
PART 1 - GENERAL

- 1.1 ACTION AND INFORMATIONAL SUBMITTALS
- .1 Submit in accordance with Section 01 33 00 - Submittal Procedures.
 - .2 Product Data:
 - .1 Submit manufacturer's instructions, printed product literature and data sheets. Include product characteristics, performance criteria, physical size, finish and limitations.
 - .3 Shop Drawings:
 - .1 Indicate on drawings:
 - .1 Mounting arrangements.
 - .2 Operating and maintenance clearances.
 - .2 Shop drawings and product data accompanied by:
 - .1 Detailed drawings of bases, supports, and anchor bolts.
 - .2 Acoustical sound power data, where applicable.
 - .3 Points of operation on performance curves.
 - .4 Manufacturer to certify current model production.
 - .5 Certification of compliance to applicable codes.
 - .3 In addition to transmittal letter referred to in Section 01 33 00 - Submittal Procedures: use MCAC "Shop Drawing Submittal Title Sheet". Identify section and paragraph number.
- 1.2 CLOSEOUT SUBMITTALS
- .1 Submit in accordance with Section 01 78 00 - Closeout Submittals.
 - .2 Operation and Maintenance Data: submit operation and maintenance data.
 - .1 Operation and maintenance manual approved by, and final copies deposited with, Departmental Representative before final inspection.
 - .2 Operation data to include:
 - .1 Control schematics for systems including environmental controls.
 - .2 Description of systems and their controls.
 - .3 Description of operation of systems at various loads together with reset schedules and seasonal variances.

-
- .4 Operation instruction for systems and component.
 - .5 Description of actions to be taken in event of equipment failure.
 - .6 Valves schedule and flow diagram.
 - .7 Colour coding chart.
 - .3 Maintenance data to include:
 - .1 Servicing, maintenance, operation and trouble-shooting instructions for each item of equipment.
 - .2 Data to include schedules of tasks, frequency, tools required and task time.
 - .4 Performance data to include:
 - .1 Equipment manufacturer's performance datasheets with point of operation as left after commissioning is complete.
 - .2 Equipment performance verification test results.
 - .3 Special performance data as specified.
 - .4 Testing, adjusting and balancing reports as specified in Section 23 05 93 - Testing, Adjusting and Balancing for HVAC.
 - .5 Approvals:
 - .1 Submit 2 copies of draft Operation and Maintenance Manual to Departmental Representative for approval. Submission of individual data will not be accepted unless directed by Departmental Representative.
 - .2 Make changes as required and re-submit as directed by Departmental Representative.
 - .6 Additional data:
 - .1 Prepare and insert into operation and maintenance manual additional data when need for it becomes apparent during specified demonstrations and instructions.
 - .7 Site records:
 - .1 Departmental Representative will provide 1 set of reproducible mechanical drawings. Provide sets of white prints as required for each phase of work. Mark changes as work progresses and as changes occur. Include changes to existing mechanical systems, control systems and low voltage control wiring.
 - .2 Transfer information weekly to reproducibles, revising reproducibles to show work as actually installed.
 - .3 Use different colour waterproof ink for each service.
 - .4 Make available for reference purposes and inspection.

- .8 As-built drawings:
 - .1 Prior to start of Testing, Adjusting and Balancing for HVAC, finalize production of as-built drawings.
 - .2 Identify each drawing in lower right hand corner in letters at least 12 mm high as follows: - "AS BUILT DRAWINGS: THIS DRAWING HAS BEEN REVISED TO SHOW MECHANICAL SYSTEMS AS INSTALLED" (Signature of Contractor) (Date).
 - .3 Submit to Departmental Representative for approval and make corrections as directed.
 - .4 Perform testing, adjusting and balancing for HVAC using as-built drawings.
 - .5 Submit completed reproducible as-built drawings with Operating and Maintenance Manuals.
- .9 Submit copies of as-built drawings for inclusion in final TAB report.

1.3 MAINTENANCE
MATERIAL SUBMITTALS

- .1 Submit in accordance with Section 01 78 00 - Closeout Submittals.
- .2 Furnish spare parts as follows:
 - .1 One filter cartridge or set of filter media for each filter or filter bank in addition to final operating set.

1.4 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: deliver materials to site in original factory packaging, labelled with manufacturer's name and address.
- .3 Storage and Handling Requirements:
 - .1 Store materials indoors in dry location and in accordance with manufacturer's recommendations in clean, dry, well-ventilated area.
 - .2 Store and protect from nicks, scratches, and blemishes.
 - .3 Replace defective or damaged materials with new.

PART 2 - PRODUCTS .1 Not Used.

PART 3 - EXECUTION

- 3.1 EXAMINATION .1 Verification of Conditions: verify that conditions of substrate previously installed under other Sections or Contracts are acceptable for installation in accordance with manufacturer's written instructions.
- .1 Visually inspect substrate in presence of Departmental Representative.
 - .2 Inform Departmental Representative of unacceptable conditions immediately upon discovery.
 - .3 Proceed with installation only after unacceptable conditions have been remedied [and after receipt of written approval to proceed from Departmental Representative.
- 3.2 PAINTING REPAIRS AND RESTORATION .1 Do painting in accordance with Section 09 91 23 - Interior Painting.
- .2 Prime and touch up marred finished paintwork to match original.
 - .3 Restore to new condition, finishes which have been damaged.
- 3.3 SYSTEM CLEANING .1 Clean interior and exterior of all systems including strainers. Vacuum interior of ductwork and air handling units.
- 3.4 FIELD QUALITY CONTROL .1 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 - ACTION AND INFORMATIONAL 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.

3.5 DEMONSTRATION

- .1 Departmental Representative will use equipment and systems for test purposes prior to acceptance. Supply labour, material, and instruments required for testing.
- .2 Supply tools, equipment and personnel to demonstrate and instruct operating and maintenance personnel in operating, controlling, adjusting, trouble-shooting and servicing of all systems and equipment during regular work hours, prior to acceptance.
- .3 Use operation and maintenance manual, as-built drawings, and audio visual aids as part of instruction materials.
- .4 Instruction duration time requirements 24hrs.
- .5 Departmental Representative will record these demonstrations on video tape for future reference.

3.6 PROTECTION

- .1 Protect equipment and systems openings from dirt, dust, and other foreign materials with materials appropriate to system.

END OF SECTION

PART 1 - GENERAL

- 1.1 USE OF SYSTEMS .1 Use of existing permanent heating and or ventilating systems for supplying temporary heat or ventilation is permitted only under following conditions:.
- .1 Entire system is complete, pressure tested, cleaned, flushed out.
 - .2 Specified water treatment system has been commissioned, water treatment is being continuously monitored.
 - .3 Building has been closed in, areas to be heated/ventilated are clean and will not thereafter be subjected to dust-producing processes.
 - .4 There is no possibility of damage.
 - .5 Supply ventilation systems are protected by MERV 11 filters, inspected daily, changed every week or more frequently as required.
 - .6 Return systems have approved filters over openings, inlets, outlets.
 - .7 Systems will be:
 - .1 Operated as per manufacturer's recommendations and instructions.
 - .2 Operated by Contractor.
 - .3 Monitored continuously by Contractor.
 - .8 Warranties and guarantees are not relaxed.
 - .9 Regular preventive and other manufacturers recommended maintenance routines are performed by Contractor at own expense and under supervision of Departmental Representative.
 - .10 Refurbish entire system before static completion; clean internally and externally, restore to "as- new" condition, replace filters in air systems.
- .2 Filters specified in this Section are over and above those specified in other Sections of this project.
- .3 Exhaust systems are not included in approvals for temporary heating ventilation.

PART 2 - PRODUCTS

- 2.1 NOT USED .1 Not Used.

PART 3 - EXECUTION

3.1 NOT USED .1 Not Used.

END OF SECTION

PART 1 - GENERAL1.1 GENERAL
REQUIREMENTS

- .1 Conform with requirements of front end Sections 00 and 01 as they apply to the work of this discipline.

1.2 GENERAL

- .1 This project shall be commissioned prior to substantial completion. A Commissioning Authority shall be present on behalf of the Departmental Representative and shall determine the commissioning requirements. A Commissioning Agent retained by the Contractor shall perform the commissioning activities, with assistance as required from this sub-contractor, and shall submit the results of these activities to the Commissioning Authority for review and acceptance.
- .2 The sub-contractor shall provide all required labour and materials to assist the Commissioning Agent in the completion of the commissioning activities and requirements.

PART 2 - PRODUCTS2.1 PRODUCTS

- .1 Not applicable.

PART 3 - EXECUTION3.1 Execution

- .1 Coordinate demonstration and verification of mechanical systems with the Commissioning Agent. Invite Departmental Representatives to participate in all commissioning activities.
- .2 Attend meetings with the Commissioning Agent as required to establish requirements for commissioning process throughout construction.
- .3 Perform the following key activities:
.1 Submittals - submit shop drawings and product data sheets.
.2 Manufacturer's factory tests - submit results.
.3 Equipment start-up tests - perform and submit results.

- .4 Manufacturer's start-up tests - perform and submit results.
 - .5 Verify operation and performance of systems.
 - .6 Adjust and recommission systems as necessary to achieve specified performance.
 - .7 Balancing - complete and submit results.
 - .8 Maintenance and Operations Manual - prepare and submit.
 - .9 Instruction of operating staff - provide as necessary.
- .4 Refer to Commissioning Specifications for a complete list of required activities.

END OF SECTION

PART 1 - GENERAL1.1 REFERENCES

- .1 Canadian General Standards Board (CGSB)
 - .1 CAN/CGSB-1.181-99, Ready-Mixed Organic Zinc-Rich Coating.
- .2 National Fire Code of Canada (NFCC 2015)

1.2 QUALITY ASSURANCE

- .1 Sustainability Standards Certification:
 - .1 Low-Emitting Materials: provide listing of sealants and coatings used in building, comply with VOC and chemical component limits or restriction requirements.

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.

PART 2 - PRODUCTS2.1 MATERIAL

- .1 Sealants: in accordance with the following:
 - .1 Sealants: maximum VOC limit to SCAQMD Rule 1168.

PART 3 - EXECUTION3.1 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.
- .2 Provide space for disassembly, removal of equipment and components as recommended by manufacturer 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 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 air vents at high points in piping systems.
- .2 Install isolating valve at each automatic air valve.
- .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.
- .4 Over NPS 2: isolating flanges.

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.
- .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 Provide for thermal expansion as indicated.
- .14 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 butterfly valves at branch take-offs for isolating purposes except where specified.
 - .7 Install butterfly valves on chilled water and related condenser water systems only.
 - .8 Install butterfly valves between weld neck flanges to ensure full compression of liner.
 - .9 Use chain operators on valves NPS 2 1/2 and larger where installed more than 2400mm above floor in Mechanical Rooms.

3.8 SLEEVES

- .1 General: install where pipes pass through masonry, concrete structures, fire rated assemblies, and as indicated.
- .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: 6mm 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 25mm above finished floor.
 - .3 Before installation, paint exposed exterior surfaces with heavy application of zinc-rich paint to CAN/CGSB-1.181.
- .6 Sealing:
 - .1 Foundation walls and below grade floors: 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.

3.9 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.

3.10 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 fires topping material or installation.
- .4 Insulated pipes and ducts: ensure integrity of insulation and vapour barriers.

3.11 FLUSHING OUT OF PIPING SYSTEMS

- .1 Flush system in accordance with Section 23 08 02 - Cleaning and Start-up of Mechanical Piping Systems.
- .2 Before start-up, clean interior of piping systems in accordance with requirements of Section 01 00 10 - General Instructions supplemented as specified in relevant mechanical sections.
- .3 Preparatory to acceptance, clean and refurbish equipment and leave in operating condition, including replacement of filters in piping systems.

3.12 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.
- .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.

3.13 EXISTING
SYSTEMS

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

3.14 CLEANING

- .1 Clean in accordance with Section 01 00 10 - General Instructions.
 - .1 Remove surplus materials, excess materials, rubbish, tools and equipment.

END OF SECTION

PART 1 - GENERAL1.1 REFERENCES

- .1 American Society of Mechanical Engineers (ASME)
 - .1 ASME B40.100-2013, 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.
- .3 Efficiency Valuation Organization (EVO)
 - .1 International Performance Measurement and Verification Protocol (IPMVP)
 - .1 IPMVP 2016 Version.

1.2 ACTION AND INFORMATIONAL SUBMITTALS

- .1 Submit in accordance with Section 01 33 00 - Submittal Procedures.
- .2 Product Data:
 - .1 Submit manufacturer's instructions, printed product literature and data sheets and include product characteristics, performance criteria, physical size, finish and limitations.
- .3 Certificates:
 - .1 Submit certificates signed by manufacturer certifying that materials comply with specified performance characteristics and physical properties.
- .4 Test and Evaluation Reports:
 - .1 Submit certified test reports for thermometers and pressure gauges from approved independent testing laboratories, indicating compliance with specifications for specified performance characteristics and physical properties.

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: deliver materials to site in original factory packaging, labelled with manufacturer's name and address.

PART 2 - PRODUCTS

2.1 GENERAL

- .1 Design point to be at mid-point of scale or range.

2.2 DIRECT READING THERMOMETERS

- .1 Industrial, variable angle type, mercury-free, liquid filled, 125mm scale length: to CAN/CGSB-14.4.
 - .1 Resistance to shock and vibration.

2.3 THERMOMETER WELLS

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

2.4 PRESSURE GAUGES

- .1 112mm, dial type: to ASME B40.100, Grade 2A, stainless steel bourdon tube having 0.5% accuracy full scale unless otherwise specified.
- .2 Provide:
 - .1 Snubber for pulsating operation.
 - .2 Diaphragm assembly for corrosive service.
 - .3 Gasketed pressure relief back with solid front.
 - .4 Bronze stop cock.
 - .5 Oil filled.

PART 3 - EXECUTION

3.1 EXAMINATION

- .1 Verification of Conditions: verify that conditions of substrate previously installed under other Sections or Contracts are acceptable for installation in accordance with manufacturer's written instructions.
 - .1 Visually inspect substrate in presence of Departmental Representative.
 - .2 Inform Departmental Representative of unacceptable conditions immediately upon discovery.

.3 Proceed with installation only after unacceptable conditions have been remedied [and after receipt of written approval to proceed from Departmental Representative.

3.2 GENERAL

- .1 Install thermometers and gauges so they can be easily read from floor or platform.
 - .1 If this cannot be accomplished, install remote reading units.
- .2 Install between equipment and first fitting or valve.

3.3 THERMOMETERS

- .1 Install in wells on piping. Include heat conductive material inside well.
- .2 Install in locations on inlet and outlet of:
 - .1 Water heating and cooling coils.
- .3 Install wells for balancing purposes.
- .4 Use extensions where thermometers are installed through insulation.

3.4 PRESSURE GAUGES

- .1 Install in locations as follows:
 - .1 Upstream and downstream of control valves.
 - .2 Inlet and outlet of coils.
- .2 Install gauge cocks for balancing purposes.
- .3 Use extensions where pressure gauges are installed through insulation.

3.5 NAMEPLATES

- .1 Install engraved lamicoïd nameplates in accordance with Section 23 05 53.01 - Mechanical Identification, identifying medium.

3.6 PROTECTION

- .1 Protect installed products and components from damage during construction.

- .2 Repair damage to adjacent materials caused by
thermometer and gauge installation.

END OF SECTION

PART 1 - GENERAL1.1 REFERENCES

- .1 American National Standards Institute (ANSI)/American Society of Mechanical Engineers (ASME)
 - .1 ANSI/ASME B1.20.1-2013, Pipe Threads, General Purpose (Inch).
 - .2 ANSI/ASME B16.18-2012, Cast Copper Alloy Solder Joint Pressure Fittings.
- .2 ASTM International
 - .1 ASTM A 276-16a, Standard Specification for Stainless Steel Bars and Shapes.
 - .2 ASTM B 62-15, Standard Specification for Composition Bronze or Ounce Metal Castings.
 - .3 ASTM B 283-16, Standard Specification for Copper and Copper Alloy Die Forgings (Hot-Pressed).
 - .4 ASTM B 505/B 505M-14, Standard Specification for Copper-Base 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-80-2008, Bronze Gate Globe, Angle and Check Valves.
 - .3 MSS-SP-110-2010, Ball Valves, Threaded, Socket-Welding, Solder Joint, Grooved and Flared Ends.

1.2 ACTION AND INFORMATIONAL SUBMITTALS

- .1 Provide submittals in accordance with Section 01 33 00 - Submittal Procedures.
- .2 Product Data:
 - .1 Provide manufacturer's printed product literature and data sheets for equipment and systems and include product characteristics, performance criteria, physical size, finish and limitations.

1.3 CLOSEOUT SUBMITTALS

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

1.4 MAINTENANCE MATERIAL SUBMITTALS

- .1 Extra Materials/Spare Parts:
 - .1 Tools:
 - .1 Furnish special tools for maintenance of systems and equipment.

- .2 Include following:
 - .1 Lubricant gun for expansion joints.

PART 2 - PRODUCTS

2.1 MATERIALS

- .1 Valves:
 - .1 Except for specialty valves, to be single manufacturer.
 - .2 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 B 62.
 - .2 NPS 2 and under, non-rising stem, solid wedge disc, Class 300
 - .1 Body: with long disc guides, screwed bonnet with stem retaining nut.
 - .2 Operator: Handwheel.
 - .3 NPS 2 and under, non-rising stem, solid wedge disc, Class 300:
 - .1 Body: with long disc guides, screwed bonnet with stem retaining nut.
 - .2 Operator: handwheel.
 - .4 NPS 2 and under, rising stem, split wedge disc, Class 125:
 - .1 Body: with long disc guides, screwed bonnet.

- .6 Silent Check Valves:
 - .1 NPS 2 and under:
 - .1 Body: cast high tensile bronze to ASTM B 62 with integral seat.
 - .2 Pressure rating: Class 300.
 - .3 Connections: screwed ends to ANSI B1.20.1 and with hex. shoulders.
 - .4 Disc and seat: renewable rotating disc.
 - .5 Stainless steel spring, heavy duty.
 - .6 Seat: regrindable.
- .7 Ball Valves:
 - .1 NPS 2 and under:
 - .1 Body and cap: cast high tensile bronze to ASTM B 62.
 - .2 Pressure rating: Class 300.
 - .3 Connections: screwed ends to ANSI B1.20.1 and with hexagonal shoulders solder ends to ANSI.
 - .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.
- .8 Butterfly Valves:
 - .1 NPS 2 1/2 through NPS 6, 2068 kPa with grooved ends.
 - .1 Body: cast bronze, with copper-tube dimensioned grooved ends.
 - .2 Disc: elastomer coated ductile iron with integrally cast stem.
 - .3 Operator: lever or handwheel.

