dipped galvanized housings and neoprene coated springs.
 - .2 Code: Colour code springs for load carrying capacity.
 - .2 Type : Closed spring mount with top and bottom housing separated with neoprene rubber stabilizers.
 - .3 Springs: Minimum horizontal stiffness equal to 75 percent vertical stiffness, with working deflection between 0.3 and 0.6 of maximum deflection.
 - .4 Housings: Incorporate neoprene isolation pad meeting requirements for neoprene pad isolators, and neoprene side stabilizers with minimum 7 mm (0.25 inch) clearance and limit stops.
- .5 Spring Hanger:
 - .1 Spring Isolators:
 - .1 For Exterior and Humid Areas: Provide hot dipped galvanized housings and neoprene coated springs.
 - .2 Code: Colour code springs for load carrying capacity.
 - .2 Springs: Minimum horizontal stiffness equal to 75 percent vertical stiffness, with working deflection between 0.3 and 0.6 of maximum deflection.
 - .3 Housings: Incorporate [neoprene isolation pad meeting requirements for neoprene pad isolators] [rubber hanger with threaded insert].
 - .4 Misalignment: Capable of 20 degree hanger rod misalignment.
- .6 Neoprene Pad Isolators:
 - .1 Rubber or neoprene waffle pads.
 - .1 30 durometer.
 - .2 Minimum 13 mm (1/2 inch) thick.
 - .3 Maximum loading 275 kPa (40 psi).
 - .4 Height of ribs: maximum 0.7 times width.
 - .2 Configuration: 13 mm (1/2 inch) thick waffle pads bonded each side of 6 mm (1/4 inch) thick galvanized steel plate.
- .7 Rubber Mount or Hanger: Moulded rubber designed for 13 mm (0.5 inches) deflection with threaded insert.

Part 3 Execution

3.1 INSTALLATION

- .1 Install to manufacturer's written instructions.
- .2 Install isolation for motor driven equipment.
- .3 Isolator hangers shall be installed with the housing a minimum of 1/4" (6 mm) below but as close to the structure as possible. Where isolator hangers would be concealed by non-accessible acoustical sub ceiling, install the hangers immediately below the sub ceiling for access.
- .4 Install spring hangers without binding.
- .5 On closed spring isolators, adjust so side stabilizers are clear under normal operating conditions.
- .6 Prior to making piping connections to equipment with operating weights substantially different from installed weights, block up equipment with temporary shims to final height. When full load is applied, adjust isolators to load to allow shim removal.
- .7 Support piping connections to isolated equipment resiliently as follows or according to the schedule.
 - .1 Up to 100 mm (4 inch) Diameter: First three points of support.
 - .2 125 to 200 mm (5 to 8 inch) Diameter: First four points of support.
 - .3 250 mm (10 inch) Diameter and Over: First six points of support.
 - .4 Select three hangers closest to vibration source for minimum 25 mm (1.0 inch) static deflection or static deflection of isolated equipment. Select remaining isolators for minimum 25 mm (1.0 inch) static deflection or 1/2 static deflection of isolated equipment.
- .8 Connect wiring to isolated equipment with flexible hanging loop.
- .9 All piping and ductwork shall freely pass through walls and floors without rigid connections. Penetration points shall be sleeved or otherwise formed to allow passage of piping or ductwork, and maintain a minimum of 3/4" and maximum of 1 1/4" clearance around the outside surfaces. This clearance space shall be tightly packed with 1.58 P.C.F. glass fiber and shall be caulked airtight after installation of the piping or ductwork. Penetrations through fire rated walls and floors shall be sealed to maintain the rating.

3.2 MANUFACTURER'S FIELD SERVICES

- .1 Examine systems to Section 01 45 00.
- .2 Inspect isolated equipment after installation and submit report. Include static deflections.

END OF SECTION

Part 1 General

1.1 SECTION INCLUDES

- .1 Nameplates.
- .2 Tags.
- .3 Stencils.
- .4 Pipe Markers.

1.2 RELATED SECTIONS

- .1 Section 09 91 23 - Painting: Identification painting.

1.3 REFERENCES

- .1 ASME A13.1 - Scheme for the Identification of Piping Systems.
- .2 CAN/CGSB 24.3 – Identification of Piping Systems
- .3 NFPA 13 (2016) - Standard for the Installation of Sprinkler Systems.

1.4 SUBMITTALS

- .1 Section 21 05 00: Procedures for submittals.
- .2 Submit list of wording, symbols, letter size, and colour coding for mechanical identification.
- .3 Submit valve chart and schedule, including valve tag number, location, function, and valve manufacturer's name and model number.
- .4 Product Data: Provide manufacturers catalogue literature for each product required.
- .5 Manufacturer's Installation Instructions: Indicate special procedures, and installation.

Part 2 Products

2.1 NAMEPLATES

- .1 Description: Laminated three-layer plastic with engraved black letters on light contrasting background colour. Building manager to provide colour details and identification markings.

2.2 TAGS

- .1 Plastic Tags: Laminated three-layer plastic with engraved black letters on light contrasting background colour. Tag size minimum 40 mm (1-1/2 inch) diameter. Building manager to provide colour details and identification markings.

- .2 Chart: Typewritten letter size list in anodized aluminum frame.

2.3 STENCILS

- .1 Stencils: With clean cut symbols and letters of following size:
 - .1 Ductwork and Equipment: 65 mm (2-1/2 inch) high letters.
- .2 Stencil Paint: As specified in Section 09 91 23.

2.4 PIPE MARKERS

- .1 Colour: Conform to ASME A13.1.
- .2 Plastic Pipe Markers: Factory fabricated, flexible, semi-rigid plastic, preformed to fit around pipe or pipe covering; minimum information indicating flow direction arrow and identification of fluid being conveyed.
- .3 Plastic Tape Pipe Markers: Flexible, vinyl film tape with pressure sensitive adhesive backing and printed markings.

2.5 CEILING TACKS

- .1 Description: Steel with 20 mm (3/4 inch) diameter colour coded head.
- .2 Colour code as follows:
 - .1 Yellow - HVAC equipment
 - .2 Red - Fire dampers/smoke dampers

Part 3 Execution

3.1 PREPARATION

- .1 Provide list of tags to Departmental Representative as a submittal with colour, size and wording for review before installation.
- .2 Degrease and clean surfaces to receive adhesive for identification materials.
- .3 Prepare surfaces to Section 09 91 23 for stencil painting.

3.2 INSTALLATION

- .1 Install plastic nameplates with corrosive-resistant mechanical fasteners, or adhesive. Apply with sufficient adhesive to ensure permanent adhesion and seal with clear lacquer.
- .2 Install tags with corrosion resistant chain.
- .3 Apply stencil painting to Section 09 91 23.
- .4 Install plastic markers to manufacturer's written instructions.
- .5 Identify VAVs, fans and thermostats with plastic nameplates.

- .6 Tag automatic controls, instruments, and relays. Key to control schematic.
- .7 Identify piping, concealed or exposed, with plastic pipe markers. Use tags on piping 20 mm (3/4 inch) diameter and smaller. Identify service, flow direction, and pressure. Install in clear view and align with axis of piping. Locate identification not to exceed 6 m (20 feet) on straight runs including risers and drops, adjacent to each valve and Tee, at each side of penetration of structure or enclosure, and at each obstruction.
- .8 Identify ductwork with stencilled painting or plastic markings indicating air classification (supply, return, exhaust) and flow direction.

END OF SECTION

Part 1 General

1.1 SECTION INCLUDES

- .1 Testing, adjustment, and balancing of air systems.
- .2 Fire and smoke damper testing & verification.
- .3 Measurement of final operating condition of HVAC systems.
- .4 Sound measurement of equipment operating conditions.

1.2 RELATED SECTIONS

- .1 Section 01 45 00 - Quality Assurance:
 - .1 Testing laboratory services.
 - .2 Employment of testing agency and payment for services.
 - .3 Inspection and testing allowances.
- .2 Section 21 05 00 - Closeout Submittals:
 - .1 Testing, Adjusting, and Balancing of Systems.
- .3 Section 23 31 00 - Duct Work
- .4 Section 23 33 00 - Duct Work Accessories

1.3 ALLOWANCES

- .1 Work is included in this section and is part of the Contract Sum/Price.

1.4 REFERENCES

- .1 AABC - National Standards for Total System Balance.
- .2 ADC - Test Code for Grilles, Registers, and Diffusers.
- .3 ASHRAE 111 - Practices for Measurement, Testing, Adjusting, and Balancing of Building Heating, Ventilation, Air-conditioning, and Refrigeration Systems.
- .4 NEBB - Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems.
- .5 SMACNA - HVAC Systems Testing, Adjusting, and Balancing.

1.5 QUALIFICATIONS OF TAB PERSONNEL

- .1 Submit names of personnel to perform TAB to Departmental Representative within 30 days of award of contract.
- .2 Provide documentation confirming qualifications, successful experience.

