

1 GENERAL

1.01 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 Submit drawings where required.
 - .2 Indicate on drawings:
 - .1 Mounting arrangements.
 - .2 Operating and maintenance clearances.
 - .3 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.
 - .4 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.

1.02 CLOSEOUT SUBMITTALS

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

1.03 MAINTENANCE MATERIAL SUBMITTALS

- .1 Submit in accordance with Section 01 78 00 - Closeout Submittals.
- .2 Furnish spare parts as follows:
 - .1 One glass for each gauge glass.
 - .2 One filter cartridge or set of filter media for each filter or filter bank in addition to final operating set.
- .3 Provide one set of special tools required to service equipment as recommended by manufacturers.

1.04 DELIVERY, STORAGE AND HANDLING

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

- .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 off ground, 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.

1.05 COORDINATION

- .1 Cooperate and coordinate with other trades and verify order of installation of overlapping or interconnecting services or equipment before starting Work
- .2 Coordinate installation of the Work with manufacturer's recommended installation details and procedures, supplemented by requirements of Contract Documents; provide adequate access space for maintenance and service of equipment and systems.
- .3 Coordinate location of access to cleanouts, valves, equipment, and duct access doors above continuous ceilings; coordinate access panel and door requirements with Section 08 11 00.
- .4 Not used
- .5 Install material and equipment generally in locations and routes shown, close to building structure with minimum interference with other services or free space; remove and replace improperly installed equipment as determined by Departmental Representative.
- .6 Refer to electrical, mechanical and architectural drawings when setting out work and coordinate with other applicable components of the Work when setting out locations for ductwork, equipment, and piping so that conflicts are avoided and symmetrical even spacing is maintained.
- .7 Provide coordination drawings showing the work of other trades and contractors involved in areas of potential conflict or congestion at no additional cost to the Contract.
- .8 Coordinate dimensional details with applicable architectural and structural drawings.
- .9 Full size and detailed drawings will take precedence over scale measurements from drawings when laying out the Work.
- .10 Coordinate requirements of, and connect to, equipment specified in other Sections, and to equipment supplied and installed by Department Representative; uncrate equipment, assemble, move in place, and install complete, start-up and test.

2 PRODUCTS

2.01 Not Used.

3 EXECUTION

3.01 EXAMINATION

.1 Not used.

3.02 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.

3.03 SYSTEM CLEANING

- .1 Clean interior and exterior of all systems including strainers. Vacuum interior of ductwork and air handling units.

3.04 DEMONSTRATION

- .1 Departmental Representative will use equipment and systems for test purposes prior to acceptance. Supply labour, material, and instruments required for testing.
- .2 Trial usage to apply to applicable equipment and systems.
- .3 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.
- .4 Use operation and maintenance manual, as-built drawings, and audio visual aids as part of instruction materials.
- .5 Instruction duration time requirements as specified in appropriate sections.

3.05 CLEANING

- .1 Not used.

3.06 PROTECTION

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

END OF SECTION

1 GENERAL

1.01 RELATED REQUIREMENTS

- .1 Not Used.

1.02 REFERENCE STANDARDS

- .1 Green Seal Environmental Standards (GSES)
 - .1 Standard GS-11-2015, 2nd Edition, Environmental Standard for Paints and Coatings.
- .2 National Research Council Canada (NRC)
 - .1 National Fire Code of Canada 2015 (NFC).
- .3 South Coast Air Quality Management District (SCAQMD), California State, Regulation XI. Source Specific Standards
 - .1 SCAQMD Rule 1113, Architectural Coatings.
 - .2 SCAQMD Rule 1168, Adhesive and Sealant Applications.

1.03 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 piping and equipment and include product characteristics, performance criteria, physical size, finish and limitations.

1.04 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.

1.05 DELIVERY, STORAGE AND HANDLING

- .1 Deliver, store and handle materials in accordance 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.

2 PRODUCTS

2.01 MATERIAL

- .1 Paint: zinc-rich to CAN/CGSB-1.181.
 - .1 Primers, Paints, Coatings, in accordance with manufacturer's recommendations for surface conditions.
 - .2 Primer: maximum VOC limit 250 g/L to Standard GS-11.
 - .3 Paints: maximum VOC limit 150 g/L to Standard GS-11
- .2 Sealants: in accordance with Section 07 92 00 - Joint Sealants.
 - .1 Sealants: maximum VOC limit to GSES GS-36.
- .3 Sealants: maximum VOC limit to GSES GS-36.
- .4 Adhesives: maximum VOC limit to GSES GS-36.
- .5 Fire Stopping: in accordance with Section 07 84 00 - Fire Stopping.

3 EXECUTION

3.01 APPLICATION

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

3.02 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.

3.03 CLEARANCES

- .1 Provide clearance around systems, equipment and components for observation of operation, inspection, servicing, maintenance and as recommended by manufacturer and National Fire Code of Canada and/or CSA B139.
- .2 Provide space for disassembly, removal of equipment and components as recommended by manufacturer without interrupting operation of other system, equipment, components.

3.04 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.

3.05 AIR VENTS

- .1 Install manual air vents to 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.

3.06 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.