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.

END OF SECTION

PART 1 - GENERAL1.1 REFERENCES

- .1 American Society of Mechanical Engineers (ASME)
 - .1 ASME B16.1-15, Cast Iron Pipe Flanges and Flanged Fittings.
- .2 ASTM International Inc.
 - .1 ASTM A 49-2012, Standard Specification for Heat-Treated Carbon Steel Joint Bars.
 - .2 ASTM A 126-14, Standard Specification for Gray Iron Castings for Valves, Flanges, and Pipe Fittings.
 - .3 ASTM A 536-2014, Standard Specification for Ductile Iron Castings.
 - .4 ASTM B 61-15, Standard Specification for Steam or Valve Bronze Castings.
 - .5 ASTM B 62-15, Standard Specification for Composition Bronze or Ounce Metal Castings.
 - .6 ASTM B 85/B 85M-14, Standard Specification for Aluminum-Alloy Die Castings.
 - .7 ASTM B 209-14, Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate.
- .3 Manufacturers Standardization Society of the Valve and Fittings Industry, Inc. (MSS)
 - .1 MSS SP-61-13, Pressure Testing of Steel Valves.
 - .2 MSS SP-70-11, Grey Iron Gate Valves, Flanged and Threaded Ends.
 - .3 MSS SP-71-11, Grey Iron Swing Check Valves, Flanged and Threaded Ends.
 - .4 MSS SP-82-1992, Valve Pressure Testing Methods.
 - .5 MSS SP-85-2011, Cast Iron Globe and Angle Valves, Flanged and Threaded Ends.

1.2 ACTION AND INFORMATIONAL SUBMITTALS

- .1 Provide submittals in accordance with Section 01 33 00 - Submittal Procedures.
- .2 Product Data:
 - .1 Provide manufacturer's printed product literature, specifications and datasheets for valves and include product characteristics, performance criteria, physical size, finish and limitations.

1.3 CLOSEOUT SUBMITTALS

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

1.4 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.

PART 2 - PRODUCTS2.1 MATERIAL

- .1 Valves:
 - .1 Except for specialty valves, to be of single manufacturer.
- .2 Standard specifications:
 - .1 Gate valves: MSS SP-70.
 - .2 Check valves: MSS SP-71.
- .3 Requirements common to valves, unless specified otherwise:
 - .1 Body, bonnet: cast iron to ASTM B 209 Class B.
 - .2 Connections: flanged ends plain face to ANSI B16.1.
 - .3 Inspection and pressure testing: to MSS SP-82.
 - .4 Bonnet gasket: non-asbestos.
 - .5 Stem: to have precision-machined Acme or 60 degrees V threads, top screwed for handwheel nut.
 - .6 Stuffing box: non-galling two-piece ball-jointed packing gland, gland bolts and nuts.
 - .7 Gland packing: non-asbestos.
 - .8 Handwheel: die-cast aluminum alloy to ASTM B 85/B 85M or malleable iron to ASTM A 49. Nut of bronze to ASTM B 62.
 - .9 Identification tag: with catalogue number, size, other pertinent data.
- .4 All products to have CRN registration numbers.

2.2 GATE VALVES

- .1 NPS 2 1/2 - 8, non-rising stem, inside screw, bronze trim, solid wedge disc:
 - .1 Body and multiple-bolted bonnet: with bosses in body and bonnet for taps and drains, full length disc guides designed to ensure correct re-assembly, Class 300.

- .2 Disc: solid offset taper wedge, bronze to ASTM B 62.
- .3 Seat rings: renewable bronze to ASTM B 62, screwed into body.
- .4 Stem: bronze to ASTM B 62.
- .5 Disc: solid offset taper wedge, cast iron to ASTM A 126 Class B, secured to wrought steel stem.
- .6 Seat: integral with body.
- .7 Stem: wrought steel.
- .8 Operator: handwheel.

2.3 VALVE OPERATORS

- .1 Install valve operators as follows:
 - .1 Handwheel: on valves except as specified.
 - .2 Handwheel with chain operators: on valves installed more than 2400mm above floor.

2.4 CHECK VALVES

- .1 Swing check valves, Class 300:
 - .1 Body and bolted cover: with tapped and plugged opening on each side for hinge pin. Grooved or flanged ends: plain faced with smooth finish.
 - .1 Up to NPS 16: cast iron to ASTM A 126 Class B.
 - .2 NPS 18 and over: cast iron to ASTM A 126 Class C.
 - .2 Disc: rotating for extended life.
 - .1 Up to NPS 6: bronze to ASTM B 62.
 - .2 NPS 8 and over: bronze-faced cast iron.
 - .3 Seat rings: renewable bronze to ASTM B 62 screwed into body.
 - .4 Hinge pin, bushings: renewable bronze to ASTM B 62.
- .2 Swing check valves, NPS 2 1/2 - 8 Class 300:
 - .1 Body and bolted cover: cast iron to ASTM A 126 Class B with tapped and plugged opening on each side for hinge pin.
 - .2 Flanged ends: 2 mm raised face with serrated finish.
 - .3 Rating: 250 psi steam; 500 psi CWP.
 - .4 Disc: rotating for extended life.
 - .1 Up to NPS 3: bronze to ASTM B 61.
 - .2 NPS 4 - 8: iron faced with ASTM B 61 bronze.
 - .5 Seat rings: renewable bronze to ASTM B 61, screwed into body.
 - .6 Hinge pin, bushings: renewable, bronze to ASTM B 61.

- .7 Hinge: galvanized malleable iron.
- .8 Identification tag: fastened to cover.

PART 3 - EXECUTION

3.1 INSTALLATION

- .1 Install rising stem valves in upright position with stem above horizontal.

3.2 CLEANING

- .1 Clean in accordance with Section 01 00 10 - General Instructions.
- .2 Clean installed products in accordance to manufacturer's recommendation.

END OF SECTION

PART 1 - GENERAL1.1 REFERENCES

- .1 American National Standards Institute (ANSI)/American Society of Mechanical Engineers (ASME)
 - .1 ASME B1.20.1-2013, Pipe Threads, General Purpose (Inch).
 - .2 ASME B16.1-15, Gray Iron Pipe Flanges and Flanged Fittings: Classes 25,125 and 250.
 - .3 ANSI/ASME B16.5-13, Pipe Flanges and Flanged Fittings: NPS ½ through 24.
 - .4 ANSI/ASME B16.11-11, Forged Fittings, Socket-Welding and Threaded.
 - .5 ANSI/ASME B16.25-12, Buttwelding Ends.
 - .6 ANSI/ASME B16.34-13, Valves - Flanged, Threaded and Welding Ends.
- .2 ASTM International Inc.
 - .1 ASTM A 126-14, Standard Specification for Gray Iron Castings for Valves, Flanges, and Pipe Fittings.
 - .2 ASTM A 536-2014, Standard Specification for Ductile Iron Castings.
 - .3 ASTM B 62-15, Standard Specification for Composition Bronze or Ounce Metal Castings.
 - .4 ASTM B 209M-14, Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate Metric.

1.2 ACTION AND INFORMATIONAL SUBMITTALS

- .1 Provide submittals in accordance with Section 01 33 00 - Submittal Procedures.
- .2 Product Data:
 - .1 Submit manufacturer's printed product literature, specifications and datasheets for valves and include product characteristics, performance criteria, physical size, finish and limitations.
 - .2 Submit data for valves specified in this section.

1.3 CLOSEOUT SUBMITTALS

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

1.4 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.

1.5 MAINTENANCE
MATERIAL SUBMITTALS

- .1 Extra Materials/Spare Parts:
- .2 Tools:
 - .1 Furnish special tools for maintenance of systems and equipment.
 - .2 Include following:
 - .1 Lubricant gun for expansion joints.

PART 2 - PRODUCTS

2.1 BUTTERFLY
VALVES - RESILIENT
SEAT

- .1 Except to specialty valves, to be of single manufacturer.
- .2 To be suitable for dead-end service.
- .3 CRN registration number required for products.
- .4 Sizes:
 - .1 Wafer type: NPS 2 to 30.
 - .2 Flanged end type: NPS 2 to 12.
- .5 Pressure rating for tight shut-off at temperatures up to maximum for seat material.
 - .1 NPS 2 - 12: 300 psig.
- .6 Minimum seat temperature ratings to 135 degrees C.
- .7 Application: on-off operation.
- .8 Operators:
 - .1 NPS 2 - 6: handles capable of locking in any of ten (10) positions - 0 degrees to 90 degrees. Handle and release trigger - ductile iron. Return spring and hinge pin: carbon steel. Latch plate and mounting hardware: cadmium plated carbon steel. Standard coating: black laquer.
- .9 Designed to comply with MSS SP-67 and API 609.
- .10 Compatible with ANSI Class 300/Class 300 flanges.

- .11 Construction:
 - .1 Body ductile iron.
 - .2 Disc: 316 SS plated ductile iron.
 - .3 Seat: EPDM.
 - .4 Shaft: 316 stainless steel.
 - .5 Taper pin: 316 SS.
 - .6 Key: stainless.
 - .7 O-Ring: Buna-N.
 - .8 Bushings: Teflon.

2.2 MOUNTING FLANGES

- .1 Class 300 cast iron to ANSI B16.1 or Class 300 steel to B16.5 pipe flanges.

PART 3 - EXECUTION

3.1 PREPARATION

- .1 Valve and mating flange preparation.
 - .1 Inspect adjacent pipeline, remove rust, scale, welding slag, other foreign material.
 - .2 Ensure that valve seats and pipe flange faces are free of dirt or surface irregularities which may disrupt flange seating and cause external leakage.
 - .3 Install butterfly valves with disc in almost closed position.
 - .4 Inspect valve disc seating surfaces and waterway and eliminate dirt or foreign material.

3.2 INSTALLATION OF VALVES

- .1 Install in accordance with manufacturer's instructions.
- .2 Do not use gaskets between pipe flanges and valves unless instructed otherwise by valve manufacturer.
- .3 Verify suitability of valve for application by inspection of identification tag.
- .4 Mount actuator on to valve prior to installation.
- .5 Handle valve with care so as to prevent damage to disc and seat faces.
- .6 Valves in horizontal pipe lines should be installed with stem in horizontal position to minimize liner and seal wear.

-
- .7 Ensure that valves are centered between bolts before bolts are tightened and then opened and closed to ensure unobstructed disc movement. If interference occurs due, for example to pipe wall thickness, taper bore adjacent piping to remove interference.

3.3 ACTUATOR INSTALLATION

- .1 Air hoses or electrical connections to be made by actuator manufacturer.
- .2 Cycle valve operation from fully closed to fully open then back to fully closed.
- .3 At same time, check travel stop settings for proper disc alignment.

3.4 CLEANING

- .1 Clean in accordance with Section 01 00 10 - General Instructions.
- .2 Clean installed products in accordance to manufacturer's recommendation.

END OF SECTION

PART 1 - GENERAL1.1 REFERENCES

- .1 American Society of Mechanical Engineers (ASME)
 - .1 ASME B31.1-2012, Power Piping.
- .2 ASTM International
 - .1 ASTM A 307-2014, Standard Specification for Carbon Steel Bolts and Studs, 60,000 PSI Tensile Strength.
 - .2 ASTM A 563-15, Standard Specification for Carbon and Alloy Steel Nuts.
- .3 Manufacturer's Standardization Society of the Valves and Fittings Industry (MSS)
 - .1 MSS SP 58-2009, Pipe Hangers and Supports - Materials, Design and Manufacture.
 - .2 MSS SP 69-2003, Pipe Hangers and Supports - Selection and Application.
- .4 Underwriter's Laboratories of Canada (ULC)
- .5 National Fire Code of Canada (2015)
- .6 National Plumbing Code of Canada (2015)

1.2 ACTION AND
INFORMATIONAL
SUBMITTALS

- .1 Provide submittals in accordance with Section 01 33 00 - Submittal Procedures.
- .2 Product Data:
 - .1 Provide manufacturer's printed product literature and data sheets for hangers and supports and include product characteristics, performance criteria, physical size, finish and limitations.
- .3 Shop Drawings:
 - .1 Submit shop drawings for:
 - .1 Bases, hangers and supports.
 - .2 Connections to equipment and structure.
 - .3 Structural assemblies.
- .4 Certificates:
 - .1 Submit certificates signed by manufacturer certifying that materials comply with specified performance characteristics and physical properties.

- .5 Manufacturers' Instructions:
 - .1 Provide manufacturer's installation instructions.
 - .1 Departmental Representative will make available one copy of systems supplier's installation instructions.

1.3 CLOSEOUT SUBMITTALS

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

PART 2 - PRODUCTS

2.1 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. Hangers to be seismic type.
 - .5 Provide for vertical adjustments after erection. Amount of adjustment in accordance with MSS SP 58.

2.2 GENERAL

- .1 Fabricate hangers, supports and sway braces in accordance with ANSI B31.1.
- .2 Use components for intended design purpose only. Do not use for rigging or erection purposes.

2.3 PIPE HANGERS

- .1 Finishes:
 - .1 Pipe hangers and supports: galvanized or painted with zinc-rich paint after manufacture.
 - .2 Use electro-plating galvanizing process or hot dipped galvanizing process.

-
- .3 Ensure steel hangers in contact with copper piping are copper plated or epoxy coated.
 - .2 Upper attachment structural: 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: 9mm UL listed.
 - .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 and MSS-SP 69.
 - .3 Upper attachment structural: 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 69.
 - .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 Upper attachment to concrete:
 - .1 Ceiling: carbon steel welded eye rod, clevis plate, clevis pin and cotters with weldless forged steel eye nut. Ensure eye 6mm minimum greater than rod diameter.
 - .2 Concrete inserts: wedge shaped body with knockout protector plate UL listed to MSS SP 69.
 - .5 Shop and field-fabricated assemblies:
 - .1 Trapeze hanger assemblies
 - .2 Steel brackets
 - .3 Sway braces for seismic restraint systems: to Section 23 05 48.
 - .6 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 28mm rod.
 - .7 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 to accommodate Thermal Insulation.
- .8 Adjustable clevis: material to MSS SP 69 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.
- .9 Yoke style pipe roll: carbon steel yoke, rod and nuts with cast iron roll, to MSS SP 69.
- .10 U-bolts: carbon steel to MSS SP 69 with 2 nuts at each end to ASTM A 563.
 - .1 Finishes for steel pipework: galvanized.
 - .2 Finishes for copper, glass, brass or aluminum pipework: galvanized, with formed portion plastic coated or epoxy coated.
- .11 Pipe rollers: cast iron roll and roll stand with carbon steel rod to MSS SP 69.

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 A 307.
- .4 Nuts: to ASTM A 563.

2.5 INSULATION PROTECTION SHIELDS

- .1 Insulated cold piping:
 - .1 64 kg/m³ density insulation plus insulation protection shield to: MSS SP 69, 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 69.

2.6 EQUIPMENT SUPPORTS .1 Fabricate equipment supports not provided by equipment manufacturer from structural grade steel.

2.7 EQUIPMENT ANCHOR BOLTS AND TEMPLATES .1 Provide templates to ensure accurate location of anchor bolts.

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:
.1 Manufacturer's instructions and recommendations.

.2 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.

.3 Clevis plates:
.1 Attach to concrete with 4 minimum concrete inserts, one at each corner.

.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.

3.3 HANGER SPACING

- .1 Plumbing piping: to Canadian Plumbing Code.
- .2 Fire protection: to the National Fire Code.
- .3 Copper piping: up to NPS 1/2: every 1.5m.
- .4 Flexible joint roll groove pipe: in accordance with table below for steel, but not less than one hanger at joints. Table listings for straight runs without concentrated loads and where full linear movement is not required.

- .5 Within 300mm of each elbow.

Maximum Pipe Size : NPS	Maximum Spacing Steel	Maximum Spacing Copper
up to 1-1/4	2.4 m	1.8 m
1-1/2	3.0 m	2.4 m
2	3.0 m	2.4 m
2-1/2	3.7 m	3.0 m
3	3.7 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	

- .6 Pipework greater than NPS 12: to MSS SP 69.

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.

END OF SECTION

PART 1 - GENERAL1.1 SUMMARY

- .1 Related Requirements
 - .1 Section 22 11 16 - Domestic Water Piping.
 - .2 Section 22 13 17 - Drainage Waste and Vent Piping-Cast Iron and Copper.
 - .3 Section 23 05 29 - Hangers and Supports for HVAC Piping and Equipment.

1.2 REFERENCES

- .1 Health Canada/Workplace Hazardous Materials Information System (WHMIS)
 - .1 Material Safety Data Sheets (MSDS).
- .2 National Fire Protection Association (NFPA)
 - .1 NFPA 13-2013, Standard for the Installation of Sprinkler Systems.
- .3 National Building Code of Canada (NBC) - 2015

1.3 ACTION AND INFORMATIONAL 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.
 - .1 Submit two copies of Workplace Hazardous Materials Information System (WHMIS) Material Safety Data Sheets (MSDS) in accordance with Section 01 33 00 - Submittal Procedures.
- .2 Submit shop drawings in accordance with Section 01 33 00 - Submittal Procedures.
 - .1 Shop drawings: submit drawings stamped and signed by professional engineer registered and licensed in the Province of Ontario, Canada.
 - .2 Provide separate shop drawings for each isolated system complete with performance and product data.
 - .3 Provide detailed drawings of seismic control measures for equipment and piping.
- .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.

.3 Manufacturer's Field Reports: manufacturer's field reports specified.

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.

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; 9mm minimum thick; 50 durometer; maximum loading 350 kPa.
- .2 Type EP2 - rubber waffle or ribbed; 9mm minimum thick; 30 durometer natural rubber; maximum loading 415 kPa.
- .3 Type EP3 - neoprene-steel-neoprene; 9mm minimum thick neoprene bonded to 1.71mm steel plate; 50 durometer neoprene, waffle or ribbed; holes sleeved with isolation washers; maximum loading 350 kPa.
- .4 Type EP4 - rubber-steel-rubber; 9mm minimum thick rubber bonded to 1.71mm 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 or 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 6mm minimum thick ribbed neoprene or rubber friction and acoustic pad.
- .3 Type M3 - stable open spring: 6mm 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 6mm 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.
- .6 Performance: as indicated.

