

Part 1 General

1.1 SECTION INCLUDES

- .1 Single phase electric motors.
- .2 Three phase electric motors.

1.2 RELATED SECTIONS

- .1 Section 21 05 00 – Submittal Procedures.
- .2 Section 01 61 00 – Common Product Requirements.
- .3 Section 01 78 00 - Closeout Submittals.

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 Test Reports: Indicate test results verifying nominal efficiency and power factor for three phase motors larger than 15 Kw (20 horsepower).
- .4 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.
- .3 Warranty: Include coverage for motors larger than 20 horsepower.

Part 2 Products

2.1 MANUFACTURERS

- .1 Baldor.
- .2 Toshiba.
- .3 WEG
- .4 Substitutions: Refer to Section 21 05 00.

2.2 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): 208 volts, three 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.

2.3 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.

2.4 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.

2.5 SINGLE PHASE POWER - CAPACITOR START MOTORS

- .1 Starting Torque: Three times full load torque.
- .2 Starting Current: Less than five times full load current.

- .3 Pull-up Torque: Up to 350 percent of full load torque.
- .4 Breakdown Torque: Approximately 250 percent of full load torque.
- .5 Motors: Capacitor in series with starting winding; provide capacitor-start/capacitor-run motors with two capacitors in parallel with run capacitor remaining in circuit at operating speeds.
- .6 Drip-proof Enclosure: Class A (50 degrees C temperature rise) insulation, NEMA Service Factor, prelubricated bearings.
- .7 Enclosed Motors: Class A (50 degrees C temperature rise) insulation, 1.0 Service Factor, pre-lubricated ball bearings.

2.6 THREE PHASE POWER - SQUIRREL CAGE MOTORS

- .1 Starting Torque: Between 1 and 1-1/2 times full load torque.
- .2 Starting Current: Six times full load current.
- .3 Power Output, Locked Rotor Torque, Breakdown or Pull Out Torque: NEMA Design B characteristics.
- .4 Design, Construction, Testing, and Performance: Conform to NEMA MG 1 for Design B motors.
- .5 Insulation System: NEMA Class B or better.
- .6 Testing Procedure: To IEEE 112. Load test motors to determine free from electrical or mechanical defects in compliance with performance data.
- .7 Motor Frames: NEMA Standard T-Frames of steel, aluminum, or cast iron with end brackets of cast iron or aluminum with steel inserts.
- .8 Thermistor System (Motor Frame Sizes 254T and Larger): Three PTC thermistors imbedded in motor windings and epoxy encapsulated solid state control relay for wiring into motor starter.
- .9 Bearings: Grease lubricated anti-friction ball bearings with housings equipped with plugged provision for relubrication, rated for minimum AFBMA 9, L-10 life of 20,000 hours. Calculate bearing load with NEMA minimum V-belt pulley with belt centre line at end of NEMA standard shaft extension. Stamp bearing sizes on nameplate.
- .10 Sound Power Levels: To NEMA MG 1.
- .11 Part Winding Start where indicated: Use part of winding to reduce locked rotor starting current to approximately 60 percent of full winding locked rotor current while providing approximately 50 percent of full winding locked rotor torque.
- .12 Weatherproof Epoxy Sealed Motors: Epoxy seal windings using vacuum and pressure with rotor and starter surfaces protected with epoxy enamel; bearings double shielded with waterproof non-washing grease.

- .13 Nominal Efficiency: As scheduled at full load and rated voltage when tested to IEEE 112.
- .14 Nominal Power Factor: As scheduled at full load and rated voltage when tested to IEEE 112.

Part 3 Execution

3.1 APPLICATION

- .1 Single phase motors for shaft mounted fans, oil burners, centrifugal pumps: Split phase type.
- .2 Single phase motors for shaft mounted fans or blowers: Permanent split capacitor type.
- .3 Motors located in exterior locations, wet air streams downstream of sprayed coil dehumidifiers, draw through cooling towers, air cooled condensers, humidifiers, direct drive axial fans, roll filters, explosion proof environments, dust collection systems: Totally enclosed type.

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 Flexible pipe connectors.
- .2 Expansion joints and compensators.
- .3 Pipe loops, offsets, and swing joints.

1.2 RELATED SECTIONS

- .1 Section 21 11 00 - Fire Protection Piping.
- .2 Section 22 10 00 - Plumbing Piping.
- .3 Section 23 21 00 - Hydronic Piping.

1.3 REFERENCES

- .1 MIL-E-17814E - Expansion Joints, Pipe, Slip-Type, Packed.

1.4 PERFORMANCE REQUIREMENTS

- .1 Provide structural work and equipment required to control expansion and contraction of piping. Verify that anchors, guides, and expansion joints provided, adequately protect system.
- .2 Expansion Calculations:
 - .1 Installation Temperature (hot water heating, domestic hot water): 10 degrees C (50 degrees F).
 - .2 Hot Water Heating: 99 degrees C (210 degrees F).
 - .3 Domestic Hot Water: 60 degrees C (140 degrees F).
 - .4 Installation Temperature (chilled water): 27 degrees C (80 degrees F).
 - .5 Chilled Water: 7 degrees C (45 degrees F).
 - .6 Safety Factor: 30 percent.

1.5 SUBMITTALS

- .1 Section 21 05 00: Procedures for submittals.
- .2 Product Data:
 - .1 Flexible Pipe Connectors: Indicate maximum temperature and pressure rating, face-to-face length, live length, hose wall thickness, hose convolutions per metre(foot) and per assembly, fundamental frequency of assembly, braid structure, and total number of wires in braid.
 - .2 Expansion Joints: Indicate maximum temperature and pressure rating, and maximum expansion compensation.

- .3 Design Data: Indicate selection calculations.
- .4 Manufacturer's Installation Instructions: Indicate special procedures, and external controls.

1.6 PROJECT RECORD DOCUMENTS

- .1 Section 21 05 00: Submittals for project closeout.
- .2 Record actual locations of flexible pipe connectors, expansion joints, anchors, and guides.

1.7 OPERATION AND MAINTENANCE DATA

- .1 Section 21 05 00: Submittals for project closeout.
- .2 Maintenance Data: Include adjustment instructions.

1.8 QUALIFICATIONS

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

1.9 DELIVERY, STORAGE, AND HANDLING

- .1 Section 21 05 00: Transport, handle, store, and protect products.
- .2 Accept expansion joints on site in factory packing with shipping bars and positioning devices intact. Inspect for damage.
- .3 Protect equipment from exposure by leaving factory coverings, pipe end protection, and packaging in place until installation.

1.10 WARRANTY

- .1 Warranty: Include coverage for leak free performance of packed expansion joints.

1.11 EXTRA MATERIALS

- .1 Section 21 05 00: Submittals for project closeout.
- .2 Provide two 340 gm (12 ounce) containers of packing lubricant and cartridge style grease gun.

Part 2 Products

2.1 FLEXIBLE PIPE CONNECTORS

- .1 Steel Piping:
 - .1 Manufacturers:

- .1 HYSPAN.
- .2 Substitutions: Refer to Section 21 05 00
- .2 Inner Hose: Stainless Steel.
- .3 Exterior Sleeve: Double braided stainless steel.
- .4 Pressure Rating: 862 kPa (125 psig) WSP and 204 degrees C (400 degrees F).
- .5 Joint: As specified for pipe joints.
- .6 Size: Use pipe sized units.
- .7 Maximum offset: 20 mm (3/4 inch) on each side of installed centre line.
- .2 Copper Piping – heating water, chilled water, and condenser water up to and including 50 mm (2"):
 - .1 Manufacturers:
 - .1 Hydro Flex.
 - .2 Substitutions: Refer to Section 21 05 00.
 - .2 Inner Hose: 300 series stainless steel.
 - .3 Exterior Sleeve: Braided stainless steel.
 - .4 Pressure Rating: 862 kPa (125 psig) WSP and 204 degrees C (400 degrees F).
 - .5 Joint: threaded male ends.
 - .6 Size: Use pipe sized units
 - .7 Maximum offset: 20 mm (3/4 inch) on each side of installed centre line.

2.2 ACCESSORIES

- .1 Pipe Alignment Guides:
 - .1 Manufacturers:
 - .1 Anvil.
 - .2 HYSPAN.
 - .3 Substitutions: Refer to Section 21 05 00.
 - .2 Two piece welded steel with enamel paint, bolted, with spider to fit standard pipe, frame with four mounting holes, clearance for minimum 25 mm (1 inch) thick insulation, minimum 75 mm (3 inch) travel.

Part 3 Execution

3.1 INSTALLATION

- .1 Provide support and equipment required to control expansion and contraction of piping. Provide loops, pipe offsets, and swing joints, or expansion joints where required and where indicated on the drawings.
- .2 If not otherwise indicated on the drawings 1200 mm x 1200 mm (4' x 4') expansion loops shall be installed on all copper hot water heating piping having a straight run in excess of 12 m (40'). The expansion loop shall be centred in the straight run, with alignment guides on each side of the loop and anchors at the extreme ends of the pipe run. Similar loops shall be installed on straight runs of steel steam, condensate and hot water piping which exceeds 18 m (60') in length.

- .3 Follow Manufacturer's written instructions in regard to proper length, anchoring and guiding, pre-compression, removal of spacers, and testing.
- .4 When expansion joints are installed at ambient temperatures higher than minimum system operating temperature, they shall be precompressed prior to installation, to allow for eventual contraction of piping.
- .5 Install flexible pipe connectors on pipes connected to equipment supported by vibration isolation. Provide line size flexible connectors.
- .6 Install flexible connectors at right angles to displacement. Install one end immediately adjacent to isolated equipment and anchor other end. Install in horizontal plane unless indicated otherwise.
- .7 Rigidly anchor pipe to building structure where necessary. Provide pipe guides so movement is directed along axis of pipe only. Erect piping such that strain and weight is not on cast connections or apparatus.
- .8 Provide victaulic piping with minimum one joint per 25 mm (1 inch) pipe diameter instead of flexible connector supported by vibration isolation. Victaulic piping need not be anchored.

3.2 MANUFACTURER'S FIELD SERVICES

- .1 Provide inspection services by flexible pipe manufacturer's representative for final installing and certify installation is to manufacturer's recommendations and connectors are performing satisfactorily.

END OF SECTION

Part 1 General

1.1 SECTION INCLUDES

- .1 Pipe and equipment hangers and supports.
- .2 Equipment bases and supports.
- .3 Sleeves and seals.
- .4 Flashing and sealing equipment and pipe stacks.

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 99 – Painting for Minor Works.
- .3 Section 21 11 00 - Fire Protection Piping.
- .4 Section 23 07 19 - Piping Insulation.
- .5 Section 22 10 00 - Plumbing Piping.
- .6 Section 23 21 00 - Hydronic Piping.

1.3 REFERENCES

- .1 ASME B31.1 - Power Piping.
- .2 ASME B31.2 - Fuel Gas Piping.
- .3 ASME B31.5 - Refrigeration Piping and Heat Transfer Components.
- .4 ASME B31.9 - Building Services Piping.
- .5 ASTM F708 - Design and Installation of Rigid Pipe Hangers.
- .6 MSS SP58 - Pipe Hangers and Supports - Materials, Design and Manufacturer.
- .7 MSS SP69 - Pipe Hangers and Supports - Selection and Application.
- .8 MSS SP89 - Pipe Hangers and Supports - Fabrication and Installation Practices.
- .9 NFPA 13 - Installation of Sprinkler Systems.
- .10 NFPA 14 - Installation of Standpipe, Private Hydrants, and Hose Systems.
- .11 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.
- .3 Supports for Standpipes: To NFPA 14.