- .3 TAB: performed in accordance with the requirements of standard under which TAB Firm's qualifications are approved:
 - .1 Associated Air Balance Council, (AABC) National Standards for Total System Balance, MN-1-[2002].
 - .2 National Environmental Balancing Bureau (NEBB) TABES, Procedural Standards for Testing, Adjusting, Balancing of Environmental Systems-[1998].
 - .3 Sheet Metal and Air Conditioning Contractors' National Association (SMACNA), HVAC TAB HVAC Systems - Testing, Adjusting and Balancing-[2002].
- .4 Recommendations and suggested practices contained in the TAB Standard: mandatory.
- .5 Use TAB Standard provisions, including checklists, and report forms to satisfy Contract requirements.
- .6 Use TAB Standard for TAB, including qualifications for TAB Firm and Specialist and calibration of TAB instruments.
- .7 Where instrument manufacturer calibration recommendations are more stringent than those listed in TAB Standard, use manufacturer's recommendations.
- .8 TAB Standard quality assurance provisions such as performance guarantees form part of this contract.
 - .1 For systems or system components not covered in TAB Standard, use TAB procedures developed by TAB Specialist.
 - .2 Where new procedures, and requirements, are applicable to Contract requirements have been published or adopted by body responsible for TAB Standard used (AABC, NEBB, or TABB), requirements and recommendations contained in these procedures and requirements are mandatory.
- .9 Agency: Company specializing in the testing, adjusting, and balancing of systems specified in this Section with minimum three years documented experience, and certified by AABC.
- .10 Perform Work under supervision of AABC Certified Test and Balance Supervisor.

1.6 SUBMITTALS

- .1 Section 21 05 00: Procedures for submittals.
- .2 Submit name of adjusting and balancing agency for approval within 30 days after award of Contract.
- .3 Submit draft copies of report for review prior to final acceptance of Project. Draft copies shall be submitted in electronic format (Adobe Acrobat PDF file). Provide final copies for Consultant and for inclusion in operating and maintenance manuals.
- .4 Provide final reports in letter size, soft cover or 3-ring binder manuals, complete with index page and indexing tabs, with cover identification at front and side. Also submit an electronic copy (PDF file) of the same. Include set of reduced drawings with air outlets and equipment identified to correspond with data sheets, and indicating thermostat locations.

- .5 Test Reports: Indicate data on AABC National Standards for Total System Balance forms. Submit data in either S.I. Metric to match the primary units used on the drawings and schedules.

1.7 PROJECT RECORD DOCUMENTS

- .1 Section 21 05 00: Submittals for project closeout.
- .2 Record distribution layout on representative drawing with
 - .1 Adjustment and design volume conditions.
 - .2 Actual locations of balancing dampers, fire dampers, thermostats, HVAC equipment and ductwork path.

1.8 QUALITY ASSURANCE

- .1 Perform total system balance to AABC National Standards for Field Measurement and Instrumentation, Total System Balance.

1.9 PRE-BALANCING CONFERENCE

- .1 Convene one week prior to commencing work of this section, to Section 21 05 00.

1.10 SEQUENCING

- .1 Sequence work to Section 01 11 00 – Summary of Work.
- .2 Sequence work to commence after completion of systems and schedule completion of work before Substantial Completion of Project.

1.11 SCHEDULING

- .1 Schedule work to Section 21 05 00.
- .2 Schedule and provide assistance in final adjustment and test of life safety, smoke evacuation, and/or smoke control system with Fire Authority.

1.12 PROJECT CLOSE-OUT

- .1 The Testing, Adjusting and Balancing agency as part of its contract shall act as authorized inspection agency, responsible to list all items that are installed incorrectly, require correction or have not been installed in accordance with contract drawings and/or specifications, pertaining to the air distribution, cooling and heating systems. The Mechanical Contractor shall make good these items.
- .2 Final payment on the building will not be issued until the final air balance report has been submitted to the Consultant and has been approved by the Consultant.

Part 2 Products

- .1 Not used

Part 3 Execution

3.1 EXAMINATION

- .1 Verify that systems are complete and operable before commencing work. Ensure the following conditions:
 - .1 Systems are started and operating in a safe and normal condition.
 - .2 Temperature control systems are installed complete and operable.
 - .3 Final filters are clean and in place. If required, install temporary media in addition to final filters.
 - .4 Duct systems are clean of debris.
 - .5 Fans are rotating correctly.
 - .6 Fire and volume dampers are in place and open.
 - .7 Air coil fins are cleaned and combed.
 - .8 Access doors are closed and duct end caps are in place.
 - .9 Air outlets are installed and connected.
 - .10 Duct system leakage is minimized.
- .2 Submit field reports. Report defects and deficiencies noted during performance of services which prevent system balance.
- .3 Beginning of work means acceptance of existing conditions.

3.2 PREPARATION

- .1 Provide instruments required for testing, adjusting, and balancing operations. Make instruments available to Consultant to facilitate spot checks during testing.
- .2 Provide additional balancing devices as required.

3.3 INSTALLATION TOLERANCES

- .1 Air Handling Systems: Adjust to within plus or minus 5 percent of design for supply systems and plus or minus 10 percent of design for return and exhaust systems.
- .2 Air Outlets and Inlets: Adjust total to within plus 10 percent and minus 5 percent of design to space. Adjust outlets and inlets in space to within plus or minus 10 percent of design.

3.4 ADJUSTING

- .1 Ensure recorded data represents actual measured or observed conditions.
- .2 Permanently mark settings of valves, dampers, and other adjustment devices allowing settings to be restored. Set and lock memory stops.
- .3 Make any changes in pulleys and belts, and add any manual dampers as required for correct balance, at no additional cost to the Owner.
- .4 After adjustment, take measurements to verify balance has not been disrupted or that such disruption has been rectified.

- .5 Leave systems in proper working order, replacing belt guards, closing access doors, closing doors to electrical switch boxes, and restoring thermostats to specified settings.

3.5 AIR SYSTEM PROCEDURE

- .1 Confirm total air flow rate before the start of demolition. Record conditions for final air balance. Maintain existing air balance conditions for spaces unaffected by the work.
- .2 Adjust air handling and distribution systems to provide required or design supply, return, and exhaust air quantities at site altitude.
- .3 Test and record motor full load amperes.
- .4 Make air quantity measurements in ducts by Pitot tube traverse of entire cross sectional area of duct.
- .5 Measure air quantities at air inlets and outlets.
- .6 Adjust distribution system to obtain uniform space temperatures free from objectionable drafts and noise.
- .7 Use volume control devices to regulate air quantities only to the extent that adjustments do not create objectionable air motion or sound levels. Effect volume control by duct internal devices such as dampers and splitters.
- .8 All outlets shall be adjusted to provide proper throw and directional distribution in accordance with the requirements on the drawings and/or schedules.
- .9 Vary total system air quantities by adjustment of fan speeds.
 - .1 Provide drive changes required to set airflows on belt driven units.
 - .2 Adjust fan motor speed using speed control, on electronic commutated (EC) motors and variable speed drives (VSD) serving AC motors. Indicate speed voltage (0-10 DC) on EC motors and hertz (Hz) on VSD
 - .3 Vary branch air quantities by damper regulation.
- .10 In renovated spaces, provide system schematic with required and actual air quantities recorded at each outlet or inlet. Each grille, diffuser and register shall be identified as to location and area. Include locations of pitot tube traverse locations, fire damper locations and tags, and balance damper locations.
- .11 Measure static air pressure conditions on air supply units, including filter and coil pressure drops, and total pressure across the fan. Make allowances for 50 percent loading of filters.
- .12 Adjust outside air automatic dampers, outside air, return air, and exhaust dampers for design conditions. Any re-adjustments of controls as deemed necessary, shall be made in co-operation with the Control Subcontractor.
- .13 Measure temperature conditions across outside air, return air, and exhaust dampers to check leakage.
 - .1 Test and record entering air temperatures (D.B. heating and cooling).

- .2 Test and record entering air temperatures (W.B. cooling).
- .3 Test and record leaving air temperatures (D.B. heating and cooling).
- .4 Test and record leaving air temperatures (W.B. cooling).
- .14 Where modulating dampers are provided, take measurements and balance at extreme conditions. Balance variable volume systems at maximum air flow rate, full cooling, and at minimum air flow rate, full heating. Refer to the maximum and minimum rates on the drawings and schedules.
- .15 For variable air volume system powered units set volume controller to air flow setting indicated. Confirm connections properly made and confirm proper operation for automatic variable air volume temperature control.
- .16 On fan powered VAV boxes, adjust air flow switches for proper operation.
- .17 All pitot-tube openings shall have plastic plugs of proper size in uninsulated or internally insulated ductwork. Insulated ductwork shall be provided with rubber plugs that extend to the face of the insulation. Cover the plugs on insulated ductwork with strip of grey tape.
- .18 After completion of final balance, the Balance Contractor shall permanently fix the damper operator with a strip of contact tape and spray the quadrant with bright paint to permanently mark its balanced position.

