

PART 1 GENERAL1.1 RELATED SECTIONS

- .1 Section 07 84 00 - Fire Stopping.
- .2 Section 22 11 16 - Domestic Water Piping.
- .3 Section 22 13 17 - Drainage Waste and Vent Piping - Cast Iron and Copper.
- .4 Section 22 13 18 - Drainage Waste and Vent Piping - Plastic.
- .5 Section 23 07 15 - Thermal Insulation for Piping and Equipment.
- .6 Section 23 08 01 - Performance Verification of Mechanical Piping Systems.

1.2 REFERENCES

- .1 Canadian Standards Association (CSA International)
 - .1 CSA B139-09, Installation Code for Oil-Burning Equipment, Includes Update No. 1 (2010).
 - .2 CSA C22.1-12, Canadian Electrical Code, Part 1 (22nd Edition), Safety Standard for Electrical Installations, and all Ontario Amendments.
- .2 National Fire Code of Canada (NFCC 2010)

1.3 DELIVERY, STORAGE AND HANDLING

- .1 Deliver, store and handle materials in accordance with Section 01 61 00 - Common Product Requirements and with manufacturer's written instructions.
- .2 Delivery and Acceptance Requirements:
 - .1 Deliver materials to site in original factory packaging, labelled with manufacturer's name, address.
- .3 Packaging Waste Management: remove for reuse and return by manufacturer of pallets, crates, padding and packaging materials in accordance with Section 01 74 21 - Construction/Demolition Waste Management and Disposal.

PART 2 PRODUCTS

2.1 MATERIAL

- .1 Fire stopping: in accordance with Section 07 84 00 - Fire Stopping.

PART 3 EXECUTION

3.1 APPLICATION

- .1 Manufacturer's Instructions: comply with manufacturer's written recommendations, including product technical bulletins, handling, storage and installation instructions, and datasheets.

3.2 CONNECTIONS TO EQUIPMENT

- .1 In accordance with manufacturer's instructions unless otherwise indicated.
- .2 Use valves and either unions or flanges for isolation and ease of maintenance and assembly.
- .3 Use double swing joints when equipment mounted on vibration isolation and when piping subject to movement.

3.3 CLEARANCES

- .1 Provide clearance around systems, equipment and components for observation of operation, inspection, servicing, maintenance and as recommended by manufacturer and National Fire Code of Canada, and the Canadian Electrical Code.
- .2 Provide space for disassembly, removal of equipment and components as recommended by manufacturer, and as indicated without interrupting operation of other system, equipment, components.

3.4 DRAINS

- .1 Install piping with grade in direction of flow except as indicated.
- .2 Install drain valve at low points in piping systems, at all coil connections, heat exchangers, at equipment and at section isolating valves.
- .3 Pipe each drain valve discharge separately to above floor drain.
 - .1 Discharge to be visible.

- .4 Drain valves: NPS 3/4 gate or globe valves unless indicated otherwise, with hose end male thread, cap and chain.

3.5 AIR VENTS

- .1 Install manual air vents at high points in piping systems.
- .2 Install isolating valve at each automatic air vent.
- .3 Install drain piping to approved location and terminate where discharge is visible.

3.6 DIELECTRIC COUPLINGS

- .1 General: compatible with system, to suit pressure rating of system.
- .2 Locations: where dissimilar metals are joined.
- .3 NPS 2 and under: isolating unions or bronze valves.

3.7 PIPEWORK INSTALLATION

- .1 Screwed fittings jointed with Teflon tape.
- .2 Protect openings against entry of foreign material.
- .3 Install to isolate equipment and allow removal without interrupting operation of other equipment or systems.
- .4 Assemble piping using fittings manufactured to ANSI standards.
- .5 Saddle type branch fittings may be used on mains if branch line is no larger than half size of main.
 - .1 Hole saw (or drill) and ream main to maintain full inside diameter of branch line prior to welding saddle.
- .6 Install exposed piping, equipment, rectangular cleanouts and similar items parallel or perpendicular to building lines.
- .7 Install concealed pipework to minimize furring space, maximize headroom, conserve space. All work to be concealed shall be inspected, tested and insulated as applicable prior to closing in or covering.
- .8 Slope piping, except where indicated, in direction of flow for positive drainage and venting.
- .9 Install, except where indicated, to permit separate thermal insulation of each pipe.

- .10 Group piping wherever possible and as indicated.
- .11 Ream pipes, remove scale and other foreign material before assembly.
- .12 Use eccentric reducers at pipe size changes to ensure positive drainage and venting.
- .13 Valves:
 - .1 Install in accessible locations.
 - .2 Remove interior parts before soldering.
 - .3 Install with stems above horizontal position unless indicated.
 - .4 Valves accessible for maintenance without removing adjacent piping.
 - .5 Install globe valves in bypass around control valves.
 - .6 Use gate or ball valves at branch take-offs for isolating purposes except where specified.
 - .7 Install butterfly valves on chilled water and related condenser water systems.
 - .8 Install butterfly valves between weld neck flanges to ensure full compression of liner.
 - .9 Install plug cocks or ball valves for glycol service.
- .14 See Section 23 07 15 - Thermal Insulation for Piping and Equipment for Pipe Insulation.

3.8 INSTALLATION OF ABOVE-GROUND PIPEWORK

- .1 Off set pipe around columns, beams, ducts and other obstructions where required.
- .2 Conceal piping in partitions and pipe spaces in finished areas. Where groups of pipes are to be installed in such spaces, use even spacing and neat arrangement. Where these systems are valved, arrange valves either in equally spaced increments or in straight rows, located for easy access.
- .3 Where piping is to remain exposed, neatly group with other piping in such a manner that no interference between piping and equipment occurs, and with as few crossovers and offsets as possible.
- .4 Locate large diameter piping farthest from entrance in pipe spaces where entry of maintenance personnel is intended.
- .5 Establish the location of each access door before installing piping. Install access doors where valves, gauges, indicators and adjustable or maintenance items are to be concealed.
- .6 Where it will facilitate maintenance work, offset and arrange piping close to wall.

- .7 Provide for thermal expansion and contraction of Domestic Hot and Recirculation pipework. Pipe anchors, where required, shall be of design suitable to restrain movement of pipe in all directions. Do not use anchors which are designed to resist axial forces only.
- .8 Take special care when selecting location for pipe anchors to avoid the introduction of undue reaction forces and operating weights into the structure of the building, into flanges of pumps and other equipment, and to avoid excessive pipe stresses.
- .9 Make proper allowance for thermal expansion and contraction. Install piping and equipment in such a manner that the strain and weight do not come upon cast connections, fittings or apparatus.
- .10 Provide domestic water and waste piping connections to apparatus and equipment where required.
- .11 Install water and waste piping connections, and controls supplied with equipment, in strict accordance with shop drawings and equipment supplier's instructions.
- .12 Valves, strainers, etc., at pumps and other equipment are to be line size and not reduced pipe sizes.

3.9 INSTALLATION OF BURIED PIPEWORK

- .1 Lay pipe lines straight and in alignment with building elements, as indicated on the drawings, on 100-150 mm of compacted sand and backfill with 100-150 mm of compacted sand.
- .2 Provide plumbing cleanouts in accordance with the National Plumbing Code of Canada. Establish locations for cleanouts prior to installation using mechanical and architectural layout drawings as a guide, such that final locations are acceptable to the Departmental Representative.
- .3 Accurately record the exact location of all buried pipework on the "Record" drawings.

3.10 SLEEVES

- .1 General: install where pipes pass through masonry, concrete structures, fire rated assemblies, and as indicated. Coordinate and provide supervision during concrete pouring operation.
- .2 Material: schedule 40 black steel pipe.
- .3 Construction: use annular fins continuously welded at mid-point at foundation walls and where sleeves extend above finished floors.

- .4 Sizes: 6 mm minimum clearance between sleeve and uninsulated pipe or between sleeve and insulation.
- .5 Installation:
 - .1 Concrete, masonry walls, concrete floors on grade: terminate flush with finished surface.
 - .2 Other floors: terminate 25 mm above finished floor.
 - .3 Before installation, paint exposed exterior surfaces with heavy application of zinc-rich paint.
- .6 Sealing:
 - .1 Foundation walls: fire retardant, waterproof non-hardening mastic.
 - .2 Elsewhere:
 - .1 Provide space for firestopping.
 - .2 Maintain fire rating integrity.
 - .3 Sleeves installed for future use: fill with lime plaster or other easily removable filler.
 - .4 Ensure no contact between copper pipe or tube and sleeve.

3.11 ESCUTCHEONS

- .1 Install on pipes passing through walls, partitions, floors, and ceilings in finished areas.
- .2 Construction: one piece type with set screws.
 - .1 Chrome or nickel plated brass or type 302 stainless steel.
- .3 Sizes: outside diameter to cover opening or sleeve.
 - .1 Inside diameter to fit around pipe or outside of insulation if so provided.

3.12 PREPARATION FOR FIRE STOPPING

- .1 Install firestopping within annular space between pipes, ducts, insulation and adjacent fire separation in accordance with Section 07 84 00 - Fire Stopping.
- .2 Uninsulated unheated pipes not subject to movement: no special preparation.
- .3 Uninsulated heated pipes subject to movement: wrap with non-combustible smooth material to permit pipe movement without damaging fire stopping material or installation.
- .4 Insulated pipes and ducts: ensure integrity of insulation and vapour barriers.

3.13 PRESSURE TESTING OF EQUIPMENT AND PIPEWORK

- .1 Advise Departmental Representative 48 hours minimum prior to performance of pressure tests.

- .2 Pipework: test as specified in relevant sections of heating, ventilating and air conditioning work, plumbing work, fire protection work.
- .3 Maintain specified test pressure without loss for 4 hours minimum unless specified for longer period of time in relevant mechanical sections.
- .4 Prior to tests, isolate equipment and other parts which are not designed to withstand test pressure or media.
- .5 Conduct tests in presence of Departmental Representative.
- .6 Pay costs for repairs or replacement, retesting, and making good. Departmental Representative to determine whether repair or replacement is appropriate.
- .7 Insulate or conceal work only after approval and certification of tests by Departmental Representative.

3.14 EXISTING SYSTEMS

- .1 Connect into existing piping systems at times approved by Departmental Representative.
- .2 Request written approval by Departmental Representative 10 days minimum, prior to commencement of work.
- .3 Be responsible for damage to existing plant by this work.

3.15 CLEANING

- .1 Clean in accordance with Section 01 74 11 - Cleaning.
 - .1 Remove surplus materials, excess materials, rubbish, tools and equipment.
- .2 Waste Management: separate waste materials for reuse and recycling in accordance with Section 01 74 21 - Construction/Demolition Waste Management and Disposal.

PART 1 GENERAL1.1 RELATED SECTIONS

- .1 Section 21 05 01 - Common Work Results for Mechanical.
- .2 Section 23 34 00 - HVAC Fans.
- .3 Section 23 74 00 - Packaged Outdoor HVAC Equipment.

1.2 REFERENCES

- .1 American National Standards Institute (ANSI)/American Society of Heating, Refrigeration and Air-Conditioning Engineers (ASHRAE)
 - .1 ANSI/ASHRAE 90.1-2010 (SI), Energy Standard for Buildings Except Low-Rise Residential Buildings (ANSI/ASHRAE/IES), Errata (January 18, 2013)/Addenda a thru ds/IC 90.1-2010-02 to 14/90.1-2010-15 to 16.
- .2 Electrical Equipment Manufacturers' Association Council (EEMAC)
- .3 Health Canada/Workplace Hazardous Materials Information System (WHMIS)
 - .1 Material Safety Data Sheets (MSDS).
- .4 National Electrical Manufacturers' Association (NEMA)
 - .1 NEMA MG 1-2011, Motors and Generators.

1.3 SUBMITTALS

- .1 Submittals: in accordance with Section 01 33 00 - Submittal Procedures.
- .2 Shop drawings:
 - .1 Submit manufacturer's printed product literature, specifications and datasheet in accordance with Section 01 33 00 - Submittal Procedures. Include product characteristics, performance criteria, and limitations.
- .3 Quality Control: in accordance with Section 01 45 00 - Quality Control.
 - .1 Certificates: submit certificates signed by manufacturer certifying that materials comply with specified performance characteristics and physical properties.
 - .2 Instructions: submit manufacturer's installation instructions.
- .4 Closeout Submittals:
 - .1 Provide maintenance data for motors, drives and guards for incorporation into manual specified in Section 01 78 00 - Closeout Submittals.

1.4 QUALITY ASSURANCE

- .1 Health and Safety Requirements: do construction occupational health and safety in accordance with Section 01 35 29.06 - Health and Safety Requirements.

1.5 DELIVERY, STORAGE, AND HANDLING

- .1 Packing, shipping, handling and unloading: Deliver, store and handle in accordance with Section 01 61 00 - Common Product Requirements.
- .2 Deliver, store and handle materials in accordance with manufacturer's written instructions.

1.6 WASTE MANAGEMENT AND DISPOSAL

- .1 Construction/Demolition Waste Management and Disposal: separate waste materials for reuse and recycling in accordance with Section 01 74 21 - Construction/Demolition Waste Management and Disposal.

PART 2 PRODUCTS

2.1 GENERAL

- .1 Mechanical equipment motors are to be provided by Divisions 21, 22, and 23. Coordinate power supply and overload requirements with Division 26.
- .2 Motors: high efficiency, in accordance with local Hydro company standards and to ASHRAE 90.1.
- .3 Electric motors supplied as part of specified mechanical equipment shall meet these specifications.

2.2 MOTORS

- .1 Nameplate rating of motors shall not be less than the input brake horsepower rating of the driven equipment when operating at the specified conditions. Motors shall be capable of reaching the rated RPM under normal load conditions within 15 seconds.
- .2 Motors shall operate at 1750 RPM, drip-proof with ball bearings unless otherwise noted.
- .3 Motors supplied to operate with a variable frequency drive shall be rated for inverter duty as per NEMA MG 1.

- .4 Provide motors for mechanical equipment as specified.
- .5 Motors under 373 W: speed as indicated, continuous duty, built-in overload protection, resilient mount, single phase, 120 V, unless otherwise specified or indicated.
- .6 Motors 560 W and larger: EEMAC Class B, squirrel cage induction, speed as indicated, continuous duty, drip proof, ball bearing, maximum temperature rise 40°C, 3 phase, 600 V, unless otherwise indicated.

2.3 TEMPORARY MOTORS

- .1 If delivery of specified motor will delay completion or commissioning work, install motor approved by Departmental Representative for temporary use. Work will only be accepted when specified motor is installed.

2.4 BELT DRIVES

- .1 Unless specified otherwise, belt-driven equipment shall be equipped with V-belt drives designed for at least 130% of motor nameplate HP (kW), and in accordance with manufacturer's recommendations for type of service intended. Belt drives to be at least 95% efficient, and properly balanced and aligned.
- .2 Provide matched set of belts for multiple assemblies. Select belt to suit starting torque of drive. Single belt drives may be used only for motors 1.5 kW and smaller.
- .3 Provide motor sheaves for one and two belt drives of the variable pitch type, with key adjustment. For drives with three or more belts, the sheaves shall be fixed type. Allow for changing of sheaves in the field as necessary to obtain correct design characteristics and proper position of belts within sheave.
- .4 Fit reinforced belts in sheave matched to drive.
- .5 Use cast iron or steel sheaves secured to shafts with removable keys unless otherwise indicated.
- .6 For motors under 7.5 kW: standard adjustable pitch drive sheaves, having plus or minus 10% range. Use mid-position of range for specified r/min.
- .7 For motors 7.5 kW and over: sheave with split tapered bushing and keyway having fixed pitch unless specifically required for item concerned. Provide sheave of correct size to suit balancing.
- .8 Correct size of sheave and belt position to be determined during commissioning.
- .9 Minimum drive rating: 1.5 times nameplate rating on motor. Keep overhung loads within manufacturer's design requirements on prime mover shafts.

- .10 Motor slide rail adjustment plates to allow for centre line adjustment. Fan casings to be adequately braced to support motor and slide rails without deflecting.

2.5 DRIVE GUARDS

- .1 Provide guards to enclose all exposed drives.
- .2 Guards to be designed to permit movement of motors through full distance to allow for belt tension adjustment.
- .3 Guards for belt drives:
 - .1 Expanded metal screen welded to steel frame.
 - .2 Minimum 1.2 mm thick sheet metal tops and bottoms.
 - .3 38 mm dia holes on both shaft centres for insertion of tachometer.
 - .4 Removable for servicing.
- .4 Provide means to permit lubrication and use of test instruments with guards in place.
- .5 Install belt guards to allow movement of motors for adjusting belt tension.
- .6 Guard for flexible coupling:
 - .1 "U" shaped, minimum 1.6 mm thick galvanized mild steel.
 - .2 Securely fasten in place.
 - .3 Removable for servicing.
- .7 Unprotected fan inlets or outlets:
 - .1 Wire or expanded metal screen, galvanized, 19 mm mesh.
 - .2 Net free area of guard: not less than 80% of fan openings.
 - .3 Securely fasten in place.
 - .4 Removable for servicing.

2.6 BEARINGS

- .1 Provide type of bearings as specified for individual items of equipment.
- .2 Provide oil sumps with sight glass in accessible locations for oil-lubricated bearings.
- .3 Provide extended nipples for grease lubricated bearings, if not already accessible.

PART 3 EXECUTION**3.1 MANUFACTURER'S INSTRUCTIONS**

- .1 Compliance: comply with manufacturer's written recommendations or specifications, including product technical bulletins, handling, storage and installation instructions, and datasheet.

3.2 INSTALLATION

- .1 Supply and install motors for all motor driven equipment.
- .2 Fasten securely in place.
- .3 Make removable for servicing, easily returned into, and positively in position.

3.3 FIELD QUALITY CONTROL

- .1 Manufacturer's Field Services:
 - .1 Have manufacturer of products, supplied under this Section, review Work involved in the handling, installation/application, protection and cleaning, of its products and submit written reports, in acceptable format, to verify compliance of Work.
 - .2 Manufacturer's Field Services: provide manufacturer's field services consisting of product use recommendations and periodic site visits for inspection of product installation in accordance with manufacturer's instructions.
 - .3 Include for the services of motors manufacturer's factory certified service technician in start-up and repair services to assist in start-up, performance verification, and Commissioning of the systems on the job site.
 - .4 Manufacturer's representative is to be on site with Departmental Representative for Substantial Performance review, and as required by the Contractor for Commissioning.
 - .5 Include site visits by manufacturer's representative to start-up and ensure trouble free and specified operation of the systems.
 - .6 Obtain reports, within 3 days of review, and submit, immediately, to Departmental Representative.
- .2 Performance Verification (PV):
 - .1 Verification for proper operation and reliability of the motors.
 - .2 Operate equipment and verify that performance criteria specified have been achieved.
 - .3 Inspect and test all sub-assemblies for conformance to Vendor's engineering and quality assurance specifications.

- .4 Rejected Work:
 - .1 Remove defective Work, whether result of poor workmanship, use of defective products or damage and whether incorporated in Work or not, which has been rejected by Departmental Representative as failing to conform to Technical Documents. Replace or re-execute in accordance with Technical Documents.
 - .2 Make good other Contractor's work damaged by such removals or replacements promptly.
- .3 Start-up:
 - .1 Verify that job site conditions for installation meet factory recommended and code required conditions for motors installation prior to start-up. These shall include as a minimum:
 - .1 Installation per the manufacturer's recommendations.

3.4 CLEANING

- .1 Proceed in accordance with Section 01 74 11 - Cleaning.
- .2 Upon completion and verification of performance of installation, remove surplus materials, excess materials, rubbish, tools and equipment.

PART 1 GENERAL1.1 RELATED SECTIONS

- .1 Section 21 05 01 - Common Work Results for Mechanical.
- .2 Section 23 05 53.01 - Mechanical Identification.

1.2 REFERENCES

- .1 American Society of Mechanical Engineers (ASME).
 - .1 ASME B40.100-2005, Pressure Gauges and Gauge Attachments.
 - .2 ASME B40.200-2008, Thermometers, Direct Reading and Remote Reading.
- .2 Canadian General Standards Board (CGSB).
 - .1 CAN/CGSB-14.4-M88, Thermometers, Liquid-in-Glass, Self Indicating, Commercial/Industrial Type.
 - .2 CAN/CGSB-14.5-M88, Thermometers, Bimetallic, Self-Indicating, Commercial/Industrial Type.

1.3 SUBMITTALS

- .1 Submittals in accordance with Section 01 33 00 - Submittal Procedures.
- .2 Submit shop drawings for following items:
 - .1 Thermometers.
 - .2 Pressure gauges.
 - .3 Stop cocks.
 - .4 Wells.

1.4 HEALTH AND SAFETY

- .1 Do construction occupational health and safety in accordance with Section 01 35 29.06 - Health and Safety Requirements.

1.5 WASTE MANAGEMENT AND DISPOSAL

- .1 Separate waste materials for reuse and recycling in accordance with Section 01 74 21 - Construction/Demolition Waste Management and Disposal.

- .2 Collect, separate and place in designated containers for reuse and recycling paper, plastic, polystyrene and corrugated cardboard packaging, Steel, Metal, Plastic in accordance with Waste Reduction Workplan.
- .3 Fold up metal banding, flatten and place in designated area for recycling.
- .4 Place materials defined as hazardous or toxic waste in designated containers.
- .5 Ensure emptied containers are sealed, labelled and stored safely for disposal away from children.

PART 2 PRODUCTS

2.1 GENERAL

- .1 Design point to be at midpoint of scale or range.
- .2 Scale ranges of thermometers:

Service	Range	Increments
Domestic Hot Water	0 to 115 °C	1 °C

2.2 DIRECT READING THERMOMETERS

- .1 Industrial, variable angle type, liquid filled, 125 mm scale length: to CAN/CGSB 14.4, ASME B40.200. Die cast aluminum with metallic blue finish, and clear acrylic window.

2.3 THERMOMETER WELLS

- .1 Copper pipe: copper or bronze.
- .2 Steel pipe: brass or stainless steel.

PART 3 EXECUTION

3.1 GENERAL

- .1 Install so they can be easily read from floor. If this cannot be accomplished, install remote reading units.
- .2 Install between equipment and first fitting or valve.
- .3 Locate thermostats, sensing elements, etc. to allow for easy maintenance.

- .4 Follow manufacturers' recommendations concerning distances from pipe elbows, etc.
- .5 Provide all wells, connections, etc., in pipework, ductwork, etc., to allow for the installation of thermometers, gauges and control components.

3.2 THERMOMETERS

- .1 Install in wells on piping. Provide heat conductive material inside well.
- .2 Install thermometers in the following locations:
 - .1 Domestic hot water supply, recirculation and cold water feed.
- .3 Install wells for balancing purposes.
- .4 Use extensions where thermometers are installed through insulation.

3.3 NAMEPLATES

- .1 Install engraved lamicaid nameplates as specified in Section 23 05 53.01 - Mechanical Identification, identifying medium.

PART 1 GENERAL1.1 RELATED SECTIONS

- .1 Section 21 05 01 - Common Work Results for Mechanical.
- .2 Section 23 05 05 - Installation of Pipework.

1.2 REFERENCES

- .1 American National Standards Institute (ANSI)/American Society of Mechanical Engineers (ASME)
 - .1 ANSI/ASME B1.20.1-1983 (R2006), Pipe Threads, General Purpose.
 - .2 ANSI/ASME B16.18-2012, Cast Copper Alloy Solder Joint Pressure Fittings.
- .2 American Society for Testing and Materials International (ASTM)
 - .1 ASTM A276-13, Standard Specification for Stainless Steel Bars and Shapes.
 - .2 ASTM B62-09, Standard Specification for Composition Bronze or Ounce Metal Castings.
 - .3 ASTM B283/B283M-12, Standard Specification for Copper and Copper-Alloy Die Forgings (Hot-Pressed).
 - .4 ASTM B505/B505M-12a, Standard Specification for Copper Alloy Continuous Castings.
- .3 Manufacturers Standardization Society of the Valve and Fittings Industry, Inc. (MSS)
 - .1 MSS SP-25-2008, Standard Marking System for Valves, Fittings, Flanges and Unions.
 - .2 MSS SP-80-2013, Bronze Gate Globe, Angle and Check Valves.
 - .3 MSS SP-110-2010, Ball Valves, Threaded, Socket-Welding, Solder Joint, Grooved and Flared Ends, Includes Errata.

1.3 SUBMITTALS

- .1 Submittals in accordance with Section 01 33 00 - Submittal Procedures.
- .2 Shop drawings:
 - .1 Submit shop drawings and product data in accordance with Section 01 33 00 - Submittal Procedures.
 - .2 Submit data for valves specified in this Section.

- .3 Closeout Submittals:
 - .1 Submit maintenance data for incorporation into manual specified in Section 01 78 00 - Closeout Submittals.

1.4 QUALITY ASSURANCE

- .1 Health and Safety:
 - .1 Do construction occupational health and safety in accordance with Section 01 35 29.06 - Health and Safety Requirements.

1.5 DELIVERY, STORAGE AND HANDLING

- .1 Waste Management and Disposal:
 - .1 Separate and recycle waste materials in accordance with Section 01 74 21 - Construction/Demolition Waste Management and Disposal.
- .2 Collect and separate for disposal paper, plastic, polystyrene and corrugated cardboard packaging material in appropriate on-site bins for recycling in accordance with Waste Reduction Workplan.