Part 2 Products

2.1 PIPE HANGERS AND SUPPORTS

- .1 Manufacturers:
 - .1 Anvil.
 - .2 Grinnel.
 - .3 Substitutions: Refer to Section 21 05 00.
- .2 Fire Protection Piping:
 - .1 Conform to NFPA 13.
 - .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.
- .3 Plumbing Piping - DWV:

- .1 Conform to ASME B31.9.
- .2 Cast Iron DWV Piping:
 - .1 Hangers for Pipe Sizes 13 to 38 mm (1/2 to 1-1/2 inch): Carbon steel, adjustable swivel, split ring.
 - .2 Hangers for Pipe Sizes 50 mm (2 inches) and over: Carbon steel, adjustable, clevis.
 - .3 Multiple or Trapeze Hangers: Steel channels with welded spacers and hanger rods.
 - .4 Wall Support for Pipe Sizes to 75 mm (3 inches): Cast iron hook.
 - .5 Wall Support for Pipe Sizes 100 mm (4 inches) and over: Welded steel bracket and wrought steel clamp.
 - .6 Vertical Support: Steel riser clamp.
 - .7 Floor Support: Cast iron adjustable pipe saddle, lock nut, nipple, floor flange, and concrete pier or steel support.
 - .8 Clamping for MJ couplings: Socket-pipe clamps with washers, threaded rod, and nuts (Anvil Fig. 594 & 595 or equal).
- .3 Copper Pipe Support: Carbon steel ring, adjustable, copper plated.
- .4 PVC DWV Pipe Support: to manufacturer's requirements.
- .4 Plumbing Piping - Water:
 - .1 Conform to ASME B31.9.
 - .2 Perforated strap or wire hangers are not permitted.
 - .3 Hangers to be adjustable after pipe is in place.
 - .4 Clevis hangers shall be oversized to suit the outside diameter of insulation and jacket to maintain the integrity of insulation and vapour barrier.
 - .1 Protection Saddles
 - .1 On piping 2" and smaller, carry insulation over pipe hangers. On all domestic cold water piping over 1-1/4", use oversized clevis hangers and GSS insulation protection shield to maintain integrity of vapour barrier.
 - .2 On copper piping over 2", use at each hanger or support Grinnell Fig. 167 protection shield or equal. Shields shall have a minimum length of 12" (305mm) to spread weight. Rectangular solid wood blocks, cut to suit the insulation thickness, shall be installed at hanger locations. Wedges are not permitted.
 - .5 Hangers for Pipe Sizes 15 to 40 mm (1/2 to 1-1/2 inch): Carbon steel, adjustable swivel, split ring.
 - .6 Hangers for Cold Pipe Sizes 50 mm (2 inches) and over: Carbon steel, adjustable, clevis.
 - .7 Hangers for Hot Pipe Sizes 50 to 100 mm (2 to 4 inches): Carbon steel, adjustable, clevis.
 - .8 Hangers for Hot Pipe Sizes 150 mm (6 inches) and over: Adjustable steel yoke, cast iron pipe roll, double hanger.
 - .9 Multiple or Trapeze Hangers: Steel channels with welded supports or spacers and hanger rods.

- .10 Multiple or Trapeze Hangers for Hot Pipe Sizes 150 mm (6 inches) and over: Steel channels with welded supports or spacers and hanger rods, cast iron roll.
 - .11 Wall Support for Pipe Sizes to 80 mm (3 inches): Cast iron hook.
 - .12 Wall Support for Pipe Sizes 100 mm (4 inches) and over: Welded steel bracket and wrought steel clamp.
 - .13 Wall Support for Hot Pipe Sizes 150 mm (6 inches) and over: Welded steel bracket and wrought steel clamp with adjustable steel yoke and cast iron pipe roll.
 - .14 Vertical Support: Steel riser clamp.
 - .15 Floor Support for Cold Pipe: Cast iron adjustable pipe saddle, lock nut, nipple, floor flange, and concrete pier or steel support.
 - .16 Floor Support for Hot Pipe Sizes to 100 mm (4 inches): Cast iron adjustable pipe saddle, locknut, nipple, floor flange, and concrete pier or steel support.
 - .17 Floor Support for Hot Pipe Sizes 150 mm (6 inches) and over: Adjustable cast iron pipe roll and stand, steel screws, and concrete pier or steel support.
 - .18 Copper Pipe Support: Carbon steel ring, adjustable, copper plated.
 - .19 Isolation: Copper piping shall be isolated from steel supports by appropriate use of copper plated hangers, plastic coated hangers, tinning pipe at supports, or provision of suitable lead or copper isolators.
- .5 Hydronic Piping:
- .1 Conform to ASME B31.9.
 - .2 Perforated strap or wire hangers are not permitted.
 - .3 Hangers to be adjustable after pipe is in place.
 - .4 Clevis hangers shall be oversized to suit the outside diameter of insulation and jacket to maintain the integrity of insulation and vapour barrier.
 - .1 Protection Saddles
 - .1 On piping 2" and smaller, carry insulation over pipe hangers. On all chilled water piping, and domestic cold water piping over 1-1/4", use oversized clevis hangers and GSS insulation protection shield to maintain integrity of vapour barrier.
 - .2 On insulated steel pipe over 2" use at each hanger or support, Grinnell Fig. 160, 161 or 162 to suit pipe size and insulation thickness. Pack space between saddle and pipe with insulation.
 - .3 On copper piping over 2", use at each hanger or support Grinnell Fig. 167 protection shield or equal. Shields shall have a minimum length of 12" (305mm) to spread weight. Rectangular solid wood blocks, cut to suit the insulation thickness, shall be installed at hanger locations. Wedges are not permitted.
 - .5 Where pipe expansion in excess of 12mm (1/2") axially occurs or where indicated to be installed on the drawings, provide Grinnell Fig. 171 Adjustable Pipe Roll or Grinnell Fig. 271 Pipe Roll Stand.
 - .6 Hangers for Pipe Sizes 13 to 38 mm (1/2 to 1-1/2 inch): Carbon steel, adjustable swivel, split ring.
 - .7 Hangers for Cold Pipe Sizes 50 mm (2 inches) and over: Carbon steel, adjustable, clevis.

- .8 Hangers for Hot Pipe Sizes 50 to 100 mm (2 to 4 inches): Carbon steel, adjustable, clevis.
 - .9 Hangers for Hot Pipe Sizes 150 mm (6 inches) and over: Adjustable steel yoke, cast iron roll, double hanger.
 - .10 Multiple or Trapeze Hangers: Steel channels with welded spacers and hanger rods.
 - .11 Multiple or Trapeze Hangers for Hot Pipe Sizes 150 mm (6 inches) and over: Steel channels with welded spacers and hanger rods, cast iron roll.
 - .12 Wall Support for Pipe Sizes to 76 mm (3 inches): Cast iron hook.
 - .13 Wall Support for Pipe Sizes 100 mm (4 inches) and over: Welded steel bracket and wrought steel clamp.
 - .14 Wall Support for Hot Pipe Sizes 150 mm (6 inches) and over: Welded steel bracket and wrought steel clamp with adjustable steel yoke and cast iron roll.
 - .15 Vertical Support: Steel riser clamp.
 - .16 Floor Support for Cold Pipe: Cast iron adjustable pipe saddle, lock nut, nipple, floor flange, and concrete pier or steel support.
 - .17 Floor Support for Hot Pipe Sizes to 100 mm (4 inches): Cast iron adjustable pipe saddle, lock nut, nipple, floor flange, and concrete pier or steel support.
 - .18 Floor Support for Hot Pipe Sizes 150 mm (6 inches) and over: Adjustable cast iron roll and stand, steel screws, and concrete pier or steel support.
 - .19 Copper Pipe Support: Carbon steel ring, adjustable, copper plated.
 - .20 Isolation: Copper piping shall be isolated from steel supports by appropriate use of copper plated hangers, plastic coated hangers, tinning pipe at supports, or provision of suitable lead or copper isolators.
 - .21 Hanger Rods: Mild steel threaded both ends, threaded one end, or continuous threaded.
 - .22 Inserts: Malleable iron case of 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.
- .6 Refrigerant Piping:
- .1 Conform to ASME B31.5.
 - .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.

- .7 For roof mounted piping, provide supports equivalent to:
- .1 Portable Pipe Hangers model PP 10 strut style with pipe clamp guides, Portable Pipe Hangers Model PSE-2-2 with clevis style hangers, or supports. Install to Manufacture's specifications. Supports to be aluminium with stainless steel clamps and rollers. Membrane pads to be close-cell extruded polystyrene insulation equal to Dow Chemical Roofmate. Pipe shall be a minimum of 8" above finished roof level.
 - .2 MIFAB C-Port Series. Minimum 6 1/2" in height, supports to be constructed of recycled rubber, UV resistant and designed to support rooftop equipment. Supports to be selected, sized, and configured to match equipment installation requirements and roof construction, with galvanized steel channel. All metal work including strut or pipe clamps to be stainless steel.

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 SLEEVES

- .1 Sleeves for Pipes Through Non-fire Rated Floors: 1.2 mm thick (18 gauge) galvanized steel.
- .2 Sleeves for Pipes Through Non-fire Rated Beams, Walls, Footings, and Potentially Wet Floors: Steel pipe or 1.2mm thick (18 gauge) galvanized steel.
- .3 Sleeves for Pipes Through Fire Rated and Fire Resistive Floors and Walls, and Fire Proofing: Prefabricated fire rated sleeves including seals, UL listed refer to Section 07 84 00.
- .4 Where pipes pass through floors, walls or ceilings, in finished areas and where exposed to view, supply and install chrome-plated pressed steel floor plates.
- .5 Sleeves for Round Ductwork: Galvanized steel.
- .6 Sleeves for Rectangular Ductwork: Galvanized steel or wood.
- .7 Firestopping Insulation: Glass fibre type, non-combustible; refer to Section 07 84 00.
- .8 Sealant: Acrylic; refer to Section 07 92 00.

Part 3 Execution

3.1 INSTALLATION

- .1 Install to manufacturer's written instructions.

3.2 INSERTS

- .1 Provide inserts for placement in concrete formwork.
- .2 Provide inserts for suspending hangers from reinforced concrete slabs and sides of reinforced concrete beams.
- .3 Provide hooked rod to concrete reinforcement section for inserts carrying pipe over 100 mm (4 inches).
- .4 Where concrete slabs form finished ceiling, locate inserts flush with slab surface.
- .5 Install galvanized oversize pipe sleeves on all pipes passing through walls or partitions, for building into wall construction by other trades.
- .6 All sleeves are to be large enough to accommodate pipe insulation as specified.
- .7 The Mechanical Division shall include in tender price all cost of drilling for sleeves up to 175 mm (7") in precast sections relative to work under Mechanical Division. Prior to drilling all openings/locations must be checked by the Contract Administrator. Drilling shall be done using diamond core drilling machinery.
- .8 All sleeves in mechanical rooms, janitors closets and washrooms shall extend 100 mm (4") above the finished floor level to prevent water seeping down.
- .9 Caulk the space between pipes and floor sleeves or openings, to prevent water seeping down, with an approved caulking compound. The caulking compound and method of application shall be to the Contract Administrator's approval.
- .10 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 Install heating water, glycol, chilled water, condenser water, and engine exhaust piping to ASME B31.9.
- .3 Perforated strap or wire hangers will not be permitted.
- .4 Support horizontal piping as scheduled.
- .5 Hangers in new concrete structural floor systems shall be supported by inserts placed prior to pouring of concrete. Inserts shall be Grinnell cast iron or wrought steel adjustable type.

- .6 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.
- .7 Where the structural system is open web steel joists, piping shall be supported by means of angles spanning the bottom or top chords of adjacent joists. The number of joists to be spanned in this way shall be determined by the incident load of piping.
- .8 In no case shall the hanging of piping directly from roof decking be allowed, unless special permission is obtained from the Contract Administrator.
- .9 Copper hot water piping in long runs, where expansion may be significant and where hanger rods are less than 600 mm (2") in length may require roller hangers. Any such cases which cannot be avoided shall be referred to the Contract Administrator for a decision. If necessary, roller hangers shall be installed as directed with protection saddles as specified. Expansion and contractions of domestic H.W. piping should not be a problem, as wide fluctuations in temperature are not normal. Piping shall be hung from slabs, rather than from the bottom of beams, in order to keep hanger rods sufficiently long to take up any movement.
- .10 Install hangers to provide minimum 13 mm (1/2 inch) space between finished covering and adjacent work.
- .11 Place hangers within 300 mm (12 inches) of each horizontal elbow.
- .12 Use hangers with 38 mm (1-1/2 inch) minimum vertical adjustment.
- .13 Support horizontal cast iron pipe adjacent to each hub, with 1.5 m (5 feet) maximum spacing between hangers.
- .14 Support all pipe with MJ couplings on both sides of the joint. At multiple fittings or short lengths, support every 300 mm (12").
- .15 Where several pipes can be installed in parallel and at same elevation, provide multiple or trapeze hangers.
- .16 Support riser piping independently of connected horizontal piping.
- .17 Provide copper plated hangers and supports for copper piping.
- .18 Design hangers for pipe movement without disengagement of supported pipe.
- .19 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.
- .20 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 the Contract Administrator for approval before fabrication.

- .21 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').
- .22 Vertical piping other than risers through floors shall be provided with suitable supports, sway braces, etc.
- .23 Vertical piping shall be supported at the base in an approved manner.
- .24 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.
- .25 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.
- .26 Prime coat exposed steel hangers and supports. Refer to Section 09 91 99. Hangers and supports located in crawl spaces, pipe shafts, and suspended ceiling spaces are not considered exposed.