3.07 PIPEWORK INSTALLATION

- .1 Install pipework to CSA B139.
- .2 Screwed fittings jointed with Teflon tape.
- .3 Protect openings against entry of foreign material.
- .4 Install to isolate equipment and allow removal without interrupting operation of other equipment or systems.
- .5 Assemble piping using fittings manufactured to ANSI standards.
- .6 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.
- .7 Install exposed piping, equipment, rectangular cleanouts and similar items parallel or perpendicular to building lines.
- .8 Install concealed pipework to minimize furring space, maximize headroom, conserve space.
- .9 Slope piping, except where indicated, in direction of flow for positive drainage and venting.
- .10 Install, except where indicated, to permit separate thermal insulation of each pipe.
- .11 Group piping wherever possible and as indicated.
- .12 Ream pipes, remove scale and other foreign material before assembly.

- .13 Use eccentric reducers at pipe size changes to ensure positive drainage and venting.
- .14 Provide for thermal expansion as indicated.
- .15 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 shutoff 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 Install plug cocks or ball valves for glycol service.
 - .10 Use chain operators on valves NPS 2 1/2 and larger where installed more than 2400 mm above floor in Mechanical Rooms.
- .16 Check Valves:
 - .1 Install silent check valves on discharge of pumps and in vertical pipes with downward flow and as indicated.
 - .2 Install swing check valves in horizontal lines on discharge of pumps and as indicated.

3.08 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: 6 mm minimum clearance between sleeve and uninsulated pipe or between sleeve and insulation.
- .5 Installation:
 - .1 Concrete, masonry walls, concrete floors on grade: terminate flush with finished surface.
 - .2 Other floors: terminate 25 mm above finished floor.
 - .3 Before installation, paint exposed exterior surfaces with heavy application of zinc-rich paint 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.

3.09 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 other sections included within
- .2 Before start-up, clean interior of piping systems in accordance with requirements of Section 01 74 00 - Cleaning, 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 Pework: 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.

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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 10 days minimum, prior to commencement of work.
- .3 Be responsible for damage to existing plant by this work.

END OF SECTION

1 GENERAL

1.01 RELATED REQUIREMENTS

- .1 Sections 22 11 16, 23 05 15

1.02 REFERENCE STANDARDS

- .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 A276/A276M:17, Standard Specification for Stainless Steel Bars and Shapes.
 - .2 ASTM B62:17, Standard Specification for Composition Bronze or Ounce Metal Castings.
 - .3 B283/B283M:18, Standard Specification for Copper and Copper Alloy Die Forgings (Hot-Pressed).
 - .4 ASTM B505/B505M:18, Standard Specification for Copper-Base Alloy Continuous Castings.
- .3 Manufacturers Standardization Society of the Valve and Fittings Industry, Inc. (MSS)
 - .1 MSS-SP-25, Standard Marking System for Valves, Fittings, Flanges and Unions, latest edition.
 - .2 MSS-SP-80, Bronze Gate Globe, Angle and Check Valves, latest edition.
 - .3 MSS-SP-110, Ball Valves, Threaded, Socket-Welding, Solder Joint, Grooved and Flared Ends, latest edition.

1.03 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.
 - .2 Submit WHMIS MSDS - Material Safety Data Sheets where required.
- .3 Shop Drawings:
 - .1 Submit drawings stamped where required.
 - .2 Submit data for valves specified in this Section.

1.04 CLOSEOUT SUBMITTALS

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

1.05 MAINTENANCE MATERIAL SUBMITTALS

- .1 Extra Materials/Spare Parts:
- .1 Furnish following spare parts:
 - .1 Valve seats: one for every 10 valves each size, minimum 1.
 - .2 Discs: one for every 10 valves, each size. Minimum 1.
 - .3 Stem packing: one for every 10 valves, each size. Minimum 1.
 - .4 Valve handles: 2 of each size.
 - .5 Gaskets for flanges: one for every 10 flanged joints.
- .2 Tools:
 - .1 Furnish special tools for maintenance of systems and equipment.
 - .2 Include following:
 - .1 Lubricant gun for expansion joints.

1.06 DELIVERY, STORAGE AND HANDLING

- .1 Not used.
- .2 Delivery and Acceptance Requirements:
 - .1 Deliver materials to site in original factory packaging, labelled with manufacturer's name, address.

2 PRODUCTS

2.01 MATERIALS

- .1 Not Used.
- .2 Valves:
 - .1 Except for specialty valves, to be single manufacturer.
 - .2 Products to have CRN registration numbers.
- .3 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.
- .4 Lockshield Keys:
 - .1 Where lockshield valves are specified, provide 5 keys of each size: malleable iron cadmium plated.
- .5 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, rising stem, split wedge disc, Class 125:
 - .1 Body: with long disc guides, screwed bonnet.