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.
 - .6 Performance: as indicated.
- 2.7 ACOUSTIC BARRIERS FOR ANCHORS AND GUIDES
- .1 Acoustic barriers: between pipe and support, consisting of 25mm minimum thick heavy duty duck and neoprene isolation material.
- 2.8 HORIZONTAL THRUST RESTRAINT
- .1 Spring and elastomeric element housed in box frame; assembly complete with rods and angle brackets for equipment and ductwork attachment; provision for adjustment to limit maximum start and stop movement to 9mm.
 - .2 Arrange restraints symmetrically on either side of unit and attach at centerline of thrust.
- 2.9 SEISMIC CONTROL MEASURES
- .1 General:
 - .1 Seismic control systems to work in every direction.
 - .2 Fasteners and attachment points to resist same maximum load as seismic restraint.
 - .3 Drilled or power driven anchors and fasteners not permitted.
 - .4 No equipment, equipment supports or mounts to fail before failure of structure.
 - .5 Supports of cast iron or threaded pipe not permitted.
 - .6 Seismic control measures not to interfere with integrity of firestopping.
 - .2 Static equipment:
 - .1 Anchor equipment to equipment supports. Anchor equipment supports to structure.
 - .2 Suspended equipment:
 - .1 Install tight to structure.
 - .2 Cross brace in every direction.
 - .3 Brace back to structure.
 - .4 Cable restraint system.

- .3 Seismic restraints:
 - .1 Cushioning action gentle and steady.
 - .2 Never reach metal-like stiffness.
- .3 Vibration isolated equipment:
 - .1 Seismic control measures not to jeopardize noise and vibration isolation systems. Provide 6 to 9mm clearance during normal operation of equipment and systems between seismic restraint and equipment.
 - .2 Incorporate seismic restraints into vibration isolation system to resist complete isolator unloading.
 - .3 As indicated.
- .4 Piping systems:
 - .1 Fire protection systems: to NFPA 13.
 - .2 Piping systems: hangers longer than 300mm; brace at each hanger.
 - .3 Compatible with requirements for anchoring and guiding of piping systems.
- .5 Bracing methods:
 - .1 Shall be reviewed as a shop drawing by the 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.

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 25mm minimum static deflection as follows:
 - .1 Up to NPS4: first 3 points of support. NPS5 to NPS8: first 4 points of support. NPS10 and Over: first 6 points of support.
 - .2 First point of support: static deflection of twice deflection of isolated equipment, but not more than 50mm.
- .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.

3.3 FIELD QUALITY CONTROL

- .1 Manufacturer's Field Services:
 - .1 Arrange with manufacturer's representative to review work of this Section and submit written reports to verify compliance with Contract 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.

END OF SECTION

PART 1 - GENERAL1.1 SUMMARY

- .1 Related Requirements
 - .1 Section 22 11 16 - Domestic Water Piping.
 - .2 Section 22 13 17 - Drainage Waste and Vent Piping-Cast Iron and Copper.

1.2 REFERENCES

- .1 Canadian General Standards Board (CGSB)
 - .1 CAN/CGSB-24.3-92, Identification of Piping Systems.
- .2 National Fire Protection Association (NFPA)
 - .1 NFPA 13-2016, Standard for the Installation of Sprinkler Systems.
 - .2 NFPA 14-2016, Standard for the Installation of Standpipe and Hose Systems.

1.3 ACTION AND INFORMATIONAL SUBMITTALS

- .1 Product Data:
- .2 Submittals: in accordance with Section 01 33 00 - Submittal Procedures.
- .3 Product data to include paint colour chips, other products specified in this section.
- .4 Samples:
 - .1 Submit samples in accordance with Section 01 33 00 - Submittal Procedures.
 - .2 Samples to include nameplates, labels, tags, lists of proposed legends.
- .5 Contractor to complete and submit BGIS CMMS (Computerized Maintenance Management System) forms for new, removed and modified equipment - BGIS CMMS forms to be submitted prior to Substantial Completion. Contractor to provide at start of project list or all BGIS CMMS equipment for removal or de-commissioning. Include completed BGIS CMMS inventory sheets in the O&M manual.

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.

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.

2.2 SYSTEM NAMEPLATES

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

.3 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.

-
- .4 Identification for BGIS Computerized Maintenance Management System (CMMS):
 - .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 EXISTING IDENTIFICATION SYSTEMS
- .1 Apply existing identification system to new work.
 - .2 Where existing identification system does not cover for new work, use identification system specified this section.
 - .3 Before starting work, submit samples of identification system for review by the Departmental Representative. The submission shall be in the form of a formal shop drawings submission.
- 2.4 PIPING SYSTEMS GOVERNED BY CODES
- .1 Identification:
 - .1 Sprinklers: to NFPA 13.
 - .2 Standpipe and hose systems: to NFPA 14.
- 2.5 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 75mm: 100mm long x 50mm high.
 - .2 Outside diameter of pipe or insulation 75mm and greater: 150mm long x 50mm 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 20mm and smaller: waterproof and heat-resistant pressure sensitive plastic marker tags.
 - .2 Other pipes: pressure sensitive vinyl with protective overcoating, waterproof contact adhesive undercoating, suitable for ambient of 100% RH and continuous operating temperature of 150 degrees C and intermittent temperature of 200 degrees 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
Domestic hot water supply	Green	DOM. HW SUPPLY
Dom. HWS recirculation	Green	DOM. HW CIRC
Domestic cold water supply	Green	DOM. CWS
Sanitary	Green	SAN
Plumbing vent	Green	SAN. VENT
Fire protection water	Red	FIRE PROT. WTR
Sprinklers	Red	SPRINKLERS

2.6 IDENTIFICATION DUCTWORK SYSTEMS

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

2.7 VALVES, CONTROLLERS

- .1 Brass tags with 12mm 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.

2.8 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.

2.9 LANGUAGE

- .1 Identification in English and French.
- .2 Use one nameplate and label for both languages.

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

3.3 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.
- 3.4 LOCATION OF IDENTIFICATION ON PIPING AND DUCTWORK SYSTEMS
- .1 On long straight runs in open areas: 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.
- 3.5 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 in a service room of close proximity. Provide one copy (reduced in size if required) in each operating and maintenance manual.
- .3 Number valves in each system consecutively.

END OF SECTION

PART 1 - GENERAL1.1 General

- .1 TAB means to test, adjust and balance.
- .2 TAB: performed in accordance with the requirements of:
 - .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-2005.
 - .3 Sheet Metal and Air Conditioning Contractors' National Association (SMACNA), HVAC TAB HVAC Systems - Testing, Adjusting and Balancing-2002.
- .3 Use TAB Standard provisions, including checklists, and report forms to satisfy Contract requirements.
- .4 Where instrument manufacturer calibration recommendations are more stringent than those listed in TAB Standard, use manufacturer's recommendations.

1.2 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.

1.3 EXCEPTIONS

- .1 TAB of systems and equipment regulated by codes, standards to satisfaction of authority having jurisdiction.

1.4 CO-ORDINATION

- .1 Schedule time required for TAB (including repairs, re-testing) 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.

1.5 PRE-TAB REVIEW

- .1 Review contract documents before project construction is started.
- .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.

1.6 START-UP

- .1 Follow start-up procedures as recommended by equipment manufacturer unless specified otherwise.

1.7 OPERATION OF SYSTEMS DURING TAB

- .1 Operate systems for length of time required for TAB for verification of TAB reports.

1.8 START OF TAB

- .1 Notify Departmental Representative 7 days prior to start of TAB.
- .2 Start TAB when building is essentially completed, including:
- .3 Installation of ceilings, doors, windows, other construction affecting TAB.
- .4 Application of weatherstripping, sealing, and caulking.
- .5 Provisions for TAB installed and operational.
- .6 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 Access doors, installed, closed.
 - .7 Outlets installed, volume control dampers open.
-
- 1.9 APPLICATION TOLERANCES
 - .1 Do TAB to following tolerances of design values:
 - .1 HVAC systems: plus 5%, minus 5%.
-
- 1.10 ACCURACY TOLERANCES
 - .1 Measured values accurate to within plus or minus 2% of actual values.
-
- 1.11 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.
-
- 1.12 ACTION AND INFORMATIONAL SUBMITTALS
 - .1 Submit, prior to commencement of TAB:
 - .2 Proposed methodology and procedures for performing TAB if different from referenced standard.
-
- 1.13 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.

1.14 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.

1.15 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 directed by Departmental Representative.
- .4 Pay costs to repeat TAB as required to satisfaction of Departmental Representative.

1.16 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.

1.17 COMPLETION OF TAB

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

1.18 AIR SYSTEMS

- .1 Standard: TAB to most stringent of this section or TAB standards of AABC, NEBB, SMACNA, ASHRAE.

-
- .2 Quality assurance: perform TAB under direction of supervisor qualified to standards of AABC or NEBB.
- .3 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.
- .4 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.
- .5 Locations of systems measurements to include as appropriate: main ducts, main branch, sub-branch, run-out (or grille, register or diffuser).
- 1.19 POST-OCCUPANCY TAB .1 Measure DBT, WBT (or %RH), air velocity, air flow patterns, NC levels, in occupied zone.

PART 2 - PRODUCTS

- 2.1 NOT USED .1 Not used.

PART 3 - EXECUTION

- 3.1 NOT USED .1 Not used.

END OF SECTION

PART 1 - GENERAL

1.1 REFERENCES

- .1 Health Canada/Workplace Hazardous Materials Information System (WHMIS)
 - .1 Material Safety Data Sheets (MSDS).
- .2 Sheet Metal and Air Conditioning Contractor's National Association (SMACNA)
 - .1 SMACNA HVAC Air Duct Leakage Test Manual, 2012.

1.2 ACTION AND INFORMATIONAL SUBMITTALS

- .1 Make submittals in accordance with Section 01 33 00 - Submittal Procedures.
- .2 Test Reports: submit certified test reports from approved independent testing laboratories indicating compliance with specifications for specified performance characteristics and physical properties. Include pressure test information and results as follows:
 - .1 Submit proposed report form and test report format to Departmental Representative for approval at least two weeks before proposed date of first series of tests. Do not start tests until approval received in writing from Departmental Representative.
 - .2 Prepare report of results and submit to Departmental Representative within 24 hours of completion of tests. Include:
 - .1 Schematic of entire system.
 - .2 Schematic of section under test showing test site.
 - .3 Required and achieved static pressures.
 - .4 Orifice differential pressure at test sites.
 - .5 Permissible and actual leakage flow rate (L/s) for test sites.
 - .6 Witnessed certification of results.
 - .3 Include test reports in final TAB report.
 - .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 specified.

1.3 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.

PART 2 - PRODUCTS

2.1 TEST
INSTRUMENTS

- .1 Test apparatus to include:
 - .1 Fan capable of producing required static pressure.
 - .2 Duct section with calibrated orifice plate mounted and accurately located pressure taps.
 - .3 Flow measuring instrument compatible with the orifice plate.
 - .4 Calibration curves for orifice plates used.
 - .5 Flexible duct for connecting to ductwork under test.
 - .6 Smoke bombs for visual inspections.
- .2 Test apparatus: accurate to within +/- 3% of flow rate and pressure.
- .3 Submit details of test instruments to be used to Departmental Representative at least two weeks before anticipated start date.
- .4 Test instruments: calibrated and certificate of calibration deposited with Departmental Representative no more than 14 days before start of tests.
- .5 Re-calibrated every six months thereafter.

2.2 EQUIPMENT
LEAKAGE TOLERANCES

- .1 Equipment and system components such as VAV boxes, duct heating leakage: 2% at operating pressure.

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 TEST PROCEDURES
- .1 Maximum lengths of ducts to be tested consistent with capacity of test equipment.
 - .2 Section of duct to be tested to include:
 - .1 Fittings, branch ducts, tap-ins.
 - .3 Repeat tests until specified pressures are attained. Bear costs for repairs and repetition to tests.
 - .4 Base partial system leakage calculations on SMACNA HVAC Air Duct Leakage Test Manual.
 - .5 Seal leaks that can be heard or felt, regardless of their contribution to total leakage.
- 3.3 SITE TOLERANCES
- .1 System leakage tolerances specified are stated as percentage of total flow rate handled by system. Pro-rate specified system leakage tolerances. Leakage for sections of duct systems: not to exceed total allowable leakage.
 - .2 Leakage tests on following systems not to exceed specified leakage rates.
 - .1 Small duct systems up to 250 Pa: leakage 2%.
 - .2 VAV box and duct on downstream side of VAV box: leakage 2%.
 - .3 Large low pressure duct systems up to 500 Pa: leakage 2%.
 - .4 HP duct systems up to 1000 Pa pressure classification, including upstream side of VAV boxes: leakage 1.
 - .3 Evaluation of test results to use surface area of duct and pressure in duct as basic parameters.

- 3.4 TESTING
- .1 Test ducts before installation of insulation or other forms of concealment.
 - .2 Test after seals have cured.
 - .3 Test when ambient temperature will not affect effectiveness of seals, and gaskets.
 - .4 Flexible connections to VAV boxes.
- 3.5 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 product[s] and submit written reports, in acceptable format, to verify compliance of Work with Contract.
 - .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 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.
 - .2 Performance Verification:
 - .1 Departmental Representative to witness tests and to verify reported results.
 - .2 To be certified by same TAB agency to undertake TAB on this project.

END OF SECTION

PART 1 - GENERAL1.1 RELATED
REQUIREMENTS

- .1 Section 23 31 13.01 - Metal Ducts-Low Pressure to 500 PA.
- .2 Section 23 31 13 .02 - Metal Ducts-High Pressure to 2500 PA.

1.2 REFERENCES

- .1 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" - means "not concealed" as previously defined.
 - .3 Insulation systems - insulation material, fasteners, jackets, and other accessories.
 - .2 TIAC Codes:
 - .1 CRD: Code Round Ductwork,
 - .2 CRF: Code Rectangular Finish.
- .2 Reference Standards:
 - .1 American Society of Heating, Refrigeration and Air Conditioning Engineers (ASHRAE)
 - .1 ANSI/ASHRAE/IESNA 90.1-2013, SI; Energy Standard for Buildings Except Low-Rise Residential Buildings.
 - .2 ASTM International Inc.
 - .1 ASTM B 209M-2014, Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate (Metric).
 - .2 ASTM C 335-2010e1, Standard Test Method for Steady State Heat Transfer Properties of Pipe Insulation.
 - .3 ASTM C 449/C 449M-2013, Standard Specification for Mineral Fiber-Hydraulic-Setting Thermal Insulating and Finishing Cement.
 - .4 ASTM C 553-2013, Standard Specification for Mineral Fiber Blanket Thermal Insulation for Commercial and Industrial Applications.
 - .5 ASTM C 612-2014, Standard Specification for Mineral Fiber Block and Board Thermal Insulation.
 - .6 ASTM C 921-2015, Standard Practice for Determining the Properties of Jacketing Materials for Thermal Insulation.

- .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.
- .4 Thermal Insulation Association of Canada (TIAC): National Insulation Standards 2005.
- .5 Underwriters Laboratories of Canada (ULC)
 - .1 CAN/ULC-S102-2010, Method of Test for Surface Burning Characteristics of Building Materials and Assemblies.

1.3 ACTION AND
INFORMATIONAL
SUBMITTALS

- .1 Provide submittals in accordance with Section 01 33 00 - Submittal Procedures.
- .2 Product Data:
 - .1 Provide manufacturer's printed product literature and datasheets for duct insulation, and include product characteristics, performance criteria, physical size, finish and limitations.
 - .1 Description of equipment giving manufacturer's name, type, model, year and capacity.
 - .2 Details of operation, servicing and maintenance.
 - .3 Recommended spare parts list.
- .3 Samples:
 - .1 Submit for approval: complete assembly of each type of insulation system, insulation, coating, and adhesive proposed.
 - .2 Mount sample on 12mm plywood board.
 - .3 Affix typewritten label beneath sample indicating service.
- .4 Manufacturers' Instructions:
 - .1 Provide manufacture's written duct insulation jointing recommendations. and special handling criteria, installation sequence and cleaning procedures.

PART 2 - PRODUCTS

2.1 FIRE AND SMOKE
RATING

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

2.2 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 degrees C mean temperature when tested in accordance with ASTM C 335.
- .3 TIAC Code C-1: Rigid mineral fibre board to ASTM C 612, 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 C 553 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 C 553.
 - .2 Jacket: to CGSB 51-GP-52Ma.
 - .3 Maximum "k" factor: to ASTM C 553.

2.3 JACKETS

- .1 Canvas:
 - .1 220 gm/m² cotton, plain weave, treated with dilute fire retardant lagging adhesive to ASTM C 921.
- .2 Lagging adhesive: compatible with insulation.
- .3 Aluminum:
 - .1 To ASTM B 209 with moisture barrier as scheduled in PART 3 of this section.
 - .2 Thickness: 0.50mm sheet.
 - .3 Finish: Stucco embossed or Corrugated.
 - .4 Jacket banding and mechanical seals: 19mm wide, 0.5 mm thick stainless steel.
 - .1 Stainless steel:
 - .5 Type: 304.
 - .6 Thickness: 0.50mm sheet.
 - .7 Finish: Corrugated or Stucco embossed.

2.4 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 on mineral wool, to ASTM C 449.

- .4 ULC Listed Canvas Jacket:
 - .1 220 gm/m² cotton, plain weave, treated with dilute fire retardant lagging adhesive to ASTM C 921.
- .5 Tape: self-adhesive, aluminum, reinforced, 75mm wide minimum.
- .6 Contact adhesive: quick-setting
- .7 Canvas adhesive: washable.
- .8 Tie wire: 1.5mm stainless steel.
- .9 Banding: 19mm wide, 0.5mm thick stainless steel.
- .10 Facing: 25mm stainless steel hexagonal wire mesh stitched on both faces of insulation.
- .11 Fasteners: 4mm diameter pins with 35mm diameter clips, length to suit thickness of insulation.

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 PRE-INSTALLATION REQUIREMENTS

- .1 Pressure test ductwork systems complete, witness and certify.
- .2 Ensure surfaces are clean, dry, free from foreign material.

3.3 INSTALLATION

- .1 Install in accordance with TIAC National Standards.
- .2 Apply materials in accordance with manufacturers instructions and as indicated.
- .3 Use 2 layers with staggered joints when required nominal thickness exceeds 75mm.

- .4 Maintain uninterrupted continuity and integrity of vapour retarder jacket and finishes.
.1 Ensure hangers, and supports are outside vapour retarder jacket.
- .5 Hangers and supports 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: install at 300mm on center in horizontal and vertical directions, minimum 2 rows each side.
- .7 Contractor to install thermal duct insulation on all supply duct work up to VAV boxes.