3.4 EQUIPMENT BASES AND 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 SLEEVES

- .1 Set sleeves in position in formwork. Provide reinforcing around sleeves.
- .2 Size sleeves large enough to allow for movement due to expansion and contraction. Provide for continuous insulation wrapping.
- .3 Extend sleeves through floors 25mm (1 inch) above finished floor level. Caulk sleeves.
- .4 All sleeves in mechanical rooms, janitors closets and washrooms shall extend 100 mm (4") above the finished floor level to prevent water seeping down.
- .5 Install galvanized oversize pipe sleeves on all pipes passing through walls or partitions, for building into wall construction by other trades.
- .6 All sleeves are to be large enough to accommodate pipe insulation as specified.
- .7 The Mechanical Division shall include in tender price all cost of drilling for sleeves up to 175 mm (7") in precast sections relative to work under Mechanical Division. Prior to drilling all openings/locations must be checked by the Contract Administrator. Drilling shall be done using diamond core drilling machinery.

- .8 Where piping or ductwork penetrates floor, ceiling, or wall, close off space between pipe or duct and adjacent work with insulation and caulk, air tight. Provide close fitting metal collar or escutcheon covers at both sides of penetration.
- .9 Install stainless steel escutcheons at finished surfaces.

3.6 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.)
 - .4 Copper Tubing (Hard):

.1	Up to 25mm (1")	1.8m (6 ft.)
.2	32mm (1½") to 50mm (2")	2.4m (8 ft.)
.3	63mm (2 ½") to 75mm (3")	3.0m (10 ft.)
.4	100mm (4") to 150mm (6")	3.6m (12 ft.)
.5	200mm (8") to 300mm (12")	4.8m (16 ft.)
 - .5 Cast Iron Pipe
 - .1 Maximum spacing – maximum 5 ft. (1.5m)
 - .2 Support M.J. pipe on both sides of joint. Provide with sway braces and anchors to the Contract Administrator's approval. At multiple fittings, or short lengths, support every 300mm (12").
 - .6 Plastic (PVC, CPVC, PEX)
 - .1 As recommended by manufacturer for corresponding sizes and materials.
 - .2 All sizes – do not exceed 1.2m (4 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.

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 All outdoor mounted equipment shall be restrained for the highest wind speed as specified by the project's structural engineer, the governing building code(s) or the authority having jurisdiction.
- .3 Provide minimum static deflection of isolators for equipment as indicated.
 - .1 Basement, Under 15 kW (20 hp)
 - .1 Under 400 rpm: 63 mm (2.5 inch)
 - .2 400 - 600 rpm: 25 mm (1 inch)
 - .3 600 - 800 rpm: 12 mm (0.5 inch)
 - .4 800 - 900 rpm: 5 mm (0.2 inch)
 - .5 1100 - 1500 rpm: 4 mm (0.14 inch)
 - .6 Over 1500 rpm: 3 mm (0.1 inch)
 - .2 Basement, Over 15 kW (20 hp)
 - .1 Under 400 rpm: 63 mm (2.5 inch)
 - .2 400 - 600 rpm: 50 mm (2 inch)
 - .3 600 - 800 rpm: 25 mm (1 inch)
 - .4 800 - 900 rpm: 12 mm (0.5 inch)
 - .5 1100 - 1500 rpm: 5 mm (0.2 inch)
 - .6 Over 1500 rpm: 4 mm (0.15 inch)
 - .3 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)
 - .4 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)
- .4 Consider upper floor locations critical unless otherwise indicated.

1.4 SUBMITTALS

- .1 Section 21 05 00: Procedures for submittals.
- .2 Product Data: Provide schedule of vibration isolator type with location and load on each.
- .3 Manufacturer's Installation Instructions: Indicate special procedures and setting dimensions.
- .4 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 MANUFACTURERS

- .1 Vibro-Acoustics.
- .2 Amber/Booth.
- .3 Substitutions: Refer to Section 21 05 00.

2.2 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.
- .8 Glass Fibre Pads: Neoprene jacketed pre-compressed moulded glass fibre.

Part 3 Execution

3.1 INSTALLATION

- .1 Install to manufacturer's written instructions.
- .2 Install isolation for motor driven equipment.
- .3 Where recommended by the manufacturer, isolator base plates shall be bolted to the structure or foundation. Bolting shall incorporate neoprene bushings and washers.
- .4 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.
- .5 Install spring hangers without binding.
- .6 On closed spring isolators, adjust so side stabilizers are clear under normal operating conditions.
- .7 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.
- .8 Provide pairs of horizontal limit springs on fans with more than 1.5 kPa (6.0 inch) static pressure, and on hanger supported, horizontally mounted axial fans.
- .9 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.
- .10 Connect wiring to isolated equipment with flexible hanging loop.
- .11 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 ¾" and maximum of 1¼" 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.
- .12 All outdoor equipment, piping and ductwork shall be restrained to resist wind forces per the applicable building code(s) as a minimum. Restraint attachments shall be made by bolts, welds or a positive fastening method. Friction shall not be considered. All attachments shall be proven capable of accepting the required wind load by calculations.
- .13 Install wind restraint devices per the restraint manufacturer's submittals. Any deviation from the manufacturer's instructions shall be reviewed and approved by the manufacturer.

3.2 MANUFACTURER'S FIELD SERVICES

- .1 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 99 – Painting for Minor Works.

1.3 REFERENCES

- .1 ASME A13.1 - Scheme for the Identification of Piping 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.

1.5 PROJECT RECORD DOCUMENTS

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

Part 2 Products

2.1 NAMEPLATES

- .1 Description: Laminated three-layer plastic with engraved black letters on light contrasting background colour.

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.
- .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 20-30 mm (3/4 to 1-1/4 inch) Outside Diameter of Insulation or Pipe: 200 mm (8 inch) long colour field, 15 mm (1/2 inch) high letters.
 - .2 40-50 mm (1-1/2 to 2 inch) Outside Diameter of Insulation or Pipe: 200 mm (8 inch) long colour field, 20 mm (3/4 inch) high letters.
 - .3 65-150 mm (2-1/2 to 6 inch) Outside Diameter of Insulation or Pipe: 300 mm (12 inch) long colour field, 30 mm (1-1/4 inch) high letters.
 - .4 200-250 mm (8 to 10 inch) Outside Diameter of Insulation or Pipe: 600 mm (24 inch) long colour field, 65 mm (2-1/2 inch) high letters.
 - .5 Over 250 mm (10 inch) Outside Diameter of Insulation or Pipe: 800 mm (32 inch) long colour field, 90 mm (3-1/2 inch) high letters.
 - .6 Ductwork and Equipment: 65 mm (2-1/2 inch) high letters.
- .2 Stencil Paint: As specified in Section 09 91 99, semi - Painting.1.

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.
- .4 Underground Plastic Pipe Markers: Bright coloured continuously printed plastic ribbon tape, minimum 150 mm (6 inches) wide by 0.10 mm (4 mil) thick, manufactured for direct burial service.

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
 - .3 Green - Plumbing valves
 - .4 Blue - Heating/cooling valves

Part 3 Execution

3.1 PREPARATION

- .1 Degrease and clean surfaces to receive adhesive for identification materials.
- .2 Prepare surfaces to Section 09 91 99 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 99.
- .4 Install plastic pipe markers to manufacturer's written instructions.
- .5 Install plastic tape pipe markers complete around pipe to manufacturer's written instructions.
- .6 Install underground plastic pipe markers 150 to 200 mm (6 to 8 inches) below finished grade, directly above buried pipe.
- .7 Identify air handling units, pumps, heat transfer equipment, tanks, and water treatment devices with plastic nameplates. Small devices, such as in-line pumps, may be identified with tags.
- .8 Identify control panels and major control components outside panels with plastic nameplates.
- .9 Identify thermostats relating to terminal boxes or valves with nameplates.
- .10 Identify valves in main and branch piping with tags.
- .11 Identify air terminal units and radiator valves with numbered tags.
- .12 Tag automatic controls, instruments, and relays. Key to control schematic.
- .13 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.
- .14 Identify ductwork with stencilled painting. Identify with air handling unit identification number and area served. Locate identification at air handling unit, at each side of penetration of structure or enclosure, and at each obstruction.
- .15 Provide ceiling tacks to locate valves or dampers above T-bar type panel ceilings. Locate in corner of panel closest to equipment.

END OF SECTION

Part 1 General

1.1 SECTION INCLUDES

- .1 Testing, adjustment, and balancing of air systems.
- .2 Testing, adjustment, and balancing of hydronic systems.
- .3 Measurement of final operating condition of HVAC systems.

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 Starting of Systems.
 - .2 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 CSA B149.1 - Natural gas and propane installation code
- .5 NEBB - Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems.
- .6 SMACNA - HVAC Systems Testing, Adjusting, and Balancing.

1.5 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 the Contract Administrator 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 or IP units to match the primary units used on the drawings and schedules.

1.6 PROJECT RECORD DOCUMENTS

- .1 Section 21 05 00: Submittals for project closeout.
- .2 Record actual locations of flow measuring stations, balancing valves, balancing dampers, and fire dampers.

1.7 QUALITY ASSURANCE

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

1.8 QUALIFICATIONS

- .1 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.
- .2 Perform Work under supervision of AABC Certified Test and Balance Supervisor.

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 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 Contract Administrator and has been approved by the Contract Administrator.

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 Proper thermal overload protection is in place for electrical equipment.
 - .4 Final filters are clean and in place. If required, install temporary media in addition to final filters.
 - .5 Duct systems are clean of debris.
 - .6 Fans are rotating correctly.
 - .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.
 - .11 Hydronic systems are flushed, filled, and vented.
 - .12 Service and balance valves are open.
- .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 the Contract Administrator 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 Hydronic Systems: Adjust 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 City.
- .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 Adjust air handling and distribution systems to provide required or design supply, return, and exhaust air quantities at site altitude.
- .2 Test and record motor full load amperes.
- .3 Make air quantity measurements in ducts by Pitot tube traverse of entire cross sectional area of duct.
- .4 Measure air quantities at air inlets and outlets.
- .5 Adjust distribution system to obtain uniform space temperatures free from objectionable drafts and noise.
- .6 Use volume control devices to regulate air quantities only to extend that adjustments do not create objectionable air motion or sound levels. Effect volume control by duct internal devices such as dampers and splitters.
- .7 All outlets shall be adjusted to provide proper throw and directional distribution in accordance with the requirements on the drawings and/or schedules.

- .8 Vary total system air quantities by adjustment of fan speeds. Provide drive changes required. Vary branch air quantities by damper regulation.
- .9 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.
- .10 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.
- .11 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.
- .12 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).
- .13 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.
- .14 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.
- .15 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 WATER SYSTEM PROCEDURE

- .1 Adjust water systems to provide required or design quantities.
- .2 Use calibrated fittings and pressure gauges to determine flow rates for system balance. Where flow metering devices are not installed, base flow balance on temperature difference across various heat transfer elements in the system.
- .3 Adjust systems to provide specified pressure drops and flows through heat transfer elements prior to thermal testing. Perform balancing by measurement of temperature differential in conjunction with air balancing.
- .4 Effect adjustment of water distribution systems by means of balancing cocks, valves, and fittings. Do not use service or shut-off valves for balancing unless indexed for balance point.