3.6 FIRE & SMOKE DAMPER TESTING & VERIFICATION

- .1 Testing of Fire Dampers, Ceiling Fire Stops and/or Fire/Smoke Dampers
 - .1 General
 - .1 The Testing, Adjusting and Balancing agency shall test this equipment after installation.
 - .2 Test and verify operation of all fire dampers and ceiling fire stops in this project.
 - .3 Test shall include manually releasing fusible link; allowing damper to close to ensure that it has tight-fit closing operation without binding; opening fire damper and/or closing ceiling fire stop and resetting fusible link connection.
 - .4 Instruct Sections 23 31 00 and 23 33 00 to repair all fire dampers and/or ceiling fire stops that have been identified as being faulty.
 - .2 Identification of Fire Dampers and Ceiling Fire Stops
 - .1 At all fire dampers and ceiling fire stops, supply and install tags as approved by the Consultant.
 - .2 Tags shall be mechanically fastened to duct fire damper access door, or onto or on structure near fire dampers or ceiling fire stops which have no connecting ductwork.
 - .3 After each fire damper has been tested and has been proven to operate satisfactorily as noted in previous clause, a representative of the Testing, Adjusting and Balancing agency shall label unit number and mark date and signature on tag. Tags shall have space for minimum size further dates and signatures for future checking of damper operation by Owner's staff.
 - .3 Test Report for Fire Dampers and Ceiling Fire Stops

- .1 The Testing, Adjusting and Balancing agency shall provide a Test Report.
- .2 The report shall include following for each fire damper:
 - .1 Verification that the unit is fully accessible.
 - .2 Verification that the unit has been successfully tested.
 - .3 Verification that the unit has been reset.
 - .4 Name of tester.
 - .5 Date that the unit tested successfully.
 - .6 Location schedule of all dampers i.e. each damper must be labelled.
- .3 Provide one copy of completed report to Consultant. After the Consultant has reviewed report, provide to the Mechanical Subtrade sufficient copies of report to insert one in each Maintenance/Operating Manual.

3.7 SOUND LEVELS

- .1 Testing of sounds levels in the renovated spaces after construction is complete.

3.8 SCHEDULES

- .1 Equipment requiring testing, adjusting and balancing:
 - .1 Exhaust fan
 - .2 Air terminal units
 - .3 Variable air volume units
- .2 Report Forms
 - .1 Title Page:
 - .1 Name of Testing, Adjusting, and Balancing Agency
 - .2 Address of Testing, Adjusting, and Balancing Agency
 - .3 Telephone number of Testing, Adjusting, and Balancing Agency
 - .4 Project name
 - .5 Project location
 - .6 Project Engineer
 - .7 Project Contractor
 - .8 Project altitude
 - .9 Report date
 - .2 Summary Comments:
 - .1 Design versus final performance
 - .2 Notable characteristics of system
 - .3 Description of systems operation sequence
 - .4 Summary of outdoor and exhaust flows to indicate amount of building pressurization
 - .5 Nomenclature used throughout report
 - .6 Test conditions
 - .3 Instrument List:
 - .1 Instrument

- .2 Manufacturer
- .3 Model number
- .4 Serial number
- .5 Range
- .6 Calibration date
- .4 Electric Motors:
 - .1 Manufacturer
 - .2 Model/Frame
 - .3 HP/BHP
 - .4 Phase, voltage, amperage; nameplate, actual, no load
 - .5 RPM
 - .6 Service factor
 - .7 Starter size, rating, heater elements
 - .8 Sheave Make/Size/Bore
- .5 V-Belt Drive:
 - .1 Identification/location
 - .2 Required driven RPM
 - .3 Driven sheave, diameter and RPM
 - .4 Belt, size and quantity
 - .5 Motor sheave diameter and RPM
 - .6 Centre to centre distance, maximum, minimum, and actual
- .6 Exhaust Fan Data:
 - .1 Location
 - .2 Manufacturer
 - .3 Model number
 - .4 Serial number
 - .5 Air flow, specified and actual
 - .6 Total static pressure (total external), specified and actual
 - .7 Inlet pressure
 - .8 Discharge pressure
 - .9 Sheave Make/Size/Bore
 - .10 Number of Belts/Make/Size
 - .11 Fan RPM
- .7 Duct Traverse:
 - .1 System zone/branch
 - .2 Duct size
 - .3 Area
 - .4 Design velocity
 - .5 Design air flow
 - .6 Test velocity
 - .7 Test air flow

- .8 Duct static pressure
- .9 Air temperature
- .10 Air correction factor
- .8 Terminal Unit Data:
 - .1 Manufacturer
 - .2 Type, constant, variable, single, dual duct
 - .3 Identification/number
 - .4 Location
 - .5 Model number
 - .6 Size
 - .7 Minimum static pressure
 - .8 Minimum design air flow
 - .9 Maximum design air flow
 - .10 Maximum actual air flow
 - .11 Inlet static pressure
- .9 Air Distribution Test Sheet:
 - .1 Air terminal number
 - .2 Room number/location
 - .3 Terminal type
 - .4 Terminal size
 - .5 Area factor
 - .6 Design velocity
 - .7 Design air flow
 - .8 Test (final) velocity
 - .9 Test (final) air flow
 - .10 Percent of design air flow
- .10 Sound Level Report:
 - .1 Location
 - .2 Octave bands - equipment off
 - .3 Octave bands - equipment on

END OF SECTION

Part 1 General

1.1 SECTION INCLUDES

- .1 Duct work insulation.
- .2 Duct Liner.
- .3 Insulation jackets.

1.2 RELATED SECTIONS

- .1 Section 09 91 23 - Painting
- .2 Section 23 05 53 - Mechanical Identification.
- .3 Section 23 31 00 - Duct Work: Glass fibre duct work.
- .4 Section 23 31 00 - Duct Work: Duct liner.

1.3 REFERENCES

- .1 Section 01 43 00: Requirements for references and standards.
- .2 ASTM B209 - Aluminum and Aluminum-Alloy Sheet and Plate.
- .3 ASTM C518 - Steady-State Thermal Transmission Properties by Means of the Heat Flow Metre Apparatus.
- .4 ASTM C553 - Standard Specification for Mineral Fibre Blanket Thermal Insulation for Commercial and Industrial Applications.
- .5 ASTM C612 - Standard Specification for Mineral Fibre Block and Board Thermal Insulation.
- .6 ASTM C921 - Properties of Jacketing Materials for Thermal Insulation.
- .7 ASTM C1071 - Fibrous Glass Duct Lining Insulation(Thermal Sound Absorbing Material).
- .8 ASTM E84 - Standard Test Method for Surface Burning Characteristics of Building Materials.
- .9 ASTM E96 - Water Vapour Transmission of Materials.
- .10 ASTM E162 - Standard Test Method for Surface Flammability of Materials Using a Radiant Heat Energy Source.
- .11 ASTM G21 - Standard Practice for Determining Resistance of Synthetic Polymeric Materials to Fungi.
- .12 NAIMA National Insulation Standards.

- .13 NFPA 255 - Standard Method of Test of Surface Burning Characteristics of Building Materials.
- .14 SMACNA - HVAC Duct Construction Standards - Metal and Flexible.
- .15 UL 723 - Standard for Test for Surface Burning Characteristics of Building Materials.

1.4 SUBMITTALS FOR REVIEW

- .1 Section 21 05 00: Procedures for submittals.
- .2 Product Data: Provide product description, thermal characteristics, list of materials and thickness for each service, and locations.

1.5 QUALITY ASSURANCE

- .1 Manufacturer Qualifications: Company specializing in manufacturing the Products specified in this section with minimum three years documented experience.
- .2 Applicator Qualifications: Company specializing in performing the work of this section minimum three years documented experience.

1.6 REGULATORY REQUIREMENTS

- .1 Materials: Flame spread/smoke developed rating of 25/50 to NFPA 255 / UL 723.

1.7 DELIVERY, STORAGE, AND PROTECTION

- .1 Section 21 05 00: Transport, handle, store, and protect products.
- .2 Accept materials on site in original factory packaging, labelled with manufacturer's identification, including product density and thickness.
- .3 Protect insulation from weather and construction traffic, dirt, water, chemical, and mechanical damage, by storing in original wrapping.

1.8 ENVIRONMENTAL REQUIREMENTS

- .1 Section 21 05 00: Environmental conditions affecting products on site.
- .2 Maintain ambient temperatures and conditions required by manufacturers of adhesives, mastics, and insulation cements.
- .3 Maintain temperature during and after installation for minimum period of 24 hours.

Part 2 Products

2.1 VAPOUR BARRIER EXTERNAL DUCT WRAP, GLASS FIBRE, FLEXIBLE

- .1 Insulation: ASTM C553; flexible, noncombustible blanket.