- .2 Disc: split wedge, bronze to ASTM B 283, loosely secured to stem.
- .3 Operator: handwheel.
- .3 NPS 2 and under, rising stem, solid wedge disc, Class 150:
 - .1 Body: with long disc guides, screwed bonnet.
 - .2 Operator: handwheel.
- .6 Globe Valves:
 - .1 Requirements common to globe valves, unless specified otherwise:
 - .1 Standard specification: MSS SP-80.
 - .2 Bonnet: union with hexagonal shoulders.
 - .3 Connections: screwed with hexagonal shoulders.
 - .4 Pressure testing: to MSS SP-80. Tests to be hydrostatic.
 - .5 Stuffing box: threaded to bonnet with gland follower, packing nut, high grade non-asbestos packing.
 - .6 Handwheel: non-ferrous.
 - .7 Handwheel Nut: bronze to ASTM B 62.
 - .2 NPS 2 and under, composition disc, Class 125:
 - .1 Body and bonnet: screwed bonnet.
 - .2 Disc and seat: renewable rotating PTFE disc, regrindable bronze seat, loosely secured to bronze stem to ASTM B 505.
 - .3 Operator: handwheel.
 - .3 NPS 2 and under, composition disc, Class 150:
 - .1 Body and bonnet: union bonnet.
 - .2 Disc and seat: renewable rotating PTFE disc in easily removable disc holder, regrindable bronze seat, loosely secured to bronze stem to ASTM B 505.
 - .3 Operator: handwheel.
- .7 Check Valves:
 - .1 Requirements common to check valves, unless specified otherwise:
 - .1 Standard specification: MSS SP-80.
 - .2 Connections: screwed with hexagonal shoulders.
 - .2 NPS 2 and under, swing type, bronze disc, Class 125:
 - .1 Body: Y-pattern with integral seat at 45 degrees, screw-in cap with hex head.
 - .2 Disc and seat: renewable rotating disc, two-piece hinge disc construction; seat: regrindable.
- .8 Ball Valves:
 - .1 NPS 2 and under:
 - .1 Body and cap: cast high tensile bronze to ASTM B 62.
 - .2 Pressure rating: Class 125, 860 kPa steam.
 - .3 Connections: screwed ends to ANSI B1.20.1 and with hexagonal shoulders or solder ends to ANSI.
 - .4 Stem: tamperproof ball drive.
 - .5 Stem packing nut: external to body.
 - .6 Ball and seat: replaceable stainless steel or hard chrome solid ball and Teflon seats.
 - .7 Stem seal: TFE with external packing nut.
 - .8 Operator: removable lever handle.
- .9 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.

3 EXECUTION

3.01 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

1 GENERAL

1.01 RELATED REQUIREMENTS

- .1 Not used.

1.02 REFERENCE STANDARDS

- .1 American National Standards Institute (ANSI)/American Society of Mechanical Engineers (ASME)
 - .1 ASME B16, Fittings and Valves Package, latest edition.
 - .2 ASME B16.5, Pipe Flanges and Flanged Fittings: NPS ½ through NPS 24 Metric/Inch Standard, latest edition.
 - .3 ANSI/ASME B16.10, Face-to-Face and End-to-End Dimensions Valves, latest edition.
 - .4 ANSI/ASME B16.25, Buttwelding Ends, latest edition.
 - .5 ANSI/ASME B16.34, Valves Flanged, Threaded and Welding End. Includes Supplement, latest edition.
- .2 American Petroleum Institute (API)
 - .1 API STD 598, Valve Inspection and Testing, latest edition.
- .3 ASTM International
 - .1 ASTM A49, Standard Specification for Heat-Treated Carbon Steel Joint Bars, Micro Alloyed Joint Bars, and Forged Carbon Steel Comprise Joint Bars, latest edition.
 - .2 ASTM A182/A 182M, Standard Specification for Specification for Forged or Rolled Alloy and Stainless Steel Pipe Flanges, Forged Fittings, and Valve Parts for High Temperature Service, latest edition.
 - .3 ASTM A193/A 193M-12, Standard Specification for Alloy-Steel and Stainless Steel Bolting Materials for High-Temperature or High Pressure Service and Other Special Purpose Applications, latest edition.
 - .4 ASTM A194/A194M, Standard Specification for Carbon and Alloy Steel Nuts for Bolts for High-Pressure and High-Temperature Service, or Both, latest edition.
 - .5 ASTM A 216/A216M, Standard Specification for Steel Castings, Carbon Suitable for Fusion Welding for High-Temperature Service, latest edition.
 - .6 ASTM B85/B85M, Standard Specification for Aluminum-Alloy Die Castings, latest edition.
- .5 Efficiency Valuation Organization (EVO)
 - .1 International Performance Measurement and Verification Protocol (IPMVP)
- .6 Green Seal Environmental Standards (GS)
 - .1 GS-11, Standard for Paints and Coatings, latest edition.
 - .2 GS-36, Standard for Commercial Adhesives, latest edition.
- .7 Manufacturers Standardization Society of the Valve and Fittings Industry (MSS)
 - .1 MSS SP-25, Standard Marking System for Valves, Fittings, Flanges

- and Unions, latest edition.
- .2 MSS SP-61, Pressure Testing of Valves, latest edition.

1.03 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 each valve and include product characteristics, performance criteria, physical size, finish and limitations.
- .3 Shop Drawings:
 - .1 Submit drawings when applicable.
- .4 Certificates: submit certificates signed by manufacturer certifying that materials comply with specified performance characteristics and physical properties.

1.04 CLOSEOUT SUBMITTALS

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

1.05 MAINTENANCE MATERIAL SUBMITTALS

- .1 Submit in accordance with Section 01 78 00 - Closeout Submittals.
- .2 Extra Stock Materials:
- .3 Furnish following spare parts:
 - .1 Valve seats: one for every 10 valves each size, minimum 1.
 - .2 Discs: one for every 10 valves, each size, minimum 1.
 - .3 Stem packing: one for every 10 valves, each size. Minimum 1.
 - .4 Valve handles: 2 of each size.
 - .5 Gaskets for flanges: one for every 10 flanged joints.

2 PRODUCTS

2.01 MATERIAL

- .1 Valves:
 - .1 To be of single manufacturer.
 - .2 Test valves individually.
- .2 Requirements common to valves, unless specified otherwise:
 - .1 Pressure-temperature ratings: to ANSI B16.34.
 - .2 Inspections and tests: to API 598.
 - .3 Pressure testing: to MSS SP-61.
 - .4 Flanged valves:
 - .1 Face-to-face dimensions: to ANSI B16.10.