3.7 SCHEDULES

- .1 Equipment requiring testing, adjusting and balancing:
 - .1 Air Cooled Refrigerant Condensers
 - .2 Unit Air Conditioners
 - .3 Computer Room Air Conditioning Units
 - .4 Air Coils
 - .5 Terminal Heat Transfer Units
 - .6 Air Handling Units
 - .7 Fans
 - .8 Air Filters
 - .9 Air Inlets and Outlets
- .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 Architect
 - .7 Project Engineer
 - .8 Project Contractor
 - .9 Project altitude
 - .10 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 Air Cooled Condenser:
 - .1 Identification/number
 - .2 Location
 - .3 Manufacturer
 - .4 Model number
 - .5 Serial number
 - .6 Entering DB air temperature, design and actual
 - .7 Leaving DB air temperature, design and actual
 - .8 Number of compressors
- .7 Cooling Coil Data:
 - .1 Identification/number
 - .2 Location
 - .3 Service
 - .4 Manufacturer
 - .5 Air flow, design and actual
 - .6 Entering air DB temperature, design and actual
 - .7 Entering air WB temperature, design and actual
 - .8 Leaving air DB temperature, design and actual
 - .9 Leaving air WB temperature, design and actual
 - .10 Water flow, design and actual
 - .11 Water pressure drop, design and actual
 - .12 Entering water temperature, design and actual
 - .13 Leaving water temperature, design and actual
 - .14 Saturated suction temperature, design and actual
 - .15 Air pressure drop, design and actual
- .8 Electric Duct Heater:
 - .1 Manufacturer

- .2 Identification/number
- .3 Location
- .4 Model number
- .5 Design kW
- .6 Number of stages
- .7 Phase, voltage, amperage
- .8 Test voltage (each phase)
- .9 Test amperage (each phase)
- .10 Air flow, specified and actual
- .11 Temperature rise, specified and actual
- .9 Air Moving Equipment
 - .1 Location
 - .2 Manufacturer
 - .3 Model number
 - .4 Serial number
 - .5 Arrangement/Class/Discharge
 - .6 Air flow, specified and actual
 - .7 Return air flow, specified and actual
 - .8 Outside air flow, specified and actual
 - .9 Total static pressure (total external), specified and actual
 - .10 Inlet pressure
 - .11 Discharge pressure
 - .12 Sheave Make/Size/Bore
 - .13 Number of Belts/Make/Size
 - .14 Fan RPM
- .10 Return Air/Outside Air Data:
 - .1 Identification/location
 - .2 Design air flow
 - .3 Actual air flow
 - .4 Design return air flow
 - .5 Actual return air flow
 - .6 Design outside air flow
 - .7 Actual outside air flow
 - .8 Return air temperature
 - .9 Outside air temperature
 - .10 Required mixed air temperature
 - .11 Actual mixed air temperature
 - .12 Design outside/return air ratio
 - .13 Actual outside/return air ratio
- .11 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
- .12 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

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

- .12 NFPA 255 - Standard Method of Test of Surface Burning Characteristics of Building Materials.
- .13 SMACNA - HVAC Duct Construction Standards - Metal and Flexible.
- .14 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 Manufacturers:
 - .1 Johns Manville Microlite XG
 - .2 Owens Corning SoftR Duct Wrap.
 - .3 Other acceptable manufacturers offering equivalent products.
 - .1 Knauf.
- .2 Insulation: ASTM C553; flexible, 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 72 kg/cu. meter (4.5 lb/cu. Foot).
- .3 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.
- .4 Vapour Barrier Tape:
 - .1 Kraft paper reinforced with glass fibre yarn and bonded to aluminized film, with pressure sensitive rubber based adhesive.
- .5 Outdoor Vapour Barrier Mastic:
 - .1 Vinyl emulsion type acrylic or mastic, compatible with insulation, black colour.
- .6 Tie Wire: Annealed steel, 1.5 mm (16 gauge).

2.2 JACKETS

- .1 Canvas Jacket: UL listed.
 - .1 Fabric: ASTM C921, 220 g/sq m (6 oz/sq yd), plain weave cotton treated with dilute fire retardant lagging adhesive.
 - .2 Lagging Adhesive:
 - .1 Compatible with insulation.
- .2 Mineral Fibre (Outdoor) Jacket: Asphalt impregnated and coated sheet, 2.45 kg/sq m (50 lb/square ft).
- .3 Aluminum Jacket: ASTM B209M.
 - .1 Thickness: 0.40 mm (0.016 inch) sheet.
 - .2 Finish: Smooth.
 - .3 Joining: Longitudinal slip joints and 50 mm (2 inch) laps.

- .4 Fittings: 0.4mm (0.016 inch) thick die shaped fitting covers with factory attached protective liner.
- .5 Metal Jacket Bands: 10 mm (3/8 inch) wide; 0.015 mm thick aluminum.

2.3 GLASS FIBRE DUCT LINER, RIGID

- .1 Manufacturers:
 - .1 Johns Manville Linacoustic R-300
 - .2 Owens Corning QuietR Duct Liner Board
 - .3 Other acceptable manufacturers offering equivalent products.
 - .1 Knauf.
- .2 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 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.
- .3 Adhesive:
 - .1 Waterproof , ASTM E162 fire-retardant type.
- .4 Liner Fasteners: Galvanized steel, with press-on head.

2.4 ELASTOMERIC CELLULAR THERMAL DUCT LINER

- .1 Manufacturers:
 - .1 Armacell AP Armaflex Sheets
 - .2 Other acceptable manufacturers offering equivalent products.
- .2 Insulation: Flexible, closed-cell elastomeric insulation in sheet form meeting ASTM C 534,
 - .1 'ksi' ('K') value : ASTM C177, 0.039 at 24 degrees C (0.27 at 75 degrees F).
 - .2 Maximum service temperature: 105 degrees C (220 degrees F).
 - .3 Maximum Velocity on Coated Air Side: 30.5 m/s (6,000 fpm).
 - .4 Minimum Noise Reduction Criteria: ASTM C423,
 - .1 0.35 for 32 mm (1-1/4 inches) thickness
- .3 Elastomeric Foam Adhesive
 - .1 Manufacturers:
 - .1 Armstrong 520 adhesive.
 - .2 Air dried, contact adhesive, compatible with insulation.

Part 3 Execution

3.1 EXAMINATION

- .1 Verify that duct work has been tested before applying insulation materials.
- .2 Verify that surfaces are clean, foreign material removed, and dry.

3.2 INSTALLATION

- .1 Section 01 45 00 - Quality Assurance: Manufacturer's written instructions.
- .2 Install to NAIMA National Insulation Standards.
- .3 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.
- .4 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.
- .5 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.
- .6 Where ducts are acoustically lined to the equivalent R-value, no exterior duct insulation is required, except where exposed to outside temperature and weather.
- .7 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.
- .8 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.
- .9 Install Elastomeric Cellular Thermal Duct Liner as per manufacturer's recommendations.
- .10 External Fire Wrap Duct Insulation Application:
 - .1 Install in accordance to manufactures published installation manual.

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 space	=< 400 mm (16") per side, or round duct	29mm (1 1/8") Installed 38mm (1 1/2") Nominal
Round exhaust ducts, relief ducts from external wall or roof back for length of 3000mm (10 feet) or to insulated damper, whichever is greater	All	57mm (2 1/4") Installed 75mm (3") Nominal
Round outdoor air ducts located in conditioned space to the air handler or mixed air plenum.	All	95mm (3 3/4") Installed 125mm (5") Nominal

3.5 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")

3.6 ELASTOMERIC CELLULAR THERMAL DUCT LINER

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	32mm (1 1/4")
Rooftop goosenecks - exhaust	All	50mm (2")

END OF SECTION

Part 1 General

1.1 SECTION INCLUDES

- .1 Piping insulation.
- .2 Jackets and accessories.

1.2 RELATED SECTIONS

- .1 Section 09 91 99 – Painting for Minor Works
- .2 Section 22 10 00 - Plumbing Piping: Placement of hangers and hanger inserts.
- .3 Section 23 21 00 - Hydronic Piping: Placement of hangers and hanger inserts.

1.3 REFERENCES

- .1 ASTM B209 - Aluminum and Aluminum-Alloy Sheet and Plate.
- .2 ASTM C177 - Steady-State Heat Flux Measurements and Thermal Transmission Properties by Means of the Guarded-Hot-Plate Apparatus.
- .3 ASTM C195 - Mineral Fibre Thermal Insulating Cement.
- .4 ASTM C335 - Steady-State Heat Transfer Properties of Horizontal Pipe Insulation.
- .5 ASTM C449/C449M - Mineral Fibre Hydraulic-setting Thermal Insulating and Finishing Cement.
- .6 ASTM C518 - Steady-State Thermal Transmission Properties by Means of the Heat Flow Metre Apparatus.
- .7 ASTM C533 - Calcium Silicate Block and Pipe Thermal Insulation.
- .8 ASTM C534 - Preformed Flexible Elastomeric Cellular Thermal Insulation in Sheet and Tubular Form.
- .9 ASTM C547 - Mineral Fibre Pipe Insulation.
- .10 ASTM C552 - Cellular Glass Thermal Insulation.
- .11 ASTM C578 - Rigid, Cellular Polystyrene Thermal Insulation.
- .12 ASTM C585 - Inner and Outer Diameters of Rigid Thermal Insulation for Nominal Sizes of Pipe and Tubing (NPS System).
- .13 ASTM C591 - Unfaced Preformed Cellular Polyisocyanurate Thermal Insulation.
- .14 ASTM C610 - Moulded Expanded Perlite Block and Pipe Thermal Insulation.

- .15 ASTM C921 - Properties of Jacketing Materials for Thermal Insulation.
- .16 ASTM D1056 - Flexible Cellular Materials - Sponge or Expanded Rubber.
- .17 ASTM D1667 - Flexible Cellular Materials - Vinyl Chloride Polymers and Copolymers (Closed Cell Foam).
- .18 ASTM D2842 - Water Absorption of Rigid Cellular Plastics.
- .19 ASTM E84 - Surface Burning Characteristics of Building Materials.
- .20 ASTM E96 - Water Vapour Transmission of Materials.
- .21 CAN/ULC-S102-M88 - Standard Method of Test for Surface Burning Characteristics of Building Materials and Assemblies.
- .22 NFPA 255 - Surface Burning Characteristics of Building Materials.
- .23 UL 723 - Surface Burning Characteristics of Building Materials.

1.4 QUALITY ASSURANCE

- .1 Materials: Flame spread/smoke developed rating of 25/50 or less to ASTM E84; NFPA 255; UL 723.

1.5 QUALIFICATIONS

- .1 Applicator: Company specializing in performing the work of this section with minimum three years documented experience.

1.6 DELIVERY, STORAGE, AND HANDLING

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

1.7 ENVIRONMENTAL REQUIREMENTS

- .1 Maintain ambient temperatures and conditions required by manufacturers of adhesives, mastics, and insulation cements.
- .2 Maintain temperature during and after installation for minimum period of 24 hours.

Part 2 Products

2.1 GLASS FIBRE PRE-FORMED PIPE INSULATION WITH ALL-SERVICE JACKET

- .1 Manufacturers:
 - .1 Johns Manville Micro-Lok.
 - .2 Knauf Earthwool 1000.
 - .3 Owens Corning FIBREGLAS.
 - .4 Substitutions: Refer to Section 21 05 00.
- .2 Insulation: ASTM C547; rigid moulded, non-combustible.
 - .1 'ksi' ('K') value : ASTM C335, 0.035 at 24 degrees C (0.24 at 75 degrees F).
 - .2 Minimum Service Temperature: -28.9 degrees C (-20 degrees F).
 - .3 Maximum Service Temperature: 454 degrees C (850 degrees F).
 - .4 Maximum Moisture Absorption: 0.2 percent by volume.
- .3 Vapour Barrier Jacket
 - .1 ASTM C921, White kraft paper reinforced with glass fibre yarn and bonded to aluminized film.
 - .2 Moisture Vapour Transmission: ASTM E96; 0.03 ng/(Pa s sq m) (0.02 perm inches).
 - .3 Secure with self sealing longitudinal laps and butt strips.
 - .4 Secure with outward clinch expanding staples and vapour barrier mastic.
- .4 Tie Wire: 1.3 mm (18 gauge) stainless steel with twisted ends on maximum 300 mm (12 inch) centres.
- .5 Vapour Barrier Lap Adhesive
 - .1 Compatible with insulation.

2.2 CELLULAR FOAM

- .1 Manufacturers:
 - .1 Armacell AP Armaflex.
 - .2 Substitutions: Refer to Section 21 05 00.
- .2 Insulation: ASTM C534; flexible, cellular elastomeric, moulded or sheet.
 - .1 'ksi' ('K') Value: ASTM C177 or C518; 0.04 at 24 degrees C (0.27 at 75 degrees F).
 - .2 Minimum Service Temperature: -40 degrees C (-40 degrees F).
 - .3 Maximum Service Temperature: 104 degrees C (220 degrees F).
 - .4 Maximum Moisture Absorption: ASTM D1056; 1.0 percent (pipe) by volume, 1.0 percent (sheet) by volume.
 - .5 Moisture Vapour Transmission: ASTM E96; 0.20 perm inches.

- .6 Maximum Flame Spread: ASTM E84; 25.
- .7 Maximum Smoke Developed: ASTM E84; 50.
- .8 Connection: Waterproof vapour barrier adhesive.
- .3 Elastomeric Foam Adhesive
 - .1 Manufacturers:
 - .1 Armstrong 520 adhesive.
 - .2 Air dried, contact adhesive, compatible with insulation.
 - .3 Outdoor insulation shall be covered with Armstrong Armaflex finish.