- .1 'ksi' ('K') value: ASTM C518, 0.045 W/m-K at 24 degrees C (0.31 Btu-in/(hr ft²-°F) at 75 degrees F).
- .2 Maximum service temperature: 121 degrees C (250 degrees F).
- .3 Maximum moisture absorption: 0.20 percent by volume.
- .4 Density 12 kg/cu. meter (0.75 lb/cu. Foot).
- .2 Vapour Barrier Jacket:
 - .1 Kraft paper with glass fibre yarn and bonded to aluminized film (FRK).
 - .2 Moisture vapour transmission: ASTM E96; 0.02 perm.
 - .3 Secure with pressure sensitive tape.
- .3 Vapour Barrier Tape:
 - .1 Kraft paper reinforced with glass fibre yarn and bonded to aluminized film, with pressure sensitive rubber based adhesive.
- .4 Tie Wire: Annealed steel, 1.5 mm (16 gauge).

2.2 VAPOUR BARRIER EXTERNAL GLASS FIBRE RIGID INSULATION BOARD

- .1 Insulation: ASTM C612; rigid, noncombustible blanket.
 - .1 'ksi' ('K') value : ASTM C518, 0.045 at 24 degrees C (0.31 at 75 degrees F).
 - .2 Maximum service temperature: 121 degrees C (250 degrees F).
 - .3 Maximum moisture absorption: 0.20 percent by volume.
 - .4 Density: 48 kg/cu m (3.0 lb/cu ft).
- .2 Vapour Barrier Jacket:
 - .1 Kraft paper with glass fibre yarn and bonded to aluminized film.
 - .2 Moisture vapour transmission: ASTM E96; 0.04 perm.
 - .3 Secure with pressure sensitive tape.
- .3 Vapour Barrier Tape:
 - .1 Kraft paper reinforced with glass fibre yarn and bonded to aluminized film, with pressure sensitive rubber based adhesive.
- .4 Indoor Vapour Barrier Finish:
 - .1 Cloth: Untreated; 305 g/sq m (9 oz/sq yd) weight, glass fabric.
 - .2 Vinyl emulsion type acrylic, compatible with insulation, black colour.

2.3 GLASS FIBRE DUCT LINER, FLEXIBLE

- .1 Insulation: ASTM C1071; flexible, noncombustible blanket with poly vinyl acetate polymer impregnated surface and edge coat
 - .1 'ksi' ('K') Value: ASTM C518, maximum 0.045 at 24 degrees C (0.31 at 75 degrees F).
 - .2 Maximum Service Temperature: 121 degrees C (250 degrees F).
 - .3 Maximum Velocity on Coated Air Side: 30.5 m/s (6,000 fpm).

- .4 Minimum Noise Reduction Criteria: ASTM C1071 0.30 for 13 mm (1/2 inch) thickness; 0.45 for 25 mm (1 inch) thickness; 0.60 for 40 mm (1-1/2 inches) thickness; 0.70 for 50 mm (2 inch) thickness.
- .5 Minimum 55% Certified Recycled Content.
- .2 Adhesive:
 - .1 Waterproof, ASTM E162 fire-retardant type.
- .3 Liner Fasteners: Galvanized steel, with press-on head.

2.4 GLASS FIBRE DUCT LINER, RIGID

- .1 Insulation: ASTM C612; rigid, noncombustible board with acrylic polymer meeting ASTM G21 impregnated surface and edge coat.
 - .1 'ksi' ('K') value : ASTM C518, maximum 0.27 at 24 degrees C (75 degrees F).
 - .2 Maximum service temperature: 121 degrees C (250 degrees F).
 - .3 Maximum Velocity on Coated Air Side: 24.5 m/s (5,000 fpm).
 - .4 Minimum Noise Reduction Criteria: ASTM C1071 0.55 for 25 mm (1 inch) thickness; 0.75 for 40 mm (1-1/2 inches) thickness; 0.90 for 50 mm (2 inch) thickness.
 - .5 Minimum 20% Certified Recycled Content.
- .2 Adhesive:
 - .1 Waterproof , ASTM E162 fire-retardant type.
- .3 Liner Fasteners: Galvanized steel, with press-on head.

2.5 GLASS FIBRE ROUND DUCT LINER

- .1 Insulation: Round, preformed in cylindrical sections with acrylic polymer meeting ASTM G21 impregnated surface coat.
 - .1 'ksi' ('K') value : ASTM C1071, 0.033 at 24 degrees C (0.23 at 75 degrees F).
 - .2 Maximum service temperature: 121 degrees C (250 degrees F).
 - .3 Maximum Velocity on Coated Air Side: 30.5 m/s (6,000 fpm).

Part 3 Execution

3.1 EXAMINATION

- .1 Section 01 71 00 - Examination and Preparation: Verification of existing conditions before starting work.
- .2 Verify that duct work has been tested before applying insulation materials.
- .3 Verify that surfaces are clean, foreign material removed, and dry.

3.2 INSTALLATION

- .1 Section 01 61 00-Common Product Requirements: Manufacturer's written instructions.
- .2 Install to NAIMA National Insulation Standards.
- .3 Use two layers with staggered joints when required nominal thickness exceeds 75 mm.
- .4 All duct sizes on the drawings refer to inside duct dimensions. On all acoustically lined ductwork, the external duct dimensions shall be increased by the thickness of the lining.
- .5 Insulated duct work conveying air below ambient temperature:
 - .1 Provide insulation with vapour barrier jackets.
 - .2 Finish with tape and vapour barrier jacket.
 - .3 Continue insulation through walls, sleeves, hangers, and other duct penetrations.
 - .4 Insulate entire system including fittings, joints, flanges, fire dampers, flexible connections, and expansion joints.
- .6 Insulated duct work conveying air above ambient temperature:
 - .1 Provide with or without standard vapour barrier jacket.
 - .2 Insulate fittings and joints. Where service access is required, bevel and seal ends of insulation.
- .7 Where ducts are acoustically lined to the equivalent R-value, no exterior duct insulation is required.
- .8 External Duct Insulation Application:
 - .1 Secure insulation with vapour barrier with wires and seal jacket joints with vapour barrier adhesive or tape to match jacket.
 - .2 Secure insulation without vapour barrier with staples, tape, or wires.
 - .3 Install without sag on underside of duct work. Use adhesive or mechanical fasteners where necessary to prevent sagging. Lift duct work off trapeze hangers and insert spacers.
 - .4 Seal vapour barrier penetrations by mechanical fasteners with vapour barrier adhesive.
 - .5 Stop and point insulation around access doors and damper operators to allow operation without disturbing wrapping.
- .9 Duct and Plenum Liner Application:
 - .1 Adhere insulation with adhesive for 90 percent coverage.
 - .2 Secure insulation with mechanical liner fasteners. Refer to SMACNA Standards for spacing.
 - .3 Seal and smooth joints. Seal and coat transverse joints.
 - .4 Seal liner surface penetrations with adhesive.
 - .5 Duct dimensions indicated are net inside dimensions required for air flow. Increase duct size to allow for insulation thickness.

3.3 SCHEDULES

- .1 Duct insulation shall follow the Schedules below as a minimum requirement. These requirements shall apply regardless of whether or not duct insulation is shown on the drawings.
- .2 Where duct insulation is shown on the drawings (either with the hatching convention or by means of a key note) and exceeds the requirements of the schedules below, the additional insulation requirements shall be met.

3.4 EXTERNAL DUCT WRAP, GLASS FIBRE, FLEXIBLE

DUCT SERVICE	DUCT SIZE <Inch><mm>	THICKNESS <mm><Inch>
All conditioned air supply ductwork in return plenums or un-conditioned interior space or mechanical rooms or electrical rooms	=< 400 mm (16") per side, or round duct	29mm (1 1/8") Installed 38mm (1 1/2") Nominal

3.5 EXTERNAL GLASS FIBRE RIGID INSULATION BOARD

DUCT SERVICE	DUCT SIZE <Inch><mm>	THICKNESS <mm><Inch>
All conditioned air supply ductwork in return plenums or un-conditioned interior space or mechanical rooms or electrical rooms	> 400 mm (16") per side	25mm (1")

3.6 GLASS FIBRE DUCT LINER, RIGID

DUCT SERVICE	DUCT SIZE <Inch><mm>	THICKNESS <mm><Inch>
Rectangular air supply and return air ductwork where indicated on drawings by acoustic hatching symbol.	All	25mm (1")

3.7 GLASS FIBRE DUCT LINER, FLEXIBLE

DUCT SERVICE	DUCT SIZE <Inch><mm>	THICKNESS <mm><Inch>
Rectangular air supply and return air ductwork where indicated on drawings by acoustic hatching symbol.	All	25mm (1")

END OF SECTION

Part 1 General

1.1 SECTION INCLUDES

- .1 Metal duct work.
- .2 Nonmetal duct work.
- .3 Duct cleaning.