PART 2 PRODUCTS

2.1 MATERIALS

- .1 Valves:
 - .1 Except for specialty valves, to be single manufacturer.
 - .2 All products to have CRN registration numbers.
- .2 End Connections:
 - .1 Connection into adjacent piping/tubing:
 - .1 Steel pipe systems: screwed ends to ANSI/ASME B1.20.1.
 - .2 Copper tube systems: solder ends to ANSI/ASME B16.18.
- .3 Lockshield Keys:
 - .1 Where lockshield valves are specified, provide 10 keys of each size: malleable iron cadmium plated.
- .4 Gate Valves:
 - .1 Requirements common to gate valves, unless specified otherwise:
 - .1 Standard specification: MSS SP-80.
 - .2 Bonnet: union with hexagonal shoulders.
 - .3 Connections: screwed with hexagonal shoulders.
 - .4 Inspection and pressure testing: to MSS SP-80. Tests to be hydrostatic.
 - .5 Packing: non-asbestos.
 - .6 Handwheel: non-ferrous.

- .7 Handwheel Nut: bronze to ASTM B62.
 - .2 NPS 2 and under, rising stem, solid wedge disc, Class 125:
 - .1 Body: with long disc guides, screwed bonnet.
 - .2 Operator: Handwheel.
- .5 Ball Valves:
 - .1 NPS 2 and under:
 - .1 Body and cap: cast high tensile bronze to ASTM B62.
 - .2 Pressure rating: Class 125 2760-kPa CWP, 860 kPa steam.
 - .3 Connections: screwed ends to ANSI/ASME B1.20.1 and with hexagonal shoulders.
 - .4 Stem: tamperproof ball drive.
 - .5 Stem packing nut: external to body.
 - .6 Ball and seat: replaceable stainless steel solid ball and Teflon seats.
 - .7 Stem seal: TFE with external packing nut.
 - .8 Operator: removable lever handle.

PART 3 EXECUTION

3.1 INSTALLATION

- .1 Install rising stem valves in upright position with stem above horizontal.
- .2 Remove internal parts before soldering.
- .3 Install valves with unions at each piece of equipment arranged to allow servicing, maintenance, and equipment removal.

PART 1 GENERAL**1.1 RELATED SECTIONS**

- .1 Section 21 05 01 - Common Work Results for Mechanical.
- .2 Section 03 30 00 - Cast-in-Place Concrete.
- .3 Section 23 05 48 - Vibration and Seismic Controls for HVAC Piping and Equipment.

1.2 REFERENCES

- .1 American Society of Mechanical Engineers (ASME)
 - .1 ASME B31.1-2012, Power Piping.
- .2 American Society for Testing and Materials International (ASTM)
 - .1 ASTM A125-96(2007), Standard Specification for Steel Springs, Helical, Heat-Treated.
 - .2 ASTM A307-12, Standard Specification for Carbon Steel Bolts, Studs, and Threaded Rod 60,000 PSI Tensile Strength.
 - .3 ASTM A563-07a, Standard Specification for Carbon and Alloy Steel Nuts.
- .3 Factory Mutual (FM)
- .4 Health Canada/Workplace Hazardous Materials Information System (WHMIS)
 - .1 Material Safety Data Sheets (MSDS).
- .5 Manufacturer's Standardization Society of the Valves and Fittings Industry (MSS)
 - .1 MSS SP-58-2009, Pipe Hangers and Supports - Materials, Design, Manufacture, Selection, Application, and Installation.
- .6 National Building Code of Canada (NBC) - 2010.
- .7 Underwriter's Laboratories of Canada (ULC)

1.3 SYSTEM DESCRIPTION

- .1 Design Requirements:
 - .1 Construct pipe hanger and support to manufacturer's recommendations utilizing manufacturer's regular production components, parts and assemblies.
 - .2 Base maximum load ratings on allowable stresses prescribed by ASME B31.1 or MSS SP-58.
 - .3 Ensure that supports, guides, anchors do not transmit excessive quantities of heat to building structure.

- .4 Design hangers and supports to support systems under conditions of operation, allow free expansion and contraction, prevent excessive stresses from being introduced into pipework or connected equipment.
- .5 Provide for vertical adjustments after erection and during commissioning. Amount of adjustment in accordance with MSS SP-58.
- .6 Must be designed to withstand seismic forces in region being installed in accordance with NBC and in accordance with 23 05 48 - Vibration and Seismic Controls for HVAC Piping and Equipment.

1.4 SUBMITTALS

- .1 Provide submittals in accordance with Section 01 33 00 - Submittal Procedures.
- .2 Submit shop drawings and product data for following items:
 - .1 Bases, hangers and supports.
 - .2 Connections to equipment and structure.
 - .3 Structural assemblies.
- .3 Quality assurance submittals: submit following in accordance with Section 01 33 00 - Submittal Procedures.
 - .1 Certificates: submit certificates signed by manufacturer certifying that materials comply with specified performance characteristics and physical properties.
 - .2 Instructions: submit manufacturer's installation instructions.
 - .1 Departmental Representative will make available 1 copy of systems supplier's installation instructions.
- .4 Closeout Submittals:
 - .1 Provide maintenance data for incorporation into manual specified in Section 01 78 00 - Closeout Submittals.
- .5 Shop drawings from Contractor's Seismic Engineer certifying compliance to seismic requirements.

1.5 QUALITY ASSURANCE

- .1 Health and Safety:
 - .1 Do construction occupational health and safety in accordance with Section 01 35 29.06 - Health and Safety Requirements.

1.6 DELIVERY, STORAGE AND HANDLING

- .1 Packing, shipping, handling and unloading:
 - .1 Deliver, store and handle in accordance with Section 01 61 00 - Common Product Requirements.
 - .2 Deliver, store and handle materials in accordance with manufacturer's written instructions.

- .2 Waste Management and Disposal:
 - .1 Construction/Demolition Waste Management and Disposal: separate waste materials for reuse and recycling in accordance with Section 01 74 21 - Construction/Demolition Waste Management and Disposal.

PART 2 PRODUCTS

2.1 GENERAL

- .1 Fabricate hangers, supports and sway braces in accordance with ASME B31.1 and MSS SP-58.
- .2 Use components for intended design purpose only. Do not use for rigging or erection purposes.
- .3 Concrete bases, pits, curbs, etc. associated with mechanical equipment are not part of Divisions 21 and 22, unless indicated otherwise.
- .4 Provide equipment shop drawings, templates, dimensions and other information to enable Division 03 to form suitable bases, pits, curbs, etc. Layout of bases, pits, curbs, etc., to be provided by Divisions 21 and 22.

2.2 PIPE HANGERS

- .1 Finishes:
 - .1 Pipe hangers and supports: galvanized after manufacture.
 - .2 Use hot dipped galvanizing process.
 - .3 Ensure steel hangers in contact with copper piping are epoxy coated.
- .2 Upper attachment to structural steel: suspension from lower flange of I-Beam:
 - .1 Cold piping NPS 2 maximum: malleable iron C-clamp with hardened steel cup point setscrew, locknut and carbon steel retaining clip.
 - .1 Rod: 13 mm FM approved.
 - .2 Cold piping NPS 2 1/2 or greater, hot piping: malleable iron beam clamp, eye rod, jaws and extension with carbon steel retaining clip, tie rod, nuts and washers, UL listed to MSS SP-58.
- .3 Upper attachment to structural steel: suspension from upper flange of I-Beam:
 - .1 Cold piping NPS 2 maximum: ductile iron top of beam C-clamp with hardened steel cup point setscrew, locknut and carbon steel retaining clip, UL listed to MSS SP-58.
 - .2 Cold piping NPS 2 1/2 or greater, hot piping: malleable iron top of beam jaw clamp with hooked rod, spring washer, plain washer and nut UL listed.
- .4 Hanger rods: threaded rod material to MSS SP-58:
 - .1 Ensure that hanger rods are subject to tensile loading only.

- .2 Provide linkages where lateral or axial movement of pipework is anticipated.
- .3 Do not use 22 mm or 28 mm rod.
- .5 Pipe attachments: material to MSS SP-58:
 - .1 Attachments for steel piping: carbon steel galvanized.
 - .2 Attachments for copper piping: copper plated black steel.
 - .3 Use insulation shields for hot pipework.
 - .4 Oversize pipe hangers and supports.
- .6 Adjustable clevis: material to MSS SP-58 and UL listed, clevis bolt with nipple spacer and vertical adjustment nuts above and below clevis.
 - .1 Ensure "U" has hole in bottom for rivetting to insulation shields.
- .7 U bolts: carbon steel to MSS SP-58 with 2 nuts at each end to ASTM A563.
 - .1 Finishes for steel pipework: galvanized.
 - .2 Finishes for copper or brass pipework: galvanized, with formed portion plastic coated.

2.3 GRADE SUPPORTS

- .1 2 NPS pipe, and smaller.
 - .1 250 mm x 400 mm x 75 mm high density polypropylene base.
 - .2 Hot dip galvanized strut c/w clevis hanger, rods, nuts, and washers.
- .2 2 ½ - 8 NPS pipe size.
 - .1 250 mm x 400 mm x 75 mm high density polypropylene base.
 - .2 Hot dip galvanized strut c/w clevis hanger, rods, nuts, and washers.
 - .3 40 mm frame assembly c/w gusset plates for rigidity.

2.4 RISER CLAMPS

- .1 Steel or cast iron pipe: galvanized carbon steel to MSS SP-58, type 42, UL listed.
- .2 Copper pipe: carbon steel copper plated to MSS SP-58, type 42.
- .3 Bolts: to ASTM A307.
- .4 Nuts: to ASTM A563.

2.5 INSULATION PROTECTION SHIELDS

- .1 Insulated cold piping:
 - .1 64 kg/m³ density insulation plus insulation protection shield to: MSS SP-58, galvanized sheet carbon steel. Length designed for maximum 3 m span.

- .2 Insulated hot piping:
 - .1 Curved plate 300 mm long, with edges turned up, welded-in centre plate for pipe sizes NPS 12 and over, carbon steel to comply with MSS SP-58.

2.6 CONSTANT SUPPORT SPRING HANGERS

- .1 Springs: alloy steel to ASTM A125, shot peened, magnetic particle inspected, with +/-5% spring rate tolerance, tested for free height, spring rate, loaded height and provided with Certified Mill Test Report (CMTR).
- .2 Load adjustability: 10% minimum adjustability each side of calibrated load. Adjustment without special tools. Adjustments not to affect travel capabilities.
- .3 Provide upper and lower factory set travel stops.
- .4 Provide load adjustment scale for field adjustments.
- .5 Total travel to be actual travel +20%. Difference between total travel and actual travel 25 mm minimum.
- .6 Individually calibrated scales on each side of support calibrated prior to shipment, complete with calibration record.

2.7 VARIABLE SUPPORT SPRING HANGERS

- .1 Vertical movement: 13 mm minimum, 50 mm maximum, use single spring pre-compressed variable spring hangers.
- .2 Vertical movement greater than 50 mm: use double spring pre-compressed variable spring hanger with 2 springs in series in single casing.
- .3 Variable spring hanger complete with factory calibrated travel stops. Provide certificate of calibration for each hanger.
- .4 Steel alloy springs: to ASTM A125, shot peened, magnetic particle inspected, with +/-5% spring rate tolerance, tested for free height, spring rate, loaded height and provided with CMTR.

2.8 EQUIPMENT SUPPORTS

- .1 Fabricate equipment supports not provided by equipment manufacturer from structural grade steel. Submit calculations with shop drawings.

2.9 EQUIPMENT ANCHOR BOLTS AND TEMPLATES

- .1 Provide templates to ensure accurate location of anchor bolts.

2.10 OTHER EQUIPMENT SUPPORTS

- .1 Fabricate equipment supports from structural grade steel.
- .2 Submit structural calculations with shop drawings.

PART 3 EXECUTION3.1 MANUFACTURER'S INSTRUCTIONS

- .1 Compliance: comply with manufacturer's written recommendations or specifications, including product technical bulletins, handling, storage and installation instructions, and datasheet.

3.2 INSTALLATION

- .1 Install in accordance with:
 - .1 Manufacturer's instructions and recommendations.
 - .2 Ensure that steel hangers do not come in contact with copper piping.
- .2 Vibration Control Devices:
 - .1 Install on piping systems at pumps, boilers, chillers, fluid cooler, and as indicated in accordance with Section 23 05 48 - Vibration and Seismic Controls for HVAC Piping and Equipment.
- .3 Clamps on riser piping:
 - .1 Support independent of connected horizontal pipework using riser clamps and riser clamp lugs welded to riser.
 - .2 Bolt-tightening torques to industry standards.
 - .3 Steel pipes: install below coupling or shear lugs welded to pipe.
 - .4 Cast iron pipes: install below joint.
- .4 Provide supplementary structural steelwork where structural bearings do not exist or where concrete inserts are not in correct locations.
- .5 Use approved constant support type hangers where:
 - .1 Vertical movement of pipework is 13 mm or more.
 - .2 Transfer of load to adjacent hangers or connected equipment is not permitted.
- .6 Use variable support spring hangers where:
 - .1 Transfer of load to adjacent piping or to connected equipment is not critical.
 - .2 Variation in supporting effect does not exceed 25% of total load.

3.3 HANGER SPACING

- .1 Plumbing piping: to Provincial Code.
- .2 Copper piping: up to NPS 1/2: every 1.5 m.
- .3 Other piping: in accordance with table below, but not less than one hanger at joints.
- .4 Within 300 mm of each elbow.

Maximum Pipe Size : NPS	Maximum Spacing Steel	Maximum Spacing Copper
up to 1-1/4	2.1 m	1.8 m
1-1/2	2.7 m	2.4 m
2	3.0 m	2.4 m
2-1/2	3.6 m	3.0 m
3	3.6 m	3.0 m
3-1/2	3.7 m	3.3 m
4	3.7 m	3.6 m
5	4.3 m	
6	4.3 m	
8	4.3 m	
10	4.9 m	
12	4.9 m	

3.4 HANGER INSTALLATION

- .1 Install hanger so that rod is vertical under operating conditions.
- .2 Adjust hangers to equalize load.
- .3 Support from structural members. Where structural bearing does not exist or inserts are not in suitable locations, provide supplementary structural steel members.

3.5 HORIZONTAL MOVEMENT

- .1 Angularity of rod hanger resulting from horizontal movement of pipework from cold to hot position not to exceed 4 degrees from vertical.
- .2 Where horizontal pipe movement is less than 13 mm, offset pipe hanger and support so that rod hanger is vertical in the hot position.

3.6 FINAL ADJUSTMENT

- .1 Adjust hangers and supports:
 - .1 Ensure that rod is vertical under operating conditions.
 - .2 Equalize loads.

- .2 Adjustable clevis:
 - .1 Tighten hanger load nut securely to ensure proper hanger performance.
 - .2 Tighten upper nut after adjustment.
- .3 C-clamps:
 - .1 Follow manufacturer's recommended written instructions and torque values when tightening C-clamps to bottom flange of beam.
- .4 Beam clamps:
 - .1 Hammer jaw firmly against underside of beam.

3.7 FIELD QUALITY CONTROL

- .1 Site Tests: conduct following tests in accordance with Section 01 45 00 - Quality Control and submit report as described in PART 1 - SUBMITTALS.
- .2 Manufacturer's Field Services:
 - .1 Obtain written report from manufacturer verifying compliance of Work, in handling, installing, applying, protecting and cleaning of product and submit Manufacturer's Field Reports as described in PART 1 - SUBMITTALS.
 - .2 Provide manufacturer's field services consisting of product use recommendations and periodic site visits for inspection of product installation in accordance with manufacturer's instructions.
 - .3 Schedule site visits, to review Work, as directed in PART 1 - QUALITY ASSURANCE.

PART 1 GENERAL1.1 RELATED SECTIONS

- .1 Section 21 05 01 - Common Work Results for Mechanical.
- .2 Section 23 05 29 - Hangers and Supports for HVAC Piping and Equipment.
- .3 Section 23 05 93 - Testing, Adjusting and Balancing for HVAC.

1.2 REFERENCES

- .1 Health Canada/Workplace Hazardous Materials Information System (WHMIS)
 - .1 Material Safety Data Sheets (MSDS).
- .2 National Building Code of Canada (NBC) - 2010.
- .3 National Fire Protection Association (NFPA)
 - .1 NFPA 13-2013, Standard for the Installation of Sprinkler Systems.

1.3 DEFINITIONS

- .1 Priority Two (P2) Buildings: buildings in which life safety is of paramount concern. It is not necessary that P2 buildings remain operative during or after earthquake activity.
- .2 SRS: acronym for Seismic Restraint System.

1.4 SEISMIC RESTRAINT SYSTEM DESCRIPTION

- .1 SRS fully integrated into, and compatible with:
 - .1 Noise and vibration controls specified in this specification section.
 - .2 Structural, mechanical, electrical design of project.
- .2 Systems, equipment not required to be operational during and after seismic event.
- .3 During seismic event, SRS to prevent systems and equipment from causing personal injury and from moving from normal position.
- .4 Designed by Professional Engineer specializing in design of SRS and registered in the Province of Ontario.
- .5 Refer to architectural drawings for spatial limitations imposed by order picker route.

- .6 SRS to be designed to most stringent requirements of NBC 2010.

1.5 SUBMITTALS

- .1 Submittals: in accordance with Section 01 33 00 - Submittal Procedures.
 - .1 Submit manufacturer's printed product literature, specifications and datasheet in accordance with Section 01 33 00 - Submittal Procedures. Include product characteristics, performance criteria, and limitations.
- .2 Submit shop drawings in accordance with Section 01 33 00 - Submittal Procedures.
 - .1 Provide system shop drawings complete with performance and product data.
 - .2 Provide detailed drawings of seismic control measures for equipment and piping.
- .3 Shop drawings for seismic restraint systems: submit drawings stamped and signed by professional engineer registered or licensed in the Province of Ontario.
- .4 Submit design data including:
 - .1 Full details of design criteria.
 - .2 Design calculations (including restraint loads resulting from seismic forces in accordance with National Building Code, detailed work sheets, tables).
 - .3 Separate shop drawings for each SRS and devices for each system.
 - .4 Identification of location of devices.
 - .5 Schedules of types of SRS equipment and devices.
 - .6 Details of fasteners and attachments to structure, anchorage loadings, attachment methods.
 - .7 Installation procedures and instructions.
- .5 Submit additional copy of shop drawings and product data to Departmental Representative for review of connection points to building structure.
- .6 Closeout Submittals:
 - .1 Provide maintenance data including monitoring requirements for incorporation into manuals specified in Section 01 78 00 - Closeout Submittals.

1.6 QUALITY ASSURANCE

- .1 Health and Safety:
 - .1 Do construction occupational health and safety in accordance with Section 01 35 29.06 - Health and Safety Requirements.

1.7 DELIVERY, STORAGE, AND HANDLING

- .1 Packing, shipping, handling and unloading:
 - .1 Deliver, store and handle in accordance with Section 01 61 00 - Common Product Requirements.

- .2 Deliver, store and handle materials in accordance with manufacturer's written instructions.
- .2 Waste Management and Disposal:
 - .1 Construction/Demolition Waste Management and Disposal: separate waste materials for reuse and recycling in accordance with Section 01 74 21 - Construction/Demolition Waste Management and Disposal.

PART 2 PRODUCTS

2.1 GENERAL

- .1 Size and shape of bases type and performance of vibration isolation as indicated.

2.2 ELASTOMERIC PADS

- .1 Type EP1 - neoprene waffle or ribbed; 9 mm minimum thick; 50 durometer; maximum loading 350 kPa.
- .2 Type EP2 - rubber waffle or ribbed; 9 mm minimum thick; 30 durometer natural rubber; maximum loading 415 kPa.
- .3 Type EP3 - neoprene-steel-neoprene; 9 mm minimum thick neoprene bonded to 1.71 mm steel plate; 50 durometer neoprene, waffle or ribbed; holes sleeved with isolation washers; maximum loading 350 kPa.
- .4 Type EP4 - rubber-steel-rubber; 9 mm minimum thick rubber bonded to 1.71 mm steel plate; 30 durometer natural rubber, waffle or ribbed; holes sleeved with isolation washers; maximum loading 415 kPa.

2.3 ELASTOMERIC MOUNTS

- .1 Type M1 - colour coded; neoprene in shear; maximum durometer of 60; threaded insert and two bolt-down holes; ribbed top and bottom surfaces.

2.4 SPRINGS

- .1 Design stable springs: ratio of lateral to axial stiffness is equal to or greater than 1.2 times ratio of static deflection to working height. Select for 50% travel beyond rated load. Units complete with levelling devices.
- .2 Ratio of height when loaded to diameter of spring between 0.8 to 1.0.
- .3 Cadmium plate for outdoor 100% relative humidity installations.

- .4 Colour code springs.

2.5 SPRING MOUNT

- .1 Zinc or cadmium plated hardware; housings coated with rust resistant paint.
- .2 Type M2 - stable open spring: support on bonded 6 mm minimum thick ribbed neoprene or rubber friction and acoustic pad.
- .3 Type M3 - stable open spring: 6 mm minimum thick ribbed neoprene or rubber friction and acoustic pad, bonded under isolator and on isolator top plate; levelling bolt for rigidly mounting to equipment.
- .4 Type M4 - restrained stable open spring: supported on bonded 6 mm minimum thick ribbed neoprene or rubber friction and acoustic pad; built-in resilient limit stops, removable spacer plates.
- .5 Type M5 - enclosed spring mounts with snubbers for isolation up to 950 kg maximum.

2.6 HANGERS

- .1 Colour coded springs, rust resistant, painted box type hangers. Arrange to permit hanger box or rod to move through a 30 degrees arc without metal to metal contact.
- .2 Type H1 - neoprene - in-shear, moulded with rod isolation bushing which passes through hanger box.
- .3 Type H2 - stable spring, elastomeric washer, cup with moulded isolation bushing which passes through hanger box.
- .4 Type H3 - stable spring, elastomeric element, cup with moulded isolation bushing which passes through hanger box.
- .5 Type H4 - stable spring, elastomeric element with precompression washer and nut with deflection indicator.

2.7 ACOUSTIC BARRIERS FOR ANCHORS AND GUIDES

- .1 Acoustic barriers: between pipe and support, consisting of 25 mm minimum thick heavy duty duck and neoprene isolation material.

2.8 SEISMIC CONTROL MEASURES

- .1 SRS Manufacturer
 - .1 SRS from one manufacturer regularly engaged in SRS production.

- .2 General
 - .1 SRS to provide gentle and steady cushioning action and avoid high impact loads.
 - .2 SRS to restrain seismic forces in every direction.
 - .3 Fasteners and attachment points to resist same load as seismic restraints.
 - .4 SRS of Piping systems compatible with:
 - .1 Expansion, anchoring and guiding requirements.
 - .2 Equipment vibration isolation and equipment SRS.
 - .5 SRS utilizing cast iron, threaded pipe, other brittle materials not permitted.
 - .6 Seismic control measures not to interfere with integrity of firestopping.
 - .7 Attachments to RC structure:
 - .1 Use high strength mechanical expansion anchors.
 - .2 Drilled or power driven anchors not permitted.
- .3 SRS for Static Equipment, Systems
 - .1 Floor-mounted equipment, systems:
 - .1 Anchor equipment to equipment supports.
 - .2 Anchor equipment supports to structure.
 - .3 Use size of bolts scheduled in approved shop drawings.
 - .2 Suspended equipment, systems:
 - .1 Use one or combination of following methods:
 - .1 Install tight to structure.
 - .2 Cross-brace in every direction.
 - .3 Brace back to structure.
 - .4 Slack cable restraint system.
 - .2 SCS to prevent sway in horizontal plane, "rocking" in vertical plane, sliding and buckling in axial direction.
 - .3 Hanger rods to withstand compressive loading and buckling.
 - .3 Seismic restraints:
 - .1 Cushioning action gentle and steady.
 - .2 Never reach metal-like stiffness.
- .4 SRS for Vibration Isolated Equipment
 - .1 Floor mounted equipment, systems:
 - .1 Use one or combination of following methods:
 - .1 Vibration isolators with built-in snubbers.
 - .2 Vibration isolators and separate snubbers.
 - .3 Built-up snubber system approved by Departmental Representative, consisting of structural elements and elastomeric layer.
 - .2 Incorporate seismic restraints into vibration isolation system to resist complete isolator unloading.
 - .3 SRS not to jeopardize noise and vibration isolation systems. Provide 4-8 mm clearance between seismic restraint snubbers and equipment during normal operation of equipment and systems.
 - .4 Cushioning action: gentle and steady by utilizing elastomeric material or other means in order to avoid high impact loads.

- .2 Suspended equipment, systems:
 - .1 Use one or combination of following methods:
 - .1 Slack cable restraint system.
 - .2 Brace back to structure via vibration isolators and snubbers.
- .5 Piping systems:
 - .1 Piping systems: hangers longer than 300 mm; brace at each hanger.
 - .2 Compatible with requirements for anchoring and guiding of piping systems.
- .6 Bracing methods:
 - .1 Approved by Departmental Representative.
 - .2 Structural angles or channels.
 - .3 Cable restraint system incorporating grommets, shackles and other hardware to ensure alignment of restraints and to avoid bending of cables at connection points. Incorporate neoprene into cable connections to reduce shock loads.
- .7 Slack Cable Restraint System (SCS)
 - .1 Use elastomer materials or similar to avoid high impact loads and provide gentle and steady cushioning action.
 - .2 SCS to prevent sway in horizontal plane, "rocking" in vertical plane, sliding and buckling in axial direction.
 - .3 Hanger rods to withstand compressive loading and buckling.