2.3 JACKETS

- .1 PVC Plastic
 - .1 Jacket: ASTM C921, One piece moulded type fitting covers and sheet material, off white colour.
 - .1 Minimum Service Temperature: -40 degrees C (-40 degrees F).
 - .2 Maximum Service Temperature: 66 degrees C (150 degrees F).
 - .3 Moisture Vapour Transmission: ASTM E96; 0.002 perm inches.
 - .4 Maximum Flame Spread: ASTM E84; 25.
 - .5 Maximum Smoke Developed: ASTM E84; 50.
 - .6 Connections: installed in accordance with manufacturer's recommendations using PVC adhesive to seal joints, and tape or butt strips where joined to adjacent pipe covering. Use staples and insulation coating as specified at circumferential joints.
 - .2 Covering Adhesive Mastic
 - .1 Compatible with insulation.
- .2 Canvas Jacket: UL listed
 - .1 Fabric: ASTM C921, 220 g/sq m (6 oz/sq yd), plain weave cotton treated with dilute fire retardant lagging adhesive.
 - .2 Lagging Adhesive
 - .1 Bakelite 120-18 white fire retardant lagging adhesive.
 - .3 Coating
 - .1 Finish with two full brush coats of Bakelite 120-09 white fire retardant paint.
- .3 Aluminum Jacket: ASTM B209.
 - .1 Thickness: 0.40 mm (0.016 inch) sheet.
 - .2 Finish: Embossed.
 - .3 Joining: Longitudinal slip joints and 50 mm (2 inch) laps.
 - .4 Fittings: 0.4 mm (0.016 inch) thick die shaped fitting covers with factory attached protective liner.
 - .5 Metal Jacket Bands: 10 mm (3/8 inch) wide; 0.38 mm (0.015 inch) thick aluminum.

Part 3 Execution

3.1 EXAMINATION

- .1 Verify that piping has been tested before applying insulation materials.
- .2 Verify that surfaces are clean, foreign material removed, and dry.

3.2 INSTALLATION

- .1 Install materials to manufacturer's written instructions.
- .2 On exposed piping, locate insulation and cover seams in least visible locations.
- .3 Insulated dual temperature pipes or cold pipes conveying fluids below ambient temperature:
 - .1 Provide vapour barrier jackets, factory applied or field applied.
 - .2 Insulate fittings, joints, and valves with moulded insulation of like material and thickness as adjacent pipe.
 - .3 Finish with glass cloth and vapour barrier adhesive.
 - .4 PVC fitting covers may be used.
 - .5 Continue insulation through walls, sleeves, pipe hangers, and other pipe penetrations.
 - .6 Insulate entire system including fittings, valves, unions, flanges, strainers, flexible connections, pump bodies, and expansion joints.
- .4 For insulated pipes conveying fluids above ambient temperature:
 - .1 Provide standard jackets, with or without vapour barrier, factory applied or field applied.
 - .2 Insulate fittings, joints, and valves with insulation of like material and thickness as adjoining pipe.
 - .3 Finish with glass cloth and adhesive.
 - .4 PVC fitting covers may be used, except on steam and condensate piping systems.
 - .5 For hot piping conveying fluids 60 degrees C (140 degrees F) or less, do not insulate flanges and unions at equipment, but bevel and seal ends of insulation.
 - .6 For hot piping conveying fluids over 60 degrees C (140 degrees F), insulate flanges and unions at equipment.
- .5 Inserts and Shields:
 - .1 Application: Piping 40 mm (1-1/2 inches) diameter or larger.
 - .2 Shields: Galvanized steel between pipe hangers or pipe hanger rolls and inserts.
 - .3 Insert Location: Between support shield and piping and under the finish jacket.
 - .4 Insert Configuration: Minimum 150 mm (6 inches) long, of same thickness and contour as adjoining insulation; may be factory fabricated.
 - .5 Insert Material: hydrous calcium silicate insulation or other heavy density insulating material suitable for the planned temperature range.
- .6 Finish insulation at supports, protrusions, and interruptions.

- .7 Pipe supports:
 - .1 All piping shall be supported in such a manner that neither the insulation nor the vapor/weather barrier is compromised by the hanger or the effects of the hanger. In all cases, hanger spacing shall be such that the circumferential joint may be made outside the hanger. On cold systems, vapor barrier shall be continuous, including material covered by the hanger saddle.
 - .2 Piping systems 3" (75 mm) in diameter or less may be supported by placing saddles of the proper length and spacing under the insulation as designated by the insulation manufacturer.
 - .3 Where pipe shoes and roller supports are required, insulation shall be inserted in the pipe shoe to minimize pipe heat loss. Where possible, the pipe shoe shall be sized to be flush with the outer pipe insulation diameter.
 - .4 On vertical runs, insulation support rings shall be used as required.
- .8 For all pipe in exposed in occupied areas, finish with PVC jacket.
- .9 For exterior piping applications, provide vapour barrier jacket. Insulate fittings, joints, and valves with insulation of like material and thickness as adjoining pipe, and finish with glass mesh reinforced vapour barrier cement. Cover with aluminum jacket with seams located on bottom side of horizontal piping.
- .10 On outdoor chilled water and refrigerant lines, the insulation system shall be completely vapor sealed before the weather-resistant jacket is applied. The outer jacket shall not compromise the vapor barrier by penetration of fasteners, etc. Vapor stops at butt joints shall be applied at every fourth pipe section joint and at each fitting to provide isolation of water incursion. Piping 38mm (1-1/2 inches) and less shall have UV resistant PVC jacket. Pipes larger than 38mm (1-1/2 inches) shall have aluminium jacket.
- .11 Fittings and Valves
 - .1 Shall be insulated with pre-formed fiberglass fittings, fabricated sections of fiberglass pipe insulation. Thickness shall be equal to adjacent pipe insulation. Finish shall be with pre-formed PVC fitting covers or as otherwise specified on contract drawings.
 - .2 Flanges, couplings and valve bonnets shall be covered with an oversized pipe insulation section sized to provide the same insulation thickness as on the main pipe section. An oversized insulation section shall be used to form a collar between the two insulation sections with low-density blanket insulation being used to fill gaps. Jacketing shall match that used on straight pipe sections. Rough cut ends shall be coated with suitable weather or vapor resistant mastic as dictated by the system location and service. On hot systems where fittings are to be left exposed, insulation ends should be beveled away from bolts for easy access.
 - .3 On cold systems, particular care must be given to vapor sealing the fitting cover or finish to the pipe insulation vapor barrier. All valve stems shall be sealed with caulking to allow free movement of the stem but provide a seal against moisture incursion. Valve handle extensions are recommended.
- .12 Accessory Materials

- .1 All accessory materials shall be installed in accordance with project drawings and specifications, manufacturer's instructions, and/or in conformance with the current edition of the Midwest Insulation Contractors Association (MICA) "Commercial & Industrial Insulation Standards."

3.3 TOLERANCE

- .1 Substituted insulation materials: Thermal resistance within 10 percent at normal conditions, as materials indicated.

3.4 FIBROUS GLASS INSULATION SCHEDULE

	PIPING SYSTEMS	PIPE SIZE <Inch><mm>	THICKNESS <Inch><mm>
Plumbing Systems			
	Domestic Hot Water Supply & Domestic Hot Water Recirc	=< 2" (50mm)	1" (25mm)
	Domestic Cold Water, medical gas piping	=< 2" (50mm)	1" (25mm)
	Vent piping and medical and/or lab vacuum exhaust piping for developed length of 3000 mm (10 ft) from all roof and/or wall terminals.	all	2" (50mm)
	Plumbing Vents Within 10 Feet (3 Metres) of the Exterior	all	2" (50mm)
Heating Systems			
	Heating water & glycol supply and return, low pressure steam, steam condensate	=< 2" (50mm)	1" (25mm)
Cooling Systems			
	Chilled water & glycol	all	1" (25mm)
	Cold Condensate Drains	all	1" (25mm)
	Condensate Drains from Cooling Coils	all	1" (25mm)
	Refrigerant Suction	all	3/4" (19mm)
	Refrigerant Hot Gas	all	3/4" (19mm)

3.5 CELLULAR FOAM PIPE INSULATION SCHEDULE

	PIPING SYSTEMS	PIPE SIZE <Inch><mm>	THICKNESS <Inch><mm>
	Refrigerant Suction	all	3/4" (19mm)
	Refrigerant Hot Gas	all	3/4" (19mm)

END OF SECTION

Part 1 General

1.1 SECTION INCLUDES

- .1 Pipe and pipe fittings for:
 - .1 Heating water piping system.
 - .2 Chilled water piping system.
- .2 Valves:
 - .1 Ball valves.
 - .2 Check valves.

1.2 RELATED SECTIONS

- .1 Section 09 21 16 – Gypsum Board Assemblies.
- .2 Section 09 91 99 – Painting for Minor Works.
- .3 Section 23 05 16 - Piping Expansion Compensation.
- .4 Section 23 05 53 - Mechanical Identification.
- .5 Section 23 05 48 - Vibration Isolation.
- .6 Section 23 07 19 - Piping Insulation.
- .7 Section 23 05 16 – Piping Expansion Compensation.
- .8 Section 23 05 29 – Supports and Anchors.

1.3 REFERENCES

- .1 ASME -Welding and Brazing Qualifications.
- .2 ASME B16.3 - Malleable Iron Threaded Fittings Class 50 and 300.
- .3 ASME B16.18 - Cast Copper Alloy Solder Joint Pressure Fittings.
- .4 ASME B16.22 - Wrought Copper and Copper Alloy Solder Joint Pressure Fittings.
- .5 ASME B31.5 - Refrigeration Piping and Heat Transfer Components.
- .6 ASME B31.9 - Building Services Piping.
- .7 ASTM A53/A53M - Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless.
- .8 ASTM A234/A234M - Piping Fittings of Wrought-Carbon Steel and Alloy Steel for Moderate and High Temperature Service.

- .9 ASTM B32 - Solder Metal.
- .10 ASTM B88 - Seamless Copper Water Tube.

1.4 SYSTEM DESCRIPTION

- .1 Where more than one piping system material is specified, ensure system components are compatible and joined to ensure the integrity of the system is not jeopardized. Provide necessary joining fittings. Ensure flanges, union, and couplings for servicing are consistently provided.
- .2 All valves must be installed with stems upright or horizontal; not inverted.
- .3 Valve body materials shall be compatible with piping system materials. Valves shall meet all pressure, temperature, and fluid handling requirements of the system.
- .4 A valve drain shall be provided at the base of each riser and at the low points of the system. Manual air vents shall be provided at the top of each riser and at the high points of the system.
- .5 All valves installed in concealed locations, i.e., ceiling spaces, shall be compactly arranged so that they are easily accessible through common access plates or doors.
- .6 On cooling coils supply and install drain valves with hose end connections at the top of the coil header of headers to allow the coils to be filled with glycol.
- .7 Use grooved mechanical couplings and fasteners only in accessible locations.
- .8 Use unions, flanges, and couplings downstream of valves and at equipment or apparatus connections. Do not use direct welded or threaded connections to valves, equipment or other apparatus.
- .9 Use non-conducting dielectric connections whenever jointing dissimilar metals in open systems.
- .10 Provide pipe hangers and supports to ASTM B31.9 unless indicated otherwise.
- .11 Use ball or butterfly valves for shut-off and to isolate equipment, part of systems, or vertical risers.
- .12 Use globe or butterfly valves for throttling, bypass, or manual flow control services.
- .13 Use plug cocks for throttling service. Use non-lubricated plug cocks only when shut-off or isolating valves are also provided.
- .14 Use 3/4 inch (20 mm) ball valves with cap for drains at main shut-off valves, low points of piping, bases of vertical risers, and at equipment. Pipe to nearest floor drain.

1.5 SUBMITTALS

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

- .2 Product Data: Include data on pipe materials, pipe fittings, valves, and accessories. Provide manufacturers catalogue information. Indicate valve data and ratings.
- .3 Welders Certificate: Include welders certification of compliance with ASME SEC 9 and applicable provincial labour regulations.
- .4 Manufacturer's Installation Instructions: Indicate hanging and support methods, joining procedures.

1.6 PROJECT RECORD DOCUMENTS

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

1.7 OPERATION AND MAINTENANCE DATA

- .1 Submit to Section 21 05 00.
- .2 Include valve schedule complete with valve tags, location, service, normally open/normally closed.
- .3 Maintenance Data: Include installation instructions, spare parts lists, exploded assembly views.

1.8 QUALIFICATIONS

- .1 Manufacturer: Company specializing in manufacturing the Products specified in this section with minimum three years documented experience.
- .2 All carbon steel pipe and fittings shall be manufactured in Canada or the United States of America. This does not include stainless steel.
- .3 Installer: Company specializing in performing the work of this section with minimum 5 years documented experience.
- .4 Welders: Certify to ASME SEC 9 and applicable provincial labour regulations.