- .2 Flange dimensions: to ANSI B16.5 with 1.6 mm raised face.
- .5 Butt-weld valves:
 - .1 End-to-end dimensions: to ANSI B16.10.
 - .2 End dimensions: to ANSI B16.25 bored for standard pipe schedule.
- .6 Handwheel: non-heating type with raised rim of die-cast aluminum alloy to ASTM B 85 or malleable iron to ASTM A 49.
- .7 Markings: to MSS SP-25.
- .8 Identification:
 - .1 Plate showing catalogue number, size, material of body disc, stem seat, fluid, pressure-temperature rating.
 - .2 Body markings: manufacturer, size, primary service rating, material symbol.
- .9 CRN registration number required for all products.

2.02 GATE VALVES

- .1 NPS 2 1/2 - 12, rising stem, OS&Y, solid wedge disc, flanged ends, Class 150
 - .1 Body and multiple-bolted integral yoke and bonnet: cast steel to ASTM A 216/A 216M WCB, with full length disc guides designed to ensure correct re-assembly.
 - .2 Body/bonnet joint: male-female face with corrugated metallic gasket.
 - .3 Bonnet studs: to ASTM A 193/A 193M Type B7.
 - .4 Bonnet nuts: to ASTM A 194/A 194M Type 2H.
 - .5 Stuffing box: including non-galling two-piece ball jointed packing gland, with swing-type eye bolts and nuts.
 - .6 Gland packing: containing corrosion inhibitor to prevent stem pitting.
 - .7 Yoke sleeve: Ni-Resist, minimum melting point above 954 degrees C.
 - .8 Hydraulic grease fitting: for lubrication of yoke sleeve bearing surfaces.
 - .9 Disc: with disc stem ring to connect to stem, guided throughout its travel.
 - .1 NPS 2 1/2 - 6: solid corrosion and heat resistant 13% chromium steel with minimum hardness of 350 HB.
 - .2 NPS 8 and larger: carbon steel faced with corrosion and heat resistant 13 chromium steel with minimum hardness of 350 HB.
 - .10 Seat ring: seamless carbon steel with hard-faced cobalt-chromium-tungsten alloy seating surface, slipped in, seal welded, ground to match disc.
 - .11 Stem: heat treated corrosion and heat resistant 13% chromium steel with accurately-cut precision-machined Acme or 60 degrees V threads, top screwed for handwheel nut, T-head disc-stem connection.
 - .12 Operator: see elsewhere in this Section.

2.03 GLOBE VALVES

- .1 NPS 2 1/2 - 12, rising stem, OS&Y, flanged ends, Class 150
 - .1 Body and multiple-bolted integral yoke and bonnet: cast steel to ASTM A 216/A 216M WCB.
 - .2 Body/bonnet joint: male-female face with corrugated metallic gasket.

- .3 Bonnet studs: to ASTM A 193/A 193M Type B7.
- .4 Bonnet nuts: to ASTM A 194/A 194M Type 2H.
- .5 Stuffing box: including non-galling two-piece ball-jointed packing gland, with swing-type eye bolts and nuts.
- .6 Gland packing: containing corrosion inhibitor to prevent stem pitting.
- .7 Yoke bushing: Ni-Resist, minimum melting point above 954 degrees C.
- .8 Hydraulic grease fitting: for lubrication of yoke sleeve bearing surfaces.
- .9 Disc: plug type with 15 degrees taper seat and bottom guide or ball type with 35 degrees taper seat.
- .10 Seat rings: with 1.6 mm thick cobalt-chromium-tungsten alloy facings with minimum hardness of 375 HB (cold), slipped in, seal welded, ground to match disc.
- .11 Stem: heat treated corrosion and heat resistant 13% chromium steel with bonnet bushing, long engagement with yoke bushing for accurate seating, accurately-cut precision-machined Acme or 60 degrees V threads, top screwed for handwheel nut.
- .12 Operator: see elsewhere in this Section.

2.04 VALVE OPERATORS

- .1 Handwheel: on all valves.
- .2 Handwheel with chain operators: on valves installed more than 2400 mm above floor in mechanical equipment rooms.
- .3 Motors:
 - .1 Application: full open and full close applications.
- .4 Hydraulic operators:
 - .1 Application: conveyor and feeder drives.
- .5 Pneumatic operators:
 - .1 Application: media with high dirt content, media with high viscosity, high ambient temperatures, large flow quantities, damp environments and where there is a risk of explosion.

2.05 BYPASSES FOR GATE AND GLOBE VALVES

- .1 Locations: on valves as indicated.
- .2 Position of bypass valve on main valves
- .3 Size of bypass valve:
 - .1 Main valve up to NPS 8: NPS 3/4.
 - .2 Main valve NPS 10 and over: NPS 1.
- .4 Type of bypass valves:
 - .1 On gate valve: globe, with composition disc, bronze trim, to Section 23 05 23.01 - Valves - Bronze.
 - .2 On globe valve: globe, with bronze disc, bronze trim, to Section 23 05 23.01 - Valves - Bronze.

2.06 CHECK VALVES

- .1 NPS 2 1/2 and over, flanged ends, Class 150: swing check.
 - .1 Body and multiple-bolted cap: cast steel to ASTM A 216/A 216M WCB.
 - .2 Cap studs: to ASTM A 193/A 193M Type B7.
 - .3 Cap nuts: to ASTM A 194/A 194M Type 2H.
 - .4 Body/cap joint: male-female face with corrugated metallic gasket.
 - .5 Disc: heat treated corrosion and heat resistant 13% chromium steel.
 - .6 Seat rings: heat treated corrosion and heat resistant 13% chromium steel, slipped in, seal welded, ground to match disc.
 - .7 Hinge: ASTM A 182/A 182M.
 - .8 Hinge pin: ASTM A 182/A 182M.
 - .9 Hinge pin plugs: ASTM A 182/A 182M.