PART 3 EXECUTION

3.1 MANUFACTURER'S INSTRUCTIONS

- .1 Compliance: comply with manufacturer's written recommendations or specifications, including product technical bulletins, handling, storage and installation instructions, and datasheet.

3.2 INSTALLATION

- .1 Seismic control measures to meet requirements of NBC.
- .2 Install vibration isolation equipment in accordance with manufacturer's instructions and adjust mountings to level equipment.
- .3 Ensure piping, ducting and electrical connections to isolated equipment do not reduce system flexibility and that piping, conduit and ducting passage through walls and floors do not transmit vibrations.
- .4 Unless indicated otherwise, support piping connected to isolated equipment with spring mounts or spring hangers with 25 mm minimum static deflection as follows:
 - .1 Up to NPS 4: first 3 points of support. NPS 5 to NPS 8: first 4 points of support. NPS 10 and Over: first 6 points of support.

- .2 First point of support: static deflection of twice deflection of isolated equipment, but not more than 50 mm.
- .5 Where isolation is bolted to floor use vibration isolation rubber washers.
- .6 Block and shim level bases so that ductwork and piping connections can be made to rigid system at operating level, before isolator adjustment is made. Ensure that there is no physical contact between isolated equipment and building structure.
- .7 Attachment points and fasteners:
 - .1 To withstand same maximum load that seismic restraint is to resist and in every direction.
- .8 Slack Cable Systems (SCS):
 - .1 Connect to suspended equipment so that axial projection of wire passes through centre of gravity of equipment.
 - .2 Use appropriate grommets, shackles, other hardware to ensure alignment of restraints and to avoid bending of cables at connection points.
 - .3 Piping systems: provide transverse SCS at 10 m spacing maximum, longitudinal SCS at 20 m maximum or as limited by anchor/slack cable performance.
 - .4 Small pipes may be rigidly secured to larger pipes for restraint purposes, but not reverse.
 - .5 Orient restraint wires on ceiling hung equipment at approximately 90 degrees to each other (in plan), tie back to structure at maximum of 45 degrees to structure.
 - .6 Adjust restraint cables so that they are not visibly slack but permit vibration isolation system to function normally.
 - .7 Tighten cable to reduce slack to 40 mm under thumb pressure. Cable not to support weight during normal operation.
- .9 Install SRS at least 25 mm from equipment, systems, services.
- .10 Miscellaneous equipment not vibration-isolated:
 - .1 Bolt through house-keeping pad to structure.
- .11 Co-ordinate connections with other disciplines.
- .12 Vertical tanks:
 - .1 Anchor through house-keeping pad to structure.
 - .2 Provide steel bands above centre of gravity.

3.3 FIELD QUALITY CONTROL

- .1 Inspection and Certification:
 - .1 SRS: inspected and certified by Contractor's Seismic Engineer upon completion of installation.
 - .2 Provide written report to Departmental Representative with certificate of compliance.

- .3 Sound and vibration testing professional engineer to take vibration measurement for HVAC systems after start up and TAB of systems to Section 23 05 93 - Testing, Adjusting and Balancing for HVAC.
- .4 Take vibration measurements for equipment listed below.
 - .1 Outdoor HVAC units.
 - .2 General exhaust fans.
- .5 Provide Departmental Representative with notice 24 h in advance of commencement of tests.
- .6 Establish adequacy of equipment isolation and acceptability of noise levels in occupied areas and where appropriate, remedial recommendations (including sound curves).
- .7 Submit complete report of test results including sound curves.
- .8 Commissioning Documentation:
 - .1 Upon completion and acceptance of certification, hand over to Departmental Representative complete set of construction documents, revised to show "as-built" conditions.
- .2 Manufacturer's Field Services:
 - .1 Arrange with manufacturer's representative to review work of this Section and submit written reports to verify compliance with Technical Documents.
 - .2 Manufacturer's Field Services: consisting of product use recommendations and periodic site visits to review installation, scheduled as follows:
 - .1 After delivery and storage of products.
 - .2 After preparatory work is complete but before installation commences.
 - .3 Twice during the installation, at 25% and 60% completion stages.
 - .4 Upon completion of installation.
 - .3 Submit manufacturer's reports to Departmental Representative within 3 days of manufacturer representative's review.
 - .4 Make adjustments and corrections in accordance with written report.

3.4 CLEANING

- .1 Proceed in accordance with Section 01 74 11 - Cleaning
- .2 Upon completion and verification of performance of installation, remove surplus materials, excess materials, rubbish, tools and equipment.

PART 1 GENERAL

1.1 RELATED SECTIONS

- .1 Section 09 91 23 - Painting.

1.2 REFERENCES

- .1 Canadian Standards Association (CSA)
 - .1 CSA B149.1-10, Natural Gas and Propane Installation Code, Includes Update No. 1 (2010).
- .2 Canadian General Standards Board (CGSB)
 - .1 CAN/CGSB-24.3-92, Identification of Piping Systems.
- .3 National Fire Protection Association (NFPA)
 - .1 NFPA 13-2013, Standard for the Installation of Sprinkler Systems.
 - .2 NFPA 14-2013, Standard for the Installation of Standpipe and Hose Systems.

1.3 SUBMITTALS

- .1 Shop drawings:
 - .1 Submittals: in accordance with Section 01 33 00 - Submittal Procedures.
 - .2 Shop drawings to include paint colour chips, other products specified in this section.

1.4 QUALITY ASSURANCE

- .1 Quality assurance submittals: submit following in accordance with Section 01 33 00 - Submittal Procedures.
- .2 Health and Safety:
 - .1 Do construction occupational health and safety in accordance with Section 01 35 29.06 - Health and Safety Requirements.

1.5 DELIVERY, STORAGE, AND HANDLING

- .1 Packing, shipping, handling and unloading:
 - .1 Deliver, store and handle in accordance with Section 01 61 00 - Common Product Requirements.

- .2 Deliver, store and handle materials in accordance with manufacturer's written instructions.
- .2 Waste Management and Disposal:
 - .1 Construction/Demolition Waste Management and Disposal: separate waste materials for reuse and recycling in accordance with Section 01 74 21 - Construction/Demolition Waste Management and Disposal.
 - .2 Dispose of unused paint, coating material at official hazardous material collections site approved by Departmental Representative.
 - .3 Do not dispose of unused paint, coating material into sewer system, into streams, lakes, onto ground or in locations where it will pose health or environmental hazard.

PART 2 PRODUCTS

2.1 MANUFACTURER'S EQUIPMENT NAMEPLATES

- .1 Metal or plastic laminate nameplate mechanically fastened to each piece of equipment by manufacturer.
- .2 Lettering and numbers raised or recessed.
- .3 Information to include, as appropriate:
 - .1 Equipment: manufacturer's name, model, size, serial number, capacity.
 - .2 Motor: voltage, Hz, phase, power factor, duty, frame size.
- .4 Ensure that manufacturers' nameplates, CSA approval, pressure vessel approval and other attached plates as required do not become obscured by insulation, paint or other materials.

2.2 SYSTEM NAMEPLATES

- .1 Provide identification nameplates for all mechanical systems and on all control panels.
- .2 Colours:
 - .1 Hazardous: red letters, white background.
 - .2 Elsewhere: black letters, white background (except where required otherwise by applicable codes).
- .3 Construction:
 - .1 3 mm thick laminated plastic, matte finish, with square corners, letters accurately aligned and machine engraved into core.

.4 Sizes:

.1 Conform to following table:

Size # mm	Sizes (mm)	No. of Lines	Height of Letters (mm)
1	10 x 50	1	3
2	13 x 75	1	5
3	13 x 75	2	3
4	20 x 100	1	8
5	20 x 100	2	5
6	20 x 200	1	8
7	25 x 125	1	12
8	25 x 125	2	8
9	35 x 200	1	20

.2 Use maximum of 25 letters/numbers per line.

.5 Locations:

.1 Terminal cabinets, control panels: use size #5.

.2 Equipment in Mechanical Rooms: use size #9.

.6 Identification for PWGSC Preventive Maintenance Support System (PMSS):

.1 Use arrangement of Main identifier, Source identifier, Destination identifier.

.2 Equipment in Mechanical Room:

.1 Main identifier: size #9.

.2 Source and Destination identifiers: size #6.

.3 Terminal cabinets, control panels: size #5.

.3 Equipment elsewhere: sizes as appropriate.

2.3 IDENTIFICATION OF PIPING SYSTEMS

.1 Identify contents by background colour marking, pictogram (as necessary), legend; direction of flow by arrows. To CAN/CGSB-24.3 except where specified otherwise.

.2 Pictograms:

.1 Where required: Workplace Hazardous Materials Information System (WHMIS) regulations.

.3 Legend:

.1 Block capitals to sizes and colours listed in CAN/CGSB-24.3.

.4 Arrows showing direction of flow:

.1 Outside diameter of pipe or insulation less than 75 mm: 100 mm long x 50 mm high.

.2 Outside diameter of pipe or insulation 75 mm and greater: 150 mm long x 50 mm high.

.3 Use double-headed arrows where flow is reversible.

- .5 Extent of background colour marking:
- .1 To full circumference of pipe or insulation.
 - .2 Length to accommodate pictogram, full length of legend and arrows.
- .6 Materials for background colour marking, legend, arrows:
- .1 Pipes and tubing 20 mm and smaller: waterproof and heat resistant pressure sensitive plastic marker tags.
 - .2 Other pipes: pressure sensitive plastic coated cloth vinyl with protective overcoating, waterproof contact adhesive undercoating, suitable for ambient of 100% RH and continuous operating temperature of 150°C and intermittent temperature of 200°C.
- .7 Colours and Legends:
- .1 Where not listed, obtain direction from Departmental Representative.
 - .2 Colours for legends, arrows: to following table:
- | | |
|--------------------|-----------------|
| Background colour: | Legend, arrows: |
| Yellow | BLACK |
| Green | WHITE |
| Red | WHITE |
- .3 Background colour marking and legends for piping systems:

Contents	Background colour marking	Legend
City water	Green	CITY WATER
Domestic hot water supply	Green	DOM. HW SUPPLY
Dom. HWS recirculation	Green	DOM. HW CIRC
Domestic cold water supply	Green	DOM. CWS
Storm water	Green	STORM
Sanitary	Green	SAN
Plumbing vent	Green	SAN. VENT

2.4 IDENTIFICATION DUCTWORK SYSTEMS

- .1 50 mm high stencilled letters and directional arrows 150 mm long x 50 mm high.
- .2 Colours: black, or co-ordinated with base colour to ensure strong contrast.

2.5 VALVES, CONTROLLERS

- .1 Brass tags with 12 mm stamped identification data filled with black paint.
- .2 Include flow diagrams for each system, of approved size, showing charts and schedules with identification of each tagged item, valve type, service, function, normal position, location of tagged item.

2.6 CONTROLS COMPONENTS IDENTIFICATION

- .1 Identify all systems, equipment, components, controls, sensors with system nameplates specified in this section.
- .2 Inscriptions to include function and (where appropriate) fail-safe position.

2.7 LANGUAGE

- .1 Identification in English and French.
- .2 Use one nameplate and label for each language.

PART 3 EXECUTION

3.1 MANUFACTURER'S INSTRUCTIONS

- .1 Compliance: comply with manufacturer's written recommendations or specifications, including product technical bulletins, handling, storage and installation instructions, and datasheet.

3.2 TIMING

- .1 Provide identification only after painting specified Section 09 91 23 - Painting has been completed.

3.3 INSTALLATION

- .1 Perform work in accordance with CAN/CGSB-24.3 except as specified otherwise.
- .2 Provide ULC or CSA registration plates as required by respective agency.
- .3 Identify systems, equipment to conform to PWGSC PMSS.

3.4 NAMEPLATES

- .1 Locations:
 - .1 In conspicuous location to facilitate easy reading and identification from operating floor.
- .2 Standoffs:
 - .1 Provide for nameplates on hot and/or insulated surfaces.

- .3 Protection:
 - .1 Do not paint, insulate or cover.

3.5 LOCATION OF IDENTIFICATION ON PIPING AND DUCTWORK SYSTEMS

- .1 On long straight runs in open areas in boiler rooms, equipment rooms, galleries, tunnels: at not more than 17 m intervals and more frequently if required to ensure that at least one is visible from any one viewpoint in operating areas and walking aisles.
- .2 Adjacent to each change in direction.
- .3 At least once in each small room through which piping or ductwork passes.
- .4 On both sides of visual obstruction or where run is difficult to follow.
- .5 On both sides of separations such as walls, floors, partitions.
- .6 Where system is installed in pipe chases, ceiling spaces, galleries, confined spaces, at entry and exit points, and at access openings.
- .7 At beginning and end points of each run and at each piece of equipment in run.
- .8 At point immediately upstream of major manually operated or automatically controlled valves, and dampers. Where this is not possible, place identification as close as possible, preferably on upstream side.
- .9 Identification easily and accurately readable from usual operating areas and from access points.
 - .1 Position of identification approximately at right angles to most convenient line of sight, considering operating positions, lighting conditions, risk of physical damage or injury and reduced visibility over time due to dust and dirt.

3.6 VALVES, CONTROLLERS

- .1 Valves and operating controllers, except at plumbing fixtures, radiation, or where in plain sight of equipment they serve: Secure tags with non ferrous chains or closed "S" hooks.
- .2 Install one copy of flow diagrams, valve schedules mounted in frame behind non-glare glass where directed by Departmental Representative. Provide one copy (reduced in size if required) in each operating and maintenance manual.
- .3 Number valves in each system consecutively.

3.7 CLEANING

- .1 Proceed in accordance with Section 01 74 11 - Cleaning.
- .2 Upon completion and verification of performance of installation, remove surplus materials, excess materials, rubbish, tools and equipment.

PART 1 GENERAL

1.1 RELATED SECTIONS

- .1 Section 21 05 01 - Common Work Results for Mechanical.
- .2 Division 22 - Plumbing.
- .3 Division 23 - Heating, Ventilating and Air Conditioning (HVAC).

1.2 GENERAL

- .1 Furnish all labour and equipment for the testing, adjustment and balancing of air systems as indicated on the drawings and described in the specifications, to obtain design quantities as indicated, and record all readings for submission in the form of a balancing report.
- .2 Verify operating conditions and/or adjust the following systems:
 - .1 HVAC systems.
 - .2 Domestic hot water system.
- .3 The work of this section is to be coordinated with the work of other sections.
- .4 The Balancing Contractor will be the single agent responsible for the complete testing, adjusting and balancing of all systems specified.

1.3 QUALIFICATIONS OF TAB PERSONNEL

- .1 Submit names of personnel to perform TAB to Departmental Representative within 90 days of award.
- .2 TAB: performed in accordance with the requirements of standard under which TAB Firm's qualifications are approved:
 - .1 Associated Air Balance Council, (AABC) National Standards for Total System Balance, MN-1-2002.
 - .2 National Environmental Balancing Bureau (NEBB) TABES, Procedural Standards for Testing, Adjusting, Balancing of Environmental Systems, 7th Edition, 2005.
 - .3 Sheet Metal and Air Conditioning Contractors' National Association (SMACNA), HVAC TAB HVAC Systems - Testing, Adjusting and Balancing-2002.
- .3 Recommendations and suggested practices contained in the TAB Standard: mandatory.

- .4 Use TAB Standard provisions, including checklists, and report forms to satisfy requirements.
- .5 Use TAB Standard for TAB, including qualifications for TAB Firm and Specialist and calibration of TAB instruments.
- .6 Where instrument manufacturer calibration recommendations are more stringent than those listed in TAB Standard, use manufacturer's recommendations.
- .7 TAB Standard quality assurance provisions such as performance warranties form part of this Work.
 - .1 For systems or system components not covered in TAB Standard, use TAB procedures developed by TAB Specialist.
 - .2 Where new procedures, and requirements, are applicable to requirements, have been published or adopted by body responsible for TAB Standard used (AABC, NEBB, or TABB), requirements and recommendations contained in these procedures and requirements are mandatory.

1.4 PURPOSE OF TAB

- .1 Test to verify proper and safe operation, determine actual point of performance, evaluate qualitative and quantitative performance of equipment, systems and controls at design, average and low loads using actual or simulated loads.
- .2 Adjust and regulate equipment and systems to meet specified performance requirements and to achieve specified interaction with other related systems under normal and emergency loads and operating conditions.
- .3 Balance systems and equipment to regulate flow rates to match load requirements over full operating ranges.

1.5 EXCEPTIONS

- .1 TAB of systems and equipment regulated by codes, standards to satisfaction of Authority Having Jurisdiction.

1.6 CO-ORDINATION

- .1 Schedule time required for TAB (including repairs, retesting) into project construction and completion schedule to ensure completion before acceptance of project.
- .2 Do TAB of each system independently and subsequently, where interlocked with other systems, in unison with those systems.

1.7 PRE-TAB REVIEW

- .1 Review Technical Documents before project construction is started and confirm in writing to Departmental Representative adequacy of provisions for TAB and other aspects of design and installation pertinent to success of TAB.
- .2 Review specified standards and report to Departmental Representative in writing proposed procedures which vary from standard.
- .3 During construction, co-ordinate location and installation of TAB devices, equipment, accessories, measurement ports and fittings.

1.8 START-UP

- .1 Follow start-up procedures as recommended by equipment manufacturer unless specified otherwise.
- .2 Follow special start-up procedures specified elsewhere in Division 23.

1.9 OPERATION OF SYSTEMS DURING TAB

- .1 Operate systems for length of time required for TAB and as required by Departmental Representative for verification of TAB reports.

1.10 START OF TAB

- .1 Notify Departmental Representative 14 days prior to start of TAB.
- .2 Start TAB when building is essentially completed, including:
 - .1 Installation of ceilings, doors, windows, other construction affecting TAB.
 - .2 Application of weatherstripping, sealing, and caulking.
 - .3 Pressure, leakage, other tests specified elsewhere Division 23.
 - .4 Provisions for TAB installed and operational.
 - .5 Start-up, verification for proper, normal and safe operation of mechanical and associated electrical and control systems affecting TAB including but not limited to:
 - .1 Proper thermal overload protection in place for electrical equipment.
 - .2 Air systems:
 - .1 Filters in place, clean.
 - .2 Duct systems clean.
 - .3 Ducts, air shafts, ceiling plenums are airtight to within specified tolerances.
 - .4 Correct fan rotation.
 - .5 Fire, smoke, volume control dampers installed and open.
 - .6 Coil fins combed, clean.
 - .7 Access doors, installed, closed.
 - .8 Outlets installed, volume control dampers open.

- .3 Liquid systems:
 - .1 Flushed, filled, vented.
 - .2 Correct pump rotation.
 - .3 Strainers in place, baskets clean.
 - .4 Isolating and balancing valves installed, open.
 - .5 Calibrated balancing valves installed, at factory settings.
 - .6 Chemical treatment systems complete, operational.
- .4 System pressure tests to be completed.
- .5 Systems in continuous operation and under proper control
- .6 Balancing Contractor has obtained all applicable shop drawings, fan curves, pump curves, etc.
- .7 Sufficient test ports, balancing dampers, access doors, etc., have been provided.
- .8 Manufacturer's start-up procedures have been successfully completed.

1.11 APPLICATION TOLERANCES

- .1 Do TAB to following tolerances of design values:
 - .1 Other HVAC systems: plus 5%, minus 5%.
 - .2 Hydronic systems: plus or minus 10%.

1.12 ACCURACY TOLERANCES

- .1 Measured values accurate to within plus or minus 2% of actual values.

1.13 INSTRUMENTS

- .1 Prior to TAB, submit to Departmental Representative list of instruments used together with serial numbers.
- .2 Calibrate in accordance with requirements of most stringent of referenced standard for either applicable system or HVAC system.
- .3 Calibrate within 3 months of TAB. Provide certificate of calibration to Departmental Representative.

1.14 TEST PORTS AND CAPS

- .1 Drill test holes in locations indicated, and where required for proper flow measurement.
- .2 Provide additional test holes if and where requested by the Departmental Representative to verify system operation.

- .3 Provide test connections, gauge connections, gauges and instruments, etc., where required for proper water balancing.

1.15 SUBMITTALS

- .1 Submit, prior to commencement of TAB:
 - .1 Proposed methodology and procedures for performing TAB if different from referenced standard.

1.16 PRELIMINARY TAB REPORT

- .1 Submit for checking and approval of Departmental Representative, prior to submission of formal TAB report, sample of rough TAB sheets. Include:
 - .1 Details of instruments used.
 - .2 Details of TAB procedures employed.
 - .3 Calculations procedures.
 - .4 Summaries.

1.17 TAB REPORT

- .1 Format in accordance with referenced standard.
- .2 TAB report to show results in SI units and to include:
 - .1 Project record drawings.
 - .2 System schematics.
- .3 Submit 6 copies of TAB Report to Departmental Representative for verification and approval, in both official languages in D-ring binders, complete with index tabs.

1.18 VERIFICATION

- .1 Reported results subject to verification by Departmental Representative.
- .2 Provide personnel and instrumentation to verify up to 30% of reported results.
- .3 Number and location of verified results as approved by Departmental Representative.
- .4 Pay costs to repeat TAB as required to satisfaction of Departmental Representative.

1.19 SETTINGS

- .1 After TAB is completed to satisfaction of Departmental Representative replace drive guards, close access doors, lock devices in set positions, ensure sensors are at required settings.

- .2 Permanently mark settings to allow restoration at any time during life of facility. Do not eradicate or cover markings.

1.20 COMPLETION OF TAB

- .1 TAB considered complete when final TAB Report received and approved by Departmental Representative.

1.21 AIR SYSTEMS

- .1 Standard: TAB to most stringent of this section or TAB standards of AABC, NEBB, SMACNA, and ASHRAE.
 - .1 Do TAB of systems, equipment, components, controls specified Division 23.
- .2 Qualifications: personnel performing TAB to be current member in good standing of AABC or NEBB.
- .3 Quality assurance: perform TAB under direction of supervisor qualified to standards of AABC or NEBB.
- .4 Measurements: to include as appropriate for systems, equipment, components, controls: air velocity, static pressure, flow rate, pressure drop (or loss), temperatures (dry bulb, wet bulb, dewpoint), duct cross sectional area, RPM, electrical power, voltage, noise, vibration.
- .5 Locations of equipment measurements: to include as appropriate:
 - .1 Inlet and outlet of dampers, filter, coil, humidifier, fan, other equipment causing changes in conditions.
 - .2 At controllers, controlled device.
- .6 Locations of systems measurements to include as appropriate: main ducts, main branch, sub-branch, run-out (or grille, register or diffuser).
- .7 Provide new pulleys and belts and/or adjust where necessary to achieve design conditions. Do not exceed motor nameplate amperage. Advise Departmental Representative if duty cannot be met within nameplate amperage.
- .8 Measure air quantities at each air inlet and outlet using the approved methods. Air measurements at grilles and diffusers are to be taken using a hood attachment.

1.22 OTHER TAB REQUIREMENTS

- .1 General requirements applicable to work specified this paragraph:
 - .1 Qualifications of TAB personnel: as for air systems specified this section.
 - .2 Quality assurance: as for air systems specified this section.

- .2 Measurement of noise and vibration from equipment specified in Division 23.
- .3 Building pressure conditions: Adjust HVAC systems, equipment, controls to ensure specified pressure conditions during winter and summer design conditions.
- .4 Zone pressure differences:
 - .1 Adjust HVAC systems, equipment, controls to establish specified air pressure differentials, with systems in every possible combinations of normal operating modes.

1.23 POST-OCCUPANCY TAB

- .1 Measure DBT, WBT, %RH, air velocity, air flow patterns, NC levels, in occupied zone of following areas: West Bay, Core Bay, East Bay and office area.
- .2 Participate in systems checks twice during Warranty Period - #1 approximately 3 months after acceptance and #2 within 1 month of termination of Warranty Period.

PART 2 PRODUCTS

2.1 NOT USED

- .1 Not used.

PART 3 EXECUTION

3.1 NOT USED

- .1 Not used.

PART 1 GENERAL1.1 RELATED SECTIONS

- .1 Section 21 05 01 - Common Work Results for Mechanical.
- .2 Section 23 05 29 - Hangers and Supports for HVAC Piping and Equipment.
- .3 Section 23 31 13.01 - Metal Ducts - Low Pressure to 500 PA.
- .4 Section 23 33 53 - Duct Liners.