3.4 DUCTWORK INSULATION SCHEDULE

- .1 Insulation types and thicknesses: conform to following table based on ASHRAE 90.1:

	TIAC Code	Vapour Retarder	Thickness (mm)
Rectangular cold temperature supply air ducts	C-1	yes	50
Round cold temperature supply air ducts	C-2	yes	50
Rectangular warm air ducts	C-1	yes	25
Round warm air ducts	C-1	yes	25
Supply, none return and exhaust ducts exposed in space being served			
Outside air ducts to mixing plenum	C-1	yes	50
Mixing plenums	C-1	yes	25
Acoustically lined ducts	none		

- .2 Exposed round ducts 600 mm and larger, smaller sizes where subject to abuse:
.1 Use TIAC code C-1 insulation, scored to suit diameter of duct.

.1 Finishes: conform to following table:

	TIAC Code	
	Rectangular	Round
Indoor, concealed	none	none
Indoor, exposed within mechanical room	CRF/1	CRD/2
Indoor, exposed elsewhere	CRF/2	CRD/3

END OF SECTION

PART 1 - GENERAL1.1 REFERENCES

- .1 American Society of Heating, Refrigeration and Air Conditioning Engineers (ASHRAE)
 - .1 ANSI/ASHRAE 90.1-2013-SI Edition, Energy Standard for Buildings Except Low-Rise Residential Buildings.

- .2 ASTM International Inc.
 - .1 ASTM B 209-2014, Standard Specification for Aluminum & Aluminum Alloy Sheet and Plate.
 - .2 ASTM C 335-2010e1, Standard Test Method for Steady State Heat Transfer Properties of Horizontal Pipe Insulation.
 - .3 ASTM C 449/C 449M-2013, Standard Specification for Mineral Fiber-Hydraulic-Setting Thermal Insulating and Finishing Cement.
 - .4 ASTM C 533-2013, Standard Specification for Calcium Silicate Block and Pipe Thermal Insulation.
 - .5 ASTM C 547-2015, Standard Specification for Mineral Fiber Pipe Insulation.
 - .6 ASTM C 553-2013, Standard Specification for Mineral Fiber Blanket Thermal Insulation for Commercial and Industrial Applications.
 - .7 ASTM C 612-2014, Standard Specification for Mineral Fiber Block and Board Thermal Insulation.
 - .8 ASTM C 921-2015, Standard Practice for Determining the Properties of Jacketing Materials for Thermal Insulation.

- .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.

1.2 ACTION AND INFORMATIONAL SUBMITTALS

- .1 Provide submittals in accordance with Section 01 33 00 - Submittal Procedures.

- .2 Product Data:
 - .1 Provide manufacturer's printed product literature and datasheets for insulation and adhesives, include product characteristics, performance criteria, physical size, finish and limitations.

- .3 Samples:

.1 Provide for review: complete assembly of each type of insulation system, insulation, coating, and adhesive proposed.

.1 Mount sample on 12 mm plywood board.

.2 Affix typewritten label beneath sample indicating service.

.4 Manufacturer's Instructions:

.1 Include procedures to be used and installation standards to be achieved.

PART 2 - PRODUCTS

2.1 FIRE AND SMOKE RATING

- .1 Fire and smoke ratings to CAN/ULC-S102:
- .1 Maximum flame spread rating: 25.
 - .2 Maximum smoke developed rating: 50.

2.2 INSULATION

- .1 Mineral fibre: includes glass fibre, rock wool, slag wool.
- .2 Thermal conductivity ("k" factor) not to exceed specified values at 24 degrees C mean temperature when tested in accordance with ASTM C 335.
- .3 TIAC Code A-1: rigid moulded mineral fibre without factory applied vapour retarder jacket.
- .1 Mineral fibre: ASTM C 547.
 - .2 Maximum "k" factor: ASTM C 547.
- .4 TIAC Code A-3: rigid moulded mineral fibre with factory applied vapour retarder jacket.
- .1 Mineral fibre: ASTM C 547.
 - .2 Jacket: to CGSB 51-GP-52MA.
 - .3 Maximum "k" factor: ASTM C 547.
- .5 TIAC Code C-1: rigid mineral fibre board, unfaced.
- .1 Mineral fibre: ASTM C 612.
 - .2 Maximum "k" factor: ASTM C 612.
- .6 TIAC Code C-4: rigid mineral fibre board faced with factory applied vapour retarder jacket.
- .1 Mineral fibre: ASTM C 612.
 - .2 Jacket: to CGSB 51-GP-52MA.
 - .3 Maximum "k" factor: ASTM C 612.
- .7 TIAC Code C-2: mineral fibre blanket unfaced or faced with factory applied vapour retarder jacket (as scheduled in PART 3 of this section).

- .1 Mineral fibre: ASTM C 553.
- .2 Jacket: to CGSB 51-GP-52MA.
- .3 Maximum "k" factor: ASTM C 553.

- .8 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.
 - .4 Certified by manufacturer free of potential stress corrosion cracking corrodents.

- .9 TIAC Code A-2: rigid moulded calcium silicate in sections and blocks, and with special shapes to suit project requirements.
 - .1 Insulation: ASTM C 533.
 - .2 Maximum "k" factor: ASTM C 533.
 - .3 Design to permit periodic removal and re-installation.

- .10 Type E-6 Shall be batt type fibreglass blanket complete with foil encapsulating blanket. No exposed insulation fibres are acceptable.
 - .1 Secure insulation "blankets" to the back of all linear radiant heating panels using 2.0mm galvanized tie wires on approximately 450mm centres.
 - .2 Jacket to be compliant with CGSB 51-GP-52.M
 - .3 Insulation to be compliant with CGSB 51-GP-11M.

2.3 CEMENT

- .1 Thermal insulating and finish
 - .1 To: ASTM C 449/C 449M.
 - .2 Air drying on mineral wool, to ASTM C 449.

2.4 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.
 - .3 Minimum service temperatures: -20 degrees C.
 - .4 Maximum service temperature: 65 degrees C.
 - .5 Moisture vapour transmission: 0.02 perm.
 - .6 Thickness: .75mm.
 - .7 Fastenings:
 - .1 Use solvent weld adhesive compatible with insulation to seal laps and joints.
 - .2 Tacks.
 - .3 Pressure sensitive vinyl tape of matching colour.
 - .8 Special requirements:
 - .1 Outdoor: UV rated material at least 0.5mm

- thick.
- .9 Covering adhesive: compatible with insulation.
 - .2 Canvas:
 - .1 220 gm/m² cotton, plain weave, treated with dilute fire retardant lagging adhesive to ASTM C 921.
 - .2 Lagging adhesive: compatible with insulation.
 - .3 Aluminum:
 - .1 To ASTM B 209.
 - .2 Thickness: 0.50mm sheet.
 - .3 Finish: stucco embossed or corrugated.
 - .4 Joining: longitudinal and circumferential slip joints with 50mm laps.
 - .5 Fittings: 0.5mm thick die-shaped fitting covers with factory-attached protective liner.
 - .6 Metal jacket banding and mechanical seals: stainless steel, 19mm wide, 0.5mm thick at 300mm spacing.
 - .4 Stainless steel:
 - .1 Type: 304.
 - .2 Thickness: 0.25mm.
 - .3 Finish: corrugated or stucco embossed.
 - .4 Joining: longitudinal and circumferential slip joints with 50mm laps.
 - .5 Fittings: 0.5mm thick die-shaped fitting covers with factory-attached protective liner.
 - .6 Metal jacket banding and mechanical seals: stainless steel, 19mm wide, 0.5mm thick at 300mm spacing.

2.5 INSULATION SECUREMENTS

- .1 Tape: self-adhesive, aluminum, reinforced, 50mm wide minimum.
- .2 Contact adhesive: quick setting.
- .3 Canvas adhesive: washable.
- .4 Tie wire: 1.5mm diameter stainless steel.
- .5 Bands: Stainless steel, 19mm wide, 0.5mm thick.
- .6 Facing: 25mm galvanized steel hexagonal wire mesh on both faces of insulation.
- .7 Fasteners: 4mm diameter pins with 35mm diameter clips. Length of pin to suit thickness of insulation.

-
- | | | |
|---|----|---|
| <u>2.6 VAPOUR RETARDER
LAP ADHESIVE</u> | .1 | Water based, fire retardant type, compatible with insulation. |
| <u>2.7 INDOOR VAPOUR
RETARDER FINISH</u> | .1 | Vinyl emulsion type acrylic, compatible with insulation. |
| <u>2.8 OUTDOOR VAPOUR
RETARDER MASTIC</u> | .1 | Vinyl emulsion type acrylic, compatible with insulation. |
| | .2 | Reinforcing fabric: Fibrous glass, untreated 305 g/m ² . |

PART 3 - EXECUTION

- | | | |
|---|----|---|
| <u>3.1 APPLICATION</u> | .1 | Manufacturer's Instructions: comply with manufacturer's written recommendations, including product technical bulletins, handling, storage and installation instructions, and datasheets. Insulation thicknesses shall conform to ASHRAE 90.1. |
| | .2 | Apply 25mm thick layer of Type E-6 insulation to the top of all linear radiant panels. |
| <u>3.2 PRE-
INSTALLATION
REQUIREMENTS</u> | .1 | Pressure testing of equipment and adjacent piping systems complete, witnessed and certified. |
| | .2 | Surfaces clean, dry, free from foreign material. |
| <u>3.3 INSTALLATION</u> | .1 | Install in accordance with TIAC National Standards
.1 Hot equipment: To TIAC code 1503-H.
.2 Cold equipment: to TIAC code 1503-C. |
| | .2 | Elastomeric Insulation: to remain dry. Overlaps to manufacturer's instructions. Joints tight and sealed properly. |
| | .3 | Provide vapour retarder as recommended by manufacturer. |
| | .4 | Apply materials in accordance with insulation and equipment manufacturer's instructions and this specification. |

-
- .5 Use two layers with staggered joints when required nominal wall thickness exceeds 75mm.
 - .6 Maintain uninterrupted continuity and integrity of vapour retarder jacket and finishes.
 - .1 Hangers, supports outside vapour retarder jacket.
 - .7 Supports, Hangers:
 - .1 Apply high compressive strength insulation, suitable for service, at oversized saddles and shoes where insulation saddles have not been provided.
- 3.4 REMOVABLE,
PRE-FABRICATED,
INSULATION AND
ENCLOSURES
-
- .1 Application: At expansion joints, valves, flanges and unions at equipment.
 - .2 Installation to permit movement of expansion joint and to permit periodic removal and replacement without damage to adjacent insulation.

END OF SECTION

PART 1 - GENERAL1.1 SUMMARY

- .1 Related Requirements
 - .1 Section 22 11 16 - Domestic Water Piping.

1.2 REFERENCES

- .1 American Society of Heating, Refrigeration and Air Conditioning Engineers (ASHRAE)
 - .1 ASHRAE Standard 90.1-2013, Energy Standard for Buildings Except Low-Rise Residential Buildings (IESNA co-sponsored; ANSI approved; Continuous Maintenance Standard).
- .2 American Society for Testing and Materials International (ASTM)
 - .1 ASTM B 209M-2014, Standard Specification for Aluminum and Aluminum Alloy Sheet and Plate [Metric].
 - .2 ASTM C 335-2010E1, Standard Test Method for Steady State Heat Transfer Properties of Horizontal Pipe Insulation.
 - .3 ASTM C 449/C 449M-2013, Standard Specification for Mineral Fiber-Hydraulic-Setting Thermal Insulating and Finishing Cement.
 - .4 ASTM C 547-2012, Mineral Fiber Pipe Insulation.
 - .5 ASTM C 921-2010, Standard Practice for Determining the Properties of Jacketing Materials for Thermal Insulation.
- .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

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 ACTION AND INFORMATIONAL 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.
 - .1 Submit two copies of Workplace Hazardous Materials Information System (WHMIS) Material Safety Data Sheets (MSDS) in accordance with Section 01 33 00 - Submittal Procedures.
 - .3 Shop Drawings:
 - .1 Submit shop drawings in accordance with Section 01 33 00 - Submittal Procedures.
 - .4 Samples:
 - .1 Submit samples in accordance with Section 01 33 00 - Submittal Procedures.
 - .2 Submit for approval: complete assembly of each type of insulation system, insulation, coating, and adhesive proposed. Mount sample on 12mm plywood board. Affix label beneath sample indicating service.
 - .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 Departmental Representative will make available one copy of systems supplier's installation instructions.

PART 2 - PRODUCTS

- 2.1 FIRE AND SMOKE RATING
- .1 In accordance with CAN/ULC-S102.
 - .1 Maximum flame spread rating: 25.
 - .2 Maximum smoke developed rating: 50.
- 2.2 INSULATION
- .1 Mineral fibre specified includes glass fibre, rock wool, slag wool.

-
- .2 Thermal conductivity ("k" factor) not to exceed specified values at 24 degrees C mean temperature when tested in accordance with ASTM C 335.
 - .3 TIAC Code A-1: rigid moulded mineral fibre without factory applied vapour retarder jacket.
 - .1 Mineral fibre: to CAN/ULC-S702.
 - .2 Maximum "k" factor: to CAN/ULC-S702.
 - .4 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 C 547.
 - .2 Jacket: to CGSB 51-GP-52Ma.
 - .3 Maximum "k" factor: to CAN/ULC-S702 ASTM C 547.
 - .5 Insulation: with vapour retarder jacket.
 - .1 Jacket: to CGSB 51-GP-52Ma.
 - .2 Maximum "k" factor: .26.
 - .3 Certified by manufacturer: free of potential stress corrosion cracking corrodants.
- 2.3 INSULATION SECUREMENT
- .1 Tape: self-adhesive, aluminum, reinforced, 50mm wide minimum.
 - .2 Contact adhesive: quick setting.
 - .3 Canvas adhesive: washable.
 - .4 Tie wire: 1.5mm diameter stainless steel.
 - .5 Bands: stainless steel, 19mm wide, 0.5mm thick.
- 2.4 CEMENT
- .1 Thermal insulating and finishing cement:
 - .1 Air drying on mineral wool, to ASTM C 449/C 449M.
- 2.5 VAPOUR RETARDER LAP ADHESIVE
- .1 Water based, fire retardant type, compatible with insulation.

2.6 INDOOR VAPOUR
RETARDER FINISH

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

2.7 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 paint finish.
 - .3 Minimum service temperatures: -20 degrees C.
 - .4 Maximum service temperature: 65 degrees C.
 - .5 Moisture vapour transmission: 0.02 perm.
 - .6 Thickness: 0.5mm.
 - .7 Fastenings:
 - .1 Use solvent weld adhesive compatible with insulation to seal laps and joints.
 - .2 Tacks.
 - .3 Pressure sensitive vinyl tape of matching colour.
- .2 Canvas:
 - .1 220 gm/m² cotton, plain weave, treated with dilute fire retardant lagging adhesive to ASTM C 921.
 - .2 Lagging adhesive: compatible with insulation.
- .3 Aluminum:
 - .1 To ASTM B 209.
 - .2 Thickness: 0.50mm sheet.
 - .3 Finish: smooth or stucco embossed.
 - .4 Joining: longitudinal and circumferential slip joints with 50mm laps.
 - .5 Fittings: 0.5mm thick die-shaped fitting covers with factory-attached protective liner.
 - .6 Metal jacket banding and mechanical seals: stainless steel, 19mm wide, 0.5mm thick at 300mm spacing.
- .4 Stainless steel:
 - .1 Type: 304.
 - .2 Thickness: 0.25mm.
 - .3 Finish: smooth or stucco embossed.
 - .4 Joining: longitudinal and circumferential slip joints with 50mm laps.
 - .5 Fittings: 0.5mm thick die-shaped fitting covers with factory-attached protective liner.
 - .6 Metal jacket banding and mechanical seals: stainless steel, 19mm wide, 0.5mm thick at 300mm spacing.

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 manufacturers' instructions and this specification.
- .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.
- 3.4 REMOVABLE, PRE-FABRICATED, INSULATION AND ENCLOSURES
- .1 Application: at expansion joints, valves, 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: aluminum SS PVC or high temperature fabric.

- 3.5 INSTALLATION OF ELASTOMERIC INSULATION
- .1 Insulation to remain dry. Overlaps to manufacturers' 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 wire bands, Tape at 300mm on centre.
 - .2 Seals: lap seal adhesive, lagging adhesive.
 - .3 Installation: TIAC Code 1501-H.
 - .3 TIAC Code: C-2 with vapour retarder jacket.
 - .1 Insulation securements: SS wire bands, tape at 300mm on centre.
 - .2 Seals: lap seal adhesive, lagging adhesive.
 - .3 Installation: TIAC Code: 1501-C.
 - .4 Thickness of insulation as listed in following table per ASHRAE 90.1.
 - .1 Run-outs to individual units and equipment not exceeding 4000mm long.
 - .2 Do not insulate exposed runouts to plumbing fixtures, chrome plated piping, valves, fittings.

Applic a-tion	Temp degree s C	TIAC code	Pipe sizes (NPS) and insulation thickness (mm)					
			1 1/4 to 2	2 1/2 to 4	5 to 6	8 & over		
Domestic HWS	Run out	A-1	25	25	25	38	38	38
Heating Water/Glycol		A-1	25	25				
Domestic CWS/ Chilled Water with vapour retarder		C-2	25	25	25	25	25	25
Cooling Coil cond. drain		C-2	25	25	25	25	25	25

- .5 Finishes:
 - .1 Exposed indoors: canvas or PVC jacket.
 - .2 Concealed, indoors: canvas on valves, fittings.
No further finish.
 - .3 Use vapour retarder jacket on TIAC code A-3
insulation compatible with insulation.
 - .4 Finish attachments: SS bands, at 150mm on centre.
Seals: closed.
 - .5 Installation: to appropriate TIAC code CRF/1
through CPF/5.

END OF SECTION

PART 1 - GENERAL

- 1.1 CLEANING AND START-UP OF MECHANICAL PIPING SYSTEMS
- .1 In accordance with Section 23 08 02 - Cleaning and Start-up of Mechanical Piping Systems.
- 1.2 HYDRONIC SYSTEMS - PERFORMANCE VERIFICATION (PV)
- .1 Perform hydronic systems performance verification after cleaning is completed and system is in full operation.
- .2 When systems are operational, perform following tests:
- .1 Conduct full scale tests at maximum design flow rates, temperatures and pressures for continuous consecutive period of 48 hours to demonstrate compliance with design criteria.
 - .2 Verify performance of hydronic system circulating pumps as specified, recording system pressures, temperatures, fluctuations by simulating maximum design conditions and varying.
 - .1 Pump operation.
 - .2 Boiler and/or chiller operation.
 - .3 Pressure bypass open/closed.
 - .4 Control pressure failure.
 - .5 Maximum heating demand.
 - .6 Maximum cooling demand.
 - .7 Boiler and/or chiller failure.
 - .8 Cooling tower (and/or industrial fluid cooler) fan failure.
 - .9 Outdoor reset. Re-check heat exchanger output supply temperature at 100% and 50% reset, maximum water temperature.
- 1.3 HYDRONIC SYSTEM CAPACITY TEST
- .1 Perform hydronic system capacity tests after:
- .1 TAB has been completed
 - .2 Verification of operating, limit, safety controls.
 - .3 Verification of primary and secondary pump flow rates.
 - .4 Verification of accuracy of temperature and pressure sensors and gauges.
- .2 Calculate system capacity at test conditions.