1.2 RELATED SECTIONS

- .1 Section 01 11 00 - Summary of Work..
- .2 Section 23 05 29 - Supports And Anchors: Sleeves.
- .3 Section 23 07 13 - Duct Insulation: External insulation and duct liner.
- .4 Section 23 33 00 - Duct Work Accessories.
- .5 Section 23 36 00 - Air Terminal Units.
- .6 Section 23 37 00 - Air Outlets And Inlets.
- .7 Section 23 05 93 - Testing, Adjusting, And Balancing.

1.3 REFERENCES

- .1 ASTM A36/A36M - Carbon Structural Steel.
- .2 ASTM A90/A90M - Weight (Mass) of Coating on Iron and Steel Articles with Zinc or Zinc-Alloy Coatings.
- .3 ASTM A167 - Stainless and Heat-Resisting Chromium-Nickel Steel Plate, Sheet, and Strip.
- .4 ASTM A480/A480M - General Requirements for Flat-Rolled Stainless and Heat-Resisting Steel Plate, Sheet, and Strip.
- .5 ASTM A568/A568M - General Requirements for Steel Sheet, Carbon, and High-Strength, Low-Alloy, Hot-Rolled and Cold-Rolled.
- .6 ASTM A653/A653M - Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process.
- .7 ASTM A1008/A1008M - Steel, Sheet, Cold-Rolled Carbon, Structural, High-Strength Low-Alloy and High Strength Low-Alloy with Improved Formability.
- .8 ASTM A1011/A1011M - Standard Specification for Steel, Sheet, and Strip Hot-Rolled, Carbon, Structural, High-Strength, Low-Alloy with Improved Formability.
- .9 ASTM B209 - Aluminum and Aluminum-Alloy Sheet and Plate.

- .10 AWS D9.1 - Sheet Metal Welding Code.
- .11 NBS PS 15 - Voluntary Product Standard for Custom Contact-Moulded Reinforced-Polyester Chemical Resistant Process Equipment.
- .12 NFPA 90A - Installation of Air Conditioning and Ventilating Systems.
- .13 NFPA 90B - Installation of Warm Air Heating and Air-Conditioning Systems.
- .14 SMACNA - HVAC Air Duct Leakage Test Manual.
- .15 SMACNA - HVAC Duct Construction Standards - Metal and Flexible.
- .16 UL 181 - Factory-Made Air Ducts and Connectors.

1.4 PERFORMANCE REQUIREMENTS

- .1 No variation of duct configuration or sizes permitted except by written permission. Size round ducts installed in place of rectangular ducts to ASHRAE table of equivalent rectangular and round ducts.

1.5 SUBMITTALS

- .1 Section 21 05 00: Procedures for submittals.
- .2 Test Reports: Indicate pressure tests performed. Include date, section tested, test pressure, and leakage rate, following SMACNA HVAC Air Duct Leakage Test Manual.

1.6 PROJECT RECORD DOCUMENTS

- .1 Section 21 05 00: Submittals for project closeout.
- .2 Record actual locations of ducts and duct fittings. Record changes in fitting location and type. Show additional fittings used.

1.7 QUALITY ASSURANCE

- .1 Perform Work to SMACNA - HVAC Duct Construction Standards - Metal and Flexible.
- .2 Maintain one copy of document on site.

1.8 QUALIFICATIONS

- .1 Manufacturer: Company specializing in manufacturing the Products specified in this section with minimum three years' experience.
- .2 Installer: Company specializing in performing the work of this section with minimum three years documented experience.

1.9 ENVIRONMENTAL REQUIREMENTS

- .1 Do not install duct sealants when temperatures are less than those recommended by sealant manufacturers.
- .2 Maintain temperatures during and after installation of duct sealants.

Part 2 Products

2.1 MATERIALS

- .1 Galvanized Steel Ducts: ASTM A653 galvanized steel sheet, lock-forming quality, having G60 zinc coating of to ASTM A90.
- .2 Steel Ducts: ASTM A1008, A568.
- .3 Insulated Flexible Ducts:
 - .1 Thermally insulated flexible duct with acoustically rated black CPE core permanently bonded to a coated spring steel wire helix, with fibreglass insulation over fibreglass scrim and polyethylene vapour barrier. Pressure rating of 6" W.G. (positive) for 4" – 20" I.D. Temperature range -20 °F to 200 °F continuous, R-value R-4.2.
 - .2 The ductwork shall meet NFPA Pamphlet 90A paragraph 113 (a) for flame spread and smoke rating and to meet Underwriter's Laboratories of Canada requirements.
 - .3 Flexible air ducts shall conform to UL-181 Standard and NFPA 90A. Flexible air ducts shall have a fire rating of at least one-half hour as measured by UL-181 Standard, paragraph No. 7, Flame Penetration Test.
- .4 Fasteners: Rivets, bolts, or sheet metal screws.
- .5 Sealant:
 - .1 Non-hardening, water resistant, fire resistive, compatible with mating materials; liquid used alone or with tape, or heavy mastic.
- .6 Hanger Rod: ASTM A36; steel, galvanized; threaded both ends, threaded one end, or continuously threaded.

2.2 DUCT WORK FABRICATION

- .1 Fabricate and support to SMACNA HVAC Duct Construction Standards - Metal and Flexible, and as indicated. Unless otherwise indicated fabrication shall conform to standards for duct pressure class rating of +2" w.g. Provide duct material, gauges, reinforcing, and sealing for operating pressures indicated.
- .2 Construct T's, bends, and elbows with radius of not less than 1-1/2 times width of duct on centreline. Where not possible and where rectangular elbows are used, provide air-foil turning vanes. Where acoustical lining is indicated, provide turning vanes of perforated metal with glass fibre insulation.

- .3 Increase duct sizes gradually, not exceeding 15 degrees divergence wherever possible; maximum 30 degrees divergence upstream of equipment and 45 degrees convergence downstream.
- .4 Fabricate continuously welded round and oval duct fittings two gauges heavier than duct gauges indicated in SMACNA Standard. Joints: minimum 100 mm (4 inch) cemented slip joint, brazed or electric welded. Prime coat welded joints.
- .5 Provide standard 45 degree lateral wye takeoffs unless otherwise indicated where 90 degree conical tee connections may be used.
- .6 All rectangular ducts shall be constructed by breaking the corners and grooving the longitudinal seams using Pittsburgh seam or other approved airtight seam.
- .7 All elbows and transformation pieces shall be constructed using Pittsburgh corner seams or double seam corners. All transverse joints shall be constructed using S-slips, Bar Slips, Drive Slips, etc. where recommended in ASHRAE guide. All slips shall be not less than one gauge heavier than duct material. Open corners will not be accepted.

2.3 MANUFACTURED DUCT WORK AND FITTINGS

- .1 Manufacture to SMACNA HVAC Duct Construction Standards - Metal and Flexible, and as indicated. Provide duct material, gauges, reinforcing, and sealing for operating pressures indicated.
- .2 Flat Oval Ducts:
 - .1 Machine made from round spiral lockseam duct with light reinforcing corrugations; fittings manufactured of at least two gauges heavier metal than duct.

Part 3 Execution

3.1 INSTALLATION

- .1 Install to manufacturer's written instructions.
- .2 Install and seal ducts to SMACNA HVAC Duct Construction Standards - Metal and Flexible.
- .3 Duct sizes are inside clear dimensions. For lined ducts, maintain sizes inside lining.
- .4 No variation of duct sizes will be permitted except by written permission of the Consultant. In the event that additional offsets and changes in direction are required in the duct system, these changes shall be made by the Sheet Metal Trade without additional cost to the Owner. All ductwork shall be to the recommended practices as laid down by the Sheet Metal and Air Conditioning Contractors National Association (SMACNA).
- .5 Where the width of the duct exceeds 450 mm (18") in its largest dimension such ductwork shall be suitably stiffened by breaking the sheets diagonally.
- .6 If ductwork is insulated, cross breaking may be omitted providing the ducts are 2 gauges heavier than shown on the above schedule.