1.2 REFERENCES

- .1 American National Standards Institute (ANSI)/American Society of Heating, Refrigeration and Air Conditioning Engineers (ASHRAE)
 - .1 ANSI/ASHRAE 90.1-2010 (SI), Energy Standard for Buildings Except Low-Rise Residential Buildings (ANSI/ASHRAE/IES), Errata (January 18, 2013)/Addenda a thru ds/IC 90.1-2010-02 to 14/90.1-2010-15 to 16.
- .2 American Society for Testing and Materials International (ASTM)
 - .1 ASTM C335/C335M-10e1, Standard Test Method for Steady-State Heat Transfer Properties of Pipe Insulation.
 - .2 ASTM C411-11, Standard Test Method for Hot Surface Performance of High Temperature Thermal Insulation.
 - .3 ASTM C449-07(2013), Standard Specification for Mineral Fiber Hydraulic-Setting Thermal Insulating and Finishing Cement.
 - .4 ASTM C534/C534M-13, Standard Specification for Preformed Flexible Elastomeric Cellular Thermal Insulation in Sheet and Tubular Form.
 - .5 ASTM C547-12, Standard Specification for Mineral Fiber Pipe Insulation.
 - .6 ASTM C553-11, Standard Specification for Mineral Fiber Blanket Thermal Insulation for Commercial and Industrial Applications.
 - .7 ASTM C612-10, Standard Specification for Mineral Fiber Block and Board Thermal Insulation.
 - .8 ASTM C795-08(2013), Standard Specification for Thermal Insulation for Use in Contact with Austenitic Stainless Steel.
 - .9 ASTM C921-10, Standard Practice for Determining the Properties of Jacketing Materials for Thermal Insulation.
 - .10 ASTM C1393-11, Standard Specification for Perpendicularly Oriented Mineral Fiber Roll and Sheet Thermal Insulation for Pipes and Tanks.
- .3 Canadian General Standards Board (CGSB)
 - .1 CGSB 51-GP-52Ma-89, Vapour Barrier, Jacket and Facing Material for Pipe, Duct and Equipment Thermal Insulation.
 - .2 CAN/CGSB-51.53-95, Poly (Vinyl Chloride) Jacketing Sheet, for Insulated Pipes, Vessels and Round Ducts.

- .4 Thermal Insulation Association of Canada (TIAC): National Insulation Standards (2005).
- .5 Underwriters Laboratories of Canada (ULC)
 - .1 CAN/ULC-S102-10, Method of Test for Surface Burning Characteristics of Building Materials and Assemblies.
 - .2 CAN/ULC-S701-11, Standard for Thermal Insulation, Polystyrene, Boards and Pipe Covering.

1.3 DEFINITIONS

- .1 For purposes of this section:
 - .1 "CONCEALED" insulated mechanical services and equipment in suspended ceilings and non accessible chases and furred-in spaces.
 - .2 "EXPOSED" will mean "not concealed" as defined herein.
 - .3 Insulation systems insulation material, fasteners, jackets, and other accessories.
- .2 TIAC Codes:
 - .1 CRD: Code Round Ductwork.
 - .2 CRF: Code Rectangular Finish.

1.4 SHOP DRAWINGS

- .1 Submit shop drawings in accordance with Section 01 33 00 - Submittal Procedures.
- .2 Submit for approval manufacturer's catalogue literature related to installation, fabrication for duct jointing recommendations.

1.5 MANUFACTURER'S INSTRUCTIONS

- .1 Submit manufacturer's installation instructions in accordance with Section 01 33 00 - Submittal Procedures.
- .2 Installation instructions to include procedures used, and installation standards achieved.

1.6 QUALIFICATIONS

- .1 Installer: specialist in performing work of this section, member of TIAC.

1.7 DELIVERY, STORAGE AND HANDLING

- .1 Deliver materials to site in original factory packaging, labelled with manufacturer's name, address.

- .2 Protect from weather and construction traffic.
- .3 Protect against damage from any source.
- .4 Store at temperatures and conditions recommended by manufacturer.

1.8 WASTE MANAGEMENT AND DISPOSAL

- .1 Separate and recycle waste materials in accordance with Section 01 74 21 - Construction/Demolition Waste Management and Disposal.
- .2 Remove from site and dispose of packaging materials at appropriate recycling facilities.
- .3 Collect and separate for disposal paper, plastic, polystyrene, corrugated cardboard packaging material in appropriate on-site bins for recycling in accordance with Waste Reduction Workplan.
- .4 Divert unused metal materials from landfill to metal recycling facility approved by Departmental Representative.
- .5 Divert unused adhesive material from landfill to official hazardous material collections site approved by Departmental Representative.
- .6 Do not dispose of unused adhesive materials into sewer systems, into lakes, streams, onto ground or in other locations where it will pose health or environmental hazard.

PART 2 PRODUCTS

2.1 COMPATIBILITY OF COMPONENTS

- .1 Mechanical fasteners, adhesives, sealers, vapour coatings, mastics, laggings and bedding compounds to be compatible with materials to which they are applied and shall not soften, corrode or otherwise attack such material in either wet or dry state and shall be only those recommended by the manufacturer of the insulation as suitable for the application proposed. Apply within ambient temperatures recommended by the manufacturer.

2.2 FIRE AND SMOKE RATING

- .1 To CAN/ULC-S102:
 - .1 Maximum flame spread rating: 25.
 - .2 Maximum smoke developed rating: 50.

2.3 INSULATION

- .1 Mineral fibre: as specified includes glass fibre, rock wool, slag wool.
- .2 Thermal conductivity ("k" factor) not to exceed specified values at 24°C mean temperature when tested in accordance with ASTM C335/C335M.
- .3 TIAC Code C 1: Rigid mineral fibre board to ASTM C612, with factory applied vapour retarder jacket to CGSB 51-GP-52Ma (as scheduled in PART 3 of this Section).
- .4 TIAC Code C 2: Mineral fibre blanket to ASTM C553 faced with factory applied vapour retarder jacket to CGSB 51-GP-52Ma (as scheduled in PART 3 of this section).
 - .1 Mineral fibre: to ASTM C553.
 - .2 Jacket: to CGSB 51-GP-52Ma.
 - .3 Maximum "k" factor: to ASTM C553.
- .5 Rigid Insulation:
 - .1 Ducting and Fittings: Rigid insulation with vapour barrier to be composed of fibrous glass or mineral wool fibres formed into rigid board having a factory applied vapour barrier, and suitable for application on exposed or concealed rectangular ducts and plenums.
 - .2 Vapour Barrier:
 - .1 Vapour barrier shall be composed of aluminum foil minimum .61 mm thick, reinforced with fibreglass yarn mesh and laminated to permanently treated fire resistant kraft paper. Vapour barrier shall meet or exceed the following:
 - .1 Water Vapour Permeability: 0.3 perms max.
 - .2 Moisture Absorption: Less than 0.2% by volume.
 - .3 Application: Thicknesses as indicated in insulation schedule.
- .6 Flexible Insulation:
 - .1 Ducting and Fittings:
 - .1 Flexible insulation with factory applied vapour barrier to be composed of fibrous glass formed into a flexible blanket and be suitable for application on exterior of round ducts. Do not use on rectangular ductwork.
 - .2 Vapour Barrier:
 - .1 The vapour barrier shall be composed of aluminum foil min .61 mm thick, reinforced with fibreglass yarn mesh and laminated to permanently treated fire resistant kraft paper.
 - .3 Applications: Thicknesses as indicated in insulation schedule.

2.4 JACKETS

- .1 Canvas:
 - .1 220 gm/m² cotton, plain weave, treated with dilute fire retardant lagging adhesive to ASTM C921.

- .2 Lagging adhesive: compatible with insulation.

2.5 ACCESSORIES

- .1 Vapour retarder lap adhesive:
 - .1 Water based, fire retardant type, compatible with insulation.
- .2 Indoor Vapour Retarder Finish:
 - .1 Vinyl emulsion type acrylic, compatible with insulation.
- .3 Insulating Cement: hydraulic setting or air drying on mineral wool, to ASTM C449.
- .4 ULC Listed Canvas Jacket:
 - .1 220 gm/m² cotton, plain weave, treated with dilute fire retardant lagging adhesive to ASTM C921 untreated.
- .5 Outdoor Vapour Retarder Mastic:
 - .1 Vinyl emulsion type acrylic, compatible with insulation.
 - .2 Reinforcing fabric: Fibrous glass, untreated 305 g/m².
- .6 Tape: self-adhesive, aluminum, plain reinforced, 75 mm wide minimum.
- .7 Contact adhesive: quick-setting.
- .8 Canvas adhesive: washable.
- .9 Tie wire: 1.5 mm stainless steel.
- .10 Banding: 19 mm wide, 0.5 mm thick stainless steel.
- .11 Facing: 25 mm galvanized steel hexagonal wire mesh stitched on both faces of insulation.
- .12 Fasteners: 4 mm diameter weld pins with 35 mm diameter clips, length to suit thickness of insulation.

PART 3 EXECUTION

3.1 PRE-INSTALLATION REQUIREMENTS

- .1 Pressure test ductwork systems complete, witness and certified.
- .2 Surfaces clean, dry, free from foreign material.

3.2 INSTALLATION

- .1 Install in accordance with TIAC National Standards.
- .2 Apply materials in accordance with manufacturer's instructions and this specification so that the finished job is uniform in diameter and smooth in finish.
- .3 Use two layers with staggered joints when required nominal thickness exceeds 75mm.
- .4 Maintain uninterrupted continuity and integrity of vapour retarder jacket and finishes.
 - .1 Hangers, supports are outside vapour retarder jacket.
- .5 Supports, Hangers in accordance with Section 23 05 29 - Hangers and Supports for HVAC Piping and Equipment.
 - .1 Apply high compressive strength insulation where insulation may be compressed by weight of ductwork.
- .6 Fasteners: At 300 mm oc in horizontal and vertical directions, minimum two rows each side.
- .7 Mitre insulation at elbows and cover joints with tape.
- .8 Insulation and vapour barrier shall be continuous where services pass through walls and floors.
- .9 Jackets:
 - .1 Jackets on exposed ductwork of types indicated shall be continuous over any vapour barrier or coating.
 - .2 Lap seams minimum 50 mm in least visible location. Use adhesive lagging to secure overlapping edges.
 - .3 In mechanical rooms, provide galvanized steel corner beads on rigid insulation complete with thermo-canvas covering.

3.3 DUCTWORK INSULATION SCHEDULE

- .1 Exhaust air ductwork for a minimum distance of 2 meters from the terminal at the roof or exterior wall or as noted on the drawings.
- .2 Insulation types and thicknesses: conform to following table:

	TIAC Code	Vapour Retarder	Thickness (mm)
Rectangular supply air ducts	C-1	yes	50
Supply and return air ducts within exterior enclosure	C-1	yes	50

Exhaust duct from exterior wall cap to 1500mm inside building	C-1	no	25
Acoustically lined ducts	none		

.3 Finishes: conform to following table:

	TIAC Code	
	Rectangular	Round
Indoor, concealed	none	none

.4 The above tables in this part are to be read in conjunction with Section 23 33 53 Part 3.1.2.

3.4 CLEANING

- .1 Clean in accordance with Section 01 74 11 - Cleaning.
- .1 Remove surplus materials, excess materials, rubbish, tools and equipment.
- .2 Waste Management: separate waste materials for reuse and recycling in accordance with Section 01 74 21 - Construction/Demolition Waste Management and Disposal.

PART 1 GENERAL**1.1 RELATED SECTIONS**

- .1 Section 21 05 01 - Common Work Results for Mechanical.
- .2 Section 22 11 16 - Domestic Water Piping.
- .3 Section 23 05 05 - Installation of Pipework.
- .4 Section 23 31 13.01 - Metal Ducts - Low Pressure to 500 PA.
- .5 Section 23 23 00 - Refrigerant Piping.
- .6 Section 26 05 23 - Heat Tracing for Piping.

1.2 REFERENCES

- .1 American National Standards Institute (ANSI)/American Society of Heating, Refrigeration and Air Conditioning Engineers (ASHRAE)
 - .1 ANSI/ASHRAE 90.1-2010 (SI), Energy Standard for Buildings Except Low-Rise Residential Buildings (ANSI/ASHRAE/IES), Errata (January 18, 2013)/Addenda a thru ds/IC 90.1-2010-02 to 14/90.1-2010-15 to 16.
- .2 American Society for Testing and Materials International (ASTM)
 - .1 ASTM B209M-10, Standard Specification for Aluminum and Aluminum Alloy Sheet and Plate (Metric).
 - .2 ASTM C335/C335M-10e1, Standard Test Method for Steady State Heat Transfer Properties of Pipe Insulation.
 - .3 ASTM C411-11, Standard Test Method for Hot-Surface Performance of High-Temperature Thermal Insulation.
 - .4 ASTM C449-07(2013), Standard Specification for Mineral Fiber-Hydraulic-Setting Thermal Insulating and Finishing Cement.
 - .5 ASTM C533-13, Standard Specification for Calcium Silicate Block and Pipe Thermal Insulation.
 - .6 ASTM C534/C534M-13, Standard Specification for Preformed Flexible Elastomeric Cellular Thermal Insulation in Sheet and Tubular Form.
 - .7 ASTM C547-12, Standard Specification for Mineral Fiber Pipe Insulation.
 - .8 ASTM C795-08(2013), Standard Specification for Thermal Insulation for Use in Contact with Austenitic Stainless Steel.
 - .9 ASTM C921-10, Standard Practice for Determining the Properties of Jacketing Materials for Thermal Insulation.
 - .10 ASTM C1393-11, Standard Specification for Perpendicularly Oriented Mineral Fiber Roll and Sheet Thermal Insulation for Pipes and Tanks.

- .3 Canadian General Standards Board (CGSB)
 - .1 CAN/CGSB-51.53-95, Poly (Vinyl Chloride) Jacketting Sheet, for Insulated Pipes, Vessels and Round Ducts.
 - .2 CGSB 51-GP-52MA-89, Vapour Barrier Jacket and Facing Material for Pipe, Duct and Equipment Thermal Insulation.
- .4 Department of Justice Canada (Jus)
 - .1 Canadian Environmental Assessment Act (CEAA), 1995, c. 37.
 - .2 Canadian Environmental Protection Act (CEPA), 1999, c. 33.
 - .3 Transportation of Dangerous Goods Act (TDGA), 1992, c. 34.
- .5 Health Canada/Workplace Hazardous Materials Information System (WHMIS)
 - .1 Material Safety Data Sheets (MSDS).
- .6 Manufacturer's Trade Associations
 - .1 Thermal Insulation Association of Canada (TIAC): National Insulation Standards (Revised 2005).
- .7 Underwriters' Laboratories of Canada (ULC)
 - .1 CAN/ULC-S102-10, Standard Method of Test for Surface Burning Characteristics of Building Materials and Assemblies.
 - .2 CAN/ULC-S701-11, Standard for Thermal Insulation, Polystyrene, Boards and Pipe Covering.
 - .3 CAN/ULC-S702-09-AM1, Standard for Thermal Insulation, Mineral Fibre, for Buildings, Includes Amendment 1.
 - .4 CAN/ULC-S702.2-10, Mineral Fibre Thermal Insulation, for Buildings, Part 2: Installation.

1.3 DEFINITIONS

- .1 For purposes of this section:
 - .1 "CONCEALED" - insulated mechanical services in suspended ceilings and non-accessible chases and furred-in spaces.
 - .2 "EXPOSED" - will mean "not concealed" as specified.
- .2 TIAC ss:
 - .1 CRF: Code Rectangular Finish.
 - .2 CPF: Code Piping Finish.

1.4 SUBMITTALS

- .1 Submittals: in accordance with Section 01 33 00 - Submittal Procedures.
- .2 Product Data:
 - .1 Submit manufacturer's printed product literature, specifications and datasheet in accordance with Section 01 33 00 - Submittal Procedures. Include product characteristics, performance criteria, and limitations.

- .3 Submit two copies of Workplace Hazardous Materials Information System (WHMIS) Material Safety Data Sheets (MSDS) in accordance with Section 01 33 00 - Submittal Procedures.
- .4 Shop Drawings:
 - .1 Submit shop drawings in accordance with Section 01 33 00 - Submittal Procedures.
- .5 Quality assurance submittals: submit following in accordance with Section 01 33 00 - Submittal Procedures.
 - .1 Certificates: submit certificates signed by manufacturer certifying that materials comply with specified performance characteristics and physical properties.
 - .2 Instructions: submit manufacturer's installation instructions.

1.5 QUALITY ASSURANCE

- .1 Qualifications:
 - .1 Health and Safety:
 - .1 Do construction occupational health and safety in accordance with Section 01 35 29.06 - Health and Safety Requirements.
 - .2 Installer to specialize in performing work of this section and member of TIAC.

1.6 DELIVERY, STORAGE AND HANDLING

- .1 Packing, shipping, handling and unloading:
 - .1 Deliver, store and handle in accordance with manufacturer's written instructions and Section 01 61 00 - Common Product Requirements.
 - .2 Deliver, store and handle materials in accordance with manufacturer's written instructions.
 - .3 Deliver materials to site in original factory packaging, labelled with manufacturer's name, address.
- .2 Storage and Protection:
 - .1 Protect from weather, construction traffic.
 - .2 Protect against damage.
 - .3 Store at temperatures and conditions required by manufacturer.
- .3 Waste Management and Disposal:
 - .1 Construction/Demolition Waste Management and Disposal: separate waste materials for reuse and recycling in accordance with Section 01 74 21 - Construction/Demolition Waste Management and Disposal.
 - .2 Place excess or unused insulation and insulation accessory materials in designated containers.

.3 Divert unused metal materials from landfill to metal recycling facility approved by Departmental Representative.

.4 Dispose of unused adhesive material at official hazardous material collections site approved by Departmental Representative.

PART 2 PRODUCTS

2.1 COMPATIBILITY OF COMPONENTS

- .1 Mechanical fasteners, adhesives, sealers, vapour coatings, mastics, laggings and bedding compounds to be compatible with materials to which they are applied and shall not soften, corrode or otherwise attack such material in either wet or dry state and shall be only those recommended by the manufacturer of the insulation as suitable for the application proposed. Apply within ambient temperatures recommended by the manufacturer.

2.2 FIRE AND SMOKE RATING

- .1 In accordance with CAN/ULC-S102.
 - .1 Maximum flame spread rating: 25.
 - .2 Maximum smoke developed rating: 50.

2.3 INSULATION

- .1 Mineral fibre specified includes glass fibre, rock wool, slag wool.
- .2 Thermal conductivity ("k" factor) not to exceed specified values at 24°C mean temperature when tested in accordance with ASTM C335/335M.
- .3 TIAC Code A-1: rigid moulded mineral fibre without factory applied vapour retarder jacket.
 - .1 Mineral fibre: to CAN/ULC-S702, ASTM C547.
 - .2 Maximum "k" factor: to CAN/ULC-S702.
- .4 TIAC Code A-3: rigid moulded mineral fibre with factory applied vapour retarder jacket.
 - .1 Mineral fibre: to CAN/ULC-S702, CGSB 51-GP-52Ma.
 - .2 Jacket: to CGSB 51-GP-52Ma.
 - .3 Maximum "k" factor: to CAN/ULC-S702.
- .5 TIAC Code C-2: mineral fibre blanket faced with factory applied vapour retarder jacket (as scheduled in PART 3 of this section).
 - .1 Mineral fibre: to CAN/ULC-S702, ASTM C547.
 - .2 Jacket: to CGSB 51-GP-52Ma.
 - .3 Maximum "k" factor: to CAN/ULC-S702.

- .6 TIAC Code A-6: flexible unicellular tubular elastomer.
 - .1 Insulation: with vapour retarder jacket.
 - .2 Jacket: to CGSB 51-GP-52Ma.
 - .3 Maximum "k" factor: as per manufacturer requirements.
 - .4 Certified by manufacturer: free of potential stress corrosion cracking corrodants.

2.4 INSULATION SECUREMENT

- .1 Tape: self-adhesive, aluminum, reinforced, 50 mm wide minimum.
- .2 Contact adhesive: quick setting.
- .3 Canvas adhesive: washable.
- .4 Tie wire: 1.5 mm diameter stainless steel.
- .5 Bands: stainless steel, 19mm wide, 0.5 mm thick.

2.5 CEMENT

- .1 Thermal insulating and finishing cement:
 - .1 Hydraulic setting or air drying on mineral wool, to ASTM C449.

2.6 VAPOUR RETARDER LAP ADHESIVE

- .1 Water based, fire retardant type, compatible with insulation.

2.7 INDOOR VAPOUR RETARDER FINISH

- .1 Vinyl emulsion type acrylic, compatible with insulation.

2.8 OUTDOOR VAPOUR RETARDER FINISH AND JACKETING

- .1 Vinyl emulsion type acrylic, compatible with insulation.
- .2 Reinforcing fabric: Fibrous glass, untreated 305 g/m².
- .3 Cover outdoor piping with self-adhesive weatherproof membrane.

2.9 JACKETS

- .1 Polyvinyl Chloride (PVC):
 - .1 One-piece moulded type and sheet to CAN/CGSB-51.53 with pre-formed shapes as required.
 - .2 Colours: to match adjacent finish paint by Departmental Representative.
 - .3 Minimum service temperatures: -20°C.
 - .4 Maximum service temperature: 65°C.
 - .5 Moisture vapour transmission: 0.02 perm.
 - .6 Fastenings:
 - .1 Use solvent weld adhesive compatible with insulation to seal laps and joints.
 - .2 Tacks.
 - .3 Pressure sensitive vinyl tape of matching colour.
 - .7 Special requirements:
 - .1 Indoor: labels.
- .2 Canvas:
 - .1 220 and 120 gm/m² cotton, plain weave, treated with dilute fire retardant lagging adhesive to ASTM C921.
 - .2 Lagging adhesive: compatible with insulation.
- .3 Aluminum:
 - .1 To ASTM B209M.
 - .2 Thickness: 0.50 mm sheet.
 - .3 Finish: stucco embossed.
 - .4 Joining: longitudinal and circumferential slip joints with 50 mm laps.
 - .5 Fittings: 0.5 mm thick die-shaped fitting covers with factory-attached protective liner.
 - .6 Metal jacket banding and mechanical seals: stainless steel, 19 mm wide, 0.5 mm thick at 300 mm spacing.

2.10 MINERAL FIBRE PIPE INSULATION

- .1 Mineral Fibre Insulation:
 - .1 Piping:
 - .1 Preformed mineral fibre insulation with integral jacket shall be composed of incombustible, fine diameter, glass fibres or mineral wool fibres, bonded together with an inert thermosetting resin and have a factory applied, all service type vapour barrier jacket.
 - .2 Insulation to be preformed into 0.914 m, 1.83 m cylindrical sections or segments to suit standard pipe sizes. For insulation thickness see schedule at the end of this Section.
 - .2 Specification Compliance:
 - .1 ASTM C547.
 - .2 ASTM C411.

- .3 Flexible elastomeric thermal insulation for pipe and fittings may be used in place of mineral fibre provided that all conditions of the specifications are met, and that the insulation exposed to sunlight is suitably protected in accordance with the manufacturer's recommendations.
- .2 Covering:
- .1 All service type, factory applied vapour barrier jackets to be of high intensity, white kraft bonded to aluminum foil, reinforced with fibreglass yarn. Jacket to have a minimum 38.1 mm longitudinal (self seal) lap and shall be sealed circumferentially with a 76.2 mm wide butt strip of like jacketing material, with self seal or butt strip adhesive.
- .2 Jacket and adhesive used to secure jacket to insulation shall bear ULC-S102 label "Standard Test Method of Surface Burning Characteristics of Building Materials", having flame spread of 25 and smoke developed less than 50, and have a maximum water vapour permeability of 0.02 perms and a minimum beach puncture resistance of 50 units.
- .3 Fittings:
- .1 Insulate all fittings, flanges, pump bodies, strainers, water meters, and valve bodies with factory precut, flexible insulation having a K-factor of not more than 0.04 W/m² °C at 24°C.
- .2 Where PVC jacketing is used, seal all seam edges of cover with an approved vapour barrier adhesive mastic. Wrap the circumferential edge with an approved pressure sensitive, colour matching tape, overlapping adjacent pipe insulation and itself at least 50 mm on the downward side.
- .3 On fittings, where the medium temperature exceeds 95°C, provide 2 layers of insulation, tied in place.
- .4 Applications: Use mineral fibre insulation of thicknesses indicated in insulation schedule for both concealed and exposed areas unless noted otherwise, on the following:
- .1 All domestic hot and cold water piping, except for run-outs to fixtures.

2.11 FLEXIBLE ELASTOMERIC PIPE INSULATION

- .1 For refrigerant suction and hot gas lines throughout, 12 mm thickness for suction lines 1.7°C and above and smaller than 65 mm dia., 19 mm thickness on all other lines.
- .2 Materials to comply with ASTM C534/C534M.
- .3 Attach using quick-setting contact adhesive along seams and joints, as recommended by insulation manufacturer.
- .4 All joints to be covered with self-adhesive PVC tape as recommended by the insulation manufacturer.

- .5 Use appropriate products where exposed to sunlight to avoid UV deterioration.