-
- .3 Using manufacturer's published data and calculated capacity at test conditions, extrapolate system capacity at design conditions.
 - .4 When capacity test is completed, return controls and equipment status to normal operating conditions.
 - .5 Submit sample of system water to approved testing agency to determine if chemical treatment is correct. Include cost.
 - .6 Heating system capacity test:
 - .1 Perform capacity test when ambient temperature is within 10% of design conditions. Simulate design conditions by:
 - .1 Increasing OA flow rates through heating coils (in this case, monitor heating coil discharge temperatures to ensure that coils are not subjected to freezing conditions) or
 - .2 Reducing space temperature by turning off heating system for sufficient period of time before starting testing.
 - .2 Test procedures:
 - .1 Open fully heat exchanger, heating coil and radiation control valves.
 - .2 With boilers on full firing and hot water heating supply temperature stabilized, record flow rates and supply and return temperatures simultaneously.
 - .3 Conduct flue gas analysis test on boilers at full load and at low fire conditions.
 - .7 Chilled water system capacity test:
 - .1 Perform capacity test when ambient temperature is within 10% of design conditions. Simulate design conditions by:
 - .1 Adding heat from building heating system or;
 - .2 Raising space temperature by turning off cooling and air systems for sufficient period of time before starting testing and pre-heating building to summer design space temperature (occupied) or above. Set OAD and RAD for minimum outside air if OAT is near outside design temperature or to maximum recirculation if RAT is greater than OAT. RAT to be at least 23 degrees C minimum.
 - .2 Test procedures:
 - .1 Open fully cooling coil control valves.
 - .2 Set thermostats on associated AHU's for maximum cooling.

- .3 Set AHU's for design maximum air flow rates.
- .4 Set load or demand limiters on chillers to 100%.
- .5 After system has stabilized, record chilled water, and condenser water flow rates and supply and return temperatures simultaneously.

1.4 GLYCOL SYSTEMS

- .1 Test to prove concentration will prevent freezing to minus 40 degrees C Test inhibitor strength and include in procedural report. Refer to ASTM E 202.

1.5 POTABLE WATER SYSTEMS

- .1 When cleaning is completed and system filled:
 - .1 Verify performance of equipment and systems as specified elsewhere in Division 23.
 - .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.

1.6 WET AND DRY PIPE SPRINKLER SYSTEM, STANDPIPE AND HOSE SYSTEMS

- .1 Cleaning, testing, start-up, performance verification of equipment, systems, components, and devices is specified elsewhere in Division 23.
- .2 Verification of controls, detection devices, alarm devices is specified Division 26.
- .3 Demonstrate that fire hose will reach to most remote location regardless of partitions, and obstructions.
- .4 Verify operation of interlocks between HVAC systems and fire alarm systems.

1.7 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 each fixture to verify drainage and no leakage.

PART 2 - PRODUCTS

2.1 NOT USED .1 Not Used.

PART 3 - EXECUTION

3.1 NOT USED .1 Not Used.

END OF SECTION

PART 1 - GENERAL

- 1.1 SUMMARY .1 Section Includes:
.1 Procedures and cleaning solutions for cleaning mechanical piping systems.
- 1.2 REFERENCES .1 American Society for Testing and Materials International (ASTM)
.1 ASTM E 202-00, Standard Test Methods for Analysis of Ethylene Glycols and Propylene Glycols.
- 1.3 ACTION AND INFORMATIONAL SUBMITTALS .1 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.
.2 Quality assurance submittals: submit following in accordance with Section 01 33 00 - Submittal Procedures.
.1 Instructions: submit manufacturer's installation instructions.
.1 Departmental Representative will make available 1 copy of systems supplier's installation instructions.
- 1.4 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.

PART 2 - PRODUCTS

- 2.1 CLEANING SOLUTIONS .1 Tri-sodium phosphate: 0.40 kg per 100 L water in system.
.2 Sodium carbonate: 0.40 kg per 100 L water in system.
.3 Low-foaming detergent: 0.01 kg per 100 L water in system.

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 CLEANING
HYDRONIC SYSTEMS

- .1 Timing: systems operational, hydrostatically tested and with safety devices functional, before cleaning is carried out.
- .2 Cleaning Agency:
 - .1 Retain qualified water treatment specialist to perform system cleaning.
- .3 Install instrumentation such as flow meters, orifice plates, pitot tubes, flow metering valves only after cleaning is certified as complete by water treatment specialist.
- .4 Cleaning procedures:
 - .1 Provide detailed report outlining proposed cleaning procedures at least 4 weeks prior to proposed starting date. Report to include:
 - .1 Cleaning procedures, flow rates, elapsed time.
 - .2 Chemicals and concentrations used.
 - .3 Inhibitors and concentrations.
 - .4 Specific requirements for completion of work.
 - .5 Special precautions for protecting piping system materials and components.
 - .6 Complete analysis of water used to ensure water will not damage systems or equipment.
- .5 Conditions at time of cleaning of systems:
 - .1 Systems: free from construction debris, dirt and other foreign material.
 - .2 Control valves: operational, fully open to ensure that terminal units can be cleaned properly.
 - .3 Strainers: clean prior to initial fill.
 - .4 Install temporary filters on pumps not equipped with permanent filters.
 - .5 Install pressure gauges on strainers to detect plugging.

-
- .6 Report on Completion of Cleaning:
 - .1 When cleaning is completed, submit report, complete with certificate of compliance with specifications of cleaning component supplier.

 - .7 Hydronic Systems:
 - .1 Fill system with water, ensure air is vented from system.
 - .2 Fill expansion tanks 1/3 to 1/2 full, charge system with compressed air to at least 35 kPa (does not apply to diaphragm type expansion tanks).
 - .3 Use water metre to record volume of water in system to +/- 0.5%.
 - .4 Add chemicals under direct supervision of chemical treatment supplier.
 - .5 Closed loop systems: circulate system cleaner at 60 degrees C for at least 36 h. Drain as quickly as possible. Refill with water and inhibitors. Test concentrations and adjust to recommended levels.
 - .6 Flush velocity in system mains and branches to ensure removal of debris. System pumps may be used for circulating cleaning solution provided that velocities are adequate.
 - .7 Add chemical solution to system.
 - .8 Establish circulation, raise temperature slowly to maximum design. Circulate for 12 h, ensuring flow in all circuits. Remove heat, continue to circulate until temperature is below 38 degrees C. Drain as quickly as possible. Refill with clean water. Circulate for 6 h at design temperature. Drain and repeat procedures specified above. Flush through low point drains in system. Refill with clean water adding to sodium sulphite (test for residual sulphite).

 - .8 Glycol Systems:
 - .1 In addition to procedures specified above perform specified procedures.
 - .2 Test to prove concentration will prevent freezing to minus 40 degrees C. Test inhibitor strength and include in procedural report. Refer to ASTM E 202.
-
- 3.3 START-UP OF
HYDRONIC SYSTEMS
- .1 After cleaning is completed and system is filled:
 - .1 Establish circulation and expansion tank level, set pressure controls.
 - .2 Ensure air is removed.
 - .3 Check pumps to be free from air, debris, possibility of cavitation when system is at design temperature.
 - .4 Dismantle system pumps used for cleaning,

inspect, replace worn parts, install new gaskets and new set of seals.

.5 Clean out strainers repeatedly until system is clean.

.6 Commission water treatment systems.

.7 Check water level in expansion tank with cold water with circulating pumps OFF and again with pumps ON.

.8 Repeat with water at design temperature.

.9 Check pressurization to ensure proper operation and to prevent water hammer, flashing, cavitation. Eliminate water hammer and other noises.

.10 Bring system up to design temperature and pressure slowly.

.11 Perform TAB as specified in Section 23 05 93 - Testing, Adjusting and Balancing for HVAC.

.12 Adjust pipe supports, hangers, springs as necessary.

.13 Monitor pipe movement, performance of expansion joints, loops, guides, anchors.

.14 Re-tighten bolts using torque wrench, to compensate for heat-caused relaxation. Repeat several times during commissioning.

.15 Check operation of drain valves.

.16 Adjust valve stem packings as systems settle down.

.17 Fully open balancing valves (except those that are factory-set).

.18 Check operation of over-temperature protection devices on circulating pumps.

.19 Adjust alignment of piping at pumps to ensure flexibility, adequacy of pipe movement, absence of noise or vibration transmission.

END OF SECTION

PART 1 - GENERAL1.1 REFERENCES

- .1 American National Standards Institute (ANSI)/American Welding Society (AWS)
 - .1 ANSI/AWS A5.8/A5.8M-11, AMD1 Specification Filler Metals for Brazing and Braze Welding.
- .2 ASME
 - .1 ANSI/ASME B16.4-11, Gray-Iron Threaded Fittings Classes 125 and 250.
 - .2 ANSI/ASME B16.15-13, Cast Copper Alloy Threaded Fittings Classes 125 and 250.
 - .3 ANSI B16.18-12, Cast Copper Alloy, Solder Joint Pressure Fittings.
 - .4 ANSI/ASME B16.22-13, Wrought Copper and Copper-Alloy Solder Joint Pressure Fittings.
- .3 ASTM International
 - .1 ASTM B 32-14, Standard Specification for Solder Metal.
 - .2 ASTM B 61-15, Standard Specification for Steam or Valve Bronze Castings.
 - .3 ASTM B 62-15, Standard Specification for Composition Bronze or Ounce Metal Castings.
 - .4 ASTM B 88M-2013, Standard Specification for Seamless Copper Water Tube Metric.
 - .5 ASTM E 202-12, Standard Test Methods for Analysis of Ethylene Glycols and Propylene Glycols.
- .4 Manufacturers Standardization Society (MSS)
 - .1 MSS SP 67-2011, Butterfly Valves.
 - .2 MSS SP 70-2011, Cast Iron Gate Valves, Flanged and Threaded Ends.
 - .3 MSS SP 71-2011, Grey Iron Swing Check Valves, Flanged and Threaded Ends.
 - .4 MSS SP 80-2013, Bronze Gate, Globe, Angle and Check Valves.
 - .5 MSS SP 85-2011, Cast Iron Globe and Angle Valves, Flanged and Threaded Ends.

1.2 ACTION AND INFORMATIONAL SUBMITTALS

- .1 Submit in accordance with Section 01 33 00 - Submittal Procedures.
- .2 Product Data:
 - .1 Submit manufacturer's instructions, printed product literature and data sheets for hydronic systems and include product characteristics, performance criteria, physical size, finish and limitations.

-
- .3 Shop Drawings:
.1 Indicate on manufacturers' catalogue literature the following: valves.
- .4 Certificates: submit certificates signed by manufacturer certifying that materials comply with specified performance characteristics and physical properties.
- 1.3 CLOSEOUT SUBMITTALS
- .1 Submit in accordance with Section 01 78 00 - Closeout Submittals.
- .2 Operation and Maintenance Data: submit operation and maintenance data for hydronic systems for incorporation into manual.
- 1.4 QUALITY ASSURANCE
- .1 Regulatory Requirements: ensure Work is performed in compliance with applicable Provincial regulations.
- PART 2 - PRODUCTS
- 2.1 TUBING
- .1 Hard drawn copper tubing: to ASTM B 88M.
- 2.2 FITTINGS
- .1 Cast bronze threaded fittings: to ANSI/ASME B16.15.
- .2 Wrought copper and copper alloy solder joint pressure fittings: to ANSI/ASME B16.22.
- .3 Cast iron threaded fittings: to ANSI/ASME B16.4.
- .4 Cast copper alloy solder joint pressure fittings: to ANSI B16.18.
- 2.3 FLANGES
- .1 Brass or bronze: threaded.
- .2 Cast iron: threaded.
- .3 Orifice flanges: slip-on, raised face, 2100 kPa.

2.4 JOINTS

- .1 Solder, tin-antimony, 95:5: to ASTM B 32.
- .2 Silver solder BCUP: to ANSI/AWS A5.8.
- .3 Brazing: as indicated.

2.5 VALVES

- .1 Connections:
 - .1 NPS 2 and smaller: ends for soldering.
 - .2 NPS 2 1/2 and larger: flanged ends.
- .2 Gate Valves: application: isolating equipment, control valves, pipelines:
 - .1 NPS 2 and under:
 - .1 Class 125, rising stem wedge disc, as specified Section 23 05 23.01 - Valves - Bronze.
 - .2 NPS 2 1/2 and over:
 - .1 Rising stem, wedge disc, bronze trim, as specified Section 23 05 23.02 - Valves - Cast Iron.
- .3 Swing check valves:
 - .1 NPS 2 and under:
 - .1 Class 125, swing, with composition disc, as specified Section 23 05 23.01 - Valves - Bronze.
 - .2 NPS 2 1/2 and over:
 - .1 Flanged ends: as specified Section 23 05 23.02 - Valves - Cast Iron.
- .4 Silent check valves:
 - .1 NPS 2 and under:
 - .1 As specified Section 23 05 23.01 - Valves - Bronze.
 - .2 NPS 2 1/2 and over:
 - .1 Flanged ends: as specified Section 23 05 23.02 - Valves - Cast Iron.
- .5 Ball valves:
 - .1 NPS 2 and under: as specified Section 23 05 23.01 - Valves - Bronze.

PART 3 - EXECUTION

- 3.1 EXAMINATION
- .1 Verification of Conditions: verify that conditions of substrate previously installed under other Sections or Contracts are acceptable for hydronic systems installation in accordance with manufacturer's written instructions.
 - .1 Visually inspect substrate in presence of Departmental Representative.
 - .2 Inform Departmental Representative of unacceptable conditions immediately upon discovery.
 - .3 Proceed with installation only after unacceptable conditions have been remedied and after receipt of written approval to proceed from Departmental Representative.
- 3.2 MANUFACTURER'S INSTRUCTIONS
- .1 Compliance: comply with manufacturer's written recommendations or specifications, including product technical bulletins, handling, storage and installation instructions, and datasheet.
- 3.3 PIPING INSTALLATION
- .1 Connect to equipment in accordance with manufacturer's instruction unless otherwise indicated.
 - .2 Install concealed pipes close to building structure to keep furring space to minimum. Install to conserve headroom and space. Run exposed piping parallel to walls. Group piping where ever practical.
 - .3 Slope piping in direction of drainage and for positive venting.
 - .4 Use eccentric reducers at pipe size change installed to provide positive drainage or positive venting.
 - .5 Provide clearance for installation of insulation and access for maintenance of equipment, valves and fittings.
 - .6 Assemble piping using fittings manufactured to ANSI standards.

3.4 VALVE INSTALLATION

- .1 Install rising stem valves in upright position with stem above horizontal.
- .2 Install gate valves at branch take-offs and to isolate each piece of equipment, and as indicated.
- .3 Install chain operators on valves NPS 2 1/2 and over where installed more than 2400mm above floor.

3.5 CIRCUIT BALANCING VALVES

- .1 Install flow measuring stations and flow balancing valves as indicated.
- .2 Remove handwheel after installation and TAB is complete.
- .3 Tape joints in prefabricated insulation on valves installed in chilled water mains.

3.6 FLUSHING AND CLEANING

- .1 Flush and clean in presence of Departmental Representative.
- .2 Flush after pressure test for a minimum of 4 hours.
- .3 Fill with solution of water and non-foaming, phosphate-free detergent 3% solution by weight. Circulate for minimum of 8 hours.
- .4 Refill system with clean water. Circulate for at least 4 hours. Clean out strainer screens/baskets regularly. Then drain.
- .5 Refill system with clean water. Circulate for at least 2 hours. Clean out strainer screens/baskets regularly. Then drain.
- .6 Drainage to include drain valves, dirt pockets, strainers, low points in system.
- .7 Re-install strainer screens/baskets only after obtaining Departmental Representative's approval.

3.7 FILLING OF
SYSTEM

- .1 Refill system with clean water adding water treatment as specified and premixed glycol as specified.

3.8 FIELD QUALITY
CONTROL

- .1 Testing:
 - .1 Test system in accordance with Section 21 05 01 - Common Work Results for Mechanical.
 - .2 For glycol systems, retest with ethylene glycol to ASTM E 202, inhibited, for use in building system after cleaning. Repair leaking joints, fittings or valves.
- .2 Balancing:
 - .1 Balance water systems to within plus or minus 5% of design output.
- .3 Glycol Charging:
 - .1 Retest for concentration to ASTM E 202 after cleaning.
 - .2 Provide report to Departmental Representative.

END OF SECTION

PART 1 - GENERAL1.1 REFERENCES

- .1 American National Standards Institute/American Water Works Association (ANSI/AWWA)
 - .1 ANSI/AWWA C111/A21.11-07, Standard for Rubber-Gasket Joints for Ductile-Iron Pressure Pipe and Fittings.

- .2 American Society of Mechanical Engineers (ASME)
 - .1 ASME B16.1-15, Gray Iron Pipe Flanges and Flanged Fittings: Classes 25, 125, and 250.
 - .2 ASME B16.3-11, Malleable Iron Threaded Fittings: Classes 150 and 300.
 - .3 ASME B16.5-13, Pipe Flanges and Flanged Fittings: NPS ½ through NPS 24 Metric/Inch Standard.
 - .4 ASME B16.9-12, Factory-Made Wrought Butt Welding Fittings.
 - .5 ASME B18.2.1-12, Square Hex, Heavy Hex and Askey Head Bolts and Hex, Heavy Hex, Hex Flange, Loded Head and Lag Screws (Inch Series).
 - .6 ASME B18.2.2-15, Nuts for General Applications: Machine Screw Nuts, Hex, Square, Hex Flange, and Coupling Nuts (Inch Series).

- .3 ASTM International
 - .1 ASTM A 47/A 47M-99(2014), Standard Specification for Ferritic Malleable Iron Castings.
 - .2 ASTM A 53/A 53M-10, Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc Coated Welded and Seamless.
 - .3 ASTM A 536-84(2014), Standard Specification for Ductile Iron Castings.
 - .4 ASTM B 61-15, Standard Specification for Steam or Valve Bronze Castings.
 - .5 ASTM B 62-15, Standard Specification for Composition Bronze or Ounce Metal Castings.
 - .6 ASTM E 202-12, Standard Test Method for Analysis of Ethylene Glycols and Propylene Glycols.