1.9 REGULATORY REQUIREMENTS

- .1 All pressure piping systems for use in Manitoba shall be designed and constructed in accordance with the applicable ANSI/ASME Piping Codes and the Manitoba Labour and Immigration, Steam and Pressure Plants Act.
- .2 Conform to ASME B31.9 code for installation of piping system.
- .3 Welding Materials and Procedures: Conform to ASME SEC 9 and applicable provincial labour regulations.
- .4 Provide certificate of compliance from authority having jurisdiction indicating approval of welders.

1.10 DELIVERY, STORAGE, AND HANDLING

- .1 Section 21 05 00: Transport, handle, store, and protect products.
- .2 Accept valves on site in shipping containers with labeling in place. Inspect for damage.
- .3 Provide temporary protective coating on cast iron and steel valves.
- .4 Provide temporary end caps and closures on piping and fittings. Maintain in place until installation.
- .5 Protect piping systems from entry of foreign materials by temporary covers, completing sections of the work, and isolating parts of completed system.

Part 2 Products

2.1 HEATING WATER AND GLYCOL PIPING, ABOVE GROUND

- .1 Steel Pipe: ASTM A53, Schedule 40, black.
 - .1 Fittings: ASTM B16.3, malleable iron or ASTM A234, forged steel welding type fittings.
 - .2 Joints: Threaded, or AWS D1.1, welded.
 - .3 Mechanical Grooved Couplings: Malleable iron housing clamps to engage and lock, "C" shaped elastomeric sealing gasket, steel bolts, nuts, and washers; galvanized for galvanized pipe.
- .2 Copper Tubing: ASTM B88, Type L hard drawn. Up to 50mm (2") diameter only.
 - .1 Fittings: ASME B16.18, cast brass, or ASME B16.22, solder wrought copper.
 - .2 Joints: Up to 50mm (2") diameter: Solder, lead free, ASTM B32, 95-5 tin-antimony, or tin and silver, with melting range 220 to 280 degrees C (430 to 535 degrees F).

2.2 CHILLED WATER PIPING, ABOVE GRADE

- .1 Steel Pipe: ASTM A53, Schedule 40, black.
 - .1 Fittings: ASTM B16.3, malleable iron or ASTM A234, forged steel welding type fittings.
 - .2 Joints: Threaded, or AWS D1.1, welded.
 - .3 Mechanical Grooved Couplings: Malleable iron housing clamps to engage and lock, "C" shaped elastomeric sealing gasket, steel bolts, nuts, and washers; galvanized for galvanized pipe.
- .2 Copper Tubing: ASTM B88, Type L hard drawn.
 - .1 Fittings: ASME B16.18, cast brass, or ASME B16.22, solder wrought copper.
 - .2 Joints: Up to 50mm (2") diameter: Solder, lead free, ASTM B32, 95-5 tin-antimony, or tin and silver, with melting range 220 to 280 degrees C (430 to 535 degrees F). Diameters 63mm (2-1/2") to 100mm (4"): Braze, AWS A5.8

BCuP silver/phosphorus/copper alloy with melting range 640 - 805 degrees C
(1190 - 1480 degrees F).

2.3 EQUIPMENT DRAINS AND OVERFLOWS

- .1 Steel Pipe: ASTM A53, Schedule 40 galvanized.
 - .1 Fittings: Galvanized cast iron, or ASTM B16.3 malleable iron.
 - .2 Joints: Threaded, or grooved mechanical couplings.
- .2 Copper Tubing: ASTM B88, Type L, annealed.
 - .1 Fittings: ASME B16.22, wrought copper.
 - .2 Joints: Solder, lead free, ASTM B32, 95-5 tin-antimony, or tin and silver, with melting range 220 to 280 degrees C (430 to 535 degrees F).

2.4 UNIONS, FLANGES, AND COUPLINGS

- .1 Unions for Pipe 50 mm(2 inches) and Under:
 - .1 Ferrous Piping: 1034 kPa (150 psig) malleable iron, threaded.
 - .2 Copper Pipe: Bronze, soldered joints.
- .2 Flanges for Pipe Over 50 mm(2 inches):
 - .1 Ferrous Piping: 1034 kPa (150 psig) forged steel, slip-on.
 - .2 Copper Piping: Bronze.
 - .3 Gaskets: 1.6 mm(1/16 inch) thick preformed neoprene.
- .3 Grooved and Shouldered Pipe End Couplings:
 - .1 Housing Clamps: Malleable iron to engage and lock, designed to permit some angular deflection, contraction, and expansion.
 - .2 Sealing Gasket: C-shape elastomer composition for operating temperature range from -34 degrees C (-30 degrees F) to 110 degrees C (230 degrees F).
 - .3 Accessories: Steel bolts, nuts, and washers.
- .4 Dielectric Connections: Union with galvanized or plated steel threaded end, copper solder end, water impervious isolation barrier.

2.5 BALL VALVES

- .1 Up To and Including 50 mm(2 inches):
 - .1 Manufacturers:
 - .1 MAS
 - .2 Red-White/Toyo
 - .3 Kitz
 - .4 Substitutions: Refer to Section 21 05 00.
 - .2 Bronze one piece body, stainless steel ball, teflon seats and stuffing box ring, lever handle solder ends.
- .2 Over 50 mm(2 inches):

- .1 Manufacturers:
 - .1 Kitz
 - .2 MAS
 - .3 American 4001
 - .4 American 4000
 - .5 Substitutions: Refer to Section 21 05 00.
- .2 Cast steel body, chrome plated steel ball, teflon seat and stuffing box seals, lever handle, [or gear drive handwheel for sizes 250 mm(10 inches) and over,] flanged.

2.6 PLUG VALVES

- .1 Up To and Including 50 mm (2 inches):
 - .1 Manufacturers:
 - .1 Nordstrom Valves, Inc. MSS SP-78, Type II.
 - .2 Substitutions: Refer to Section 21 05 00.
 - .2 Cast-iron or bronze body, bronze tapered plug, [40 percent] [70 percent] [full] port opening, non-lubricated, teflon packing, threaded ends.
 - .3 Operator: One plug valve wrench for every ten plug valves minimum of one.
- .2 Over 50 mm (2 inches):
 - .1 Manufacturers:
 - .1 Nordstrom Valves, Inc. MSS SP-78, Type II.
 - .2 Substitutions: Refer to Section 21 05 00.
 - .2 Cast iron body and plug, [40 percent] [70 percent] [full] port opening, pressure lubricated, teflon packing, flanged ends.
 - .3 Operator: Each plug valve with a wrench with set screw.

2.7 SWING CHECK VALVES

- .1 Up To and Including 50 mm(2 inches):
 - .1 Manufacturers:
 - .1 Red-White/Toyo
 - .2 Kitz
 - .3 Substitutions: Refer to Section 21 05 00.
 - .2 Bronze body, bronze trim, bronze rotating swing disc, with composition disc, solder ends.
- .2 Over 50 mm (2 inches):
 - .1 Manufacturers:
 - .1 Red-White/Toyo
 - .2 Kitz
 - .3 Substitutions: Refer to Section 21 05 00.
 - .2 Iron body, bronze trim, bronze or bronze faced rotating swing disc, renewable disc and seat, flanged ends.

Part 3 Execution

3.1 PREPARATION

- .1 Ream pipe and tube ends. Remove burrs.
- .2 Remove scale and dirt on inside and outside before assembly.
- .3 Prepare piping connections to equipment with flanges or unions.
- .4 Keep open ends of pipe free from scale and dirt. Protect open ends with temporary plugs or caps.
- .5 After completion, fill, clean, and treat systems.

3.2 INSTALLATION

- .1 Install to manufacturer's written instructions.
- .2 Install heating water, glycol, chilled water, and condenser water piping to ASME B31.9.
- .3 Route piping in orderly manner, parallel to building structure, and maintain gradient. Grade hydronic piping up in flow direction or as noted.
- .4 Install piping to conserve building space, and not interfere with use of space.
- .5 Group piping whenever practical at common elevations.
- .6 Sleeve pipe passing through partitions, walls and floors.
- .7 Slope piping and arrange to drain at low points.
- .8 Install piping to allow for expansion and contraction without stressing pipe, joints, or connected equipment. Refer to Section 23 05 16.
- .9 Install drain valves (ball valves) c/w hose and cap and chain on each pump (pipe to nearest floor drain), at system low points so that entire system can be drained, and at each zone or branch / riser isolation valve so branch or riser can be drained down completely.
- .10 Provide clearance in hangers and from structure and other equipment for installation of insulation and access to valves and fittings. Refer to Section 23 07 19.
- .11 Provide access where valves and fittings are not exposed. Coordinate size and location of access doors with Section 09 21 16.
- .12 Prepare unfinished pipe, fittings, supports, and accessories, ready for finish painting. Refer to Section 09 91 99.
- .13 Install valves with stems upright or horizontal, not inverted.

3.3 Pressure Testing

- .1 Do not insulate pipe prior to pressure testing. Pressure test in sections if necessary before concealing or insulating pipe.
- .2 Do not introduce water for testing where freezing conditions exist or where piping systems being tested are located above sensitive areas or equipment that may be damaged or contaminated by water leakage.
- .3 Hydraulically test all pipe. Pneumatic testing not permitted without prior approval from the Contract Administrator and the Authority Having Jurisdiction.
- .4 Hydronic pipe testing shall be in accordance with the applicable ASME piping code, the Contractor's registered Quality Assurance Program (for systems where applicable), and all requirements of the Department of Labour .
- .5 Should leaks develop in any part of the piping system, remove and replace defective sections, fittings and equipment. Pipe dope, caulking, tape, lead wool, dresser couplings, etc. shall not be used to correct deficiencies. The contractor shall be responsible for all cleanup related to leakage during flushing, testing, and chemical treatment of piping, including original building piping if included in the testing.
- .6 Test piping system in sections as required by the progress of work.
- .7 Subject piping to a hydrostatic pressure of at least that 1-½ times the operating pressure of the system for a period of at least 12 hours. If leaks are detected, such leaks shall be repaired and the test started over. Record results and submit witnessed (by the Contract Administrator or the City's representative) reports to the Contract Administrator.
- .8 Register pressures at the highest system point.
- .9 Provide at least 48 hours (during working days) notice to the Contract Administrator or the City's Representative prior to testing to allow the tests to be witnessed.

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 09 91 99 – Painting for Minor Works.
- .3 Section 23 05 29 - Supports And Anchors: Sleeves.
- .4 Section 23 07 13 - Duct Insulation: External insulation and duct liner.
- .5 Section 23 33 00 - Duct Work Accessories.
- .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 NFPA 91 - Exhaust Systems for Air Conveying of Vapours, Gases, Mists, and Noncombustible Particulate Solids.
- .15 NFPA 96 - Ventilation Control and Fire Protection of Commercial Cooking Operations.
- .16 SMACNA - HVAC Air Duct Leakage Test Manual.
- .17 SMACNA - HVAC Duct Construction Standards - Metal and Flexible.
- .18 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 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.

1.6 QUALITY ASSURANCE

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

1.7 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.

1.8 REGULATORY REQUIREMENTS

- .1 Construct commercial kitchen exhaust duct work to NFPA 96 standards.

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 Insulated Flexible Ducts:
 - .1 Manufacturers:
 - .1 Thermaflex G-KM
 - .2 Substitutions: Refer to Section 21 05 00.
 - .2 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.
 - .3 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.
 - .4 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.
- .3 Fasteners: Rivets, bolts, or sheet metal screws.
- .4 Sealant:
 - .1 Manufacturers:
 - .1 Duro-Dyne
 - .2 Substitutions: Refer to Section 21 05 00.
 - .2 Non-hardening, water resistant, fire resistive, compatible with mating materials; liquid used alone or with tape, or heavy mastic.
- .5 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 Provide standard 45 degree lateral wye takeoffs unless otherwise indicated where 90 degree conical tee connections may be used.
- .5 All rectangular ducts shall be constructed by breaking the corners and grooving the longitudinal seams using Pittsburgh seam or other approved airtight seam.
- .6 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.

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 Contract Administrator. 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 City. 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 Contract Administrator 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 Slope underground ducts to plenums or low pump out points at 1:500. Provide access doors for inspection.
- .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 diffusers or light troffer boots to low pressure ducts with 0.6 m (2 feet) maximum length of flexible duct held in place with strap or clamp.
- .19 Connect flexible ducts to metal ducts with adhesive plus sheet metal screws.
- .20 Where interior of duct is visible through grilles, registers or diffusers, paint interior of duct with flat black Tremco paint formulated for galvanized surfaces.
- .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 All ductwork located outdoors shall have seams and joints sealed with grey TREMCO 555 acrylic sealant applied with gun and levelled with putty knife. Use material in accordance with manufacturer's printed recommendations.
- .24 Stainless steel ductwork exposed in finished rooms shall not have duct tape application.
- .25 Install ductwork free from pulsation, chatter, vibration or objectionable noises.
- .26 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 Contract Administrator.