- .7 All laps shall be in the direction of air flow. Rivets and bolts shall be used throughout. All edges and slips shall be hammered down to leave a smooth interior duct.
- .8 Where low pressure ductwork conflicts with mechanical and electrical piping and it is not possible to divert the ductwork or piping to stay within allowable space limitation, provide duct easements.
- .9 Easements are not required on pipes 100 mm (4") and smaller outside dimension, unless this exceeds 20% of the duct area. Any irregular or flat shaped intrusions require a duct easement. Hangers and straps in the ductwork shall be parallel to air flow. If this is not possible, provide an easement. If the easement exceeds 25% of the duct area, the duct shall be split into two ducts with the original duct area being maintained. All easements shall be approved by the Consultant before installation.
- .10 Provide openings in duct work where required to accommodate thermometers and controllers. Provide pilot tube openings where required for testing of systems, complete with metal can with spring device or screw to ensure against air leakage. Where openings are provided in insulated duct work, install insulation material inside a metal ring.
- .11 Locate pitot tube test openings in ductwork at supply fan discharges, on intake of exhaust/and return air fans, in major duct branches and everywhere pitot tube openings are required for proper balancing of air conditioning, ventilation and exhaust systems. Do not place closer than 1829mm (72 inches) to elbows. Space every 150mm (6 inches) across air stream at each location. Refer to drawings for additional opening requirements.
- .12 Locate ducts with sufficient space around equipment to allow normal operating and maintenance activities.
- .13 Use crimp joints with or without bead for joining round duct sizes 200 mm (8 inch) and smaller with crimp in direction of air flow.
- .14 Use only threaded rod for duct support in exposed areas. Strapping not allowed.
- .15 Use double nuts and lock washers on threaded rod supports.
- .16 Insulated Flexible ductwork: Maximum installed horizontal length: One continuous length at 1500 mm (5'-0"). Use standard sheet-metal elbows at drop points to outlets. Use of the flexible duct in lieu of an elbow at the diffuser drop point is not permitted. Connect flexible ducts to metal ducts with adhesive plus sheet metal screws.
- .17 Connect fan powered terminal units to supply ducts with 300 mm (one foot) maximum length of flexible duct. Do not use flexible duct to change direction.
- .18 Connect diffuser boots or light troffer boots to low pressure ducts with 1.5 m (5 feet) maximum length of insulated flexible duct held in place with strap or clamp.
- .19 Where interior of duct is visible through grilles, registers or diffusers, paint interior of duct with flat black Tremco paint formulated for galvanized surfaces.
- .20 Set plenum doors 150 to 300 mm (6 to 12 inches) above floor. Arrange door swings so that fan static pressure holds door in closed position.

- .21 During construction provide temporary closures of metal or taped polyethylene on open duct work to prevent construction dust from entering duct work system.
- .22 Seal ductwork so that it is sufficiently airtight to ensure economical and quiet performance of the system. All ductwork, except where otherwise indicated, shall have seams and joints sealed with Duro-Dyne S-2 duct sealer. Apply duct sealer and duct tape in strict accordance with manufacturer's recommendations, to joints and seams to provide an airtight, watertight installation. Prior to application, ductwork to be dry and free of grease, etc. Use 6mm bead of material along joints. Material, when dry, to have 3.2mm depth extending 25mm on each side of joint or seam.
- .23 Install ductwork free from pulsation, chatter, vibration or objectionable noises.
- .24 Should any of these defects appear after the system is in operation, correct problems by removing, replacing, or reinforcing the work as directed by the Consultant.

3.2 CLEANING

- .1 Clean ductwork within the areas of project scope by forcing air at high velocity through duct to remove accumulated dust. To obtain sufficient air, clean half the system at a time. Protect equipment which may be harmed by excessive dirt with temporary filters, or bypass during cleaning.

3.3 SCHEDULES

- .1 DUCT WORK PRESSURE CLASS SCHEDULE

AIR SYSTEM	PRESSURE CLASS
Supply and Return	250 Pa (1 inch)

END OF SECTION

Part 1 General

1.1 SECTION INCLUDES

- .1 Air turning devices/extractors.
- .2 Fire Dampers
- .3 Duct access doors.
- .4 Duct test holes.
- .5 Flexible duct connections.
- .6 Volume control dampers.

1.2 RELATED SECTIONS

- .1 Section 23 05 48 – Vibration Isolation
- .2 Section 23 31 00 - Duct Work.
- .3 Section 23 36 00 - Air Terminal Units: Pressure regulating damper assemblies.

1.3 REFERENCES

- .1 NFPA 90A - Installation of Air Conditioning and Ventilating Systems.
- .2 SMACNA - HVAC Duct Construction Standards - Metal and Flexible.
- .3 CAN/ULC-S112 Standard Method of Fire Test of Fire-Damper Assemblies
- .4 UL 33 - Heat Responsive Links for Fire-Protection Service.
- .5 UL 555 - Fire Dampers.
- .6 CAN/ULC-S112.2, Standard Method of Fire Test of Ceiling Fire Stop Flap Assemblies.

1.4 SUBMITTALS

- .1 Section 21 05 00: Procedures for submittals.
- .2 Manufacturer's Installation Instructions: Indicate for fire dampers.

1.5 PROJECT RECORD DOCUMENTS

- .1 Section 21 05 00: Submittals for project closeout.
- .2 Record actual locations of access doors.

1.6 QUALIFICATIONS

- .1 Manufacturer: Company specializing in manufacturing the Products specified in this section with minimum three years documented experience.

1.7 REGULATORY REQUIREMENTS

- .1 Products Requiring Electrical Connection: Listed and classified by Underwriters' Laboratories Inc., and testing firm acceptable to the authority having jurisdiction as suitable for the purpose specified and indicated.

1.8 DELIVERY, STORAGE, AND HANDLING

- .1 Section 21 05 00: Transport, handle, store, and protect products.
- .2 Protect dampers from damage to operating linkages and blades.

Part 2 Products

2.1 AIR TURNING DEVICES/EXTRACTORS

- .1 Multi-blade device with radius blades attached to pivoting frame and bracket, steel construction, with push-pull operator strap.

2.2 DUCT ACCESS DOORS

- .1 Fabricate to SMACNA HVAC Duct Construction Standards - Metal and Flexible, and as indicated.
- .2 Fabrication: Rigid and close-fitting of galvanized steel with sealing gaskets and quick fastening locking devices. For insulated duct work, install minimum 25 mm (one inch) thick insulation with sheet metal cover.
 - .1 Less than 300 mm (12 inches) Square: Secure with sash locks.
 - .2 Up to 450 mm (18 inches) Square: Provide two hinges and two sash locks.
 - .3 Up to 600 x 1200 mm (24 x 48 inches): Three hinges and two compression latches.
 - .4 Larger Sizes: Provide an additional hinge.
- .3 Access doors with sheet metal screw fasteners are not acceptable.
- .4 Doors in insulated ductwork to be double panel construction with a 25mm (1") insulating filler.
- .5 In certain locations where it is inconvenient to swing access doors, removable doors with 4 cam locks will be accepted. However, all such locations shall be approved by the Consultant prior to installation.

2.3 DUCT TEST HOLES

- .1 Temporary Test Holes: Cut or drill in ducts as required. Cap with neat patches, neoprene plugs, threaded plugs, or threaded or twist-on metal caps.

- .2 Permanent Test Holes: Factory fabricated, air tight flanged fittings with screw cap. Provide extended neck fittings to clear insulation;

2.4 FIRE DAMPERS

- .1 Depending on the rating of fire separation, rating, construction and testing of the fire damper will conform to most recent issue of all of following:
 - .1 National Building Code of Canada
 - .2 ULC S 112
 - .3 NFPA 252
 - .4 ULC or ULI 10(b)
- .2 Use type 'B' dynamic fire dampers, i.e. blades out of air stream, to be used in all ducts passing through fire separations. Combination fire damper-balancing damper, with blades in air stream shall be used on sidewall or return, or floor mounted supply, up to maximum size of 0.372 sq.m (576 sq.in.). For sidewall return above 0.372 sq.m (576 sq.in.) in size, use a type 'A' fire damper, i.e. blades in air stream.
- .3 Horizontal Dampers: Galvanized steel, 0.76 mm (22 gauge) frame, stainless steel closure spring, and lightweight, heat retardant non-asbestos fabric blanket.
- .4 Curtain Type Dampers: Galvanized steel with interlocking blades. Provide stainless steel closure springs and latches for horizontal installations. Configure with blades out of air stream except at all locations unless otherwise indicated on the drawings, and for 250 Pa (1.0 inch) pressure class ducts up to 300 mm (12 inches) in height.
- .5 Multiple Blade Dampers: 1.5 mm (16 gauge) galvanized steel frame and blades, oil-impregnated bronze or stainless steel sleeve bearings and plated steel axles, 3.2 x 12.7 mm (1/8 x 1/2 inch) plated steel concealed linkage, stainless steel closure spring, blade stops, and lock.
- .6 Fusible Links: UL 33, separate at 71°C, (160°F) with adjustable link straps for combination fire/balancing dampers.

2.5 FLEXIBLE DUCT CONNECTIONS

- .1 Fabricate to SMACNA HVAC Duct Construction Standards - Metal and Flexible, and as indicated.
- .2 Connector: Fabric crimped into metal edging strip.
 - .1 Fabric: UL listed fire-retardant neoprene coated woven glass fibre fabric to NFPA 90A, minimum density 1.0 kg/sq m (30 oz per sq yd).
 - .2 Net Fabric Width: Approximately 75mm (3 inches) wide.
 - .3 Metal: 75 mm (3 inch) wide, 0.6 mm thick (24 gauge) galvanized steel.