- .4 CSA International
 - .1 CSA B242-05(R2016), Groove and Shoulder Type Mechanical Pipe Couplings.
 - .2 CSA W48-14, Filler Metals and Allied Materials for Metal Arc Welding.

1.2 ACTION AND INFORMATIONAL SUBMITTALS

- .1 Submit in accordance with Section 01 33 00 - Submittal Procedures.
- .2 Product Data:
 - .1 Submit manufacturer's instructions, printed product literature and data sheets for hydronic systems and include product characteristics, performance criteria, physical size, finish and limitations.

1.3 CLOSEOUT SUBMITTALS

- .1 Submit in accordance with Section 01 78 00 - Closeout Submittals.
- .2 Operation and Maintenance Data: submit operation and maintenance data for hydronic systems for incorporation into manual.
 - .1 Include special servicing requirements.

PART 2 - PRODUCTS

2.1 PIPE

- .1 Steel pipe: to ASTM A 53/A 53M, Grade B, as follows:
 - .1 To NPS 6: Schedule 40.

2.2 PIPE JOINTS

- .1 NPS 2 and under: screwed fittings with lead-free pipe dope.
- .2 NPS 2-1/2 and over: welding fittings and flanges to CSA W48.
- .3 Flanges: plain, weld neck to ANSI/AWWA C111/ A21.11.
- .4 Orifice flanges: slip-on raised face, 2100 kPa.
- .5 Flange gaskets: to ANSI/AWWA C111/ A21.11.
- .6 Pipe thread: taper.
- .7 Bolts and nuts: to ASME B18.2.1.

2.3 FITTINGS

- .1 Screwed fittings: malleable iron, to ASME B16.3, Class 150.
- .2 Pipe flanges and flanged fittings:

- .1 Cast iron: to ASME B16.1, Class 125.
- .2 Steel: to ASME B16.5.
- .3 Butt-welding fittings: steel, to ASME B16.9.
- .4 Unions: malleable iron, to ASTM A 47/A 47M and ASME B16.3.

2.4 VALVES

- .1 Connections:
 - .1 NPS 2 and smaller: screwed ends.
 - .2 NPS 2-1/2 and larger: flanged ends.
- .2 Gate valves: to MSS-SP-70 application: isolating equipment, control valves, pipelines:
 - .1 NPS 2 and under:
 - .1 Class 125, rising stem, wedge disc, as specified Section 23 05 23.01 - Valves - Bronze.
 - .2 NPS 2-1/2 and over:
 - .1 Mechanical Rooms: rising stem, wedge disc, lead free trim, as specified Section 23 05 23.02 - Valves - Cast Iron.
 - .1 Operators: chain.
- .3 Butterfly valves: to MSS-SP-67 application: isolating cells or section of multiple component equipment (i.e. multi-section coils, multi-cell cooling towers):
 - .1 NPS 2-1/2 and over: lug type.
- .4 Balancing, for TAB:
 - .1 Sizes: calibrated balancing valves, as specified this section.
- .5 Swing check valves: to MSS-SP-71.
 - .1 NPS 2 and under:
 - .1 Class 125, swing, with composition disc, as specified Section 23 05 23.01 - Valves - Bronze.
 - .2 NPS 2-1/2 and over:
 - .1 Flanged ends: as specified Section 23 05 23.02 - Valves - Cast Iron.
- .6 Silent check valves:
 - .1 NPS 2 and under:
 - .1 As specified Section 23 05 23.01 - Valves - Bronze.
 - .2 NPS 2-1/2 and over:
 - .1 Flanged ends: as specified Section 23 05 23.02 - Valves - Cast Iron.

PART 3 - EXECUTION

- 3.1 EXAMINATION .1 Verification of Conditions: verify that conditions of substrate previously installed under other Sections or Contracts are acceptable for hydronic systems installation in accordance with manufacturer's written instructions.
- .1 Visually inspect substrate in presence of Departmental Representative.
 - .2 Inform Departmental Representative of unacceptable conditions immediately upon discovery.
 - .3 Proceed with installation only after unacceptable conditions have been remedied and after receipt of written approval to proceed from Departmental Representative.
- 3.2 PIPING INSTALLATION .1 Install pipework in accordance with Section 23 05 05 - Installation of Pipe Work.
- 3.3 CIRCUIT BALANCING VALVES .1 Install flow measuring stations and flow balancing valves as indicated.
- .2 Remove handwheel after installation and when TAB is complete.
 - .3 Tape joints in prefabricated insulation on valves installed in chilled water mains.
- 3.4 CLEANING, FLUSHING AND START-UP .1 In accordance with Section 23 08 02 - Cleaning and Start-Up of Mechanical Piping Systems.
- 3.5 TESTING .1 Test system in accordance with Section 21 05 01 - Common Work Results for Mechanical.
- .2 For glycol systems, retest with ethylene glycol to ASTM E 202, inhibited, for use in building system after cleaning. Repair leaking joints, fittings or valves.

3.6 BALANCING

- .1 Balance water systems to within plus or minus 5% of design output.
- .2 In accordance with Section 23 05 93 - Testing, Adjusting and Balancing for HVAC for applicable procedures.

3.7 GLYCOL CHARGING

- .1 Include mixing tank and positive displacement pump for glycol charging.
- .2 Retest for concentration to ASTM E 202 after cleaning.

3.8 PERFORMANCE
VERIFICATION

- .1 In accordance with Section 23 08 01 - Performance Verification Mechanical Piping Systems.

3.9 PROTECTION

- .1 Protect installed products and components from damage during construction.
- .2 Repair damage to adjacent materials caused by hydronic systems installation.

END OF SECTION

PART 1 - GENERAL1.1 REFERENCES

- .1 ASME
 - .1 ASME Boiler and Pressure Vessel Code (BPVC), Section VII-2013.
- .2 ASTM International
 - .1 ASTM A 47/A 47M-99(2009), Standard Specification for Ferritic Malleable Iron Castings.
 - .2 ASTM A 278/A 278M-01(2011), Standard Specification for Gray Iron Castings for Pressure-Containing Parts for Temperatures up to 650 degrees F (350 degrees C).
 - .3 ASTM A 536-84(2009), Standard Specification for Ductile Iron Castings.
 - .4 ASTM B 62-09, Standard Specification for Composition Bronze or Ounce Metal Castings.
- .3 CSA Group
 - .1 CSA B51-09, Boiler, Pressure Vessel, and Pressure Piping Code.

1.2 ACTION AND INFORMATIONAL SUBMITTALS

- .1 Submit in accordance with Section 01 33 00 - Submittal Procedures.
- .2 Product Data:
 - .1 Submit manufacturer's instructions, printed product literature and data sheets for expansion tanks, air vents, separators, valves, and strainers and include product characteristics, performance criteria, physical size, finish and limitations.

1.3 CLOSEOUT SUBMITTALS

- .1 Submit in accordance with Section 01 78 00 - Closeout Submittals.
- .2 Operation and Maintenance Data: submit operation and maintenance data for hydronic specialties for incorporation into manual.

PART 2 - PRODUCTS2.1 AUTOMATIC AIR VENT

- .1 Standard float vent: brass body and NPS 1/8 connection and rated at 620 kPa working pressure.
- .2 Industrial float vent: cast iron body and NPS 1/2 connection and rated at 860 kPa working pressure.
- .3 Float: solid material suitable for 115 degrees C working temperature.

2.2 PIPE LINE STRAINER

- .1 NPS 1/2 to 2: bronze body to ASTM B 62, solder end connections, Y pattern.
- .2 NPS 2 1/2 to 12: cast steel body to ASTM A 278/A 278M, Class 30, flanged connections.
- .3 NPS 2 to 12: T type with ductile iron body to ASTM A 536 malleable iron body to ASTM A 47M, grooved ends.
- .4 Blowdown connection: NPS 1.
- .5 Screen: stainless steel brass with 1.19mm perforations.
- .6 Working pressure: 860 kPa.

2.3 Expansion Tank

- .1 Shall be vertical or horizontal with capacity as shown, with diaphragm or bladder sealed in elastomer suitable for 115°C operating temperature, and 860kPa pressure with ASME stamp and certification. Precharged to 35kPa above system static head, and complete with unit mounted temperature and pressure gauges. Expansion tanks for glycol systems shall have diaphragms or bladders suitable for the glycol used.
- .2 Tanks of total volume less than 100 litres shall be diaphragm type. Tanks of 100 litres or larger shall be replaceable bladder type.

2.4 HEAT EXCHANGER

- .1 Plate Heat Exchanger:
 - .1 Water to Glycol.
 - .1 Designed, constructed and tested in accordance ASME Boiler and Pressure Vessel Code and provincial pressure vessel regulations.
 - .2 Frames: carbon steel with baked epoxy enamel paint, side bolts and shroud.
 - .3 Plates: type 304 stainless steel.
 - .4 Gaskets: nitrile rubber
 - .5 Nozzles: ASA rubber rated flange type.
 - .6 Supports: as required.
 - .7 Piping connections: as indicated.
 - .8 Capacity: as indicated
 - .9 Working pressure: primary 1075 kPa, secondary 1075 kPa.

2.5 PUMPS

- .1 Shall be vertical in-line, close coupled, single suction, centrifugal pumps of capacity as scheduled.

Pumps to be fitted with cast iron casing, enclosed bronze impeller, stainless steel shaft, mechanical seal, and spacer coupling for motors of 10 HP or larger.

Motors shall be ODP 1750 rpm for indoor installations and TEFC 1,750 rpm for outdoor installations. Motors of 1 HP and larger shall meet ASHRAE 90.1 high efficiency standards.
- .2 Pump shall operate within a flow range of 25% below, to 10% above, the flow at the most efficient point for the impeller selected. Change motor speed as required to achieve these conditions.

2.6 Air Eliminator

- .1 Air Eliminators shall be full flow coalescing type. Selection shall be based upon system flow with pipe size as a minimum in accordance with the basis of design. Separator shall be fabricated steel, rated for 1035kPa working pressure, and stamped and registered in accordance with ASME Section VIII, Division 1 for unfired pressure vessels. Enter water velocity shall be less than 3.05 m/s. Unit shall include internal elements to suppress turbulence and provide air elimination efficiency of 100% free air, 100% entrained air, and 99.6% dissolved air at the installed location. The elements must consist of a copper core tube with continuous wound copper wire medium permanently attached and followed by a separate continuous wound copper wire permanently affixed. Each unit shall have a separate venting chamber to prevent system contaminants from harming the float and

venting valve operation. At the top of the venting chamber shall be an integral full port float actuated brass venting mechanism. Units shall include a valved side tap to flush floating dirt or liquids and for quick bleeding of large amounts of air during system fill or refill.

PART 3 - EXECUTION

3.1 EXAMINATION

- .1 Verification of Conditions: verify that conditions of substrate previously installed under other Sections or Contracts are acceptable for hydronic specialties installation in accordance with manufacturer's written instructions.
 - .1 Visually inspect substrate in presence of Departmental Representative.
 - .2 Inform Departmental Representative of unacceptable conditions immediately upon discovery.
 - .3 Proceed with installation only after unacceptable conditions have been remedied and after receipt of written approval to proceed from Departmental Representative.

3.2 APPLICATION

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

3.3 GENERAL

- .1 Run drain lines and blow off connections to terminate above nearest drain.
- .2 Maintain adequate clearance to permit service and maintenance.
- .3 Should deviations beyond allowable clearances arise, request and follow Departmental Representative's directive.
- .4 Check shop drawings for conformance of tappings for ancillaries and for equipment operating weights.

3.4 STRAINERS

- .1 Install in horizontal or down flow lines.
- .2 Ensure clearance for removal of basket.

-
- .3 Install ahead of each automatic control valve larger than NPS 1 and radiation and as indicated.

3.5 AIR VENTS

- .1 Install at high points of systems.
- .2 Install gate valve on automatic air vent inlet. Run discharge to nearest drain.

3.6 PUMP INSTALLATION

- .1 In line circulators: Support at flanges or near unions on outlets of unit. Make lubrication points accessible. Check rotation.
- .2 Ensure that pump body does not support piping or equipment. Provide stanchions or hangers for this purpose. Refer to manufacturer's installation instructions for details.
- .3 Pipe drain tapping to floor drain.
- .4 Install volute venting pet cock in accessible location.

3.7 CLEANING

- .1 Progress Cleaning: clean in accordance with Section 01 00 10 - General Instructions.
 - .1 Leave Work area clean at end of each day.
- .2 Final Cleaning: upon completion remove surplus materials, rubbish, tools and equipment in accordance with Section 01 00 10 - General Instructions.

END OF SECTION

PART 1 - GENERAL1.1 RELATED
REQUIREMENTS

- .1 Section 23 05 94 - Pressure Testing of Ducted Air Systems.

1.2 REFERENCES

- .1 American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE)
- .2 ASTM International
 - .1 ASTM A 653/A 653M-2015, Standard Specification for Steel Sheet, Zinc Coated (Galvanized) or Zinc-Iron Alloy Coated (Galvannealed) by the Hot-Dip Process.
- .3 National Fire Protection Association (NFPA)
 - .1 NFPA 90A-15, Standard for the Installation of Air-Conditioning and Ventilating Systems.
 - .2 NFPA 90B-2015, Standard for the Installation of Warm Air Heating and Air-Conditioning Systems.
- .4 Sheet Metal and Air Conditioning Contractors' National Association (SMACNA)
 - .1 SMACNA HVAC Duct Construction Standards - Metal and Flexible, 2005.
 - .2 SMACNA HVAC Air Duct Leakage Test Manual, 2012.
 - .3 SMACNA IAQ Guideline for Occupied Buildings Under Construction 2007.

1.3 ACTION AND
INFORMATIONAL
SUBMITTALS

- .1 Submit in accordance with Section 01 33 00 - Submittal Procedures.
- .2 Product Data:
 - .1 Submit manufacturer's instructions, printed product literature and data sheets for metal ducts and include product characteristics, performance criteria, physical size, finish and limitations.
- .3 Test and Evaluation Reports:
 - .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 During construction meet or exceed the requirements of SMACNA IAQ Guideline for Occupied Buildings Under Construction.

PART 2 - PRODUCTS2.1 SEALCLASSIFICATION

- .1 Classification as follows:

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

- .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.
 - .3 Class C: transverse joints and connections made air tight with gaskets sealant. Longitudinal seams unsealed.
 - .4 Unsealed seams and joints.

2.2 SEALANT

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

2.3 TAPE

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

2.4 DUCT LEAKAGE

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

2.5 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 400mm: with single thickness turning vanes.
 - .2 Over 400mm: with double thickness turning vanes.
- .4 Branches:
 - .1 Rectangular main and branch: with radius on branch 1.5 times width of duct 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 Full or Short radiused elbows as indicated.
- .7 Obstruction deflectors: maintain full cross-sectional area.
 - .1 Maximum included angles: as for transitions.

2.6 FIRE STOPPING

- .1 Retaining angles around duct, on both sides of fire separation.
- .2 Fire stopping material and installation must not distort duct.

2.7 GALVANIZED STEEL

- .1 Lock forming quality: to ASTM A 653/A 653M, Z90 zinc coating.
- .2 Thickness, fabrication and reinforcement: to SMACNA.
- .3 Joints: to SMACNA.

2.8 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 SMACNA.
.3 Hangers: galvanized steel angle with galvanized steel rods to SMACNA and 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 concrete: manufactured concrete inserts.
.2 For steel joist: manufactured joist clamp.
.3 For steel beams: manufactured beam clamps:

PART 3 - EXECUTION

3.1 GENERAL

- .1 Do work in accordance with NFPA 90A, NFPA 90B, ASHRAE SMACNA and as indicated.
- .2 Do not break continuity of insulation vapour barrier with hangers or rods.
.1 Insulate strap hangers 100mm beyond insulated duct Ensure diffuser is fully seated.
- .3 Support risers ASHRAE SMACNA as indicated.
- .4 Install breakaway joints in ductwork on sides of fire separation.
- .5 Install proprietary manufactured flanged duct joints in accordance with manufacturer's instructions.
- .6 Manufacture duct in lengths and diameter to accommodate installation of acoustic duct lining.

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 and as follows:

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

3.3 SEALING AND TAPING

- .1 Apply sealant in accordance with SMACNA and to manufacturer's recommendations.
- .2 Bed tape in sealant and recoat with minimum of 1 coat of sealant to manufacturers recommendations.

3.4 LEAKAGE TESTS

- .1 Refer to Section 23 05 94 - Pressure Testing of Ducted Air Systems.
- .2 In accordance with SMACNA HVAC Duct Leakage Test Manual.
- .3 Do leakage tests in sections.
- .4 Make trial leakage tests as instructed to demonstrate workmanship.
- .5 Do not install additional ductwork until trial test has been passed.
- .6 Test section minimum of 30m long with not less than three branch takeoffs and two 90 degrees elbows.
- .7 Complete test before performance insulation or concealment Work.

END OF SECTION

PART 1 - GENERAL1.1 RELATED
REQUIREMENTS

- .1 Section 23 07 13 - Duct Insulation.

1.2 REFERENCES

- .1 American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE)
- .2 ASTM International
 - .1 ASTM A 653/A 653M-2015, Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy Coated (Galvannealed) by the Hot-Dip Process. (Metric).
- .3 Sheet Metal Air Conditioning Contractors' National Association (SMACNA)
 - .1 SMACNA HVAC Duct Construction Standards, Metal and Flexible, 2005.
 - .2 SMACNA HVAC Air Duct Leakage Test Manual, 2012.
 - .3 SMACNA IAQ Guideline for Occupied Buildings Under Construction, 2007.

1.3 ACTION AND
INFORMATIONAL
SUBMITTALS

- .1 Submit in accordance with Section 01 33 00 - Submittal Procedures.
- .2 Product Data:
 - .1 Submit manufacturer's instructions, printed product literature and data sheets for metal ducts and include product characteristics, performance criteria, physical size, finish and limitations.
- .3 Test and Evaluation Reports:
 - .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 During construction meet or exceed the requirements of SMACNA IAQ Guideline for Occupied Buildings Under Construction.