3.2 CLEANING

- .1 Clean duct system and force 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

3.4 DUCT WORK MATERIAL SCHEDULE

	AIR SYSTEM	MATERIAL
	Low Pressure Supply (Heating Systems)	Steel
	Low Pressure Supply (System with Cooling Coils)	Steel
	Return and Relief	Steel
	General Exhaust	Steel
	Outside Air Intake	Steel

3.5 DUCT WORK PRESSURE CLASS SCHEDULE

	AIR SYSTEM	PRESSURE CLASS
	Supply (System with Cooling Coils)	500 Pa (2 inch)
	Return and Relief	250 Pa (1 inch)
	General Exhaust	125 Pa (1/2 inch)
	Outside Air Intake	125 Pa (1/2 inch)
	Intake and Exhaust	250 Pa (1 inch)

END OF SECTION

Part 1 General

1.1 SECTION INCLUDES

- .1 Air turning devices/extractors.
- .2 Backdraft 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 25 30 00 – Instrument and Control Elements

1.3 REFERENCES

- .1 NFPA 90A - Installation of Air Conditioning and Ventilating Systems.
- .2 NFPA 92A - Smoke-Control Systems.
- .3 NFPA 96 - Ventilation Control and Fire Protection of Commercial Cooking Operations.
- .4 SMACNA - HVAC Duct Construction Standards - Metal and Flexible.
- .5 CAN/ULC-S112 Standard Method of Fire Test of Fire-Damper Assemblies

1.4 SUBMITTALS

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

- .1 Gravity Backdraft Dampers, Size 450 x 450 mm (18 x 18 inches) or smaller, provided with Air Moving Equipment: Air moving equipment manufacturers standard construction.
- .2 Multi-Blade, Parallel Action Gravity Balanced Backdraft Dampers: 1.5 mm (16 gauge) thick galvanized steel, with centre pivoted blades of maximum 150 mm (6 inch) width, with felt or flexible vinyl sealed edges, linked together in rattle-free manner with 90 degree stop, steel ball bearings, and plated steel pivot pin; adjustment device to permit setting for varying differential static pressure.

2.3 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 Contract Administrator prior to installation.

2.4 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;

2.5 FLEXIBLE DUCT CONNECTIONS

- .1 Manufacturers:
 - .1 Duro-Dyne.
 - .2 Substitutions: Refer to Section 21 05 00.
- .2 Fabricate to SMACNA HVAC Duct Construction Standards - Metal and Flexible, and as indicated.
- .3 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 Single Blade Dampers: Fabricate for duct sizes up to 150 x 760 mm (6 x 30 inch).
- .3 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.
- .4 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 on exhaust fans or exhaust ducts nearest to outside and 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 for cleaning kitchen exhaust duct work to NFPA 96. 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 Provide duct test holes where indicated and required for testing and balancing purposes.
- .5 Provide flexible connections immediately adjacent to equipment in ducts associated with fans and motorized equipment, and supported by vibration isolators. Refer to Section 23 05 48. For fans developing static pressures of 1250 Pa (5.0 inches wg) and over, cover connections with leaded vinyl sheet, held in place with metal straps.
- .6 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.
- .7 Do not locate single blade volume dampers immediately behind diffusers and grilles. This application does not allow uniform airflow across the outlet face.
- .8 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 General Fan Components:
 - .1 Wheels and Inlets:
 - .2 Housings
 - .3 Bearings and Drives
 - .4 Electrical Components
- .2 Inline Fans
- .3 Range Hoods
- .4 Fan Accessories.

1.2 RELATED WORK

- .1 Section 23 05 13 - Motors.
- .2 Section 23 05 48 - Vibration Isolation.
- .3 Section 23 05 53 - Mechanical Identification.
- .4 Section 23 05 93 – Testing, Adjusting, And Balancing.
- .5 Section 23 07 13 - Duct Insulation.
- .6 Section 23 31 00 - Duct Work.

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 762 - Power Roof Ventilators For Restaurant Exhaust Appliances

- .10 UL/cUL 705 – Power Ventilators
- .11 UL/cUL 793 - Automatically Operated Roof Vents for Smoke and Heat

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 GENERAL FAN COMPONENTS

- .1 Performance Ratings: Conform to AMCA 210 and bear the AMCA Certified Rating Seal.
- .2 Sound Ratings: AMCA 301, tested to AMCA 300 ,and bear AMCA Certified Sound Rating Seal.
- .3 Fabrication: Conform to AMCA 99.

- .4 Performance Base: Sea level conditions.
- .5 Temperature Limit: Maximum 150 degrees C (300 degrees F).
- .6 Static and Dynamic Balance: Balance all wheels to balance grade G6.3 per ANSI S2.19 (ISO 1940). Eliminate vibration or noise transmission to occupied areas.
- .7 Performance Requirements on Schedules.
- .8 Wheel And Inlet: Refer to individual sections.
- .9 Housing
 - .1 Heavy gauge steel, spot welded, adequately braced, designed to minimize turbulence with spun inlet bell and shaped cut-off.
 - .2 Factory finish before assembly with enamel or prime coat.
- .10 Bearings And Drives
 - .1 Shafts: Hot rolled steel, ground and polished, with key- way, protectively coated with lubricating oil, and shaft guard.
 - .2 V-Belt Drive: Cast iron or steel sheaves, dynamically balanced, keyed. Variable and adjustable pitch sheaves for motors 11.2 kW(15 hp) and under, selected so required rpm is obtained with sheaves set at mid-position. Fixed sheave for 15 kW(20 hp) and over, matched belts, and drive rated as recommended by manufacturer or minimum 1.5 times nameplate rating of the motor.
 - .3 Belt Guard: Fabricate to SMACNA Standard; of 2.8 mm(12 gauge) thick, 20 mm(3/4 inch) diamond mesh wire screen welded to steel angle frame or equivalent, prime coated. Secure to fan or fan supports without short circuiting vibration isolation, with provision for adjustment of belt tension, lubrication, and use of tachometer with guard in place.
- .11 Electrical Characteristics And Components
 - .1 Refer to schedule
 - .2 Motor: Refer to Section 23 05 13.

2.2 RANGE HOODS

- .1 Manufacturer Broan Allure QS1
 - .1 Fan Tech
 - .2 Substitutions: Refer to Section 21 05 00
- .2 Performance
 - .1 Air delivery shall be no less than 220 cfm. Sound level to be no greater than 1.5 sones at 100 cfm; 5.0 sones at 220 cfm. Air and sound ratings to be certified by HVI. Unit shall be U.L. and c.U.L. listed.
- .3 All Range Hoods:
 - .1 Range hood shall no sharp edges.
 - .2 Finish: baked-on polyester paint, white

- .3 Fully-enclosed bottom and dishwasher-safe full filters.
- .4 Axial blade centrifugal blower
- .5 Twin, 50-watt (max.) halogen flood lights, lamps by mechanical contractor
- .4 RH-1:
 - .1 Unit complete with blower and light operation using an adjustable 2-speed rocker, located in face of hood.

2.3 ELECTRIC MAKE-UP AIR HEATERS

- .1 Manufacturer: Thermolec Model Minimate FER.
- .2 Other acceptable manufacturers offering equivalent products.
 - .1 Substitutions: Refer to Section 21 05 00
- .3 Assembly: UL listed and labelled assembly with terminal box and cover, and built-in controls.
- .4 Heating Elements: Exposed helical coil of nickel-chrome resistance wire with refractory ceramic support bushings
- .5 Cabinet: 1.2 mm(0.0478 inch) steel with easily removed front panel with integral air outlet and inlet grilles.
- .6 Element Hangers: Quiet operating, ball bearing cradle type providing unrestricted longitudinal movement, on enclosure brackets.
- .7 Fan: Direct drive propeller type, statically and dynamically balanced.
- .8 Motor: Permanently lubricated, sleeve bearings for horizontal models, ball bearings for vertical models.
- .9 Control: Provided with unit c/w SRC control and appropriate flow switches and thermal overloads. Unit shall control the discharge air temperature to meet remote temperature sensor requirements,
- .10 Performance Characteristics:
 - .1 Refer to schedule

Part 3 Execution

3.1 INSTALLATION

- .1 Install to manufacturer's written instructions.
- .2 Install fans with resilient mountings and flexible electrical leads. Refer to Section 23 05 48.

- .3 Install flexible connections specified in Section 23 33 00 between fan inlet and discharge ductwork. Ensure metal bands of connectors are parallel with minimum 25 mm(one inch) flex between ductwork and fan while running.
- .4 Provide safety screen where inlet or outlet is exposed.
- .5 Pipe scroll drains to nearest floor drain.
- .6 Provide backdraft dampers on discharge of exhaust fans and as indicated. Refer to Section 23 33 00.

END OF SECTION

Part 1 General

1.1 SECTION INCLUDES

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

1.2 RELATED SECTIONS

- .1 Section 09 91 99 – Painting for Minor Works.

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 MANUFACTURERS

- .1 Unless otherwise listed:
 - .1 Price Industries.
 - .2 Nailor Industries
 - .3 Titus
 - .4 Ventex.
- .2 Substitutions: Refer to Section 21 05 00.

2.2 ROUND CEILING DIFFUSERS

- .1 Type: Round, stamped or spun, multi-core diffuser to discharge air in 360 degree pattern.
- .2 Refer to the schedule for frame, materials of fabrication, finishes, and accessories.

2.3 SQUARE CEILING DIFFUSERS

- .1 Type: Square, stamped diffuser to discharge air in 360 degree pattern.
- .2 Refer to the schedule for frame, materials of fabrication, finishes, and accessories.

2.4 CEILING GRID CORE EXHAUST AND RETURN REGISTERS/GRILLES

- .1 Type: Fixed grilles of 13 x 13 x 13 mm (1/2 x 1/2 x 1/2 inch) louvers.
- .2 Refer to the schedule for frame, materials of fabrication, finishes, and accessories.

2.5 WALL SUPPLY REGISTERS/GRILLES

- .1 Type: Streamlined and individually adjustable blades, 19 mm (3/4 inch) minimum depth, 19 mm (3/4 inch) maximum spacing with spring or other device to set blades.
- .2 Refer to the schedule for frame, materials of fabrication, finishes, and accessories.

2.6 LOUVERS

- .1 150 mm (6 inch) Fixed Blade Louver:
 - .1 Type: 150 mm (6 inch) deep with blades on 45 degree slope with centre baffle and return bend, heavy channel frame, aluminum birdscreen with 13 mm (1/2 inch) square mesh for exhaust and 19 mm (3/4 inch) for intake.

- .2 Fabrication: 2.0 mm (0.81 inch) extruded aluminum, welded assembly, with factory baked enamel finish - custom colour to be selected by the architect.
- .3 Mounting: Exterior.

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 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.
- .6 Paint ductwork visible behind air outlets and inlets matte black.
- .7 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 Contractor, the suspended ceiling subtrade and electrical subtrade.
- .8 Should there be any conflict in the location of grilles, registers and diffusers with lights, etc. the matter shall be referred to the Contract Administrator for directive. If requested by the Contract Administrator, 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 City.

END OF SECTION

Part 1 General

1.1 SECTION INCLUDES

- .1 Air conditioning units.
- .2 Controls and control panels.

1.2 RELATED SECTIONS

- .1 Section 23 05 13 - Motors: Evaporator and condenser fan motors.

1.3 REFERENCES

- .1 ASHRAE 52.1 – Gravimetric and Dust-Spot Procedures for Testing Air-Cleaning Devices Used in General Ventilation for Removing Particulate Matter.
- .2 ASHRAE 52.2 – Method of Testing General Ventilation Air-Cleaning Devices for Removal Efficiency by Particle Size.
- .3 ASHRAE/IESNA 90.1 - Energy Efficient Design of New Buildings except Low-Rise Residential Buildings.
- .4 ASME SEC 8D - Boilers and Pressure Vessel Codes - Rules for Construction of Pressure Vessels.
- .5 CAN/CSA B52 - Mechanical Refrigeration Code.
- .6 NFPA 90A - Installation of Air Conditioning and Ventilation Systems.

1.4 SUBMITTALS FOR REVIEW

- .1 Section 21 05 00: Procedures for submittals.
- .2 Shop Drawings: Indicate manufactured products and assemblies. Indicate water, drain, refrigeration, rough-in connections, and electrical characteristics and connection requirements.
- .3 Product Data: Provide for manufactured products and assemblies. Indicate water, drain, refrigeration, rough-in connections, and electrical characteristics and connection requirements.