2.6 VOLUME CONTROL DAMPERS.

- .1 Fabricate to SMACNA HVAC Duct Construction Standards - Metal and Flexible, and as indicated.

- .2 Splitter Dampers:
 - .1 Material: Same gauge as duct to 600 mm (24 inches) size in either direction, and two gauges heavier for sizes over 600 mm(24 inches).
 - .2 Blade: Fabricate of double thickness sheet metal to streamline shape, secured with continuous hinge or rod.
 - .3 Operator: Minimum 6 mm (1/4 inch) diameter rod in self aligning, universal joint action, flanged bushing with set screw.
- .3 Single Blade Dampers: Fabricate for duct sizes up to 150 x 760 mm (6 x 30 inch).
- .4 Multi-Blade Damper: Fabricate of opposed blade pattern with maximum blade sizes 200 x 1825 mm (8 x 72 inch). Assemble centre and edge crimped blades in prime coated or galvanized channel frame with suitable hardware.
- .5 End Bearings: Except in round duct work 300 mm (12 inches) and smaller, provide end bearings. On multiple blade dampers, provide oil-impregnated nylon or sintered bronze bearings.
- .6 Quadrants:
 - .1 Provide locking, indicating quadrant regulators on single and multi-blade dampers.
 - .2 On insulated ducts mount quadrant regulators on stand-off mounting brackets, bases, or adapters.
 - .3 Where rod lengths exceed 750 mm (30 inches) provide regulator at both ends.

Part 3 Execution

3.1 PREPARATION

- .1 Verify that electric power is available and of the correct characteristics.

3.2 INSTALLATION

- .1 Install accessories to manufacturer's written instructions, NFPA 90A, and follow SMACNA HVAC Duct Construction Standards - Metal and Flexible. Refer to Section 23 31 00 for duct construction and pressure class.
- .2 Provide backdraft dampers where indicated.
- .3 Provide duct access doors for inspection and cleaning before and after filters, coils, fans, automatic dampers, at fire dampers, combination fire and smoke dampers, and elsewhere as indicated. Provide minimum 300 x 300 mm (12 x 12 inch) size for all fire dampers. Enlarge duct if necessary to accommodate properly sized access door.
- .4 Generally access doors at heating coils shall approximate width of coil for ease of cleaning.
- .5 Provide duct test holes where indicated and required for testing and balancing purposes. Plug test holes with removable caps.
- .6 Provide fire dampers at locations indicated, where ducts and outlets pass through fire rated components, and where required by authorities having jurisdiction. Install with required

- perimeter mounting angles, sleeves, breakaway duct connections, corrosion resistant springs, bearings, bushings and hinges.
- .7 Demonstrate re-setting of fire dampers to Owner's representative.
 - .8 Provide flexible connections immediately adjacent to equipment in ducts connected to mechanical equipment.
 - .9 Use splitter dampers only where indicated.
 - .10 Provide balancing dampers on high velocity systems where indicated. Refer to Section 23 36 00.
 - .11 Provide balancing dampers on duct take-off to diffusers, grilles, and registers, regardless of whether dampers are specified as part of the diffuser, grille, or register assembly.
 - .12 Do not locate single blade volume dampers immediately behind diffusers and grilles. This application does not allow uniform airflow across the outlet face.
 - .13 To minimize generated duct noise, locate volume dampers at least two duct diameters from a fitting and as far away as possible from the outlet or inlet.

END OF SECTION

Part 1

General

1.1 SECTION INCLUDES

- .1 Cabinet and Ceiling Exhaust Fans

1.2 RELATED WORK

- .1 Section 23 05 48 – Vibration Isolation
- .2 Section 23 05 53 - Mechanical Identification.
- .3 Section 23 05 93 – Testing, Adjusting, And Balancing.
- .4 Section 23 07 13 - Duct Insulation.
- .5 Section 23 31 00 - Duct Work.
- .6 Section 26 05 80 - Equipment Wiring: Electrical characteristics and wiring connections.

1.3 REFERENCES

- .1 AFBMA 9 - Load Ratings and Fatigue Life for Ball Bearings.
- .2 AFBMA 11 - Load Ratings and Fatigue Life for Roller Bearings.
- .3 AMCA 99 - Standards Handbook.
- .4 AMCA 210 - Laboratory Methods of Testing Fans for Aerodynamic Performance Rating.
- .5 AMCA 300 - Reverberant Room Method for Sound Testing of Fans.
- .6 AMCA 301 - Method of Calculating Fan Sound Ratings from Laboratory Test Data.
- .7 ISO 1940 – Mechanical Vibration. Balance quality requirements for rotors in a constant (rigid) state.
- .8 SMACNA - HVAC Duct Construction Standards - Metal and Flexible.
- .9 UL/cUL 705 – Power Ventilators

1.4 SUBMITTALS

- .1 Section 21 05 00: Procedures for submittals.
- .2 Shop Drawings: Indicate assembly of centrifugal fans and accessories including fan curves with specified operating point clearly plotted, sound power levels for both fan inlet and outlet at rated capacity, and electrical characteristics and connection requirements.

- .3 Product Data: Provide data on centrifugal fans and accessories including fan curves with specified operating point clearly plotted, sound power levels for both fan inlet and outlet at rated capacity, and electrical characteristics and connection requirements.
- .4 Manufacturer's Installation Instructions.

1.5 OPERATION AND MAINTENANCE DATA

- .1 Section 21 05 00: Submittals for project closeout.
- .2 Maintenance Data: Include instructions for lubrication, motor and drive replacement, spare parts list, and wiring diagrams.

1.6 DELIVERY, STORAGE, AND HANDLING

- .1 Section 21 05 00: Transport, handle, store, and protect products.
- .2 .Protect motors, shafts, and bearings from weather and construction dust.

1.7 ENVIRONMENTAL REQUIREMENTS

- .1 Do not operate fans for any purpose until ductwork is clean, filters in place, bearings lubricated, and fan has been test run under observation.

1.8 EXTRA MATERIALS

- .1 Section 21 05 00: Submittals for project closeout.

Part 2 Products

2.1 CABINET AND CEILING EXHAUST FANS

- .1 Centrifugal Fan Unit: Direct driven with galvanized steel housing resilient mounted motor, gravity backdraft damper in discharge. Ceiling hanger supports or frame provided to support hanging from underside of deck. Units to be mounted in ceiling tile. Acoustic lining to attain specified sound ratings is acceptable.
- .2 Electrical Characteristics and Components
 - .1 Electrical Characteristics:
 - .1 See Schedule.
 - .2 UL/cUL listed.
 - .3 Wiring Terminations: Provide terminal lugs to match branch circuit conductor quantities, sizes, and materials indicated. Enclose terminal lugs in terminal box sized to code.
 - .4 Disconnect Switch: Cord and plug in housing for thermal overload protected motor and wall mounted switch.
 - .3 Grille: Moulded white plastic or aluminum with baked white enamel finish.
 - .4 Sound level: Maximum 0.8 sones permissible sound output.

Part 3 Execution

3.1 INSTALLATION

- .1 Install to manufacturer's written instructions.
- .2 Install fans with vibration damped mountings and flexible electrical leads.
- .3 Install 1000 mm duct with 90° elbow lined with acoustic insulation for acoustic treatment.
Duct to discharge to ceiling plenum. Route as required to prevent interferences.

END OF SECTION

Part 1 General

1.1 SECTION INCLUDES

- .1 Variable volume terminal units.

1.2 RELATED SECTIONS

- .1 Section 23 31 00 - Duct Work.
- .2 Section 23 33 00 - Duct Work Accessories.
- .3 Section 23 37 00 - Air Outlets And Inlets.
- .4 Section 25 30 00 – Instruments and Control Elements
- .5 Section 26 05 80 - Equipment Wiring: Electrical characteristics and wiring connections.

1.3 REFERENCES

- .1 ADC 1062 - Air Distribution and Control Device Test Code.
- .2 NFPA 90A - Installation of Air Conditioning and Ventilation Systems.
- .3 UL 181 - Factory-Made Air Ducts and Connectors.
- .4 UL 1995 / CSA 236 - Standard of Safety for Heating and Cooling Equipment
- .5 AHRI 880 – Performance Rating of Air Terminals
- .6 AHRI 885 - Procedure for Estimating Occupied Space Sound Levels in the Application of Air Terminals and Air Outlets
- .7 ASHRAE 130 - Methods of Testing Air Terminal Units
- .8 AHRI 410 Air Cooling and Heating Coils

1.4 PERFORMANCE TOLERANCES

- .1 Base performance on tests conducted to ADC 1062.
- .2 AHRI 880 – Performance Rating of Air Terminals
- .3 AHRI 885 - Procedure for Estimating Occupied Space Sound Levels in the Application of Air Terminals and Air Outlets

1.5 SUBMITTALS

- .1 Section 21 05 00: Procedures for submittals.