PART 2 - PRODUCTS2.1 DUCTWORK

- .1 Material:
 - .1 Galvanized steel with Z90 designation zinc coating lock forming quality: to ASTM A 653/A 653M.
 - .2 Thickness: to SMACNA.
- .2 Construction: round and oval.
 - .1 Ducts: factory fabricated, spiral wound, with matching fittings and specials to SMACNA.
 - .2 Transverse joints up to 900mm: slip type with tape and sealants.
 - .3 Transverse joints over 900mm: Vanstone.
 - .4 Fittings:
 - .1 Elbows: smooth radius 5 piece (for 90 degrees), 3 piece (for 45 degrees). Centreline radius: 1.5 x diameter.
 - .2 Branches: conical transition with conical branch at 45 degrees and 45 degrees elbow.
- .3 Construction: rectangular:
 - .1 Ducts: to SMACNA.
 - .2 Transverse joints: welded proprietary duct joints SMACNA seal Class A and B.
 - .3 Fittings:
 - .1 Elbows: smooth radius; centreline radius 1.5 x width of duct. No vanes.
 - .2 Branches: with conical branch at 45 degrees and 45 degrees elbow.
- .4 Fire stopping:
 - .1 50 x 50 x 3mm retaining angles around duct, on both sides of fire separation.
 - .2 Fire stopping material must not distort duct.

2.2 SEAL
CLASSIFICATION

- .1 Classification as follows:

Maximum Pressure Pa	SMACNA Seal Class
2500	A
1500	A
1000	A
750	B

- .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 gaskets, sealant, tape or combination thereof.

2.3 SEALANT

- .1 Oil resistant, water-borne polymer type flame resistant high velocity duct sealing compound.
- .1 Temperature range of minus 30 degrees C to plus 93 degrees C.

2.4 TAPE

- .1 Tape: polyvinyl treated, open weave fibre glass, 50mm wide.

2.5 HANGERS AND SUPPORTS

- .1 Hangers and supports: in accordance with Section 23 05 29 - Hangers and Supports for HVAC Piping Equipment.
- .1 Band hangers: use on round and oval ducts up to 500mm diameter, of same material as duct but next sheet metal thickness heavier than duct.
 - .2 Trapeze hangers: ducts over 500mm diameter or longest side, to SMACNA.
 - .3 Hangers: galvanized steel angle with galvanized steel rods to SMACNA and 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 concrete: manufactured concrete inserts.
 - .2 For steel joist: manufactured joist clamp.
 - .3 For steel beams: manufactured beam clamps.

PART 3 - EXECUTION3.1 GENERAL

- .1 Do work in accordance with SMACNA as indicated.
- .2 Do not break continuity of insulation vapour barrier with hangers or rods.
 - .1 Insulate band hangers 100mm beyond insulated duct.
 - .2 Ensure diffuser is fully seated.
- .3 Support risers in accordance with SMACNA as indicated.
- .4 Install breakaway joints in ductwork on sides of fire separation.

3.2 HANGERS

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

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

3.3 SEALING AND TAPING

- .1 Apply sealant in accordance with SMACNA and to manufacturer's recommendations.
- .2 Bed tape in sealant and recoat with minimum of one coat of sealant to manufacturer's recommendations.

3.4 LEAKAGE TESTS

- .1 Refer to Section 23 05 94 - Pressure Testing of Ducted Air Systems.
- .2 In accordance with SMACNA HVAC Duct Leakage Test Manual.
- .3 Perform leakage tests in sections.
- .4 Perform trial leakage tests, as instructed to demonstrate quality of work.
- .5 Do not install additional ductwork until trial tests have been achieved.

- .6 Test section minimum of 30m long with not less than 3 branch takeoffs and two 90 degrees elbows.
- .7 Complete tests before performing insulation or concealment Work.

END OF SECTION

PART 1 - GENERAL

- 1.1 REFERENCES .1 Sheet Metal and Air Conditioning Contractors' National Association (SMACNA)
.1 SMACNA - HVAC Duct Construction Standards - Metal and Flexible, 2005.
- 1.2 ACTION AND INFORMATIONAL SUBMITTALS .1 Submit in accordance with Section 01 33 00 - Submittal Procedures.
.2 Product Data:
.1 Submit manufacturer's instructions, printed product literature and data sheets for air duct accessories and include product characteristics, performance criteria, physical size, finish and limitations.
.2 Indicate:
.1 Flexible connections.
.2 Duct access doors.
.3 Turning vanes.
.4 Instrument test ports.

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 degrees C to plus 90 degrees 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 0.6mm thick complete with sheet metal angle frame.

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

2.4 TURNING VANES

- .1 Factory or shop fabricated double thickness with trailing edge, to recommendations of SMACNA and as indicated.

2.5 INSTRUMENT TEST

- .1 1.6mm thick steel zinc plated after manufacture.
- .2 Cam lock handles with neoprene expansion plug and handle chain.
- .3 28mm 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.

2.7 FIRE DAMPERS

- .1 Fire dampers shall be listed and bear label of ULC, and shall meet requirements of NFPA 90A and authorities having jurisdiction. These dampers shall ONLY be used in systems designed to be off during a fire alarm condition.
- .2 To be factory fabricated for fire rating requirement to maintain integrity of membrane being pierced. Dampers shall be "out of airstream" type except where stated otherwise.
- .3 Mild steel, fire link actuated top hinged door, multi-blade hinged weighted to close and lock in closed position when released or having negator-spring-closing operator for multi-leaf type or roll door type in horizontal position with vertical air flow, sized to maintain full flow cross section. Link to be 165°F (74°C).
- .4 Fire damper assemblies shall be galvanized steel. Fire damper assemblies installed within parking garage intake and exhaust air openings shall be 304 stainless steel.
- .5 To be complete with frame and 40 x 40 x 3 mm angle iron on full perimeter of frame on both sides of barrier being pierced.

2.8 SILENCERS

- .1 Supply pre-fabricated type RLC rectangular silencers.
- .2 Silencer modules, sizes, acoustic insertion losses, and pressure drops are listed in the schedule.
- .3 All galvanized construction.
- .4 Class I silencer casings shall be 23 gauge galvanized with lock seams airtight using mastic sealant in the seam and stiffened within half splitter assemblies to ASHRAE and SMACNA standards. Connections shall be two 2" 50 mm slip connections each end.
- .5 Galvanized splitter construction shall consist of solid radiused noes, perforated metal panels adequately stiffened for flatness in two directions, and contoured into diffuser tails that are partially radiused at the point of abrupt discharge.

- .6 Acoustic media (behind the perforated) shall be acoustic quality fibreglass to ensure catalogue performance and adequately protected, pre-compressed and supported to minimize dusting, erosion and settling. Media shall further be protected by fibreglass cloth when channel velocities exceed 450 fpm (23 m/s). Mineral wool is not acceptable.
- .7 Performance quoted in the schedule must be substantiated by appropriate laboratory testing across the module-size range all test data having been reduced according to ASTM E477-1973. The foregoing must be so certified when submitting for approval by a professional engineer.

PART 3 - EXECUTION

3.1 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: 100mm.
 - .3 Minimum distance between metal parts when system in operation: 75mm.
 - .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 600mm for person size entry.
 - .2 1200 x 1200mm for servicing entry.
 - .3 300 x 300mm for viewing.
 - .4 As indicated.
 - .2 Locations:
 - .1 Fire and smoke dampers.
 - .2 Control dampers.
 - .3 Devices requiring maintenance.
 - .4 Required by code.
 - .5 Reheat coils.
 - .6 Elsewhere as indicated.

-
- .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 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.
 - .5 Fire Dampers:
 - .1 Install fire dampers to NFPA 90A-1985 and in accordance with conditions of ULC listings. Locate in fire walls and partitions where indicated or required by Code. All fire dampers installed within supply and return ductwork connecting to air handling systems, fans, or any other forced air system shall be dynamic type fire dampers.
 - .2 Prior to installation, the contractor shall submit the manufacturer's ULC Listed installation instructions c/w the appropriate framing instructions as a shop drawing submission. Prior to installation, photos shall be submitted by the mechanical contractor indicating all framing for the fire dampers has been provided in accordance with the listed installation. Coordinate with the General Contractor with respect to the framing for the fire dampers.
 - .3 After completion, have installation approved prior to concealment.

.4 For fireproof ceiling assemblies, suspend unit from structure independently of ceiling system. Maintain integrity of rated ceiling assembly as per NFPA and ULC.

.5 Install access door adjacent to each fire damper.

END OF SECTION

PART 1 - GENERAL

1.1 RELATED REQUIREMENTS .1 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.
.2 SMACNA IAQ Guideline for Occupied Buildings Under Construction, 2007.

1.3 ACTION AND INFORMATIONAL SUBMITTALS .1 Submit in accordance with Section 01 33 00 - Submittal Procedures.
.2 Product Data:
.1 Submit manufacturer's instructions, printed product literature and data sheets for dampers and include product characteristics, performance criteria, physical size, finish and limitations.
.2 During construction meet or exceed the requirements of SMACNA IAQ Guideline for Occupied Buildings Under Construction.

1.4 CLOSEOUT SUBMITTALS .1 Submit in accordance with Section 01 78 00 - Closeout Submittals.
.2 Operation and Maintenance Data: submit operation and maintenance data for dampers for incorporation into manual.

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 100mm.
- .3 Locking quadrant with shaft extension to accommodate insulation thickness.
- .4 Inside and outside nylon or bronze 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: 100mm.
- .4 Bearings: pin in bronze bushings or self-lubricating nylon.
- .5 Linkage: shaft extension with locking quadrant.
- .6 Channel frame of same material as adjacent duct, complete with angle stop.
- .7 Maximum leakage : 5% at 2500 Pa.

PART 3 - EXECUTION

3.1 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.

END OF SECTION

PART 1 - GENERAL1.1 RELATED
REQUIREMENTS

- .1 Section 23 31 13.01 - Metal Ducts-Low Pressure to 500 PA.

1.2 REFERENCES

- .1 American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc. (ASHRAE)
- .2 National Fire Protection Association (NFPA)
 - .1 NFPA 90A-12, Standard for the Installation of Air-Conditioning and Ventilating Systems.
 - .2 NFPA 90B-12, Standard for Installation of Warm Air Heating and Air-Conditioning Systems.
- .3 Sheet Metal and Air-Conditioning Contractors' National Association (SMACNA)
 - .1 SMACNA HVAC Duct Construction Standards - Metal and Flexible, 2005.
 - .2 SMACNA IAQ Guideline for Occupied Buildings under Construction, 2007.
- .4 Underwriters' Laboratories of Canada (ULC)
 - .1 CAN/ULC-S110-2013, Standard Methods of Tests for Air Ducts.

1.3 ACTION AND
INFORMATIONAL
SUBMITTALS

- .1 Submit in accordance with Section 01 33 00 - Submittal Procedures.
- .2 Product Data:
 - .1 Submit manufacturer's instructions, printed product literature and data sheets for flexible ducts and include product characteristics, performance criteria, physical size, finish and limitations.
 - .2 Indicate:
 - .1 Thermal properties.
 - .2 Friction loss.
 - .3 Acoustical loss.
 - .4 Leakage.
 - .5 Fire rating.
- .3 Test and Evaluation Reports:
 - .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 During construction meet or exceed the requirements of SMACNA IAQ Guideline for Occupied Buildings Under Construction.

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 METALLIC - INSULATED

- .1 Type 2: spiral wound flexible aluminum with factory applied, 37mm thick flexible glass fibre thermal insulation with vapour barrier and vinyl jacket, as indicated.
- .2 Performance:
 - .1 Factory tested to 2.5 kPa without leakage.
 - .2 Maximum relative pressure drop coefficient: 3.

2.3 METALLIC ACOUSTIC INSULATED - MEDIUM PRESSURE

- .1 Type 5: spiral wound, flexible perforated aluminum with factory applied 37mm thick flexible mineral fibre thermal insulation and sleeved by aluminum foil/mylar laminate Type M vapour barrier, as indicated.
- .2 Performance:
 - .1 Factory tested to 2.5 kPa without leakage.
 - .2 Maximum relative pressure drop coefficient: 3.
 - .3 Acoustical performance: Minimum attenuation (dB/m) to following table:

Duct Diam:	Frequency (Hz)				
	125	250	500	1000	2000
100	0.6	3	12	27	0
150	1.2	3	12	22	27
200	2.0	5	12	19	20
300	2.4	5	12	16	15

PART 3 - EXECUTION

3.1 DUCT
INSTALLATION

- .1 Install in accordance with: CAN/ULC-S110, UL 181, NFPA 90A, NFPA 90B, SMACNA and ASHRAE.

END OF SECTION

PART 1 - GENERAL1.1 RELATED
REQUIREMENTS

- .1 Section 23 33 00 - Air Duct Accessories.

1.2 REFERENCES

- .1 American National Standards Institute/Air Movement and Control Association (ANSI/AMCA)
 - .1 ANSI/AMCA Standard 99-2010, Standards Handbook.
 - .2 ANSI/AMCA Standard 210-2007/(ANSI/ASHRAE 51-07), Laboratory Methods of Testing Fans for Aerodynamic Performance Rating.
 - .3 ANSI/AMCA Standard 300-2008, Reverberant Room Method for Sound Testing of Fans.
 - .4 ANSI/AMCA Standard 301-1990, Methods for Calculating Fan Sound Ratings from Laboratory Test Data.
- .2 The Master Painters Institute (MPI)
 - .1 Architectural Painting Specification Manual - current edition.
 - .1 MPI #18, Primer, Zinc Rich, Organic.

1.3 ACTION AND
INFORMATIONAL
SUBMITTALS

- .1 Submit in accordance with Section 01 33 00 - Submittal Procedures.
- .2 Product Data:
 - .1 Submit manufacturer's instructions, printed product literature and data sheets for HVAC fans and include product characteristics, performance criteria, physical size, finish and limitations.
- .3 Shop Drawings:
 - .1 Provide:
 - .1 Fan performance curves showing point of operation, bhp kW and efficiency.
 - .2 Sound rating data at point of operation.
 - .2 Indicate:
 - .1 Motors, sheaves, bearings, shaft details.
 - .2 Minimum performance achievable with variable speed controllers.

PART 2 - PRODUCTS2.1 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, total static pressure, bhp 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 Standard 99.
 - .4 Sound ratings: comply with ANSI/AMCA Standard 301, tested to ANSI/AMCA Standard 300. Supply unit with ANSI/AMCA certified sound rating seal.
 - .5 Performance ratings: based on tests performed in accordance with ANSI/AMCA Standard 210. Supply unit with ANSI/AMCA certified rating seal, except for propeller fans smaller than 300mm diameter.

2.2 FANS GENERAL

- .1 Motors:
 - .1 For use with variable speed controllers.
 - .2 Sizes as indicated or specified.
- .2 Accessories and hardware: matched sets of V-belt drives, adjustable motor bases, belt guards, coupling guards fan as specified in Section.
- .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 Flexible connections: to Section 23 33 00 - Air Duct Accessories.

2.3 CABINET FANS -
GENERAL PURPOSE

- .1 Fan characteristics and construction: as centrifugal fans.
- .2 Cabinet hung single or multiple wheel with DWDI centrifugal fans in factory fabricated casing complete with vibration isolators and seismic control measures, motor, variable speed V-belt drive.

-
- .3 Fabricate casing of zinc coated or phosphate treated steel of 1.5mm thickness reinforced and braced for rigidity. Provide removable panels for access to interior. Paint uncoated, steel parts with corrosion resistant paint to MPI #18. Finish inside and out, over prime coat, with rust resistant enamel. Internally line cabinet with 50mm thick rigid acoustic insulation, pinned and cemented complete with metal nosings on exposed edges. Include solid state speed controller factory mounted on cabinet and wired to fan.

PART 3 - EXECUTION

3.1 FAN INSTALLATION

- .1 Install fans as indicated complete with resilient mountings, flexible electrical leads and flexible connections in accordance with Section 23 33 00 - Air Duct Accessories.
- .2 Provide sheaves and belts required for final air balance.
- .3 Bearings and extension tubes to be easily accessible.
- .4 Access doors and access panels to be easily accessible.

3.2 ANCHOR BOLTS AND TEMPLATES

- .1 Size anchor bolts to withstand seismic acceleration and velocity forces as specified.

END OF SECTION

PART 1 - GENERAL1.1 REFERENCES

- .1 American National Standards Institute/Air Movement and Control Association (ANSI/AMCA)
 - .1 ANSI/AMCA Standard 210-2007/(ANSI/ASHRAE 51-07), Laboratory Methods of Testing Fans for Aerodynamic Performance Rating.
- .2 National Fire Protection Association (NFPA)
 - .1 NFPA 90A-15, Standard for the Installation of Air Conditioning and Ventilating Systems.
- .3 Underwriter's Laboratories (UL)
 - .1 UL 181-2005(R2013), Factory-Made Air Ducts and Air Connectors.
- .4 International Organization of Standardization (ISO)
 - .1 ISO 3741-2010, Acoustics-Determination of Sound Power Levels of Noise Sources Using Sound Pressure - Precision Methods for Reverberation Rooms.

1.2 ACTION AND INFORMATIONAL SUBMITTALS

- .1 Submit in accordance with Section 01 33 00 - Submittal Procedures.
- .2 Product Data:
 - .1 Submit manufacturer's instructions, printed product literature and data sheets for air terminal units and include product characteristics, performance criteria, physical size, finish and limitations.
- .3 Shop Drawings:
 - .1 Indicate the following:
 - .1 Capacity.
 - .2 Pressure drop.
 - .3 Noise rating.
 - .4 Leakage.
- .4 Certificates: submit certificates signed by manufacturer certifying that materials comply with specified performance characteristics and physical properties.
- .5 Test and Evaluation Reports:
 - .1 Test data: to ANSI/AMCA Standard 210.
 - .1 Submit published test data on DIN (Direct Internal Noise), in accordance with ISO 3741 made by independent testing agency for 0, 2.5 and 6 m/s branch velocity or inlet velocity.

.2 Sound power level with minimum inlet pressure of 0.25 0.5 1 1.5 kPa in accordance with ISO 3741 for 2nd through 7th octave band, also made by independent testing agency.

.3 Pressure loss through silencer shall not exceed 60% of inlet velocity pressure maximum.

1.3 CLOSEOUT SUBMITTALS

- .1 Submit in accordance with Section 01 78 00 - Closeout Submittals.
- .2 Operation and Maintenance Data: submit operation and maintenance data for air terminal units for incorporation into manual.

PART 2 - PRODUCTS

2.1 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 certified ADC (Air Diffusion Council) testing agency signifying adherence to codes and standards.

2.2 MANUFACTURED UNITS

- .1 Terminal units of the same type to be product of one manufacturer.