1.5 SUBMITTALS FOR INFORMATION

- .1 Section 21 05 00: Submittals for information.
- .2 Submit manufacturer's installation instructions. Indicate assembly, support details, connection requirements, and include start-up instructions.
- .3 Manufacturer's Field Reports: Indicate conditions at initial start-up including date, and initial set points.

1.6 SUBMITTALS FOR CLOSEOUT

- .1 Section 21 05 00: Submittals for project closeout.
- .2 Operation and Maintenance Data: Include manufacturer's descriptive literature, operating instructions, installation instructions, and maintenance and repair data.

1.7 QUALITY ASSURANCE

- .1 Manufacturer Qualifications: Company specializing in manufacturing the Products specified in this section with minimum three years documented experience.
- .2 Installer Qualifications: Company specializing in performing the work of this section with minimum 3 years experience approved by manufacturer.
- .3 Fabricate and label refrigeration system to CAN/CSA B52.
- .4 The units shall be rated in accordance with Air-conditioning, Heating, and Refrigeration Institute's (AHRI) Standard 210 and bear the ARI Certification label.
- .5 Energy-Efficiency Ratio: Minimum prescribed by ASHRAE/IESNA 90.1.
- .6 Coefficient of Performance: Minimum prescribed by ASHRAE/IESNA 90.1 and NECB 2011 whichever is higher.
- .7 Provide equipment to operate using HCFC-free refrigerants.

1.8 REGULATORY REQUIREMENTS

- .1 Conform to NFPA 90A for the installation of computer room air conditioning units.
- .2 Products Requiring Electrical Connection: Listed and classified by Underwriters' Laboratories, Inc., as suitable for the purpose specified and indicated.

1.9 WARRANTY

- .1 Section 21 05 00: Submittals for project closeout.
- .2 Warranty Period:
 - .1 Compressors: Manufacturer's standard, minimum seven (7) years from date of Substantial Completion.
 - .2 Parts and Defects: Manufacturer's standard, minimum five (5) years from date of Substantial Completion.

1.10 MAINTENANCE SERVICE

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

1.11 EXTRA MATERIALS

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

- .2 Provide one set of filters for each unit.

Part 2 Products

2.1 MANUFACTURERS

- .1 Mitsubishi
- .2 Daikin
- .3 LG
- .4 Substitutions: Refer to Section 21 05 00.

2.2 AIR CONDITIONING UNITS

- .1 Description: Packaged, air cooled, factory assembled, pre-wired and pre-piped unit, consisting of cabinet, fans filters, humidifier, controls.

2.3 EVAPORATOR FANS AND MOTORS

- .1 Fans: Multi speed, Double inlet, forward curved centrifugal fans, statically and dynamically balanced, on steel shaft with self-aligning permanently lubricated ball bearings, directly driven.
- .2 Unit configuration shall be as scheduled on drawings.

2.4 COMPRESSORS

- .1 Type: DC twin-rotor rotary compressor with Variable Speed Inverter Drive Technology up to 3 tons, Frame Compliant Scroll compressor with Variable Speed Inverter Drive Technology for larger than 3 tons, vibration isolators, accumulator and high pressure safety switch.
- .2 To prevent liquid from accumulating in the compressor during the off cycle, a minimal amount of current shall be automatically, intermittently applied to the compressor motor windings to maintain sufficient heat to vaporize any refrigerant. No crankcase heater is to be used.
- .3 Compressors: Individually serviceable without dismantling other components [or removing unit from service].
- .4 Refrigerant: R-410A.

2.5 FILTER

- .1 Return air shall be filtered by means of an easily removable MERV 8 filter shall be furnished.

2.6 EVAPORATOR COILS

- .1 The evaporator coil shall be of nonferrous construction with pre-coated aluminum fins on copper tubing. All tube joints shall be brazed with silver alloy. The coils shall be pressure tested at the factory. A condensate pan and drain shall be provided under the coil.

2.7 CONDENSERS

- .1 Air Cooled: The L shaped condenser coil shall be of copper tubing with flat aluminum fins to reduce debris build up and allow maximum airflow. The coil shall be protected with an integral metal guard.
- .2 Refrigerant flow from the condenser shall be controlled by means of an electronic linear expansion valve (LEV) metering device. The LEV shall be controlled by a microprocessor controlled step motor.
- .3 The fan shall be mounted in front of the coil, pulling air across it from the rear and dispelling it through the front. The fan shall be provided with a raised guard to prevent external contact with moving parts.
- .4 The outdoor unit shall be equipped with an electronic control board that interfaces with the indoor unit to perform all necessary operation functions.
- .5 The outdoor unit shall be capable of cooling operation down to 0°F (-18°C) ambient temperature without additional low ambient controls (optional wind baffle shall be required).
- .6 The outdoor unit shall be able to operate with a maximum height difference of 100 feet (30 meters) between indoor and outdoor units.

2.8 ELECTRICAL PANEL

- .1 The electrical power of the unit shall be 208volts or 230 volts, single phase, 60 hertz. The unit shall be capable of satisfactory operation within voltage limits of 187 volts to 253 volts.
- .2 Power for the indoor unit shall be supplied from the outdoor unit via Mitsubishi Electric A-Control using three (3) fourteen (14) gauge AWG conductors plus ground wire connecting the units.
- .3 The outdoor unit shall be controlled by the microprocessor located in the indoor unit.
- .4 The control signal between the indoor unit and the outdoor unit shall be pulse signal 24 volts DC.
- .5 The unit shall have Pulse Amplitude Modulation circuit to utilize 98% of input power supply.
- .6 Disconnect Switch: Non-automatic moulded case circuit breaker with handle accessible with panel closed.

2.9 ELECTRONIC CONTROL SYSTEM

- .1 The control system shall consist of a minimum of two (2) microprocessors, one on each indoor and outdoor unit, interconnected by a single non-polar two-wire cable. The microprocessor located in the indoor unit shall have the capability of monitoring return air temperature and indoor coil temperature, receiving and processing commands from a wired or wireless controller, providing emergency operation and controlling the outdoor unit. The control signal between the indoor and outdoor unit shall be pulse signal 24 volts DC. The indoor units shall have the ability to control supplemental heat via connector CN24 and a 12 VDC output.
- .2 A three (3) conductor 14 gauge AWG wire with ground shall provide power feed and bi-directional control transmission between the outdoor and indoor units. . If code requires a disconnect mounted near the indoor unit, a 3-Pole Disconnect shall be used – all three conductors must be interrupted.
- .3 The system shall be capable of automatic restart when power is restored after power interruption. The system shall have self-diagnostics ability, including total hours of compressor run time. Diagnostics codes for indoor and outdoor units shall be displayed on the wired controller panel.
- .4 The indoor unit control board shall have auxiliary control contact connectors to provide:
 - .1 Back-up Heat
 - .2 Remote Switch
 - .3 Central control
 - .4 IT terminal
 - .5 Lossany Control

2.10 WIRED REMOTE CONTROLLER

- .1 The Wired Remote Controller shall be wall mount. There shall be a built-in weekly timer with up to 8 pattern settings per day. The controller shall consist of an On/Off button, Increase/Decrease Set Temperature buttons, a Cool/Auto/Fan/Dry mode selector, a Timer Menu button, a Timer On/Off button, Set Time buttons, a Fan Speed selector, a Ventilation button, a Test Run button, and a Check Mode button. The controller shall have a built-in temperature sensor. Temperature shall be displayed in either Fahrenheit (°F) or Celsius (°C), and Temperature changes shall be by increments of 1°F (0.5°C). The controller shall have the capability of controlling multiple systems, as a group with the same mode and set-point for all, at a maximum developed control cable distance of 1,500 feet (500 meters).
- .2 The control voltage from the wired controller to the indoor unit shall be 12/24 volts, DC. Field wiring shall run directly from the indoor unit to the wall mounted controller with no splices. Up to two wired controllers shall be able to be used to control one indoor unit.

2.11 OPTIONS

- .1 An optional drain lift mechanism, capable of lifting condensate 23-5/8”(600mm) above the drain pan, shall be provided

2.12 PERFORMANCE

- .1 See schedule on drawings

Part 3 Execution

3.1 EXAMINATION

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

3.2 INSTALLATION

- .1 Install to manufacturer's written instructions.
- .2 Provide adequate drainage connections for condensate.
- .3 Provide service valves and piping from units to condensing units.

END OF SECTION

Part 1 General

1.1 SECTION INCLUDES

- .1 Fan-coil units.

1.2 RELATED SECTIONS

- .1 Section 23 05 13 - Motors.
- .2 Section 23 21 00 - Hydronic Piping.

1.3 SUBMITTALS FOR REVIEW

- .1 Section 21 05 00: Procedures for submittals.
- .2 Product Data: Provide typical catalogue of information including arrangements.
- .3 Shop Drawings:
 - .1 Indicate cross sections of cabinets, grilles, bracing and reinforcing, and typical elevations.
 - .2 Submit schedules of equipment and enclosures typically indicating length and number of pieces of element and enclosure, corner pieces, end caps, cap strips, access doors, pilaster covers, and comparison of specified heat required to actual heat output provided.
 - .3 Indicate mechanical and electrical service locations and requirements.,

1.4 SUBMITTALS FOR INFORMATION

- .1 Section 21 05 00: Submittals for information.
- .2 Manufacturer's Instructions: Indicate installation instructions and recommendations.

1.5 SUBMITTALS AT PROJECT CLOSEOUT

- .1 Section 21 05 00: Submittals for project closeout.
- .2 Project Record Documents: Record actual locations of components and locations of access doors in radiation cabinets required for access or valving.
- .3 Operation and Maintenance Data: Include manufacturers descriptive literature, operating instructions, installation instructions, maintenance and repair data, and parts listings.
- .4 Warranty: Submit manufacturer warranty and ensure forms have been completed in the City's name and registered with manufacturer.

1.6 QUALITY ASSURANCE

- .1 Manufacturer Qualifications: 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 WARRANTY

- .1 Section 21 05 00: Submittals for project closeout.
- .2 Provide five year manufacturers warranty for fan-coil unit.
- .3 Provide one year manufacturer's warranty for fin-tube radiation.
- .4 Provide two year manufacturer's warranty for unit heaters.

1.9 EXTRA MATERIALS

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

Part 2 Products

2.1 FAN-COIL UNITS – HORIZONTAL HIDEAWAY

- .1 Manufacturer: Daikin Applied Model HHBB.
- .2 Other acceptable manufacturers offering equivalent products.
 - .1 Carrier.
 - .2 Trane
 - .3 Substitutions: Refer to Section 21 05 00.
- .3 Style: 2-pipe fan coil
- .4 Coils:
 - .1 Evenly spaced aluminum fins mechanically bonded to seamless copper tubes, designed for 1380 kPa (200 psi) and 104 degrees C (220 degrees F).
 - .2 Coils provided with seamless copper tubing headers, complete with vent and drain.
 - .3 Coil casing to be 1.3mm (18 ga.) galvanized steel.
 - .4 Provide painted galvanized drain pan under cooling coil, easily removable for cleaning, with drain connection.
- .5 Cabinet: 1.5 mm(16 ga.) steel with exposed corners and edges rounded, easily removed panels, glass fibre insulation and integral air outlet and return plenum.
- .6 Finish: Factory apply baked colour on visible surfaces of enclosure or cabinet.
- .7 Fans: Centrifugal forward-curved double-width wheels, statically and dynamically balanced, belt drivendriven.

- .8 Motor: Tap wound electronically commutative with sleeve bearings, resiliently mounted.
- .9 Control: factory wired, located in cabinet.
- .10 Filter: Easily removed 50 mm(2 inch) thick glass fibre throw-away type, on the return plenum.
- .11 Capacity: As Scheduled

Part 3 Execution

3.1 INSTALLATION

- .1 Install to manufacturer's written instructions.
- .2 Install equipment exposed to finished areas after walls and ceiling are finished and painted. Avoid damage.
- .3 Protection: Provide finished cabinet units with protective covers during balance of construction.
- .4 Fan-Coil Units: Install as indicated. Coordinate to assure correct recess size for recessed units.

3.2 CLEANING

- .1 After construction is completed, including painting, clean exposed surfaces of units. Vacuum clean coils and inside of cabinets.
- .2 Touch-up marred or scratched surfaces of factory-finished cabinets, using finish materials provided by manufacturer.
- .3 Install new filters.

3.3 SCHEDULES

- .1 Refer to schedules on drawings.

END OF SECTION