2.12 EQUIPMENT INSULATION

- .1 Includes valves, valve bonnets, strainers, flanges and fittings unless otherwise specified.
- .2 Hot Equipment:
 - .1 Hot Curved Surfaces 20 °C to 400 °C.
 - .1 Mineral fibre blanket, thermal resistivity of 28 to 32 m. °C/W, with wire or bands and 13 mm cement reinforced with one layer of reinforcing mesh.
 - .2 Thicknesses: 50 mm.
 - .2 Hot Flat Surfaces 20 to 400 °C.
 - .1 Mineral fibre board, thermal resistivity of 28 to 32m. °C/W, with wire or bands and 13 mm cement reinforced with one layer of reinforcing mesh.
 - .2 Thicknesses: 50 mm.
- .3 Fastenings.
 - .1 Tape: self adhesive, 100 mm wide.
 - .2 Contact adhesive, quick setting.
 - .3 Lap seal adhesive: quick setting for joints and lap sealing of vapour barriers.
 - .4 Canvas:
 - .1 Washable adhesive for cementing canvas lagging cloth to equipment insulation.
- .4 Jackets:
 - .1 Application:
 - .1 Exposed in mechanical room, and elsewhere.
 - .2 Materials: ULC listed, plain weave, cotton fabric at 220 g/m2.
 - .2 TIAC code A-1 or C-1.
 - .3 TIAC code C-2 unfaced with wire or bands and 13 mm cement precede by one layer of reinforcing mesh.
 - .1 Thicknesses:
 - .1 Domestic hot water storage tanks: 25 mm.

2.13 WEATHERPROOF CAULKING

- .1 At flashings, wherever barrier joint is required, and at expansion joints, provide silicone based heat resistant caulking, set into fabric reinforcing cloth extending 75 mm each side of caulk line.

2.14 PIPING COMPONENTS

- .1 On all fittings and elbows build up ends of insulation on piping with segmented, preformed pipe insulation cut to same thickness as adjoining pipe insulation. This also applies to flanged piping connector systems, if installed.

- .2 Vapour seal ends of insulation with pressure sensitive vapour barrier adhesive and poly-ethylene tapes.
- .3 Fasteners: stainless steel or aluminum insulation straps for all piping.
- .4 For bell and spigot flanges, shape to fit over and provide minimum 12 mm cover over bell using insulation thickness indicated in schedule.

PART 3 EXECUTION

3.1 MANUFACTURER'S INSTRUCTIONS

- .1 Compliance: comply with manufacturer's written recommendations or specifications, including product technical bulletins, handling, storage and installation instructions, and datasheet.

3.2 PRE-INSTALLATION REQUIREMENT

- .1 Pressure testing of piping systems and adjacent equipment to be complete, witnessed and certified.
- .2 Surfaces clean, dry, free from foreign material.

3.3 INSTALLATION

- .1 Install in accordance with TIAC National Standards.
- .2 Apply materials in accordance with manufacturer's instructions and this specification so that the finished job is uniform in diameter and smooth in finish.
- .3 Use two layers with staggered joints when required nominal wall thickness exceeds 75 mm.
- .4 Maintain uninterrupted continuity and integrity of vapour retarder jacket and finishes.
 - .1 Install hangers, supports outside vapour retarder jacket.
- .5 Supports, Hangers:
 - .1 Apply high compressive strength insulation, suitable for service, at oversized saddles and shoes where insulation saddles have not been provided.
- .6 Mitre insulation at elbows and cover joints with tape.
- .7 Insulation and vapour barrier shall be continuous where services pass through walls and floors.

- .8 Pack spaces between sleeves and pipe covering with insulation. Packing shall extend the full length of the sleeve, and be finished at both ends with caulking compound.

3.4 REMOVABLE, PRE-FABRICATED, INSULATION AND ENCLOSURES

- .1 Application: at expansion joints, valves, primary flow measuring elements, flanges and unions at equipment.
- .2 Design: to permit movement of expansion joint and to permit periodic removal and replacement without damage to adjacent insulation.
- .3 Insulation:
 - .1 Insulation, fastenings and finishes: same as system.
 - .2 Jacket: PVC, aluminum.

3.5 INSTALLATION OF ELASTOMERIC INSULATION

- .1 Insulation to remain dry. Overlaps to manufacturer's instructions. Ensure tight joints.
- .2 Provide vapour retarder as recommended by manufacturer.

3.6 PIPING INSULATION SCHEDULES

- .1 Includes valves, valve bonnets, strainers, flanges and fittings unless otherwise specified.
- .2 TIAC Code: A-1.
 - .1 Securements: SS bands at 300 mm on centre.
 - .2 Seals: lap seal adhesive, lagging adhesive.
 - .3 Installation: TIAC Code 1501-H.
- .3 TIAC Code: A-3.
 - .1 Securements: SS bands at 300 mm on centre.
 - .2 Seals: VR lap seal adhesive, VR lagging adhesive.
 - .3 Installation: TIAC Code: 1501-C.
- .4 TIAC Code: A-6.
 - .1 Insulation securements: ss bands.
 - .2 Seals: lap seal adhesive, lagging adhesive.
- .5 TIAC Code: C-2 with vapour retarder jacket.
 - .1 Insulation securements: ss bands.
 - .2 Seals: lap seal adhesive, lagging adhesive.

.3 Installation: TIAC Code: 1501-C.

.6 Thickness of insulation as listed in following table.

.1 Run-outs to individual units and equipment not exceeding 4000 mm long.

.2 Do not insulate exposed runouts to plumbing fixtures, chrome plated piping.

Application	Temp degrees C	TIAC code	Pipe sizes (NPS) and insulation thickness (mm)					
			Run out	to 1	1 ¼ to 2	2 ½ to 4	5 to 6	8& over
Domestic HWS		A-1	25	25	25	38	38	38
Domestic HWR		A-1	25	25	25	38	38	38
Domestic CWS		A-3	25	25	25	25	25	25
Refrigerant hot gas liquid suction	4 - 13	A-6	19	19	19	19	19	19
Refrigerant hot gas liquid suction	below 4	A-6	19	19	19	19	19	19
Cooling Coil cond. drain		C-2	25	25	25	25	25	25

.7 Finishes:

.1 Exposed indoors: canvas jacket.

.2 Exposed in mechanical rooms: PVC jacket.

.3 Concealed, indoors: canvas on valves, fittings. No further finish.

.4 Use vapour retarder jacket on TIAC code A-3 insulation compatible with insulation.

.5 Outdoors: water-proof aluminum jacket.

.6 Finish attachments: SS bands, at 150 mm on centre. Seals: wing.

.7 Installation: to appropriate TIAC code CRF/1 through CPF/5.

3.7 BARRIER-FREE ACCESSIBLE FIXTURES

.1 Insulate hot and cold water and drain lines exposed below barrier-free plumbing fixtures.

.2 Insulation to be pre-formed resilient molded PVC or vinyl.

3.8 CLEANING

- .1 Proceed in accordance with Section 01 74 11 - Cleaning.
- .2 Upon completion and verification of performance of installation, remove surplus materials, excess materials, rubbish, tools and equipment.

PART 1 GENERAL1.1 RELATED SECTIONS

- .1 Section 22 42 01 - Plumbing Specialties and Accessories.
- .2 Section 23 05 93 - Testing, Adjusting and Balancing for HVAC.

1.2 REFERENCES

- .1 American Society for Testing and Materials International (ASTM)
 - .1 ASTM E202-12, Standard Test Methods for Analysis of Ethylene Glycols and Propylene Glycols.

1.3 POTABLE WATER SYSTEMS

- .1 When cleaning is completed and system filled:
 - .1 Verify performance of equipment and systems as specified elsewhere in Division 23 and Division 22.
 - .2 Check for proper operation of water hammer arrestors. Run one outlet for 10 seconds, then shut of water immediately. If water hammer occurs, replace water hammer arrestor or recharge air chambers. Repeat for each outlet and flush valve.
 - .3 Confirm water quality consistent with supply standards, verifying that no residuals remain resulting from flushing and/or cleaning.

1.4 SANITARY AND STORM DRAINAGE SYSTEMS

- .1 Buried systems: perform tests prior to back-filling. Perform hydraulic tests to verify grades and freedom from obstructions.
- .2 Ensure that traps are fully and permanently primed.
- .3 Ensure that fixtures are properly anchored, connected to system.
- .4 Operate flush valves and operate each fixture to verify drainage and no leakage.
- .5 Cleanouts: refer to Section 22 42 01 - Plumbing Specialties and Accessories.

PART 2 PRODUCTS

2.1 NOT USED

.1 Not Used.

PART 3 EXECUTION

3.1 NOT USED

.1 Not Used.

PART 1 GENERAL

1.1 RELATED SECTIONS

- .1 Section 21 05 01 - Common Work Results for Mechanical.
- .2 Section 23 05 05 - Installation of Pipework.
- .3 Section 23 05 29 - Hangers and Supports for HVAC Piping and Equipment.
- .4 Section 23 07 15 - Thermal Insulation for Piping and Equipment.
- .5 Section 23 82 22 - Packaged Air Cooled Split Air Conditioning Units.

1.2 REFERENCES

- .1 American National Standards Institute (ANSI)
 - .1 ANSI/AHRI 495-2005, Performance Rating of Refrigerant Liquid Receivers.
 - .2 ANSI/AHRI 700-2012, Specification for Fluorocarbon Refrigerants.
 - .3 ANSI/AHRI 710-2009, Performance Rating of Liquid-Line Driers.
- .2 American Society of Mechanical Engineers (ASME)
 - .1 ASME B16.22-2012, Wrought Copper and Copper Alloy Solder-Joint Pressure Fittings.
 - .2 ASME B16.24-2011, Cast Copper Alloy Pipe Flanges and Flanged Fittings: Class 150, 300, 600, 900, 1500 and 2500.
 - .3 ASME B16.26-2011, Cast Copper Alloy Fittings for Flared Copper Tubes.
 - .4 ASME B16.34-2013, Valves - Flanged, Threaded and Welding End.
 - .5 ASME B31.5-2013, Refrigeration Piping and Heat Transfer Components.
- .3 American Society for Testing and Materials International (ASTM)
 - .1 ASTM A307-12, Standard Specification for Carbon Steel Bolts, Studs, and Threaded Rod 60,000 PSI Tensile Strength.
 - .2 ASTM B280-13, Standard Specification for Seamless Copper Tube for Air Conditioning and Refrigeration Field Service.
- .4 Canadian Standards Association (CSA International)
 - .1 CSA B52-05(R2009), Mechanical Refrigeration Code.
- .5 Environment Canada (EC)
 - .1 EPS 1/RA/1-96, Environmental Code of Practice for the Elimination of Fluorocarbon Emissions from Refrigeration and Air Conditioning Systems.
- .6 Health Canada / Workplace Hazardous Materials Information System (WHMIS)
 - .1 Material Safety Data Sheets (MSDS).

1.3 SUBMITTALS

- .1 Submittals in accordance with Section 01 33 00 - Submittal Procedures.
- .2 Shop drawings:
 - .1 Submit manufacturer's printed product literature, specifications and datasheet for piping, fittings and equipment.
 - .2 Submit shop drawings in accordance with Section 21 05 01 - Common Work Results for Mechanical for all equipment supplied under this Section, including:
 - .1 Valves.
 - .2 Piping schematics, with sizes indicated.
- .3 Test Reports: submit certified test reports from approved independent testing laboratories indicating compliance with specifications for specified performance characteristics and physical properties.
- .4 Certificates: submit certificates signed by manufacturer certifying that materials comply with specified performance characteristics and physical properties.
- .5 Instructions: submit manufacturer's installation instructions.
- .6 Closeout submittals: submit maintenance and engineering data for incorporation into manual specified in Section 01 78 00 - Closeout Submittals.

1.4 QUALIFICATIONS

- .1 Installation shall be performed by refrigeration mechanics/technicians certified in the Province of Ontario.

1.5 QUALITY ASSURANCE

- .1 Health and Safety:
 - .1 Do construction occupational health and safety in accordance with Section 01 35 29.06 - Health and Safety Requirements.

1.6 DELIVERY, STORAGE AND HANDLING

- .1 Waste Management and Disposal:
 - .1 Remove from site and dispose of packaging materials at appropriate recycling facilities.
 - .2 Collect and separate for disposal paper, plastic, polystyrene and corrugated cardboard packaging material in appropriate on-site bins for recycling in accordance with Waste Reduction Workplan.
 - .3 Separate for reuse and recycling and place in designated containers Steel, Metal, Plastic waste in accordance with Waste Reduction Workplan.

- .4 Divert unused metal materials from landfill to metal recycling facility as approved by Departmental Representative.

PART 2 PRODUCTS

2.1 TUBING

- .1 Processed for refrigeration installations, deoxidized, dehydrated and sealed.
 - .1 Hard copper: to ASTM B280, type ACR.
 - .2 Annealed copper: to ASTM B280, with minimum wall thickness as per CSA B52 and ASME B31.5.

2.2 FITTINGS

- .1 Service: design pressure 2070 kPa and temperature 121 °C.
- .2 Brazed:
 - .1 Fittings: wrought copper to ANSI/ASME B16.22.
 - .2 Joints: silver solder, 15% Ag-80% Cu-5%P or copper-phosphorous, 95% Cu-5%P and non-corrosive flux.
- .3 Flanged:
 - .1 Bronze or brass, to ANSI/ASME B16.24, Class 150 and Class 300.
 - .2 Gaskets: suitable for service.
 - .3 Bolts, nuts and washers: to ASTM A307, heavy series.
- .4 Flared:
 - .1 Bronze or brass, for refrigeration, to ASME B16.26.
- .5 Long radius type for elbows and return bends.
- .6 Flexible connections: 10 mm nominal or less shall be made using coiled soft copper tubing. For larger sizes, use seamless flexible bronze hose with bronze wire braid covering. Use factory sealed neoprene jacket unit where freezing may occur.

2.3 PIPE SLEEVES

- .1 Hard copper or steel, sized to provide 6 mm clearance around between sleeve and uninsulated pipe or between sleeve and insulation.

2.4 VALVES

- .1 22 mm and under: Class 500, 3.5 Mpa, globe or angle non-directional type, diaphragm, packless type, with forged brass body and bonnet, moisture proof seal for below freezing applications, brazed connections.

- .2 Over 22 mm: Class 375, 2.5 Mpa, globe or angle type, diaphragm, packless type, back-seating, cap seal, with cast bronze body and bonnet, moisture proof seal for below freezing applications, brazed connections.
- .3 Stop valves:
 - .1 22 mm nominal od or less shall be diaphragm packless type with integral mounting bracket, forged brass bodies and bonnets, globe and angle, non-directional type.
 - .2 28 mm nominal od or larger shall be heavy globe or angle body, positive sealing, self aligning, heavy nylon disc.
 - .3 Purge, drain, charging, angle or globe type with flare or brazing type outlet connection shall have stem for socket wrench and removable seal cap.

2.5 SIGHT GLASS

- .1 Provide moisture indicating, double sight glass:
 - .1 Upstream from expansion valve.
 - .2 Near receiver outlet.
 - .3 Elsewhere as indicated.

PART 3 EXECUTION

3.1 MANUFACTURER'S INSTRUCTIONS

- .1 Compliance: comply with manufacturer's written recommendations or specifications, including product technical bulletins, handling, storage and installation instructions, and datasheet.

3.2 GENERAL

- .1 Install in accordance with CSA B52, EPS 1/RA/1 and ASME B31.5 and Section 23 05 05 - Installation of Pipework.
- .2 Install systems and related controls in accordance with reviewed shop drawings.

3.3 INSPECTION

- .1 Upon delivery, inspect components for damage or gas loss and report to Departmental Representative in writing.

3.4 ACCESSIBILITY

- .1 Provide clearance around all equipment and components for observation of operation, inspection, service and maintenance without removal of any equipment, components or piping.
- .2 Install access doors in equipment and ducts, and as necessary to provide accessibility.

3.5 BRAZING PROCEDURES

- .1 Bleed inert gas into pipe during brazing.
- .2 Remove valve internal parts, solenoid valve coils, sight glass.
- .3 Do not apply heat near expansion valve and bulb.

3.6 PIPING INSTALLATION

- .1 General:
 - .1 Soft annealed copper tubing: bend without crimping or constriction. Hard drawn copper tubing: do not bend. Minimize use of fittings.
- .2 Hot gas lines:
 - .1 Pitch at least 1:240 down in direction of flow to prevent oil return to compressor during operation or as directed by manufacturer.
 - .2 Provide trap at base of risers greater than 2400mm high and at each 7600mm thereafter.
 - .3 Provide inverted deep trap at top of risers.
 - .4 Provide double risers for compressors having capacity modulation.
 - .1 Large riser: install traps as specified.
 - .2 Small riser: size for 5.1 m/s at minimum load. Connect upstream of traps on large riser.
- .3 Piping:
 - .1 Clean and purge refrigerant lines and fittings.
 - .2 When multiple runs are installed, spread pipes 150 mm minimum to allow for expansion and contraction.
 - .3 Install straight, parallel and close to walls and ceilings, with specified pitch.
 - .4 Keep elbows and fittings to minimum.
 - .5 Correlate equipment provided with Departmental Representative and propose changes to line sizing required, before proceeding with installation.
 - .6 Locate double risers in hot gas or suction piping as indicated.

.7 Install piping to prevent condensate or oil from flowing back into compressor or evaporator. Locate suction accumulator in suction line between evaporator and compressor.

.8 Connect branch suction lines from top of suction main using wye fitting. Install ancillaries and accessories such as back pressure compensating regulators and back pressure regulators horizontal.

.9 Enclose tubing exposed to mechanical injury in rigid or flexible conduit.

.10 Keep piping joints sealed except when fabricating.

.11 Limit breakable joints to equipment connections not normally brazed. Limit flared joints to 10 mm nominal outside diameter for field assembly and 16 mm nominal outside diameter for factory assembly.

3.7 PRESSURE AND LEAK TESTING

.1 Close valves on factory charged equipment and other equipment not designed for test pressures.

.2 Leak test to CSA B52 before evacuation to 2 MPa and 1 MPa on high and low sides respectively.

.3 Test Procedure: build pressure up to 35 kPa with refrigerant gas on high and low sides. Supplement with nitrogen to required test pressure. Test for leaks with electronic or halide detector. Repair leaks and repeat tests.

3.8 PIPE INSULATION

.1 Insulate pipework upon successful pressure testing witnessed and approved by the Departmental Representative (not before). Refer to Section 23 07 15 - Thermal Insulation for Piping and Equipment for requirements.

3.9 FIELD QUALITY CONTROL

.1 Site Tests/Inspection:

.1 Close service valves on factory charged equipment.

.2 Ambient temperatures to be at least 13°C for at least 12 hours before and during dehydration.

.3 Use copper lines of largest practical size to reduce evacuation time.

.4 Use two-stage vacuum pump with gas ballast on 2nd stage capable of pulling 5Pa absolute and filled with dehydrated oil.

.5 Measure system pressure with vacuum gauge. Take readings with valve between vacuum pump and system closed.

-
- .6 Triple evacuate system components containing gases other than correct refrigerant or having lost holding charge as follows:
 - .1 Twice to 14 Pa absolute and hold for 4 h.
 - .2 Break vacuum with refrigerant to 14 kPa.
 - .3 Final to 5 Pa absolute and hold for at least 12 h.
 - .4 Isolate pump from system, record vacuum and time readings until stabilization of vacuum.
 - .5 Submit test results to Departmental Representative.
 - .7 Charging:
 - .1 Charge system through filter-drier and charging valve on high side. Low side charging not permitted.
 - .2 With compressors off, charge only amount necessary for proper operation of system. If system pressures equalize before system is fully charged, close charging valve and start up. With unit operating, add remainder of charge to system.
 - .3 Re-purge charging line if refrigerant container is changed during charging process.
 - .8 Checks:
 - .1 Make checks and measurements as per manufacturer's operation and maintenance instructions.
 - .2 Record and report measurements to Departmental Representative.
 - .9 Manufacturer's Field Services:
 - .1 Have manufacturer of products, supplied under this Section, review Work involved in the handling, installation/application, protection and cleaning, of its products and submit written reports, in acceptable format, to verify compliance of Work.
 - .2 Provide manufacturer's field services consisting of product use recommendations and periodic site visits for inspection of product installation in accordance with manufacturer's instructions.
 - .3 Schedule site visits, to review Work, at stages listed:
 - .1 After delivery and storage of products, and when preparatory Work, or other Work, on which the Work of this Section depends, is complete but before installation begins.
 - .2 Twice during progress of Work at 25% and 60% complete.
 - .3 Upon completion of the Work, after cleaning is carried out.
 - .4 Obtain reports, within 3 days of review, and submit, immediately, to Departmental Representative.

3.10 DEMONSTRATION

- .1 Instructions:
 - .1 Post instructions in frame with glass cover in accordance with Section 01 78 00 - Closeout Submittals and CSA B52.

3.11 **CLEANING**

- .1 Perform cleaning operations as specified in Section 01 74 11 and in accordance with manufacturer's recommendations.
- .2 On completion and verification of performance of installation, remove surplus materials, excess materials, rubbish, tools and equipment.

PART 1 GENERAL

1.1 RELATED SECTIONS

- .1 Section 21 05 01 - Common Work Results for Mechanical.
- .2 Section 23 05 29 - Hangers and Supports for HVAC Piping and Equipment.
- .3 Section 23 07 13 - Duct Thermal Insulation.
- .4 Section 23 33 00 - Air Duct Accessories.
- .5 Section 23 33 14 - Dampers - Balancing.

1.2 REFERENCES

- .1 American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc. (ASHRAE).
- .2 American Society for Testing and Materials International (ASTM)
 - .1 ASTM A480/A480M-13, Standard Specification for General Requirements for Flat-Rolled Stainless and Heat-Resisting Steel Plate, Sheet and Strip.
 - .2 ASTM A635/A635M-09b, Standard Specification for Steel, Sheet and Strip, Heavy-Thickness Coils, Hot-Rolled, Alloy, Carbon, Structural, High-Strength Low-Alloy, and High-Strength Low-Alloy with Improved Formability, General Requirements for.
 - .3 ASTM A653/A653M-11, Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process.
- .3 Department of Justice Canada (Jus).
 - .1 Canadian Environmental Protection Act (CEPA), 1999, c. 33.
- .4 Health Canada/Workplace Hazardous Materials Information System (WHMIS).
 - .1 Material Safety Data Sheets (MSDS).
- .5 National Fire Protection Association (NFPA).
 - .1 NFPA 90A-2012, Standard for the Installation of Air-Conditioning and Ventilating Systems.
 - .2 NFPA 90B-2012, Standard for the Installation of Warm Air Heating and Air-Conditioning Systems.
- .6 Sheet Metal and Air Conditioning Contractors' National Association (SMACNA).
 - .1 SMACNA HVAC Duct Construction Standards - Metal and Flexible, 2005, 3rd Edition.
 - .2 SMACNA HVAC Air Duct Leakage Test Manual, 2012, 2nd Edition.

- .7 Transport Canada (TC).
 - .1 Transportation of Dangerous Goods Act (TDGA), 1992, c. 34.

1.3 SUBMITTALS

- .1 Submit shop drawings in accordance with Section 01 33 00 - Submittal Procedures for the following:
 - .1 Sealants.
 - .2 Tape.
 - .3 Proprietary joints.
- .2 Submit fabrication/interference drawings in accordance with Section 21 05 01 - Common Work Results for Mechanical.

1.4 QUALITY ASSURANCE

- .1 Certification of Ratings:
 - .1 Catalogue or published ratings shall be those obtained from tests carried out by manufacturer or independent testing agency signifying adherence to codes and standards.
- .2 Health and Safety:
 - .1 Do construction occupational health and safety in accordance with Section 01 35 29.06 - Health and Safety Requirements.
- .3 Duct sealing and taping mock-up: prepare a mock-up of duct taping and sealing to the approval of the Departmental Representative. Duct sealing and taping is to be neat as it will generally be exposed.
- .4 Collection ductwork/diffuser mock-up: mock-up linear 8 m of round ductwork and diffusers, suspensions and support, and neat duct joint sealing in a location agreed with the Departmental Representative. Mock-up may become part of work once approved by the Departmental Representative. Approved mock-up sets the standard for the project.

1.5 DELIVERY, STORAGE AND HANDLING

- .1 Protect on site stored or installed absorptive material from moisture damage.
- .2 Waste Management and Disposal:
 - .1 Separate waste materials for reuse and recycling in accordance with Section 01 74 21 - Construction/Demolition Waste Management and Disposal.
 - .2 Remove from site and dispose of packaging materials at appropriate recycling facilities.

- .3 Collect and separate for disposal paper, plastic, polystyrene and corrugated cardboard packaging material in appropriate on-site bins for recycling in accordance with Waste Reduction Workplan.
- .4 Separate for reuse and recycling and place in designated containers Steel, Metal, Plastic waste in accordance with Waste Reduction Workplan.
- .5 Place materials defined as hazardous or toxic in designated containers.
- .6 Handle and dispose of hazardous materials in accordance with Regional and Municipal regulations.
- .7 Fold up metal and plastic banding, flatten and place in designated area for recycling.

PART 2 PRODUCTS

2.1 LOW PRESSURE DUCTWORK

- .1 Fabricate and install low pressure sheet metal ductwork and fittings in accordance with ASHRAE "Equipment" Manual, latest edition, Chapter 1 "Duct Construction" and SMACNA Low Pressure Duct Construction standards.
- .2 Round ductwork to be spirally formed. Longitudinal seamed duct sections are not acceptable.
- .3 Spiral duct, fittings and accessories to be factory-fabricated.

2.2 SEAL CLASSIFICATION

- .1 Classification as follows:

Maximum Pressure Pa	SMACNA Seal Class
500	C
250	C
125	C

- .2 Seal classification:
 - .1 Class A: longitudinal seams, transverse joints, duct wall penetrations and connections made airtight with sealant and tape.
 - .2 Class B: longitudinal seams, transverse joints and connections made airtight with sealant tape or combination thereof.
 - .3 Class C: transverse joints and connections made air tight with sealant and tape. Longitudinal seams unsealed.