2.3 VARIABLE VOLUME BOXES

- .1 Furnish and install single duct pressure independent variable air volume terminals of the sizes and capacities shown in the plans. Terminals shall be certified under the ARI Standard 880 Certification program and carry the ARI Seal. Non-certified terminals are not acceptable. Each unit shall be tagged to identify the reference number and design setting.
- .2 The terminal casing shall be minimum twenty-two (22) gauge galvanized steel, internally lined with 3/4" dual density glass fiber insulation which complies with UL 181 and NFPA 90A. All exposed insulation edges shall be coated with NFPA 90A approved sealant to prevent entrainment of fibres in the airstream. The discharge connection shall be slip and drive construction for attachment to metal ductwork.

2.4 FAN POWERED
VARIABLE VOLUME
BOXES

- .3 The damper shall be heavy gauge steel with peripheral gasket rotating in self-lubricating bearings. Air leakage across the fully closed damper shall not exceed 2% of the nominal catalogue rating at three (3)" inlet pressure.
- .4 The units shall be selected to achieve a room sound level not exceeding NC30 at two (2)" inlet pressure with a room effect of 10 db. Supply laboratory test results showing discharge and radiated NC levels. Provide thirty-six (36)" factor fabricated discharge attenuator.
- .5 Primary air flow sensor shall be differential pressure, averaging multi point type designed to amplify the sensed airflow signal. Provide balancing taps and airflow calibration charts for field airflow measurements.
- .6 The DDC controller and actuator shall be supplied to VAV terminal manufacturer by the BAS (Building Automation System) contractor to be installed by terminal manufacturer on the units in their factory. Controls enclosure shall be by the terminal unit manufacturer.
- .1 Furnish and install constant volume series fan powered terminals of the sizes and capacities shown on the plans. Space limitations shall be reviewed carefully to ensure that all terminals will fit the available space. Terminals should be certified under the ARI Standard 880 Certification program and carry the ARI Seal. Non-certified terminals are not acceptable.
- .2 The terminal shall be designed, built, and tested as a single unit including motor and fan assembly, primary air damper assembly, water/electric heating coils, and accessories as shipped. Unit shall ship as a complete assembly requiring no field assembly, and arranged for single point power connection. All electrical components, including low voltage controls, shall be mounted in sheet metal control enclosures. The entire terminal shall be CSA and ARI certified, and ETL listed.
- .3 The terminal casing shall be minimum twenty-two (22) gauge galvanized steel, internally lined with 3/4" dual density glass fiber insulation which complies with UL 181 and NFPA 90A. Any exposed insulation edges shall be coated with NFPA 90A approved sealant to prevent entrainment of fibers in the airstream. The terminal

shall have a round duct collar for the primary air connection and a rectangular discharge suitable for flanged duct connection. The casing shall be designed for hanging by sheet metal straps. The casing shall have a bottom access panel which allows removal of fan and servicing of terminal without disturbing duct connections. Alternatively removable panels on both sides are acceptable.

- .4 The fan shall be constructed of steel and have a forward curved, dynamically balanced wheel with direct drive motor. The motor shall be suitable for 120 volt, 60 cycle, single phase power. The motor shall be of energy efficient ECM type, brushless DC with permanent magnet rotor, with integral thermal overload protection and permanently lubricated ball bearings, and be specifically designed for use with an electronic speed controller for fan speed adjustment. Fan assembly shall include an anti-backward rotation device, tuned spring suspension, and isolation between motor and fan housing.
- .5 Provide an electronic speed controller which allows continuously adjustable fan speed from maximum to minimum as a means of setting fan airflow. The speed control shall incorporate a minimum voltage stop to ensure that the motor cannot operate in a stall mode.
- .6 The primary air damper assembly shall be heavy gauge steel with peripheral gasket, rotating in self-lubricating bearings. Air leakage past the damper in the full closed position shall not exceed 2% of the nominal catalogue rating at 3" inlet static pressure.
- .7 Sound ratings for the terminals shall not exceed 30 NC for boxes up to twelve (12)" diameter and NC 30 for larger than twelve (12)" diameter at 1.0" wg inlet static pressure. Sound performance shall be ARI certified. The radiated and discharge path attenuation function for the specified NC shall be based upon factors found in ARI Standard 885. No additional attenuation factors shall be deducted from the sound power. The supplier shall review the proposed installation drawings prior to submitting his tender to determine the ceiling conditions affecting the sound performance in order to determine the room affect. The supplier shall supply his sound calculations with the proposed selections at time of shop drawings submission. Provide inlet and outlet sound attenuators where required to achieve the specified sound criteria. Attenuators may be field fabricated provided the sound criteria are satisfied.

-
- .8 Where applicable according to the schedule hot water heating coils shall be factory installed on the terminal. Fins shall be aluminum, mechanically bonded to tubes. Tubes shall be copper with minimum wall thickness of .016", with male solder header connections. Coils shall be leak tested to 300 psi, with minimum burst pressure of 2000 psi at ambient. Coil performance data shall be based on tests run in accordance with ARI Standard 410. Provide access door immediately upstream of the coil for inspection and cleaning of the coil. Provide 1" filter on return air connection to box.
- .9 Primary air flow sensor shall be differential pressure, averaging multi point type designed to amplify the sensed airflow signal. Provide balancing taps and airflow calibration charts for field airflow measurements.
- .10 The DDC controller, actuator, and airflow transducer, shall be supplied to the VAV terminal manufacturer by the BAS (Building Automation System) Contractor to be installed by terminal manufacturer on the units in their factory. The transformer, fan relay, controls enclosure, speed controller, and main electrical disconnect, shall be by the terminal unit manufacturer.

PART 3 - EXECUTION

3.1 INSTALLATION

- .1 Install in accordance with manufacturers recommendations.
- .2 Support independently of ductwork.
- .3 Locate controls, dampers and access panels for easy access.

END OF SECTION

PART 1 - GENERAL

- 1.1 ACTION AND INFORMATIONAL SUBMITTALS
- .1 Submit in accordance with Section 01 33 00 - Submittal Procedures.
 - .2 Product Data:
 - .1 Submit manufacturer's instructions, printed product literature and data sheets for diffusers, registers and grilles and include product characteristics, performance criteria, physical size, finish and limitations.
 - .2 Indicate following:
 - .1 Capacity.
 - .2 Throw and terminal velocity.
 - .3 Noise criteria.
 - .4 Pressure drop.
 - .5 Neck velocity.
- 1.2 MAINTENANCE MATERIAL SUBMITTALS
- .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 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.
- 2.2 GENERAL
- .1 To meet capacity as indicated. Pressure drop, terminal velocity, throw, noise level, neck velocity should be in accordance with ASHRAE guidelines.
 - .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: standard as directed by Departmental Representative.
- 2.3 MANUFACTURED UNITS .1 Grilles, registers and diffusers of same generic type, products of one manufacturer.
- 2.4 SUPPLY GRILLES AND REGISTERS .1 General: steel construction. Refer to drawing schedule.
- 2.5 RETURN AND EXHAUST GRILLES AND REGISTERS .1 General: aluminum construction. Refer to drawing schedule.
- 2.6 DIFFUSERS .1 General: steel construction volume control dampers with flow straightening devices and gaskets. Refer to drawing schedule.
- 2.7 LINEAR GRILLES .1 Bar core type with margin as indicated. Refer to drawing schedule.
- .2 Plaster frame, sealing strip and accessories as indicated.
- .3 Air volume control damper with concealed adjustment.
- PART 3 - EXECUTION
- 3.1 INSTALLATION .1 Install in accordance with manufacturers instructions.
- .2 Install with flat head stainless steel or cadmium plated screws in countersunk holes where fastenings are visible.

END OF SECTION

PART 1 - GENERAL1.1 REFERENCES

- .1 American National Standards Institute/Air-Conditioning, Heating and Refrigeration Institute (ANSI/AHRI)
 - .1 ANSI/AHRI 430-14, Performance Rating of Central Station Air-Handling Units.
- .2 American National Standards Institute/American Society of Heating, Refrigeration and Air Condition Engineers/Illuminating Engineering Society (ANSI/ASHRAE/IES)
 - .1 ANSI/ASHRAE 52.2-2012, Method of Testing General Ventilation Air-Cleaning Devices for Removal Efficiency by Particle Size.
 - .2 ANSI/ASHRAE/IES 90.1-2013, Energy Standard for Buildings Except Low-Rise Residential Buildings.
- .3 Master Painters Institute (MPI)
 - .1 Architectural Painting Specification Manual - current edition.
 - .1 MPI #18.
- .4 South Coast Air Quality Management District (SCAQMD)
 - .1 SCAQMD Rule 1113-11, Architectural Coatings.
 - .2 SCAQMD Rule 1168-05, Adhesives and Sealants.

1.2 ACTION AND INFORMATIONAL SUBMITTALS

- .1 Submit in accordance with Section 01 33 00 - Submittal Procedures.
- .2 Product Data:
 - .1 Submit manufacturer's instructions, printed product literature and data sheets for insulation, filters, adhesives, and paints and include product characteristics, performance criteria, physical size, finish and limitations.
- .3 Shop Drawings:
 - .1 Indicate on drawings: fan, fan curves showing point of operation, motor drive, bearings, filters mixing box, dampers coil; include performance data.

1.3 CLOSEOUT SUBMITTALS

- .1 Submit in accordance with Section 01 78 00 - Closeout Submittals.

- .2 Operation and Maintenance Data: submit operation and maintenance data for air handling equipment for incorporation into manual.

1.4 MAINTENANCE MATERIAL SUBMITTALS

- .1 Submit in accordance with Section 01 78 00 - Closeout Submittals.
- .2 Provide 1 spare set of filters.

PART 2 - PRODUCTS

2.1 GENERAL

- .1 Factory assembled components to form units supplying air at designed conditions, as indicated. Unit shall be shipped in sections so that equipment can be moved into space and assembled in mechanical room.
- .2 Certify ratings: to ANSI/AHRI 430 with AHRI seal.
- .3 Type, as indicated, having air tight modular components, consisting of casing, fan section with motor and drive, filter section, damper, heating coil, cooling coil.

2.2 CASINGS

- .1 Galvanized steel 18mm thickness, thickness as indicated reinforced and braced for rigidity.
 - .1 Provide access for maintenance of internal parts.
 - .2 Paint steel parts, where not galvanized, with corrosion resistant paint to MPI #18.
 - .1 Paint: maximum VOC limit 250 g/L to GS-11 to SCAQMD Rule 1113.
 - .3 Finish unit, inside and out, with rust resistant enamel.
 - .1 Enamel Finish: maximum VOC limit 250 g/L to SCAQMD Rule 1113.
- .2 Line casing with solid steel liner.

2.3 ACOUSTIC LINER

- .1 Ensure that expanded polystyrene and polyurethane insulation materials were not produced with ozone depleting substances.
- .2 Insulate internal surface of panels with 50mm neoprene coated rigid duct liner of 72kg/m3 density.
 - .1 Adhesives: maximum VOC limit 80 g/L to SCAQMD Rule 1168.
 - .2 Cover with 0.8mm thick perforated galvanized sheet metal.
 - .3 Cover leading and trailing edges with sheet metal nosing and at edges around access doors and panels complete with 15mm overlap.

2.4 DRAIN PANS

- .1 Construction: stainless steel, rounded corners.
- .2 Insulation: external foam type, minimum 13mm thick.
- .3 Drain connection: in bottom at low point.
- .4 Installation: slope without sag minimum 1% to ensure no standing water at any time or at any point.
- .5 Dimensions: minimum 75mm from upstream face of coil to 150mm beyond downstream face of coil or eliminator and to include return bends and headers.

2.5 FANS

- .1 Free standing AMCA-rated for sound and performance centrifugal fans with airfoil wheels, selected to operate in stable part of performance curve at times and heavy duty 100,000 hours service self-aligning split pillow block bearings.
 - .1 Provide internally mounted motor as indicated complete with adjustable V-belt drive and guard.
 - .2 Motor: to ANSI/ASHRAE/IES 90.1 high efficiency specifications and NEMA MG 1-2011 Part 30. All motors shall be inverter duty ready complete with voltage conditioning equipment.
- .2 Maximum sound power levels, as indicated.
- .3 Internally mounted motor and fan.

2.6 VIBRATION
ISOLATION

- .1 Flexible connections at inlet and outlet of fan: to Section 23 33 00 - Air Duct Accessories.
- .2 Vibration isolators on fan section complete with seismic restraints: in accordance with Section 23 05 48 - Vibration and Seismic Controls for HVAC Piping and Equipment.

2.7 VARIABLE VOLUME
DEVICES

- .1 Variable speed drives complete with Bypass and Disconnect.

2.8 FILTER BOX

- .1 Material to match casing. For flat type filter arrangement:
 - .1 Provide access to filter through hinged door with suitable hardware.
- .2 Provide blank-off plates and gaskets to prevent air bypass.
- .3 Filters:
 - .1 Minimum Efficiency Reporting Value (MERV) value 8 filtration media to ANSI/ASHRAE 52.2, to be used on return air section of air handling unit.
 - .2 Immediately prior to occupancy, replace filtration media with new filtration media with Minimum Efficiency Reporting Value (MERV) of 13 in accordance with ANSI/ASHRAE 52.2.

2.9 MIXING BOX

- .1 Material to match casing and produce uniformly mixed air temperature within plus or minus 5 degrees C of design across face of outlet.

2.10 COILS

- .1 Capacity: as indicated.
- .2 Ratings: AHRI certified.
- .3 Construction:
 - .1 Casings: 1.5mm thick galvanized sheet steel.
 - .1 Supports of galvanized steel channel.
 - .2 Blank-off plates. Insulated sandwich

construction.

- .2 Glycol and chilled water coils: cleanable fins.
 - .1 Tubes: copper.
 - .2 Fins: aluminum.
 - .3 Headers: steel.
 - .4 Pressure tests: 1.7 MPa.

2.11 VARIABLE FREQUENCY DRIVE

- .1 Furnish complete variable speed drives utilizing pulse width modulated (PWM) design as specified herein for the motors designated to be variable speed. All features shall be included within the VSD enclosure, unless otherwise specified. VSD enclosure shall be NEMA 1. The VSD shall be rated 600 volt \pm 10% and shall operate continuously without failure when connected to a three phase supply line. The VSD shall be highly reliable and rated for 250,000 hours mean time before failure (MTBF).
- .2 The VSD and options shall be tested to ANSI/UL Standard 508. The complete VSD, including all specified options, shall be assembled by the manufacturer, which shall be UL-508 certified for the building and assembly of option panels. Assembly of the option panels by a third-party panel shop is not acceptable. The appropriate UL stickers shall be applied in both the VSD and option panel, in the case where these are not contained in one panel. When these VSD's are to be located in Canada, CSA or C-UL certifications shall apply.
- .3 The adjustable frequency drive shall produce adjustable frequency output. Drives utilizing six step technology are not acceptable. To eliminate the need for isolation transformers and/or line suppression equipment, input line reactors will be an integral part of the input section of the drive. If isolation transformers or other external suppression equipment is needed to meet this specification, the supply and additional electrical installation, shall be included as part of this work. The VSD shall have an internally mounted 3% line reactor/3% impedance reactor as a minimum to reduce input current harmonic content and provide isolation from power line transients such as utility power factor correction capacitor switching transients and to reduce RFI emissions. All associated costs for installation and wiring shall be assumed by the manufacturer for externally mounted line reactors.

-
- .4 Line noise shall be no greater than 3% harmonic distortion and no more than a 16,400 volt-microsecond commutation notch area, in accordance with IEEE Standard 519-1992 for special applications.
 - .5 The VSD shall be capable of starting into a rotating load (forward or reverse) and accelerating to setpoint without tripping or damaging components.
 - .6 The VSD shall have four programmable critical frequency lockout ranges to prevent the VSD from operating at an unstable speed.
 - .7 The VSD shall have an intelligent motor overload feature to protect the motor at different operating speeds and loads. The VSD shall provide electronic motor overload protection qualified per UL508C.
 - .8 The VSD shall protect against a stalled motor. The stall frequency/time shall be programmable.
 - .9 Where the unit and internal components are to be installed within a dusty environment or air plenum, the unit shall be enclosed within a NEMA 12 enclosure.
 - .10 The output current rating of the VSD shall match or exceed the motor nameplate full load current rating.

Provide a manual 3-contactor bypass consisting of a door interlocked main fused disconnect padlockable in the off position, a built-in motor starter and a four position DRIVE/OFF/BYPASS/TEST switch controlling three contactors. In the DRIVE position, the motor is operated at an adjustable speed from the VSD. In the OFF position, the motor and VSD are disconnected. In the BYPASS position, the motor is operated at full speed from the AC power line and power is disconnected from the VSD so that service can be performed. In the TEST position, the motor is operated at full speed from the AC line power while power is applied to the input of the VSD. This allows the VSD to be given an operational test while continuing to run the motor at full speed in the bypass. In case of an external safety fault, a customer supplied normally closed dry contact shall be able to stop the motor whether in the DRIVE or BYPASS mode. The bypass circuitry shall be mounted in a separate section of the VSD enclosure. Motor overload protection shall be provided in both drive and bypass modes.

- .11 BAS interface
Provide the following BAS interface capability:
System ON/OFF.
System Status.
4 - 20 mA input for speed signal.

2.12 - HUMIDIFIERS

- .1 Direct steam injection type humidifiers to include:
 - .1 Stainless steel jacketed duct distribution manifolds. Number to suit Air Handler Unit shape and size
 - .2 Steam separator with baffle.
- .2 Steam control valve with electric actuator, field installed for modulating control. Unit to be complete with two Drain Coolers per detail.
- .3 Steam trap assembly: as recommended by manufacturer.

PART 3 - EXECUTION

3.1 EXAMINATION

- .1 Verification of Conditions: verify that conditions of substrate previously installed under other Sections or Contracts are acceptable for air handling equipment installation in accordance with manufacturer's written instructions.
 - .1 Visually inspect substrate in presence of Departmental Representative.
 - .2 Inform Departmental Representative of unacceptable conditions immediately upon discovery.
 - .3 Proceed with installation only after unacceptable conditions have been remedied and after receipt of written approval to proceed from Departmental Representative.

3.2 INSTALLATION

- .1 Provide appropriate protection apparatus.
- .2 Install units in accordance with manufacturer's instructions and as indicated.
- .3 Ensure adequate clearance for servicing and maintenance.

3.3 FANS

- .1 Install fan sheaves required for final air balance.
- .2 Install flexible connections at fan inlet and fan outlets.
- .3 Install vibration isolators.

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 HUMIDIFIERS

- .1 Install piping, steam traps, and equipment according to manufacturer's instructions.
- .2 Insulate steam and condensate piping with 38mm of type A1 insulation.
- .3 Pipe all condensate to nearest floor drain.

END OF SECTION