2.07 SILENT CHECK VALVES

- .1 Construction:
 - .1 Body: cast steel with integral seat.
 - .2 Pressure rating: Class 125
 - .3 Connections: flanged ends.
 - .4 Double bronze disc with SS seat and stem. Renewable disc, seat, stem and spring. Spring rating must match system design for silent operation and installation.
 - .5 Stainless steel spring, heavy duty.
 - .6 Seat: regrindable.

3 EXECUTION

3.01 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.

3.02 INSTALLATION

- .1 Install in accordance with manufacturer's recommendations in upright position with stem above horizontal.

3.03 COMMISSIONING

- .1 As part of commissioning activities, develop schedule of valves and record thereon identifier, location, service, purchase order number and date, manufacturer, identification data specified above.

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3.04 CLEANING

- .1 Not used

3.05 PROTECTION

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

END OF SECTION

1 GENERAL

1.01 RELATED REQUIREMENTS

- .1 Section 23 05 00, 22 11 16, 22 15 00, 23 31 13.02.

1.02 REFERENCE STANDARDS

- .1 American Society of Mechanical Engineers (ASME)
 - .1 ASME B31.1-2016, Power Piping.
- .2 ASTM International
 - .1 ASTM A 125-1996(2013), Standard Specification for Steel Springs, Helical, Heat-Treated.
 - .2 ASTM A307 - 14e1, Standard Specification for Carbon Steel Bolts and Studs, 60,000 PSI Tensile Strength.
 - .3 ASTM A563 - 15, Standard Specification for Carbon and Alloy Steel Nuts.
- .3 Canada Green Building Council (CaGBC)
 - .1 LEED Canada-NC Version 4.1, LEED (Leadership in Energy and Environmental Design): Green Building Rating System Reference Package For New Construction and Major Renovations (including Addendum 2007).
 - .2 LEED Canada-CI Version 4.1, LEED (Leadership in Energy and Environmental Design): Green Building Rating System Reference Guide For Commercial Interiors.
- .4 Factory Mutual (FM)
- .5 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 69-2009, Pipe Hangers and Supports - Selection and Application.
- .6 National Research Council Canada (NRC)
 - .1 National Plumbing Code of Canada 2015 (NPC).
- .7 Underwriter's Laboratories of Canada (ULC)

1.03 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 drawings where required.
 - .2 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.

1.04 CLOSEOUT SUBMITTALS

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

1.05 DELIVERY, STORAGE AND HANDLING

- .1 Deliver, store and handle materials in accordance with Section 01 61 00 - Common Product Requirements
- .2 Delivery and Acceptance Requirements:
 - .1 Deliver materials to site in original factory packaging, labelled with manufacturer's name, address.
- .3 Packaging Waste Management: in accordance with Section 01 74 19 - Waste Management and Disposal.

2 PRODUCTS

2.01 SYSTEM DESCRIPTION

- .1 Design Requirements:
 - .1 Construct pipe hanger and support to manufacturer's recommendations utilizing manufacturer's regular production components, parts and assemblies.
 - .2 Base maximum load ratings on allowable stresses prescribed by ASME B31.1 or MSS SP 58.
 - .3 Ensure that supports, guides, anchors do not transmit excessive quantities of heat to building structure.
 - .4 Design hangers and supports to support systems under conditions of operation, allow free expansion and contraction, prevent excessive stresses from being introduced into pipework or connected equipment.
 - .5 Provide for vertical adjustments after erection and during commissioning. Amount of adjustment in accordance with MSS SP 58.

2.03 GENERAL

- .1 Fabricate hangers, supports and sway braces in accordance with MSS SP 58. ANSI B31.1 and
- .2 Use components for intended design purpose only. Do not use for rigging or erection purposes.

-
- .3 Ensure compliance with MSS SP-69

2.04 PIPE HANGERS

- .1 Finishes:
- .1 Pipe hangers and supports: galvanize.
 - 2 Use 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: 13 mm FM approved.
 - .2 Cold piping NPS 2 1/2 or greater, hot piping: malleable iron beam clamp, eye rod, jaws and extension with carbon steel retaining clip, tie rod, nuts and washers, FM approved 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, FM approved 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 FM approved.
- .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 6 mm minimum greater than rod diameter.
 - .2 Concrete inserts: wedge shaped body with knockout protector plate FM approved to MSS SP 69.
- .5 Shop and field-fabricated assemblies:
- .1 Trapeze hanger assemblies
 - .2 Steel brackets
 - .3 Sway braces for seismic restraint systems
- .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 22 mm 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.
- .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 riveting 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: black or galvanized.
 - .2 Finishes for copper, glass, brass or aluminum pipework: to match piping material.
- .11 Pipe rollers: cast iron roll and roll stand with carbon steel rod to MSS SP 69.

2.05 RISER CLAMPS

- .1 Steel or cast iron pipe: galvanized or black carbon steel to MSS SP 58, type 42, FM approved.
- .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.

2.06 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.