2.3 SEALANT

- .1 Sealant: oil resistant, water borne, polymer type flame resistant duct sealant. Temperature range of minus 30°C to plus 93°C.

- .2 All low pressure duct joints to be sealed. This applies to all supply, return, outdoor air and exhaust air ductwork.

2.4 TAPE

- .1 Tape: polyvinyl treated, open weave fiberglass tape, 50 mm wide.

2.5 DUCT LEAKAGE

- .1 In accordance with SMACNA HVAC Air Duct Leakage Test Manual.

2.6 FITTINGS

- .1 Fabrication: to SMACNA.
- .2 Radiused elbows.
 - .1 Rectangular: standard radius. Centreline radius: 1.5 times width of duct.
 - .2 Round: smooth radius five piece. Centreline radius: 1.5 times diameter.
- .3 Mitred elbows, rectangular:
 - .1 To 400 mm: with double thickness turning vanes.
 - .2 Over 400 mm: with double thickness turning vanes.
 - .3 Use mitred elbows in locations indicated, and/or where a radiused elbow will not fit into space available.
- .4 Branches:
 - .1 Rectangular main and branch: with radius on branch 1.5 times width of duct or 45 degrees entry on branch.
 - .2 Round main and branch: enter main duct at 45 degrees with conical connection.
 - .3 Provide volume control damper in branch duct near connection to main duct.
 - .4 Main duct branches: with splitter damper.
- .5 Transitions:
 - .1 Diverging: 20 degrees maximum included angle.
 - .2 Converging: 30 degrees maximum included angle.
- .6 Offsets:
 - .1 Short radiused elbows.
- .7 Obstruction deflectors: maintain full cross-sectional area.
 - .1 Maximum included angles: as for transitions.

2.7 FIRE STOPPING

- .1 Fire stopping material and installation must not distort duct.

2.8 GALVANIZED STEEL

- .1 Lock forming quality: to ASTM A653/A653M, Z90 zinc coating.
- .2 Thickness, fabrication and reinforcement: to SMACNA.
- .3 Joints: to SMACNA.

2.9 HANGERS AND SUPPORTS

- .1 Hangers and Supports: in accordance with Section 23 05 29 - Hangers and Supports for HVAC Piping and Equipment.
 - .1 Strap hangers: of same material as duct but next sheet metal thickness heavier than duct.
 - .1 Maximum size duct supported by strap hanger: 500.
 - .2 Hanger configuration: to ASHRAE and SMACNA.
 - .3 Hangers: galvanized steel angle with lack galvanized steel rods to following table:

Duct Size (mm)	Angle Size (mm)	Rod Size (mm)
up to 750	25 x 25 x 3	6
751 to 1050	40 x 40 x 3	6
1051 to 1500	40 x 40 x 3	10
1501 to 2100	50 x 50 x 3	10
2101 to 2400	50 x 50 x 5	10
2401 and over	50 x 50 x 6	10

- .4 Upper hanger attachments:
 - .1 For steel joist: manufactured joist clamp.
 - .2 For steel beams: manufactured beam clamps.

PART 3 EXECUTION

3.1 GENERAL

- .1 Do work in accordance with SMACNA.
- .2 Do not break continuity of insulation vapour barrier with hangers or rods.
 - .1 Insulate strap hangers 100 mm beyond insulated duct.
- .3 Support risers in accordance with SMACNA.

- .4 Install breakaway joints in ductwork on sides of fire separation.
- .5 Manufacture duct in lengths and diameter to accommodate installation of acoustic duct lining.
- .6 Coordinate ductwork installation. Optimize ceiling space in suspended ceilings and maintain maximum headroom under exposed ducts. Provide detailed fabrication drawings for problem areas when requested by Departmental Representative.
- .7 Anchor riser ducts at floor slabs.
- .8 Where firestopping is required, provide retaining angles all around duct on both sides of fire separation, and pack around duct with fire-stopping material without distorting duct.

3.2 HANGERS

- .1 Strap hangers: install in accordance with SMACNA.
- .2 Angle hangers: complete with locking nuts and washers.
- .3 Hanger spacing: in accordance with SMACNA or as follows:

Duct Size (mm)	Spacing (mm)
to 1500	3000
1501 and over	2500

- .4 Support flexible ductwork at 1.2 metre maximum centres.

3.3 SEALING AND TAPING

- .1 Apply sealant to outside of joint to manufacturer's recommendations.
- .2 Bed tape in sealant and recoat with minimum of one coat of sealant to manufacturer's recommendations.
- .3 This applies to all supply, return, outdoor air and exhaust ductwork.
- .4 Taping and sealing to be done neatly since much of ductwork will remain exposed. All taping and sealing is to be done to the standard set by the approved mock-up.

3.4 LEAKAGE TESTS

- .1 In accordance with SMACNA HVAC Duct Leakage Test Manual.

- .2 Do leakage tests in sections.
- .3 Make trial leakage tests as instructed by Departmental Representative to demonstrate workmanship.
- .4 Do not install additional ductwork until trial test has been passed.
- .5 Test section minimum of 30 m long with not less than three branch takeoffs and two 90 degrees elbows.
- .6 Complete test before performance insulation or concealment Work.

PART 1 GENERAL1.1 RELATED SECTIONS

- .1 Section 21 05 01 - Common Work Results for Mechanical.
- .2 Section 23 31 13.01 - Metal Ducts - Low Pressure to 500 PA.

1.2 REFERENCES

- .1 Health Canada/Workplace Hazardous Materials Information System (WHMIS).
 - .1 Material Safety Data Sheets (MSDS).
- .2 Sheet Metal and Air Conditioning Contractors' National Association (SMACNA).
 - .1 SMACNA - HVAC Duct Construction Standards - Metal and Flexible, 2005, 3rd Edition.

1.3 SUBMITTALS

- .1 Submittals in accordance with Section 01 33 00 - Submittal Procedures.
- .2 Shop drawings:
 - .1 Submit manufacturer's printed product literature, specifications and data sheet. Indicate the following:
 - .1 Flexible connections.
 - .2 Duct access doors.
 - .3 Turning vanes.
 - .4 Instrument test ports.
- .3 Test Reports: submit certified test reports from approved independent testing laboratories indicating compliance with specifications for specified performance characteristics and physical properties.
 - .1 Certification of ratings: catalogue or published ratings to be those obtained from tests carried out by manufacturer or independent testing agency signifying adherence to codes and standards.
- .4 Certificates: submit certificates signed by manufacturer certifying that materials comply with specified performance characteristics and physical properties.
- .5 Instructions: submit manufacturer's installation instructions.
- .6 Manufacturer's Field Reports: manufacturer's field reports specified.
- .7 Closeout submittals: submit maintenance and engineering data for incorporation into manual specified in Section 01 78 00 - Closeout Submittals.

1.4 QUALITY ASSURANCE

- .1 Health and Safety:
 - .1 Do construction occupational health and safety in accordance with Section 01 35 29.06 - Health and Safety Requirements.

1.5 DELIVERY, STORAGE AND HANDLING

- .1 Waste Management and Disposal:
 - .1 Separate waste materials for reuse and recycling in accordance with Section 01 74 21 - Construction/Demolition Waste Management and Disposal.
 - .2 Remove from site and dispose of packaging materials at appropriate recycling facilities.
 - .3 Collect and separate for disposal paper, plastic, polystyrene and corrugated cardboard packaging material in appropriate on-site bins for recycling in accordance with Waste Reduction Workplan.
 - .4 Separate for reuse and recycling and place in designated containers Steel, Metal, Plastic waste in accordance with Waste Reduction Workplan.
 - .5 Divert unused metal materials from landfill to metal recycling facility as approved by Departmental Representative.

PART 2 PRODUCTS

2.1 GENERAL

- .1 Manufacture in accordance with SMACNA - HVAC Duct Construction Standards.

2.2 FLEXIBLE CONNECTIONS

- .1 Frame: galvanized sheet metal frame with fabric clenched by means of double locked seams.
- .2 Material:
 - .1 Fire resistant, self extinguishing, neoprene coated glass fabric, temperature rated at minus 40°C to plus 90°C , density of 1.3 kg/m².

2.3 ACCESS DOORS IN DUCTS

- .1 Non-Insulated Ducts: sandwich construction of same material as duct, one sheet metal thickness heavier, minimum 0.6 mm thick complete with sheet metal angle frame.

- .2 Insulated Ducts: sandwich construction of same material as duct, one sheet metal thickness heavier, minimum 0.6 mm thick complete with sheet metal angle frame and 25 mm thick rigid glass fibre insulation.
- .3 Gaskets: neoprene.
- .4 Hardware:
 - .1 Up to 300 x 300 mm: two sash locks complete with safety chain.
 - .2 301 to 450 mm: four sash locks complete with safety chain.
 - .3 451 to 1000 mm: piano hinge and minimum two sash locks.
 - .4 Doors over 1000 mm: piano hinge and two handles operable from both sides.
 - .5 Hold open devices.
 - .6 300 x 300 mm glass viewing panels.

2.4 TURNING VANES

- .1 Factory or shop fabricated double thickness with trailing edge, to recommendations of SMACNA and as indicated.
- .2 Vanes to be one metal gauge heavier than that used for duct elbow, constructed according to SMACNA Standards.

2.5 INSTRUMENT TEST

- .1 1.6 mm thick steel zinc plated after manufacture.
- .2 Cam lock handles with neoprene expansion plug and handle chain.
- .3 28 mm minimum inside diameter. Length to suit insulation thickness.
- .4 Neoprene mounting gasket.

2.6 SPIN-IN COLLARS

- .1 Conical galvanized sheet metal spin-in collars with lockable butterfly damper.
- .2 Sheet metal thickness to co-responding round duct standards.

PART 3 EXECUTION

3.1 MANUFACTURER'S INSTRUCTIONS

- .1 Compliance: comply with manufacturer's written recommendations or specifications, including product technical bulletins, handling, storage and installation instructions, and data sheet.

3.2 INSTALLATION

- .1 Flexible Connections:
 - .1 Install in following locations:
 - .1 Inlets and outlets to supply air units and fans.
 - .2 Inlets and outlets of exhaust and return air fans.
 - .3 As indicated.
 - .2 Length of connection: 100 mm.
 - .3 Minimum distance between metal parts when system in operation: 75 mm.
 - .4 Install in accordance with recommendations of SMACNA.
 - .5 When fan is running:
 - .1 Ducting on sides of flexible connection to be in alignment.
 - .2 Ensure slack material in flexible connection.
- .2 Access Doors and Viewing Panels:
 - .1 Size:
 - .1 600 x 600 mm for person size entry.
 - .2 300 x 300 mm for servicing entry.
 - .3 150 x 150 mm for viewing.
 - .4 As indicated.
 - .2 Provide doors to access and service all:
 - .1 Fire and smoke dampers.
 - .2 Control dampers.
 - .3 Devices requiring maintenance.
 - .4 Required by code.
 - .5 Humidifier dispersion tubes.
 - .6 Elsewhere as indicated.
 - .3 Provide doors for access to inspect and service all coils, controls, and other duct-mounted equipment.
- .3 Instrument Test Ports:
 - .1 General:
 - .1 Install in accordance with recommendations of SMACNA and in accordance with manufacturer's instructions.
 - .2 Locate to permit easy manipulation of instruments.
 - .3 Install insulation port extensions as required.
 - .4 Locations:
 - .1 For traverse readings:
 - .1 Ducted inlets to roof and wall exhausters.
 - .2 Inlets and outlets of other fan systems.
 - .3 Main and sub-main ducts.
 - .4 Openings to be at least 2.0 m from duct fittings. Other locations to allow proper balancing of HVAC systems.
 - .5 Provide openings at 150 mm centres across ducts in both directions.
 - .6 And as indicated.
 - .2 For temperature readings:
 - .1 At outside air intakes.

- .2 In mixed air applications in locations as approved by Departmental Representative.
 - .3 At inlet and outlet of coils.
 - .4 Downstream of junctions of two converging air streams of different temperatures.
 - .5 And as indicated.
- .4 Turning vanes:
 - .1 Install in accordance with recommendations of SMACNA and as indicated.
 - .2 Provide turning vanes in all mitred elbows, and other locations as indicated.

3.3 CLEANING

- .1 Perform cleaning operations as specified in Section 01 74 11 and in accordance with manufacturer's recommendations.
- .2 Upon completion and verification of performance of installation, remove surplus materials, excess materials, rubbish, tools and equipment.

PART 1 GENERAL1.1 RELATED SECTIONS

- .1 Section 21 05 01 - Common Work Results for Mechanical.
- .2 Section 23 31 13.01 - Metal Ducts - Low Pressure to 500 PA.

1.2 REFERENCES

- .1 Sheet Metal and Air Conditioning National Association (SMACNA)
 - .1 SMACNA HVAC Duct Construction Standards, Metal and Flexible, 2005, 3rd Edition.
- .2 Health Canada/Workplace Hazardous Materials Information System (WHMIS)
 - .1 Material Safety Data Sheets (MSDS).

1.3 SUBMITTALS

- .1 Shop drawings:
 - .1 Submit manufacturer's printed product literature, specifications and datasheet in accordance with Section 01 33 00 - Submittal Procedures. Include product characteristics, performance criteria, and limitations.
- .2 Quality assurance submittals: submit following in accordance with Section 01 33 00 - Submittal Procedures.
 - .1 Certificates: submit certificates signed by manufacturer certifying that materials comply with specified performance characteristics and physical properties.
 - .2 Instructions: submit manufacturer's installation instructions.

1.4 QUALITY ASSURANCE

- .1 Health and Safety Requirements:
 - .1 Do construction occupational health and safety in accordance with Section 01 35 29.06 - Health and Safety Requirements.

1.5 DELIVERY, STORAGE, AND HANDLING

- .1 Packing, shipping, handling and unloading:
 - .1 Deliver, store and handle in accordance with Section 01 61 00 - Common Product Requirements.

- .2 Waste Management and Disposal:
 - .1 Construction/Demolition Waste Management and Disposal: separate waste materials for reuse and recycling in accordance with Section 01 74 21- Construction/Demolition Waste Management and Disposal.

PART 2 PRODUCTS

2.1 GENERAL

- .1 Manufacture to SMACNA standards.

2.2 SINGLE BLADE DAMPERS

- .1 Fabricate from same material as duct, but one sheet metal thickness heavier. V-groove stiffened.
- .2 Size and configuration to recommendations of SMACNA, except maximum height 100 mm as indicated.
- .3 Locking quadrant with shaft extension to accommodate insulation thickness.
- .4 Inside and outside nylon end bearings.
- .5 Channel frame of same material as adjacent duct, complete with angle stop.

2.3 MULTI-BLADED DAMPERS

- .1 Factory manufactured of material compatible with duct.
- .2 Opposed blade: configuration, metal thickness and construction to recommendations of SMACNA.
- .3 Maximum blade height: 100 mm as indicated.
- .4 Bearings: self-lubricating nylon.
- .5 Linkage: shaft extension with locking quadrant.
- .6 Channel frame of same material as adjacent duct, complete with angle stop.

PART 3 EXECUTION**3.1 MANUFACTURER'S INSTRUCTIONS**

- .1 Compliance: comply with manufacturer's written recommendations or specifications, including product technical bulletins, handling, storage and installation instructions, and datasheet.

3.2 INSTALLATION

- .1 Install where indicated.
- .2 Install in accordance with recommendations of SMACNA and in accordance with manufacturer's instructions.
- .3 Locate balancing dampers in each branch duct, for supply, return and exhaust systems.
- .4 Runouts to registers and diffusers: install single blade damper located as close as possible to main ducts.
- .5 Dampers: vibration free.
- .6 Ensure damper operators are observable and accessible.
- .7 Corrections and adjustments conducted by Departmental Representative.
- .8 Use single blade dampers up to and including 300 mm duct, multi-blade opposed patterns above 300 mm duct dimension.

3.3 CLEANING

- .1 Proceed in accordance with Section 01 74 11 - Cleaning.
- .2 Upon completion and verification of performance of installation, remove surplus materials, excess materials, rubbish, tools and equipment.

PART 1 GENERAL1.1 RELATED SECTIONS

- .1 Section 21 05 01 - Common Work Results for Mechanical.
- .2 Section 23 33 00 - Air Duct Accessories.

1.2 REFERENCES

- .1 National Fire Protection Association (NFPA)
 - .1 NFPA 90A-2012, Standard for the Installation of Air Conditioning and Ventilating Systems.
- .2 Health Canada/Workplace Hazardous Materials Information System (WHMIS)
 - .1 Material Safety Data Sheets (MSDS).
- .3 Sheet Metal and Air Conditioning Contractors' National Association (SMACNA)
 - .1 SMACNA Fire, Smoke and Radiation Damper Installation Guide for HVAC Systems, 5th Edition, 2002.
- .4 Underwriters Laboratories of Canada (ULC)
 - .1 CAN/ULC-S112-10, Standard Method of Fire Test of Fire Damper Assemblies.
 - .2 CAN/ULC-S112.2-07, Standard Method of Fire Test of Ceiling Firestop Flap Assemblies.
 - .3 CAN/ULC-S505-2002, Fusible Links for Fire Protection Services.

1.3 SUBMITTALS

- .1 Shop drawings:
 - .1 Submit manufacturer's printed product literature, specifications and datasheet in accordance with Section 01 33 00 - Submittal Procedures. Include product characteristics, performance criteria, and limitations.
 - .2 Indicate the following:
 - .1 Fire dampers.
 - .2 Operators.
 - .3 Fusible links.
 - .4 Design details of break-away joints.
- .2 Quality assurance submittals: submit following in accordance with Section 01 33 00 - Submittal Procedures.
 - .1 Certificates: submit certificates signed by manufacturer certifying that materials comply with specified performance characteristics and physical properties.

.2 Instructions: submit manufacturer's written installation instructions for each type of fire damper and installation configuration.

.3 Closeout Submittals:

.1 Provide maintenance data for incorporation into manual specified in Section 01 78 00 - Closeout Submittals.

1.4 QUALITY ASSURANCE

.1 Health and Safety Requirements: do construction occupational health and safety in accordance with Section 01 35 29.06 - Health and Safety Requirements.

.2 Certificates:

.1 Catalogue or published ratings those obtained from tests carried out by manufacturer or those ordered by manufacturer from independent testing agency signifying adherence to codes and standards.

1.5 DELIVERY, STORAGE, AND HANDLING

.1 Packing, shipping, handling and unloading:

.1 Deliver, store and handle in accordance with Section 01 61 00 - Common Product Requirements.

.2 Deliver, store and handle materials in accordance with manufacturer's written instructions.

.2 Waste Management and Disposal:

.1 Construction/Demolition Waste Management and Disposal: separate waste materials for reuse and recycling in accordance with Section 01 74 21 - Construction/Demolition Waste Management and Disposal.

PART 2 PRODUCTS

2.1 FIRE DAMPERS

.1 Fire dampers: listed and bear label of ULC, Warnock Hersey, meet requirements of provincial fire authority and ANSI/NFPA 90A. Fire damper assemblies fire tested in accordance with CAN/ULC-S112.

.2 Galvanized steel construction, Type B with blade held entirely out of the airstream unless otherwise indicated.

.3 Mild steel, factory fabricated for fire rating requirement to maintain integrity of fire wall and/or fire separation.

- .4 Fire dampers: 45 minute fire damper rating for installation in fire separations having a fire rating of 45 minutes and 1 hour. 1 hour fire damper rating for installation in fire separations having a fire rating of 1.5 hours. All of the above per NBC.
- .5 Fire dampers: automatic operating type and have dynamic rating suitable for maximum air velocity and pressure differential to which it will be subjected.
- .6 Top hinged: offset single damper, round or square; multi-blade hinged or interlocking type; guillotine type; sized to maintain full duct cross section as indicated.
- .7 Fusible link actuated, weighted to close and lock in closed position when released or having negator-spring-closing operator for multi-leaf type in horizontal position with vertical air flow.
- .8 40 x 40 x 3 mm retaining angle iron frame, on full perimeter of fire damper, on both sides of fire separation being pierced.
- .9 Equip fire dampers with steel sleeve or frame installed so as not to cause disruption to ductwork or impair damper operation.
- .10 Equip sleeves or frames with perimeter mounting angles attached on both sides of wall or floor opening. Construct ductwork in fire-rated floor-ceiling or roof-ceiling assembly systems with air ducts that pierce ceiling to conform with ULC.
- .11 Design and construct dampers to not reduce duct or air transfer opening cross-sectional area.
- .12 Dampers shall be installed so that the centerline of the damper depth or thickness is located in the centerline of the wall, partition or floor slab depth or thickness.
- .13 Unless otherwise indicated, the installation details given in the SMACNA "Fire, Smoke and Radiation Damper Installation Guide for HVAC Systems" and in the manufacturer's installation instructions for fire dampers shall be followed.

PART 3 EXECUTION

3.1 MANUFACTURER'S INSTRUCTIONS

- .1 Compliance: comply with manufacturer's written recommendations or specifications, including product technical bulletins, handling, storage and installation instructions, and datasheet.

3.2 INSTALLATION

- .1 Provide fire dampers for all duct and grille penetrations at walls, ceilings, floors and shaft assemblies having a fire rating of one hour or more, dampers selected according to fire rating.

- .2 Install in accordance with NFPA 90A and in accordance with conditions of ULC listing.
- .3 Install to SMACNA Standard "Fire Damper Guide for Air Handling Systems". Fasten angles to damper sleeves using nuts and bolts, pop rivets or tack welds on 200 mm centres. Use angle on both sides of wall or floor. Seal all around fire damper assembly using fire rated material.
- .4 Maintain integrity of fire separation.
- .5 After completion and prior to concealment obtain approvals of complete installation from Authority Having Jurisdiction.
- .6 Install access door adjacent to each damper. See Section 23 33 00 - Air Duct Accessories.
- .7 Co-ordinate with installer of firestopping.
- .8 Ensure access doors/panels, fusible links, damper operators are easily observed and accessible.
- .9 Install break-away joints of approved design on each side of fire separation.

3.3 CLEANING

- .1 Proceed in accordance with Section 01 74 11 - Cleaning.
- .2 Upon completion and verification of performance of installation, remove surplus materials, excess materials, rubbish, tools and equipment.

PART 1 GENERAL1.1 RELATED SECTIONS

- .1 Section 21 05 01 - Common Work Results for Mechanical.
- .2 Section 23 05 29 - Hangers and Supports for HVAC Piping and Equipment.

1.2 REFERENCES

- .1 American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc. (ASHRAE).
- .2 Department of Justice Canada (Jus).
 - .1 Canadian Environmental Protection Act (CEPA), 1999, c. 33.
 - .2 Transportation of Dangerous Goods Act, 1992 (TDGA), c. 34.
- .3 Health Canada/Workplace Hazardous Materials Information System (WHMIS).
 - .1 Material Safety Data Sheets (MSDS).
- .4 National Fire Protection Association (NFPA).
 - .1 NFPA 90A-2012, Standard for the Installation of Air-Conditioning and Ventilating Systems.
 - .2 NFPA 90B-2012, Standard for Installation of Warm Air Heating and Air-Conditioning Systems.
- .5 Sheet Metal and Air-Conditioning Contractors' National Association (SMACNA).
 - .1 SMACNA HVAC Duct Construction Standards - Metal and Flexible, 2005, 3rd Edition.
- .6 Underwriters' Laboratories Inc. (UL).
 - .1 UL 181-05, Standard for Factory-Made Air Ducts and Air Connectors.
- .7 Underwriters' Laboratories of Canada (ULC).
 - .1 CAN/ULC-S110-07, Standard Methods of Test for Air Ducts.

1.3 SUBMITTALS

- .1 Make submittals in accordance with Section 01 33 00 - Submittal Procedures.
- .2 Shop drawings: submit shop drawings and product data of different types of flexible duct being used in accordance with Section 01 33 00 - Submittal Procedures. Shop drawings to include the following:
 - .1 Thermal properties.
 - .2 Friction loss.

- .3 Acoustical loss.
- .4 Leakage.
- .5 Fire rating.

1.4 QUALITY ASSURANCE

- .1 Certification of Ratings:
 - .1 Catalogue or published ratings to be those obtained from tests carried out by manufacturer or independent testing agency signifying adherence to codes and standards.
- .2 Health and Safety:
 - .1 Do construction occupational health and safety in accordance with Section 01 35 29.06 - Health and Safety Requirements.

1.5 DELIVERY, STORAGE AND HANDLING

- .1 Protect on site stored or installed absorptive material from moisture damage.
- .2 Waste Management and Disposal:
 - .1 Separate waste materials for reuse and recycling in accordance with Section 01 74 21 - Construction/Demolition Waste Management and Disposal.
 - .2 Remove from site and dispose of packaging materials at appropriate recycling facilities.
 - .3 Collect and separate for disposal paper, plastic, polystyrene and corrugated cardboard packaging material in appropriate on-site bins for recycling in accordance with Waste Reduction Workplan.
 - .4 Place materials defined as hazardous or toxic in designated containers.
 - .5 Handle and dispose of hazardous materials in accordance with Regional and Municipal regulations.
 - .6 Ensure emptied containers are sealed and stored safely.
 - .7 Fold up metal and plastic banding, flatten and place in designated area for recycling.