- .2 Shop Drawings: Indicate configuration, general assembly, and materials used in fabrication, and electrical characteristics and connection requirements.
- .3 Product Data: Provide data indicating configuration, general assembly, and materials used in fabrication. Include catalogue performance ratings which indicate air flow, static pressure, and NC designation. Include electrical characteristics and connection requirements.
- .4 Include schedules listing discharge and radiated sound power level for each of second through seventh octave bands at inlet static pressures of 125 to 750 Pa (.05 to 3 inch wg).
- .5 Manufacturer's Installation Instructions: Indicate support and hanging details, and service clearances required.

1.6 PROJECT RECORD DOCUMENTS

- .1 Section 21 05 00: Submittals for project closeout.
- .2 Record actual locations of units.

1.7 OPERATION AND MAINTENANCE DATA

- .1 Section 21 05 00: Submittals for project closeout.
- .2 Operation and Maintenance Data: Include manufacturer's descriptive literature, operating instructions, maintenance and repair data, and parts lists. Include directions for resetting constant volume regulators.

1.8 QUALIFICATIONS

- .1 Manufacturer: Company specializing in manufacturing the Products specified in this section with minimum three years documented experience.

1.9 REGULATORY REQUIREMENTS

- .1 Products Requiring Electrical Connection: Listed and classified by Underwriters' Laboratories Inc., or testing firm acceptable to the authority having jurisdiction as suitable for the purpose specified and indicated.

1.10 WARRANTY

- .1 Section 21 05 00: Submittals for project closeout.
- .2 Provide one year warranty.
- .3 Warranty: Include coverage of system powered control systems, operating controls, and electric motors.

1.11 EXTRA MATERIALS

- .1 Section 21 05 00: Submittals for project closeout.

Part 2 Products

2.1 MANUFACTURED UNITS

- .1 Ceiling mounted variable air volume for connection to single duct, central air systems, with digital variable volume controls.
- .2 Identify each terminal unit with clearly marked identification label and air flow indicator. Include unit nominal air flow, maximum factory set airflow, minimum factory set air flow, and coil type.

2.2 SINGLE DUCT VARIABLE VOLUME UNITS

- .1 Basic Assembly:
 - .1 Casings: Minimum 0.8 mm (22 gauge) galvanized steel.
 - .2 Lining: Minimum 13 mm (1/2inch) thick neoprene or vinyl coated fibrous glass insulation, 24 g/L(1.5 lb/cu ft) density, meeting NFPA 90A requirements and UL 181 erosion requirements..
 - .3 Plenum Air Inlets: Round stub connections for duct attachment.
 - .4 Plenum Air Outlets: S slip and drive connections.
 - .5 Face liner: Refer to schedule
- .2 Basic Unit:
 - .1 Configuration: Air volume damper assembly inside unit casing. Locate control component inside protective metal shroud.
 - .2 Volume Damper: Construct of galvanized steel with peripheral gasket and self lubricating bearings; maximum damper leakage: 2 percent of design air flow at 0.75 kPa (3 inches) inlet static pressure.
 - .3 Mount damper operator to position damper normally open.
- .3 Attenuator Section: Length of 900mm (36 inches). Line attenuator sections with matching air terminal liner.
- .4 Multi Outlet Attenuator Section: With butterfly balancing damper with lock.
- .5 Round Outlet: Discharge collar to match where scheduled.
- .6 Automatic Damper Operator:
 - .1 Electric Actuator: 24 volt with remote temperature read and reset capability.
- .7 Thermostat: Electronic type with appropriate mounting hardware. Refer to Section 25 30 00.

Part 3 Execution

3.1 INSTALLATION

- .1 Install to manufacturer's written instructions.

- .2 Provide a minimum of three duct diameters of straight inlet duct, the same size as the inlet, between the inlet and any transition, takeoff or fitting.
- .3 Provide minimum of 1.5 m (5 ft) of lined ductwork, matching the air terminal liner, directly downstream of units.
- .4 Provide ceiling access doors or locate units above easily removable ceiling components.
- .5 Support units individually from structure. Do not support from adjacent ductwork.
- .6 Connect to ductwork to Section 23 31 00.

3.2 ADJUSTING

- .1 Adjust work to Section 21 05 00.
- .2 Reset volume with damper operator attached to assembly allowing flow range modulation from 100 percent of design flow to scheduled minimum flow.

3.3 SCHEDULES

- .1 Refer to the drawing for air terminal schedules.

END OF SECTION

Part 1 General

1.1 SECTION INCLUDES

- .1 Diffusers.
- .2 Registers/grilles.

1.2 RELATED SECTIONS

- .1 Section 09 91 23 - Painting: Painting of duct work visible behind outlets and inlets.

1.3 REFERENCES

- .1 ADC 1062 - Air Distribution and Control Device Test Code.
- .2 AMCA 500 - Method of Testing Louvers for Ratings.
- .3 AMCA 511 – Certified Ratings Program
- .4 AMCA 5000 - Method of Testing Dampers for Ratings.
- .5 ARI 650 - Air Outlets and Inlets.
- .6 ASHRAE 70 - Method of Testing for Rating the Performance of Outlets and Inlets.
- .7 SMACNA - HVAC Duct Construction Standard - Metal and Flexible.
- .8 NFPA 90A - Installation of Air Conditioning and Ventilating Systems.

1.4 SUBMITTALS

- .1 Section 21 05 00: Procedures for submittals.
- .2 Product Data: Provide data for equipment required for this project. Review outlets and inlets as to size, finish, and type of mounting prior to submission. Submit schedule of outlets and inlets showing type, size, location, application, and noise level.

1.5 PROJECT RECORD DOCUMENTS

- .1 Section 21 05 00: Submittals for project closeout.
- .2 Record actual locations of air outlets and inlets.

1.6 QUALITY ASSURANCE

- .1 Test and rate air outlet and inlet performance to ADC Equipment Test Code 1062 and ASHRAE 70.
- .2 Test and rate louver performance to AMCA 500

- .3 Certified AMCA 511 – Certified Ratings Program

1.7 QUALIFICATIONS

- .1 Manufacturer: Company specializing in manufacturing the Products specified in this section with minimum three years documented experience.

Part 2 Products

2.1 GENERAL

2.2 SQUARE CEILING DIFFUSERS – SPD

- .1 Type: Square, stamped diffuser with flat pan to discharge air in 360 degree pattern.
- .2 Construction:
 - .1 Nominal 600x600 size with standard t-bar frame to match ceiling grid dimensions
 - .2 Manufacturer’s standard white finish.
- .3 Refer to the schedule for duct size,

2.3 CEILING GRID CORE EXHAUST AND RETURN REGISTERS/GRILLES - CGC

- .1 Type: Fixed grilles of 13 x 13 x 13 mm (1/2 x 1/2 x 1/2 inch) louvers.
- .2 Construction:
 - .1 Manufacturers standard white colour.
 - .2 Provide frame for installation onto surfaces or inside t-bar grid based on installation location.
 - .1 Provide countersunk screws surface painted to frame colour for surface installations.
 - .2 Provide t-bar lay-in frame sized for ceiling grid.
- .3 Refer to the schedule for size.

2.4 CEILING SLOT DIFFUSERS - SD

- .1 Type: Continuous slot, with adjustable vanes for left, right, or vertical discharge.
- .2 Construction:
 - .1 Manufacturer’s standard white finish
 - .2 Screw mounted flange frame.
 - .3 19 mm (3/4”) wide slot width.
 - .4 Refer to the schedule for size and number of slots.

Part 3 Execution

3.1 INSTALLATION

- .1 Install to manufacturer's written instructions.
- .2 Check location of outlets and inlets and make necessary adjustments in position to conform with architectural features, symmetry, and lighting arrangement.
- .3 Install diffusers to duct work with air tight connection.
- .4 All diffusers, grilles and registers shall be free of fluttering, chattering and vibration. A felt or sponge rubber gasket shall be provided behind each outlet or inlet and adequate fastenings provided to prevent leakage between the outlet and duct, wall or ceiling.
- .5 In all cases where linear diffusers are required to run continuous from one wall to another or between bulkheads, beams or other fascia the schedule size of the diffuser shall be confirmed by site measurements prior to final assembly.
- .6 Provide balancing dampers on duct take-off to diffusers, and grilles and registers, despite whether dampers are specified as part of the diffuser, or grille and register assembly.
- .7 Paint ductwork visible behind air outlets and inlets matte black.
- .8 Care should be taken to install diffusers as per the reflected ceiling plans where available so that the diffusers will fit properly in the ceiling suspension system. The sheet metal subcontractor shall co-ordinate this work with the General Contractor, the suspended ceiling subtrade and electrical subtrade.
- .9 Should there be any conflict in the location of grilles, registers and diffusers with lights, etc. the matter shall be referred to the Consultant for directive. If requested by the Consultant, the subcontractor shall relocate grilles, diffusers and registers and ductwork attached, within two feet of locations as indicated on the drawings, without extra cost to the Owner.

END OF SECTION