2.07 CONSTANT SUPPORT SPRING HANGERS

- .1 Springs: alloy steel to ASTM A 125, shot peened, magnetic particle inspected, with +/-5% spring rate tolerance, tested for free height, spring rate, loaded height and provided with Certified Mill Test Report (CMTR).
- .2 Load adjustability: 10% minimum adjustability each side of calibrated load. Adjustment without special tools. Adjustments not to affect travel capabilities.
- .3 Provide upper and lower factory set travel stops.
- .4 Provide load adjustment scale for field adjustments.
- .5 Total travel to be actual travel + 20%. Difference between total travel and actual travel 25 mm minimum.
- .6 Individually calibrated scales on each side of support calibrated prior to shipment, complete with calibration record.

2.08 VARIABLE SUPPORT SPRING HANGERS

- .1 Vertical movement: 13 mm minimum, 50 mm maximum, use single spring pre-compressed variable spring hangers.
- .2 Vertical movement greater than 50 mm: use double spring pre-compressed

variable spring hanger with 2 springs in series in single casing.

- .3 Variable spring hanger complete with factory calibrated travel stops. Provide certificate of calibration for each hanger.
- .4 Steel alloy springs: to ASTM A 125, shot peened, magnetic particle inspected, with +/-5 % spring rate tolerance, tested for free height, spring rate, loaded height and provided with CMTR.

2.10 EQUIPMENT ANCHOR BOLTS AND TEMPLATES

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

2.13 OTHER EQUIPMENT SUPPORTS

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

3 EXECUTION

3.01 MANUFACTURER'S INSTRUCTIONS

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

3.02 INSTALLATION

- .1 Install in accordance with:
 - .1 Manufacturer's instructions and recommendations.
- .2 Vibration Control Devices:
 - .1 Install on piping systems at pumps, boilers, chillers, cooling towers, and as indicated.
- .3 Clamps on riser piping:
 - .1 Support independent of connected horizontal pipework using riser clamps and riser clamp lugs welded to riser.
 - .2 Bolt-tightening torques to industry standards.
 - .3 Steel pipes: install below coupling or shear lugs welded to pipe.
 - .4 Cast iron pipes: install below joint.
- .4 Clevis plates:
 - .1 Attach to concrete with 4 minimum concrete inserts, one at each corner.
- .5 Provide supplementary structural steelwork where structural bearings do not exist or where concrete inserts are not in correct locations.
- .6 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.

- .7 Use variable support spring hangers where:
 - .1 Transfer of load to adjacent piping or to connected equipment is not critical.
 - .2 Variation in supporting effect does not exceed 25 % of total load.

3.03 HANGER SPACING

- .1 Plumbing piping: to National Plumbing Code of Canada (NPC), Ontario Building Code (2015).
- .2 Fire protection: to applicable fire code.
- .3 Gas and fuel oil piping: up to NPS 1/2: every 1.8 m.
- .4 Copper piping: up to NPS 1/2: every 1.5 m.
- .5 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.
- .6 Within 300 mm 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 | |

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

3.04 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.

3.05 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.

3.06 FINAL ADJUSTMENT

- .1 Adjust hangers and supports:
 - .1 Ensure that rod is vertical under operating conditions.
 - .2 Equalize loads.
- .2 Adjustable clevis:
 - .1 Tighten hanger load nut securely to ensure proper hanger performance.
 - .2 Tighten upper nut after adjustment.
- .3 C-clamps:
 - .1 Follow manufacturer's recommended written instructions and torque values when tightening C-clamps to bottom flange of beam.
- .4 Beam clamps:
 - .1 Hammer jaw firmly against underside of beam.

3.07 FIELD QUALITY CONTROL

- .1 Site Tests: conduct following tests in accordance with Section 01 45 00 - Quality Control and submit report as described in PART 1 - ACTION AND INFORMATIONAL SUBMITTALS.

END OF SECTION

1 GENERAL

1.01 REFERENCE STANDARDS

- .1 Canadian Gas Association (CGA)
 - .1 CSA/CGA B149.1, Natural Gas and Propane Installation Code.
- .2 National Fire Protection Association (NFPA)
 - .1 NFPA 13, Standard for the Installation of Sprinkler Systems.
 - .2 NFPA 14, Standard for the Installation of Standpipe and Hose Systems.

1.02 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.

1.03 DELIVERY, STORAGE, AND HANDLING

- .1 Packing, shipping, handling and unloading:
 - .1 Not used.
 - .2 Deliver, store and handle materials in accordance with manufacturer's written instructions.
- .2 Waste Management and Disposal:
 - .1 Not used.
 - .2 Dispose of unused paint, coating material at official hazardous material collections site approved by Departmental Representative
 - .3 Do not dispose of unused paint, coating material into sewer system, into streams, lakes, onto ground or in locations where it will pose health or environmental hazard.

2 PRODUCTS

2.02 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.

2.03 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 3 mm 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 Locations:
- .1 Terminal cabinets, control panels: use size # 5.
 - .2 Equipment in Mechanical Rooms: use size # 9.
- .5 Identification for Preventive Maintenance Support System (PMSS):
- .1 Use arrangement of Main identifier, Source identifier, Destination identifier.
 - .2 Equipment in Mechanical Room:
 - .1 Main identifier: size #9.
 - .2 Source and Destination identifiers: size #6.
 - .3 Terminal cabinets, control panels: size #5.
 - .3 Equipment elsewhere: sizes as appropriate.

2.04 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, obtain written approval of identification system from Departmental Representative

2.05 PIPING SYSTEMS GOVERNED BY CODES

- .1 Identification:
 - .1 Natural gas: to CSA/CGA B149.1 and authority having jurisdiction.
 - .2 Propane gas: to CSA/CGA B149.1 and authority having jurisdiction.
 - .3 Sprinklers: to NFPA 13.