PART 2 PRODUCTS

2.1 GENERAL

- .1 Factory fabricated to CAN/ULC-S110.
- .2 Pressure drop coefficients listed below are based on relative sheet metal duct pressure drop coefficient of 1.00.
- .3 Flame spread rating not to exceed 25. Smoke developed rating not to exceed 50.

2.2 ALUMINUM ACOUSTIC FLEXIBLE DUCT

- .1 Semi-rigid air duct manufactured from soft aluminum strip, spirally wound with mechanical triple lock seam forming a continuous and secure air tight joint.
- .2 Inner duct to be perforated with an open area of 20% to 25%, and wrapped in minimum 25mm thick glass fibre insulation covered by an aluminum jacket manufactured from soft aluminum strip, spirally wound with mechanical triple lock seam.
- .3 List in accordance with CAN/ULC-S110 and classified as Class 1.
- .4 Temperature range: -40°C to 200°C.
- .5 Maximum rated velocity: 20 m/s.
- .6 Maximum positive pressure: 1.5 kPa.
- .7 Maximum negative pressure: 0.25 kPa.
- .8 Bend radius: 2 times diameter.

PART 3 EXECUTION

3.1 DUCT INSTALLATION

- .1 Install in accordance with: CAN/ULC-S110, NFPA 90A and SMACNA.
- .2 Coordinate ductwork installation. Optimize ceiling space in suspended ceilings and maintain maximum headroom under exposed ducts. Provide detailed fabrication drawings for problem areas when requested by Departmental Representative.
- .3 Support flexible ductwork at 1.2 metre maximum centres.
- .4 Maximum length of flexible duct run shall be 1.8 m.
- .5 Flexible ductwork shall only be installed in non-visible areas above finished ceilings, and on the last duct run to supply air diffusers.

PART 1 GENERAL1.1 RELATED SECTIONS

- .1 Section 21 05 01 - Common Work Results for Mechanical.
- .2 Section 23 31 13.01 - Metal Ducts - Low Pressure to 500 PA.

1.2 REFERENCES

- .1 American Society for Testing and Materials International, (ASTM).
 - .1 ASTM C177-10, Standard Test Method for Steady-State Heat Flux Measurements and Thermal Transmission Properties by Means of the Guarded-Hot-Plate Apparatus.
 - .2 ASTM C423-09a, Standard Test Method for Sound Absorption and Sound Absorption Coefficients by the Reverberation Room Method.
 - .3 ASTM C916-85(2007), Standard Specification for Adhesives for Duct Thermal Insulation.
 - .4 ASTM C1071-12, Standard specification for Fibrous Glass Duct Lining Insulation (Thermal and Sound Absorbing Material).
 - .5 ASTM C1338-08, Standard Test Method for Determining Fungi Resistance of Insulation Materials and Facings.
 - .6 ASTM G21-09, Standard Practice for Determining Resistance of Synthetic Polymeric Materials to Fungi.
- .2 Department of Justice Canada (Jus).
 - .1 Canadian Environmental Protection Act (CEPA), 1999, c. 33.
- .3 Health Canada/Workplace Hazardous Materials Information System (WHMIS).
 - .1 Material Safety Data Sheets (MSDS).
- .4 National Fire Protection Association (NFPA).
 - .1 NFPA 90A-2012, Standard for the Installation of Air Conditioning and Ventilating Systems.
 - .2 NFPA 90B-2012, Standard for the Installation of Warm Air Heating and Air Conditioning Systems.
- .5 North American Insulation Manufacturers Association (NAIMA).
 - .1 NAIMA AH116, Fibrous Glass Duct Construction Standards, 5th Edition, 2002.
- .6 Sheet Metal and Air Conditioning Contractor's National Association (SMACNA).
 - .1 SMACNA, HVAC DCS, HVAC, Duct Construction Standards, Metal and Flexible, 2005, 3rd Edition.
 - .2 SMACNA IAQ Guideline for Occupied Buildings, 2007, 2nd Edition.

- .7 Transport Canada (TC).
 - .1 Transportation of Dangerous Goods Act (TDGA), 1992, c. 34.
- .8 Underwriter's Laboratories of Canada (ULC).
 - .1 CAN/ULC-S102-10, Standard Method of Test for Surface Burning Characteristics of Building Materials and Assemblies.

1.3 SUBMITTALS

- .1 Submit product data in accordance with Section 01 33 00 - Submittal Procedures.
- .2 Submit WHMIS MSDS - Material Safety Data Sheets.

1.4 HEALTH AND SAFETY

- .1 Do construction occupational health and safety in accordance with Section 01 35 29.06 - Health and Safety Requirements.

1.5 DELIVERY, STORAGE AND HANDLING

- .1 Store and manage hazardous materials.
- .2 Protect on site stored or installed absorptive material from moisture damage.

1.6 WASTE MANAGEMENT AND DISPOSAL

- .1 Separate waste materials for reuse and recycling in accordance with Section 01 74 21 - Construction/Demolition Waste Management and Disposal.
- .2 Remove from site and dispose of packaging materials at appropriate recycling facilities.
- .3 Collect and separate for disposal paper, plastic, polystyrene and corrugated cardboard packaging material in appropriate on-site bins for recycling in accordance with Waste Reduction Workplan.
- .4 Place materials defined as hazardous or toxic in designated containers.
- .5 Handle and dispose of hazardous materials in accordance with Regional and Municipal regulations.
- .6 Ensure emptied containers are sealed and stored safely.
- .7 Fold up metal banding, flatten and place in designated area for recycling.

PART 2 PRODUCTS

2.1 DUCT LINER

- .1 General:
 - .1 Mineral Fibre duct liner: air surface coated mat facing.
 - .2 Flame spread rating shall not exceed 25. Smoke development rating shall not exceed 50 when tested in accordance with CAN/ULC-S102, NFPA 90A and NFPA 90B.
 - .3 Fungi resistance: to ASTM C1338, ASTM G21.
- .2 Rigid:
 - .1 Use on flat surfaces where indicated.
 - .2 25 mm thick, to ASTM C1071, Type 2, fibrous glass rigid board duct liner.
 - .3 Density: 48 kg/m³ minimum.
 - .4 Thermal resistance to be minimum 0.76 (m². degrees C)/W for 25 mm thickness when tested in accordance with ASTM C177, at 24°C mean temperature.
 - .5 Minimum NRC of 0.70 at 25 mm thickness based on Type A mounting to ASTM C423.

2.2 ADHESIVE

- .1 Meet requirements of NFPA 90A and NFPA 90B.
- .2 Flame spread rating shall not exceed 25. Smoke development rating shall not exceed 50. Temperature range minus 29°C to plus 93°C.
- .3 Water-based fire retardant type.

2.3 FASTENERS

- .1 Weld pins 2.0 mm diameter, length to suit thickness of insulation. Polymer Nylon retaining clips, 32 mm square.

2.4 JOINT TAPE

- .1 Poly-Vinyl treated open weave fiberglass membrane 50 mm wide.

2.5 SEALER

- .1 Meet requirements of NFPA 90A and NFPA 90B.
- .2 Flame spread rating shall not exceed 25. Smoke development rating shall not exceed 50. Temperature range minus 68°C to plus 93°C.

PART 3 EXECUTION

3.1 GENERAL

- .1 Do work in accordance with SMACNA HVAC DCS and NAIMA FGDLS and as indicated except as specified otherwise.
- .2 Provide lining in following locations:
 - .1 Return air transfer ducts.
 - .2 Rectangular supply and return air ductwork throughout, unless indicated otherwise on drawings.
- .3 Duct dimensions, as indicated, are clear inside duct lining.

3.2 DUCT LINER

- .1 Install in accordance with manufacturer's recommendations, and as follows:
 - .1 Fasten to interior sheet metal surface with 100% coverage of adhesive to ASTM C916.
 - .1 Exposed leading edges and transverse joints to be factory coated or coated with adhesive during fabrication.
 - .2 In addition to adhesive, install weld pins not less than 2 rows per surface and not more than 425 mm on centres to compress duct liner sufficiently to hold it firmly in place.
 - .1 Spacing of mechanical fasteners in accordance with SMACNA HVAC DCS and NAIMA AH116.
- .2 In systems, where air velocities exceeds 20.3 m/sec, install galvanized sheet metal nosing to leading edges of duct liner.

3.3 JOINTS

- .1 Seal butt joints, exposed edges, weld pin and clip penetrations and damaged areas of liner with joint tape and sealer. Install joint tape in accordance with manufacturer's written recommendations, and as follows:
 - .1 Bed tape in sealer.
 - .2 Apply two coats of sealer over tape.
- .2 Replace damaged areas of liner at discretion of Departmental Representative.
- .3 Protect leading and trailing edges of duct sections with sheet metal nosing having 15mm overlap and fastened to duct.

PART 1 GENERAL1.1 RELATED SECTIONS

- .1 Section 21 05 01 - Common Work Results for Mechanical.
- .2 Section 23 05 13 - Common Motor Requirements for HVAC Equipment.
- .3 Section 23 05 29 - Hangers and Supports for HVAC Piping and Equipment.
- .4 Section 23 05 48 - Vibration and Seismic Controls for HVAC Piping and Equipment.
- .5 Section 23 05 93 - Testing, Adjusting and Balancing for HVAC.
- .6 Section 23 33 00 - Air Duct Accessories.

1.2 REFERENCES

- .1 American National Standards Institute (ANSI)/Air Conditioning and Mechanical Contractors (AMCA)
 - .1 ANSI/AMCA Standard 99-10, Standards Handbook.
 - .2 ANSI/AMCA 204-05 (R2012), Balance Quality and Vibration Levels for Fans.
 - .3 ANSI/AMCA 210-07 (R2012), Laboratory Methods of Testing Fans for Aerodynamic Performance Rating.
 - .4 ANSI/AMCA 300-08, Reverberant Room Method for Sound Testing of Fans.
 - .5 ANSI/AMCA 301-06, Methods for Calculating Fan Sound Ratings from Laboratory Test Data.
- .2 American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE)
 - .1 ANSI/ASHRAE 90.1-2010 (SI), Energy Standard for Buildings Except Low-Rise Residential Buildings (ANSI/ASHRAE/IES), Errata (January 18, 2013)/Addenda a thru ds/IC 90.1-2010-02 to 14/90.1-2010-15 to 16.
- .3 Health Canada/Workplace Hazardous Materials Information System (WHMIS)
 - .1 Material Safety Data Sheets (MSDS).
- .4 Underwriter's Laboratories (UL)
 - .1 UL 705 (cUL 705)-04, Revisions 1(2004) to 5(2011), Power Ventilators.

1.3 SYSTEM DESCRIPTION

- .1 Performance Requirements:
 - .1 Catalogued or published ratings for manufactured items: obtained from tests carried out by manufacturer or those ordered by manufacturer from independent testing agency signifying adherence to codes and standards in force.
 - .2 Capacity: flow rate, static pressure, W, efficiency, revolutions per minute, power, model, size, sound power data and as indicated on schedule.
 - .3 Fans: statically and dynamically balanced, constructed in conformity with ANSI/AMCA 99.
 - .4 Sound ratings: comply with ANSI/AMCA 301, tested to ANSI/AMCA 300. Supply unit with ANSI/AMCA certified sound rating seal.
 - .5 Performance ratings: based on tests performed in accordance with ANSI/AMCA 210. Supply unit with AMCA certified rating seal, except for propeller fans smaller than 300 mm diameter.
 - .6 Motors to be high efficiency, conforming to ASHRAE 90.1.

1.4 SUBMITTALS

- .1 Shop drawings:
 - .1 Submit manufacturer's printed product literature, specifications and datasheet in accordance with Section 01 33 00 - Submittal Procedures. Include product characteristics, performance criteria, and limitations.
- .2 Provide :
 - .1 Fan performance curves showing point of operation, kW and efficiency.
 - .2 Sound rating data at point of operation.
- .3 Indicate:
 - .1 Motors, sheaves, bearings, shaft details.
 - .2 Minimum performance achievable with variable speed controllers.
- .4 Quality assurance submittals: submit following in accordance with Section 01 33 00 - Submittal Procedures.
 - .1 Certificates: submit certificates signed by manufacturer certifying that materials comply with specified performance characteristics and physical properties.
 - .2 Instructions: submit manufacturer's installation instructions.
- .5 Closeout Submittals:
 - .1 Provide operation and maintenance data for incorporation into manual specified in Section 01 78 00 - Closeout Submittals.

1.5 QUALITY ASSURANCE

- .1 Health and Safety Requirements: do construction occupational health and safety in accordance with Section 01 35 29.06 - Health and Safety Requirements.

1.6 MAINTENANCE

- .1 Extra Materials:
 - .1 Provide maintenance materials in accordance with Section 01 78 00 - Closeout Submittals.
 - .1 Spare parts to include:
 - .1 Matched sets of belts.
 - .2 Furnish list of individual manufacturer's recommended spare parts for equipment, include:
 - .1 Bearings and seals.
 - .2 Addresses of suppliers.
 - .3 List of specialized tools necessary for adjusting, repairing or replacing.

1.7 DELIVERY, STORAGE, AND HANDLING

- .1 Packing, shipping, handling and unloading:
 - .1 Deliver, store and handle in accordance with Section 01 61 00 - Common Product Requirements.
 - .2 Deliver, store and handle materials in accordance with manufacturer's written instructions.
- .2 Waste Management and Disposal:
 - .1 Construction/Demolition Waste Management and Disposal: separate waste materials for reuse and recycling in accordance with Section 01 74 21 - Construction/Demolition Waste Management and Disposal.

PART 2 PRODUCTS

2.1 FANS GENERAL

- .1 Motors:
 - .1 For use with variable speed controllers.
 - .2 Sizes as indicated.
- .2 Accessories and hardware: matched sets of V-belt drives, adjustable slide rail motor bases, belt guards.
- .3 Factory primed before assembly in colour standard to manufacturer.
- .4 Scroll casing drains: as indicated.
- .5 Bearing lubrication systems plus extension lubrication tubes where bearings are not easily accessible.

- .6 Vibration isolation: to Section 23 05 48 - Vibration and Seismic Controls for HVAC Piping and Equipment.
- .7 Flexible connections: to Section 23 33 00 - Air Duct Accessories.

2.2 CABINET FANS

- .1 Description:
 - .1 Fan shall be inline mounted, direct driven, centrifugal exhaust fan.
- .2 Certifications:
 - .1 Fan shall be manufactured at an ISO 9001 certified facility. Fan shall be listed by Underwriters Laboratories (UL 705) and UL listed for Canada (cUL 705). Fan shall bear the AMCA Certified Ratings Seal for Sound and Air Performance.
- .3 Construction:
 - .1 The fan housing shall be minimum .912 mm galvanized steel and acoustically insulated. Blower and motor assembly shall be mounted to a minimum 1.9 mm reinforcing channel and shall be easily removable from the housing. Motor shall be mounted on vibration isolators. Unit shall be supplied with integral wiring box and disconnect receptacle shall be standard. Discharge position shall be convertible from right angle to straight through by moving interchangeable panels. The outlet duct collar shall include a reinforced aluminum damper with continuous aluminum hinge rod and brass bushings. To accommodate different mounting positions, an adjustable pre-punched mounting bracket shall be provided. Unit shall be shipped in ISTA Certified Transit Tested Packaging.
- .4 Wheel:
 - .1 Wheel shall be centrifugal forward curved type, constructed of galvanized steel. Wheel shall be balanced in accordance with ANSI/AMCA Standard 204, Balance Quality and Vibration Levels for Fans.
- .5 Motor:
 - .1 Motor shall be open drip proof type with permanently lubricated bearings, built-in thermal overload protection and disconnect plug. Motor shall be furnished at the specified voltage. Unit mounted and wired fan speed controller shall be provided.

2.3 BALANCING

- .1 Wheels shall be dynamically balanced, individually to ANSI/AMCA 204, G6.3. Factory dynamic balance all fans after their assembly. Use an IRD or PMC analyzer to measure velocity, and ensure the final reading does not exceed 2.54 mm per second. Record the exact level of vibration on the bearings as proof of the final dynamic balance at the factory.

2.4 ACCESSORIES

- .1 Belt Guard - in accordance with Section 23 05 13 - Common Motor Requirements for HVAC Equipment.

PART 3 EXECUTION

3.1 MANUFACTURER'S INSTRUCTIONS

- .1 Compliance: comply with manufacturer's written recommendations or specifications, including product technical bulletins, handling, storage and installation instructions, and datasheet.

3.2 FAN INSTALLATION

- .1 Install all components as per details on drawings as well as manufacturers' recommendations, and to applicable codes.
- .2 Install fans as shown, with resilient mountings specified in Section 23 05 48 - Vibration and Seismic Controls for HVAC Piping and Equipment, flexible electrical leads, and flexible connections in accordance with Section 23 33 00 - Air Duct Accessories.
- .3 Install fans with flexible connections on inlet ductwork and on discharge ductwork.
- .4 Align shafts, belt drive and motor, adjust belt tension and check motor rotation before start-up.
- .5 Protect motors and fans during construction and rotate fans, by hand, every month between delivery and acceptance of building.
- .6 Provide sheaves and belts required for final air balance.
- .7 Bearings and extension tubes to be easily accessible.
- .8 Access doors and access panels to be easily accessible.

3.3 FIELD QUALITY CONTROL

- .1 Manufacturer's Field Services:
 - .1 Have manufacturer of products, supplied under this Section, review Work involved in the handling, installation/application, protection and cleaning, of its products and submit written reports, in acceptable format, to verify compliance of Work.

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- .2 Manufacturer's Field Services: provide manufacturer's field services consisting of product use recommendations and periodic site visits for inspection of product installation in accordance with manufacturer's instructions.
 - .3 Include for the services of fan manufacturer's factory certified service technician in start-up and repair services to assist in start-up, performance verification, and Commissioning of the systems on the job site.
 - .4 Manufacturer's representative is to be on site with Departmental Representative for Substantial Performance review, and as required by the Contractor for Commissioning.
 - .5 Schedule site visits, to review Work, at stages listed:
 - .1 After delivery and storage of products, and when preparatory Work, or other Work, on which the Work of this Section depends, is complete but before installation begins.
 - .2 Upon completion of the Work, after cleaning is carried out.
 - .6 Include site visits by manufacturer's representative to start-up and ensure trouble free and specified operation of the system.
 - .7 Obtain reports, within 3 days of review, and submit, immediately, to Departmental Representative.
- .2 Performance Verification (PV):
- .1 Verification for proper operation and reliability of the fans and the building automation system.
 - .2 Operate equipment and verify that performance criteria specified have been achieved.
 - .3 Inspect and test all sub-assemblies for conformance to Vendor's engineering and quality assurance specifications.
 - .4 Rejected Work:
 - .1 Remove defective Work, whether result of poor workmanship, use of defective products or damage and whether incorporated in Work or not, which has been rejected by Departmental Representative as failing to conform to Technical Documents. Replace or re-execute in accordance with Technical Documents.
 - .2 Make good other Contractor's work damaged by such removals or replacements promptly.

3.4 CLEANING

- .1 Proceed in accordance with Section 01 74 11 - Cleaning.
- .2 Upon completion and verification of performance of installation, remove surplus materials, excess materials, rubbish, tools and equipment.

PART 1 GENERAL1.1 RELATED SECTIONS

- .1 Section 21 05 01 - Common Work Results for Mechanical.
- .2 Section 23 05 93 - Testing, Adjusting and Balancing for HVAC.

1.2 SYSTEM DESCRIPTION

- .1 Performance Requirements:
 - .1 Catalogued or published ratings for manufactured items: obtained from tests carried out by manufacturer or those ordered by manufacturer from independent testing agency signifying adherence to codes and standards.

1.3 SUBMITTALS

- .1 Shop drawings:
 - .1 Submit manufacturer's printed product literature, specifications and datasheet in accordance with Section 01 33 00 - Submittal Procedures. Include product characteristics, performance criteria, and limitations.
 - .2 Indicate following:
 - .1 Capacity.
 - .2 Throw and terminal velocity.
 - .3 Noise criteria.
 - .4 Pressure drop.
 - .5 Neck velocity.
- .2 Quality assurance submittals: submit following in accordance with Section 01 33 00 - Submittal Procedures.
 - .1 Certificates: submit certificates signed by manufacturer certifying that materials comply with specified performance characteristics and physical properties.
 - .2 Instructions: submit manufacturer's installation instructions.

1.4 QUALITY ASSURANCE

- .1 Health and Safety Requirements: do construction occupational health and safety in accordance with Section 01 35 29.06 - Health and Safety Requirements.
- .2 Collection ductwork/diffuser mock-up: mock-up linear 8 m of round ductwork and diffusers, suspensions and support, and neat duct joint sealing in a location agreed with the Departmental Representative. Mock-up may become part of work once approved by the Departmental Representative. Approved mock-up sets the standard for the project.

1.5 DELIVERY, STORAGE, AND HANDLING

- .1 Packing, shipping, handling and unloading:
 - .1 Deliver, store and handle in accordance with Section 01 61 00 - Common Product Requirements.
 - .2 Deliver, store and handle materials in accordance with manufacturer's written instructions.
- .2 Waste Management and Disposal:
 - .1 Construction/Demolition Waste Management and Disposal: separate waste materials for reuse and recycling in accordance with Section 01 74 21 - Construction/Demolition Waste Management and Disposal.

1.6 MAINTENANCE

- .1 Extra Materials:
 - .1 Provide maintenance materials in accordance with Section 01 78 00 - Closeout Submittals.
 - .2 Include:
 - .1 Keys for volume control adjustment.
 - .2 Keys for air flow pattern adjustment.

PART 2 PRODUCTS

2.1 GENERAL

- .1 To meet capacity, pressure drop, terminal velocity, throw, noise level, neck velocity.
- .2 Frames:
 - .1 Full perimeter gaskets.
 - .2 Plaster frames where set into plaster or gypsum board and as specified.
 - .3 Concealed fasteners.
- .3 Concealed manual volume control damper operators.
- .4 Colour: white powder coat.

2.2 MANUFACTURED UNITS

- .1 Grilles, registers and diffusers of same generic type, products of one manufacturer.
- .2 Refer to schedule of grilles and diffusers on the drawings.

PART 3 EXECUTION3.1 MANUFACTURER'S INSTRUCTIONS

- .1 Compliance: comply with manufacturer's written recommendations or specifications, including product technical bulletins, handling, storage and installation instructions, and datasheet.

3.2 INSTALLATION

- .1 Fit frames tightly to prevent leakage and smudging, and to completely cover openings.
- .2 Furnish mounting frames to suit construction finish schedule, with concealed fastenings.
- .3 Install grilles and diffusers plumb with building lines, in alignment where several grilles occur in line, and centrally in ceiling tiles unless otherwise indicated.
- .4 Install in accordance with manufacturer's instructions.
- .5 Install with cadmium plated screws in countersunk holes where fastenings are visible.

3.3 CLEANING

- .1 Proceed in accordance with Section 01 74 11 - Cleaning.
- .2 Upon completion and verification of performance of installation, remove surplus materials, excess materials, rubbish, tools and equipment.

PART 1 GENERAL1.1 RELATED SECTIONS

- .1 Section 21 05 01 - Common Work Results for Mechanical.
- .2 Section 23 31 13.01 - Metal Ducts - Low Pressure to 500 PA.
- .3 Section 23 74 00 - Packaged Outdoor HVAC Equipment.

1.2 REFERENCES

- .1 Canadian Standards Association (CSA International).
 - .1 CSA C22.2 No.46-M1988 (R2011), Electric Air-Heaters.

1.3 SUBMITTALS

- .1 Make submittals in accordance with Section 01 33 00 - Submittal Procedures.
- .2 Submit product data and include:
 - .1 Element support details.
 - .2 Heater: total kW rating, voltage, phase.
 - .3 Number of stages.
 - .4 Rating of stage: rating, voltage, phase.
 - .5 Heater element watt/density and maximum sheath temperature.
 - .6 Maximum discharge temperature.
 - .7 Physical size.
 - .8 Unit support.
 - .9 Performance limitations.
 - .10 Clearance from combustible materials.
 - .11 Internal components wiring diagrams.
 - .12 Minimum operating airflow.
 - .13 Pressure drop operating airflow.

1.4 DELIVERY, STORAGE AND HANDLING

- .1 Waste Management and Disposal:
 - .1 Separate waste materials for reuse and recycling in accordance with Section 01 74 21 - Construction/Demolition Waste Management and Disposal.
 - .2 Remove from site and dispose of packaging materials at appropriate recycling facilities.
 - .3 Collect and separate for disposal packaging material in appropriate on-site bins for recycling in accordance with Waste Reduction Workplan.

PART 2 PRODUCTS

2.1 DUCT HEATERS

- .1 Duct heaters: insert type.
- .2 Elements:
 - .1 Helical coils of nickel chrome alloy resistance wire.
- .3 Staging:
 - .1 Staged heaters: balanced line current at each stage.
 - .2 Each stage: uniform face distribution.
- .4 Maximum temperature at discharge: 40 °C.
- .5 Controls:
 - .1 Factory mounted and wired in control box. Use terminal blocks for power and control wiring to thermostat and sail switch.
 - .2 Remote mounted as indicated with terminal strips in heater terminal box for power and control wiring.
 - .3 Controls mounted in a CSA Type enclosure and to include:
 - .1 Magnetic contactors.
 - .2 Control transformers.
 - .3 SCR or step controller as indicated.
 - .4 Where controls are mounted in heater, exercise care in mounting contactors to minimize switching noise transmission through ductwork.
 - .5 High temperature cutout and air proving switch.
- .6 Performance: as indicated on schedule.
- .7 Main isolation disconnect switch.

PART 3 EXECUTION

3.1 INSTALLATION

- .1 Make power and control connections to CSA C22.2 No.46.

3.2 FIELD QUALITY CONTROL

- .1 Provide test report and include copy with Operations and Maintenance Manuals.

PART 1 GENERAL1.1 RELATED SECTIONS

- .1 Section 21 05 01 - Common Work Results for Mechanical.
- .2 Section 23 05 48 - Vibration and Seismic Controls for HVAC Piping and Equipment.
- .3 Section 23 05 93 - Testing, Adjusting and Balancing for HVAC.
- .4 Section 23 55 01 - Duct Heaters.

1.2 REFERENCES

- .1 American National Standards Institute/Air-Conditioning and Refrigeration Institute (ANSI/ARI)
 - .1 ANSI/AHRI 210/240-2008: Performance Rating of Unitary Air-Conditioning and Air-Source Heat Pump Equipment.
 - .2 ANSI/AHRI 270-2008: Sound Rating of Outdoor Unitary Equipment.
 - .3 ANSI/AHRI Standard 430-2009, Central Station Air-Handling Units.
- .2 American National Standards Institute (ANSI)/Air Conditioning and Mechanical Contractors (AMCA)
 - .1 ANSI/AMCA Standard 500-D-12, Laboratory Methods of Testing Dampers for Rating.
- .3 American Society of Heating, Refrigeration and Air Condition Engineers (ASHRAE)
 - .1 ANSI/ASHRAE 52.2-2012, Method of Testing General Ventilation Air-Cleaning Devices for Removal Efficiency by Particle Size.
 - .2 ANSI/ASHRAE 90.1-2010 (SI), Energy Standard for Buildings Except Low-Rise Residential Buildings (ANSI/ASHRAE/IES), Errata (January 18, 2013)/Addenda a thru ds/IC 90.1-2010-02 to 14/90.1-2010-15 to 16.
- .4 American Society for Testing and Materials International (ASTM)
 - .1 ASTM B117-11, Standard Practice for Operating Salt Spray (Fog) Apparatus
- .5 Canadian Standards Association (CSA International)
 - .1 CSA B52-05(R2009), Mechanical Refrigeration Code.
 - .2 CSA C22.1 HB-12, CE Code Handbook, An Explanation of Rules of the Canadian Electrical Code, Part 1.
 - .3 CSA/ANSI Z21.47-2012/CSA 2.3-2012, Gas-Fired Central Furnaces.
- .6 Health Canada/Workplace Hazardous Materials Information System (WHMIS)
 - .1 Material Safety Data Sheets (MSDS).

- .7 National Fire Protection Association (NFPA)
 - .1 NFPA 90A-2012, Installation of Air Conditioning and Ventilating Systems.
- .8 Underwriters Laboratories (UL)
 - .1 UL 1995-2011, Heating and Cooling Equipment.

1.3 SUBMITTALS

- .1 Provide submittals in accordance with Section 01 33 00 - Submittal Procedures.
- .2 Shop Drawings:
 - .1 Submit shop drawings to indicate project layout and dimensions; indicate:
 - .1 Control equipment shipped loose, showing final location in assembly.
 - .2 Dimensions, internal and external construction details, recommended method of installation with proposed structural steel support, mounting curb details, sizes and location of mounting bolt holes; include mass distribution drawings showing point loads.
 - .3 Detailed composite wiring diagrams for control systems showing factory installed wiring and equipment on packaged equipment or required for controlling devices of ancillaries, accessories, controllers.
 - .4 Pump and fan performance curves.
 - .5 Details of vibration isolation.
 - .6 Estimate of sound levels to be expected across individual octave bands in dB referred to A rating.
 - .7 Type of refrigerant used.
 - .2 Indicate following: fan, fan curves showing point of operation, motor drive, bearings, filters, mixing box, dampers; include performance data.
 - .3 Provide manufacturer's printed product literature and datasheets for insulation, filters, adhesives, and paints, and include product characteristics, performance criteria, physical size, finish and limitations.
- .3 Test Reports: submit certified test reports from approved independent testing laboratories indicating compliance with specifications for specified performance characteristics and physical properties.
- .4 Certificates: submit certificates signed by manufacturer certifying that materials comply with specified performance characteristics and physical properties.
- .5 Instructions: submit manufacturer's installation instructions.

1.4 CLOSEOUT SUBMITTALS

- .1 Provide maintenance data for incorporation into manual specified in Section 01 78 00 - Closeout Submittals.
 - .1 Indicate: brief description of unit, indexed, with details of function, operation, control, and service for components.

- .2 Provide for units, manufacturer's name, type, year, number of units, and capacity.

1.5 MAINTENANCE MATERIAL SUBMITTALS

- .1 Provide one spare set of filters.
- .2 Provide list of individual manufacturer's recommended spare parts for equipment such as bearings and seals, and addresses of suppliers, together with list of specialized tools necessary for adjusting, repairing or replacing, for placement into operating manual.
- .3 Spare filters: in addition to filters installed immediately prior to acceptance by Departmental Representative, supply 1 complete set of filters for each filter unit or filter bank.

1.6 QUALITY ASSURANCE

- .1 Health and Safety:
 - .1 Do construction occupational health and safety in accordance with Section 01 35 29.06 - Health and Safety Requirements.

1.7 DELIVERY, STORAGE AND HANDLING

- .1 Deliver materials to site in original factory packaging, labelled with manufacturer's name, address.
- .2 Packaging Waste Management: remove for reuse and return by manufacturer of pallets, crates, padding and packaging materials in accordance with Section 01 74 21 - Construction/Demolition Waste Management and Disposal.

PART 2 PRODUCTS

2.1 GENERAL

- .1 Factory assembled components to form units supplying air at designed conditions, as indicated.
- .2 Certify ratings: to ANSI/AHRI 430 with ARI seal.

2.2 PACKAGED WALL MOUNTED UNITS

- .1 General:
 - .1 Self-contained, vertical, exterior wall mount, through-the-wall air conditioner. Unit shall be factory assembled, pre-charged, pre-wired, tested and ready to operate.

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- .2 Construction Features:
- .1 Cabinet:
 - .1 Weatherproof casing constructed of .912 mm galvanized steel. Unit base constructed of 1.5 mm galvanized steel painted cabinets. Exterior casing to be finished with baked-on exterior polyester enamel paint. Cooling section shall be fully insulated with 25 mm fiberglass. Access openings appropriate for outside structure to all fan motors and compressor for making repairs and for removing internal components without removing unit from its permanent installation. Fresh air intake and outdoor coil shall be protected from intrusions by a sturdy metal grating with less than 6 mm openings.
 - .2 Drain Pan:
 - .1 Drain pan shall be constructed of .912 mm galvanized steel, bonderized and finished with baked-on exterior polyester enamel paint.
 - .3 Mounting Brackets:
 - .1 Full-length side mounting brackets shall be an integral part of the cabinet. Bottom mounting bracket shall be provided.
 - .4 Refrigeration System:
 - .1 High efficiency scroll compressor. The refrigeration circuit shall be equipped with factory installed high and low pressure controls and liquid line filter dryer. The refrigeration control shall be a factory installed capillary tube. Compressor shall be mounted on rubber grommets. Unit shall be provided with R-410A (HFC) non-ozone depleting refrigerant.
 - .5 Condenser Fan Motor:
 - .1 The condenser fan, motor and shroud shall be of slide out configuration for easy access.
 - .6 Indoor Blower Motor:
 - .1 The indoor blower motor shall be twin wheels with forward curve blades. Motor shall be high efficiency PSC type.
 - .7 Electrical Components:
 - .1 Electrical components are easily accessible for routine inspection and maintenance through front service panels. Circuit breaker/rotary disconnect access through lockable access panel.
 - .8 Control Circuit:
 - .1 Provide internal control circuit utilizing a 24VAC type transformer. A five-minute time delay circuit shall be factory installed to prevent rapid compressor short cycling. A low-pressure bypass shall be factory installed to prevent nuisance tripping during low temperature start-up.
- .3 Heating:
- .1 Refer to Section 23 55 01 - Duct Heaters.
- .4 Ventilation:
- .1 Provide integral 100% outdoor air economizer, associated dampers and controls.
- .5 Filter:
- .1 50 mm fiberglass - pleated - MERV 6.

- .6 Unit Control Options:
 - .1 High pressure control.
 - .2 Outdoor air thermostat.
- .7 Operating Controls:
 - .1 Electronic programmable, auto changeover.

PART 3 EXECUTION

3.1 APPLICATION

- .1 Manufacturer's Instructions: comply with manufacturer's written recommendations, including product technical bulletins, handling, storage and installation instructions, and datasheets.

3.2 INSTALLATION

- .1 Install as per manufacturers' instructions on roof curbs provided by manufacturer as indicated.
 - .1 Manufacturer to certify installation, supervise start-up and commission unit.
 - .2 Run drain line from cooling coil condensate drain pan to discharge over roof drain.
- .2 Provide appropriate protection apparatus.
- .3 Install units in accordance with manufacturer's instructions and as indicated.
- .4 Ensure adequate clearance for servicing and maintenance. Install such that fall arrest is not required to service equipment.

3.3 FANS

- .1 Install fan sheaves required for final air balance.
- .2 Install connections as shown on drawings.

3.4 DRIP PANS

- .1 Install deep seal P-traps on drip lines.
 - .1 Depth of water seal to be 1.5 times static pressure at this point.

3.5 FIELD QUALITY CONTROL

- .1 Manufacturer's Field Services:
 - .1 Have manufacturer of products supplied under this Section review work involved in handling, installation/application, protection and cleaning of its products, and submit written reports, in acceptable format, to verify compliance of work.
 - .2 Provide manufacturer's field services, consisting of product use recommendations and periodic site visits for inspection of product installation, in accordance with manufacturer's instructions.
 - .3 Schedule site visits to review work at stages listed:
 - .1 After delivery and storage of products, and when preparatory work on which work of this Section depends is complete, but before installation begins.
 - .2 Twice during progress of work at 25% and 60% complete.
 - .3 Upon completion of work, after cleaning is carried out.
- .2 Obtain reports within 3 days of review and submit immediately to Departmental Representative.
- .3 Performance Verification:
 - .1 Verify accessibility, serviceability of components including motorized dampers, filters, coils, fans, motors, operators, sensors, electrical disconnects.
 - .2 Verify accessibility, cleanability, drainage of drain pans for coils.
 - .3 Rooftop Air Handling Units:
 - .1 Set outside air and return air dampers for minimum outside air.
 - .2 Check for smooth, vibration less correct rotation of supply fan impeller.
 - .3 Measure supply fan capacity.
 - .4 Adjust impeller speed as necessary and repeat measurement of fan capacity.
 - .5 Measure pressure drop each component of air handling unit.
 - .6 Set outside air and return air dampers for the % of outside air required by design and repeat measurements of fan capacity.
 - .7 Reduce differences between fan capacity at minimum and maximum outside air less than 5%.
 - .8 Reduce difference between fan capacity at full cooling and fan capacity at full heating to less than 5%.
 - .9 OAD: verify for proper stroking, interlock with RAD.
 - .10 Measure DBT, WBT of SA, RA, EA.
 - .11 Measure air cooled condenser discharge DBT.
 - .12 Measure flow rates (minimum and maximum) of SA, RA, EA, relief air.
 - .13 Simulate maximum cooling load and measure refrigerant hot gas and suction temperatures and pressures.
 - .14 Use smoke test to verify no short-circuiting of EA, relief air to outside air intake or to condenser intake.

- .15 Simulate maximum heating load and:
 - .1 Verify temperature rise across heat exchanger.
 - .2 Perform flue gas analysis. Adjust for peak efficiency.
 - .3 Verify combustion air flow to heat exchanger.
 - .4 Simulate minimum heating load and repeat measurements.
- .16 Measure radiated and discharge sound power levels under maximum heating demand and under maximum cooling demand with compressors running.
- .17 Verify operating control strategies, including:
 - .1 Heat exchanger operating and high limit.
 - .2 Early morning warm-up cycle.
 - .3 Freeze protection.
 - .4 Economizer cycle operation, temperature of change-over.
 - .5 Alarms.
 - .6 Voltage drop across thermostat wiring.
 - .7 Operation of remote panel including pilot lights, failure modes.
- .18 Adjust impeller speed as necessary and repeat measurement of return fan capacity.
- .19 Check capacity of heating unit.
- .20 Measure DX refrigeration system performance.
- .21 Refer to other sections of these specifications for PV procedures for other components.
- .4 Start-Up:
 - .1 Verify accessibility, serviceability of components including motorized dampers, filters coils, fans, motors, operators, sensors, electrical disconnects.
 - .2 Verify accessibility, clean ability, drainage of drain pans for coils.

3.6 CLEANING

- .1 Perform cleaning operations as specified in Section 01 74 11 - Cleaning and in accordance with manufacturer's recommendations.
- .2 On completion and verification of performance of installation, remove surplus materials, excess materials, rubbish, tools and equipment.

PART 1 GENERAL1.1 RELATED SECTIONS

- .1 Section 21 05 01 - Common Work Results for Mechanical.
- .2 Section 22 13 17 - Drainage Waste and Vent Piping - Cast Iron and Copper.
- .3 Section 23 05 05 - Installation of Pipework.
- .4 Section 23 05 29 - Hangers and Supports for HVAC Piping and Equipment.
- .5 Section 23 05 48 - Vibration and Seismic Controls for HVAC Piping and Equipment.
- .6 Section 23 05 53.01 - Mechanical Identification.
- .7 Section 23 05 93 - Testing, Adjusting and Balancing for HVAC.
- .8 Section 23 07 15 - Thermal Insulation for Piping and Equipment.
- .9 Section 23 08 01 - Performance Verification Mechanical Piping Systems.
- .10 Section 23 23 00 - Refrigerant Piping.
- .11 Section 23 31 13.01 - Metal Ducts - Low Pressure to 500 PA.

1.2 REFERENCES

- .1 American Society for Testing and Materials (ASTM International)
 - .1 ASTM C547-12, Standard Specification for Mineral Fibre Pipe Insulation.
- .2 Air-Conditioning, Heating, and Refrigeration Institute (AHRI)
 - .1 ANSI/AHRI Standard 210/240-2008, Performance Rating of Unitary Air-Conditioning & Air-Source Heat Pump Equipment.
- .3 Canadian Standards Association (CSA International)
 - .1 CSA B52-05 (R2009), Mechanical Refrigeration Code.
 - .2 CSA C22.2 NO 236-11, Heating and Cooling Equipment (Bi-National Standard with UL 1995).
 - .3 CAN/CSA-C656-05(R2010), Performance Standard for Split-System Single-Package Central Air-Conditioners and Heat Pumps (Includes Update #1).
- .4 Environment Canada, (EC)/Environmental Protection Services (EPS)
 - .1 EPS 1/RA/2-1996, Code of Practice for Elimination of Fluorocarbons Emissions from Refrigeration and Air Conditioning Systems.

- .2 Environment Canada-1994, Ozone-Depleting Substances Alternatives and Suppliers List.
- .5 Health Canada/Workplace Hazardous Materials Information System (WHMIS)
 - .1 Material Safety Data Sheets (MSDS).

1.3 SHOP DRAWINGS AND PRODUCT DATA

- .1 Submit shop drawings in accordance with Section 01 33 00 - Submittal Procedures.
- .2 Indicate major components and accessories.
- .3 Indicate type of refrigerant used.
- .4 Shop drawings to include:
 - .1 Filters, fan accessibility.
 - .2 Suspension or anchoring of cabinet.
 - .3 Physical size.
 - .4 Thermostat, transformer, controls.
 - .5 Capacities.
 - .6 Finish.
 - .7 kW rating, voltage, phase.
 - .8 Cabinet material thickness.
 - .9 Sound power levels.
- .5 Quality assurance submittals: submit following in accordance with Section 01 33 00 - Submittal Procedures.
 - .1 Certificates: submit certificates signed by manufacturer certifying that materials comply with specified performance characteristics and physical properties.
 - .2 Instructions: submit manufacturer's installation instructions.

1.4 CLOSEOUT SUBMITTALS

- .1 Provide operation and maintenance data for incorporation into manual.

1.5 DELIVERY, STORAGE AND HANDLING

- .1 Packing, shipping, handling and unloading:
 - .1 Deliver, store and handle in accordance with manufacturer's written instructions and Section 01 61 00 - Common Product Requirements.
- .2 Waste Management and Disposal:
 - .1 Construction/Demolition Waste Management and Disposal: separate waste materials for reuse and recycling in accordance with Section 01 74 21 - Construction/Demolition Waste Management and Disposal.

- .2 Divert unused metal and wiring materials from landfill to metal recycling facility approved by Departmental Representative.
- .3 Separate and recycle waste materials.
- .4 Remove from site and dispose of packaging materials at appropriate recycling facilities.
- .5 Collect and separate for disposal paper, plastic, polystyrene and corrugated cardboard packaging material in appropriate on-site bins for recycling in accordance with Waste Reduction Workplan.
- .6 Divert unused metal and wiring materials from landfill to metal recycling facility approved by Departmental Representative.

PART 2 PRODUCTS

2.1 GENERAL

- .1 Indoor Unit (Evaporator):
 - .1 The indoor unit shall be factory assembled, wired and run tested. Contained within the unit shall be all factory wiring, internal piping, control circuit board and fan motor.
 - .2 The unit shall have a self-diagnostic function, 3-minute time delay mechanism, an auto restart function, an emergency operation function and a test run switch.
 - .3 Indoor unit and refrigerant pipes shall be charged with dry air before shipment from the factory.
 - .4 Capacities: as indicated on drawings.
- .2 Outdoor Unit (Condensing Unit):
 - .1 The outdoor unit is designed specifically for use with indoor units and is equipped with a circuit board that interfaces to the indoor units.
 - .2 The unit shall be able to provide cooling operation at -40°C.
 - .3 The outdoor unit shall be completely factory assembled, internally piped and wired. Each unit must be run tested at the factory.

2.2 UNIT CABINET

- .1 Casing shall have a white finish. Multi-directional drain and refrigerant piping providing four (4) directions for refrigerant piping and two (2) directions for draining.
- .2 The indoor unit fan shall be an assembly with a line-flow fan direct driven by a single motor. The fan shall be statically and dynamically balanced and run on a motor with permanently lubricated bearings. A manual adjustable guide vane shall be provided with the ability to change the airflow from side to side (left to right). A motorized air sweep flow louvre shall provide an automatic change in airflow by

directing the air up and down to provide for uniform air distribution. The indoor unit fan shall consist of three (3) speeds - High, Medium and Low.

- .3 Return air shall be filtered by means of easily removed catechin and enzyme filters.
- .4 The evaporator coil shall be of non-ferrous construction with pre-coated aluminum strake fins on copper tubing. All tube joints shall be brazed with PhosCopper or silver alloy. The coil shall be pressure tested at the factory. A condensate pan and drain shall be provided under the coil.
- .5 The electrical power of the unit, supplied from the outdoor unit shall be 208 volts, 1 phase, 60 hertz. The system shall be capable of satisfactory operation within voltage limits of 198 volts to 253 volts.

2.3 CONTROLLER

- .1 Unit shall have a wireless controller to perform input functions necessary to operate the system.
 - .1 The controller shall consist of a Power On/Off switch, Mode Selector, Temperature Setting, Timer Control, Fan Speed Select and Auto Vane Selector.
 - .2 Temperature changes shall be by 1 °C increments with a range of 18 °C to 30 °C.
 - .3 The microprocessor located in the indoor unit shall have the capability of sensing return air temperature and evaporator coil temperature, receiving and processing commands from the wireless controller, providing emergency operation and controlling the outdoor unit.
 - .4 The control voltage between the indoor unit and the outdoor unit shall be 208 volts AC.
 - .5 The system shall be capable of automatic restart when power is restored after power interruption.
 - .6 The system shall have auto change over between heating and cooling.
 - .7 Control system shall control the continued operation of the air sweep louvers, as well as provide on/off and system/mode function switching.

2.4 CONDENSING UNIT (OUTSIDE UNIT)

- .1 The casing shall be zinc-coated steel with acrylic or polyester coating for corrosion protection. The base shall be of Aluminum-Zinc-Magnesium alloy coated steel, or galvanized steel base.
- .2 The unit shall be furnished with a direct drive propeller type fan. The fan motor shall have inherent protection, with permanently lubricated bearings. The fan motor shall be mounted for quiet operation and shall be provided with a raised guard to prevent contact with moving parts. The outdoor unit shall have horizontal discharge airflow.

- .3 The condenser coil shall be of non-ferrous construction with pre-coated aluminum strake fins on copper tubing. The coil shall be protected with an integral metal guard. Refrigerant flow from the condenser shall be controlled by means of a linear expansion valve (LEV) metering orifice. The linear expansion valve shall be controlled by a microprocessor controlled step motor.
- .4 The compressor shall have variable compressor speed inverter technology (VCSI). The outdoor unit shall have an accumulator. The compressor shall be equipped with an internal thermal overload. The compressor shall be mounted to avoid the transmission of vibration.
- .5 The electrical power of the unit shall be 208 volts, 1 phase, 60 hertz. The unit shall be capable of satisfactory operation within voltage limits of 198 volts to 253 volts. Pulse Amplitude Modulation shall be incorporated into electrical circuit. The outdoor unit shall be controlled by the microprocessor located in the indoor unit. The control voltage between the indoor unit and the outdoor unit shall be 208 volts AC.
- .6 Capacities: as indicated on drawings.

PART 3 EXECUTION

3.1 MANUFACTURER'S INSTRUCTIONS

- .1 Compliance: comply with manufacturer's written recommendations or specifications, including product technical bulletins, handling, storage and installation instructions, and datasheet.

3.2 INSTALLATION

- .1 Install in accordance with manufacturer's instructions.
- .2 Make power and controls connections.

3.3 FIELD QUALITY CONTROL

- .1 Manufacturer's Field Services:
 - .1 Have manufacturer of products, supplied under this Section, review Work involved in the handling, installation/application, protection and cleaning, of its products and submit written reports, in acceptable format, to verify compliance of Work.
 - .2 Manufacturer's Field Services: provide manufacturer's field services consisting of product use recommendations and periodic site visits for inspection of product installation in accordance with manufacturer's instructions.

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- .3 Include for the services of split AC units manufacturer's factory certified service technician who is experienced in start-up and repair services to assist in start-up, performance verification, and Commissioning of the systems on the job site.
 - .4 Manufacturer's representative is to be on site with Departmental Representative for Substantial Performance review, and as required by the Contractor for Commissioning.
 - .5 Schedule site visits, to review Work, at stages listed:
 - .1 After delivery and storage of products, and when preparatory Work, or other Work, on which the Work of this Section depends, is complete but before installation begins.
 - .2 Twice during progress of Work at 25% and 60% complete.
 - .3 Upon completion of the Work, after cleaning is carried out.
 - .6 Include for at least four site visits by manufacturer's representative to start-up and ensure trouble free and specified operation of the system.
 - .7 Obtain reports, within 3 days of review, and submit, immediately, to Departmental Representative.
- .2 Performance Verification (PV):
- .1 Timing:
 - .1 After TAB of ducted air systems.
 - .2 At same time as PV of related air handling units.
 - .2 Operate equipment and verify that performance criteria specified have been achieved.
 - .3 Inspect and test all sub-assemblies for conformance to Vendor's engineering and quality assurance specifications.
 - .4 Rejected Work:
 - .1 Remove defective Work, whether result of poor workmanship, use of defective products or damage and whether incorporated in Work or not, which has been rejected by Departmental Representative as failing to conform to Technical Documents. Replace or re-execute in accordance with Technical Documents.
 - .2 Make good other Contractor's work damaged by such removals or replacements promptly.
- .3 Start-up:
- .1 Verify that job site conditions for installation meet factory recommended and code required conditions for split AC units installation prior to start-up. These shall include as a minimum:
 - .1 Installation per the manufacturer's recommendations.
 - .2 Start-up services shall include checking for verification of proper installation for the split AC units, their options and their interface wiring to the building automation system.

3.4 CONTROL WIRING

- .1 The Contractor shall be responsible for the interconnecting control wiring between the indoor and outdoor units and control wiring between remote controllers, centralised control and relevant components. This work shall be co-ordinated with the Electrical/Controls Contractor for the routing and trunking of the cables.
- .2 Control wiring shall not be run next to power wiring. A minimum space of 100mm between both control and power cables shall apply.

3.5 REFRIGERANT PIPEWORK

- .1 Supply, install, test and commission all interconnecting refrigeration pipework between the outdoor and indoor units. Refer to Section 23 23 00 - Refrigerant Piping.

3.6 CONDENSATE PIPEWORK

- .1 A condensate line shall be installed to each fan coil unit. This shall be installed and insulated all as per the standard specification. Minimum size of condensate pipes to be 25 mm copper, insulated and pumped or drained by gravity from each fan coil, drains to run 1:50 min falls as indicated on drawings.

3.7 CLEANING

- .1 Proceed in accordance with Section 01 74 11 - Cleaning.
- .2 Upon completion and verification of performance of installation, remove surplus materials, excess materials, rubbish, tools and equipment.