.4 Standpipe and hose systems: to NFPA 14.

2.06 IDENTIFICATION OF PIPING SYSTEMS

- .1 Identify contents by background colour marking, pictogram (as necessary), legend; direction of flow by arrows. To CAN/CGSB 24.3 except where specified otherwise.
- .2 Pictograms:
 - .1 Where required: Workplace Hazardous Materials Information System (WHMIS) regulations.
- .3 Legend:
 - .1 Block capitals to sizes and colours listed in CAN/CGSB 24.3.
- .4 Arrows showing direction of flow:
 - .1 Outside diameter of pipe or insulation less than 75 mm: 100 mm long x 50 mm high.
 - .2 Outside diameter of pipe or insulation 75 mm and greater: 150 mm long x 50 mm high.
 - .3 Use double-headed arrows where flow is reversible.
- .5 Extent of background colour marking:
 - .1 To full circumference of pipe or insulation.
 - .2 Length to accommodate pictogram, full length of legend and arrows.
- .6 Materials for background colour marking, legend, arrows:
 - .1 Pipes and tubing 20 mm and smaller: waterproof and heat-resistant pressure sensitive plastic marker tags.
 - .2 Other pipes: pressure sensitive 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 |
|--------------------------|---------------------------|-------------------|
| Raw water | Green | RAW WATER |
| River water | Green | RIVER WATER |
| Sea water | Green | SEA WATER |
| City water | Green | CITY WATER |
| Treated water | Green | TREATED WATER |
| Brine | Green | BRINE |
| Condenser water supply | Green | COND. WTR. SUPPLY |
| Condenser water return | Green | COND. WTR. RETURN |
| Chilled water supply | Green | CH. WTR. SUPPLY |
| Chilled water return | Green | CH. WTR. RETURN |
| Hot water heating supply | Yellow | HEATING SUPPLY |
| Hot water heating return | Yellow | HEATING RETURN |

| | | |
|----------------------------|----------|----------------------------|
| High temp HW Htg. supply | Yellow | HTHW HTG. SUPPLY++ |
| High temp HW Htg. return | Yellow | HTHW HTG. RETURN++ |
| Make-up water | Yellow | MAKE-UP WTR |
| Boiler feed water | Yellow | BLR. FEED WTR |
| Steam xxx kPa | Yellow | xxx kPa STEAM |
| Steam condensate (gravity) | Yellow | ST.COND.RET (GRAVITY) |
| Steam condensate (pumped) | Yellow | ST.COND.RET (PUMPED) |
| Safety valve vent | Yellow | STEAM VENT |
| Intermittent blow-off | Yellow | INT. BLOW-OFF |
| Continuous blow-off | Yellow | CONT. BLOW-OFF |
| Chilled drinking water | Green | CH. DRINK WTR |
| Drinking water return | Green | CH. DRINK WTR. CIRC |
| Domestic hot water supply | Green | DOM. HW SUPPLY |
| Dom. HWS recirculation | Green | DOM. HW CIRC |
| Domestic cold water supply | Green | DOM. CWS |
| Waste water | Green | WASTE WATER |
| Contaminated lab waste | Yellow | CONT. LAB WASTE |
| Acid waste | Yellow | ACID WASTE (add source) |
| Storm water | Green | STORM |
| Sanitary | Green | SAN |
| Plumbing vent | Green | SAN. VENT |
| Refrigeration suction | Yellow | REF. SUCTION |
| Refrigeration liquid | Yellow | REF. LIQUID |
| Refrigeration hot gas | Yellow | REF. HOT GAS |
| Engine exhaust | Yellow | ENGINE EXHAUST |
| Lubricating oil | Yellow | LUB. OIL |
| Hydraulic oil | Yellow | HYDRAULIC OIL |
| Gasoline | Yellow | GASOLINE |
| Natural gas | to Codes | |
| Propane | to Codes | |
| Gas regulator vents | to Codes | |
| Distilled water | Green | DISTILL. WTR |
| Demineralized water | Green | DEMIN. WATER |
| Chlorine | Yellow | CHLORINE |
| Nitrogen | Yellow | NITROGEN |
| Oxygen | Yellow | OXYGEN |
| Compressed air (<700kPa) | Green | COMP. AIR xxx kPa |
| Compressed air (>700kPa) | Yellow | COMP. AIR xxx kPa |
| Vacuum | Green | VACUUM |
| Fire protection water | Red | FIRE PROT. WTR |
| Sprinklers | Red | SPRINKLERS |
| Carbon dioxide | Red | CO2 |
| Instrument air | Green | INSTRUMENT AIR |

2.07 IDENTIFICATION DUCTWORK SYSTEMS

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

2.08 VALVES, CONTROLLERS

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

2.09 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.

2.10 LANGUAGE

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

3 EXECUTION

3.01 MANUFACTURER'S INSTRUCTIONS

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

3.02 TIMING

- .1 Provide identification only after painting has been completed.

3.03 INSTALLATION

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

3.04 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.

3.05 LOCATION OF IDENTIFICATION ON PIPING AND DUCTWORK SYSTEMS

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

3.06 VALVES, CONTROLLERS

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

3.07 CLEANING

- .1 Not used.
- .2 Upon completion and verification of performance of installation, remove surplus materials, excess materials, rubbish, tools and equipment.

END OF SECTION

1 GENERAL

1.01 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.

1.02 EXCEPTIONS

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

1.03 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.

1.04 PRE-TAB REVIEW

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

1.05 START-UP

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

1.06 OPERATION OF SYSTEMS DURING TAB

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

1.07 START OF TAB

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

1.08 APPLICATION TOLERANCES

- .1 Do TAB to following tolerances of design values:
 - .1 Laboratory HVAC systems: plus 5%, minus 0%.
 - .2 Other HVAC systems: plus 5%, minus 5%.
 - .3 Hydronic systems: plus or minus 5%.

1.09 ACCURACY TOLERANCES

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

1.10 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.

1.11 ACTION AND INFORMATIONAL SUBMITTALS

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

1.12 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.

1.13 TAB REPORT

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

1.14 VERIFICATION

- .1 Reported results subject to verification by Departmental Representative
- .2 Provide personnel and instrumentation to verify up to 20% 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.

1.15 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.

1.16 COMPLETION OF TAB

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

Departmental Representative.

1.17 AIR SYSTEMS

- .1 Standard: TAB to most stringent of TAB standards of AABC, NEBB, SMACNA.
- .2 Do TAB of systems, equipment, components, controls specified Division 22 & 23
- .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).

1.18 OTHER TAB REQUIREMENTS

- .1 General requirements applicable to work specified this paragraph:
 - .1 Qualifications of TAB personnel: as for air systems specified this section.
 - .2 Quality assurance: as for air systems specified this section.
- .2 Laboratory fume hoods:
 - .1 As per 23 05 93.13.
- .3 Zone pressure differences:
 - .1 Adjust HVAC systems, equipment, controls to establish specified directional airflow, with systems in every possible combinations of normal operating modes.

1.19 POST-OCCUPANCY TAB

- .1 Measure DBT, WBT (or %RH), air velocity, air flow patterns, NC levels in occupied zone of following areas: 2048 & 2050.

2 PRODUCTS

2.01 NOT USED

- .1 Not used.

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BALANCING FOR HVAC

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3 EXECUTION

3.01 NOT USED

.1 Not used.

END OF SECTION

1 GENERAL

1.01 RELATED REQUIREMENTS

- .1 Section 23 05 93.

1.02 REFERENCE STANDARDS

- .1 American National Standards Institute (ANSI)
 - .1 ANSI/ASHRAE 110-1995, Method of Testing Performance of Laboratory Fume Hoods.
 - .2 ANSI/AIHA Z9.5-2003, Laboratory Ventilation.
- .2 Public Works and Government Services Canada
 - .1 MD15128 2013, Laboratory Fume Hoods.

1.03 ACTION AND INFORMATIONAL SUBMITTALS

- .1 Submit in accordance with Contract Conditions and Section 01 33 00 - Submittal Procedures.

1.04 CLOSEOUT SUBMITTALS

- .1 Submit in accordance with Section 01 78 00 - Closeout Submittals.
- .2 Record Documentation:
 - .1 Submit list of materials used in fume hood work.

1.05 QUALITY ASSURANCE

- .1 Test Agency: fume hood tests to be performed in accordance with MD15128.

2 PRODUCTS

2.01 TESTING EQUIPMENT

- .1 Test equipment to ANSI/AIHA Z9.5 and MD15128.
- .2 Data logger:
 - .1 Speed: 10 Hz or better.
 - .2 Memory: sufficient to allow data collection for duration of test.
- .3 In-duct flow sensor to measure flow response:
 - .1 Speed: 10 Hz.
 - .2 Range: 95 L/s to 950 L/s.
 - .3 Accuracy: $\pm 5\%$.
- .4 Thermal anemometer:
 - .1 Mounting: on stand with probe fixed at each traverse grid location.
 - .2 Include: averaging function over twenty second period for each location or output recorded for 20 seconds minimum at a rate of

- one reading/second on data logger.
- .3 Accuracy:
 - .1 Below 0.50 m/s: ± 0.025 m/s.
 - .2 0.50 m/s and over: $\pm 5\%$.
- .5 Detector for tracer gas containment:
 - .1 Type: continuous reading.
 - .2 Minimum Detectable Level (MDL): 0.01 ppm.
 - .3 Accuracy: concentrations below 0.1 ppm: $\pm 25\%$; concentrations above 0.1 ppm: $\pm 10\%$.
- .6 Smoke generator:
 - .1 Use smoke generator and diffuser complying with MD15128.

3 EXECUTION

3.01 AS INSTALLED (AI) AND INTEGRATED SYSTEMS TESTS

- .1 Perform AI and integrated systems tests as follows:
 - .1 After entire laboratory HVAC and exhaust systems have been tested and balanced (TAB), and TAB and Performance Verification (PV) reports have been submitted and accepted.
 - .2 HVAC and exhaust systems are in full operation.
 - .3 Room temperatures are maintained between 22 degrees C and 24.5 degrees C., recorded and submitted with fume hood test documentation.
 - .4 At specified laboratory space pressurization.
 - .5 Under deviation of space pressurization due to laboratory door opening and closing, change of laboratory operating modes, upset conditions, and other causes of change in laboratory air pressure.
 - .6 As part of commissioning of integrated HVAC and exhaust systems and laboratory space pressurization tests included in commissioning process.
- .2 After installation, test each fume hood to ANSI/ASHRAE 110 and MD15128 at design sash position to ensure compliance with design criteria in MD15128.

3.02 "AI" TESTS FOR CAV BYPASS FUME HOODS

- .1 Cross draft tests:
 - .1 Test air currents external to fume hood to MD15128.
 - .2 Ensure velocity of cross draft does not exceed 50% of average face velocity.
 - .3 Record measurements as follows:
 - .1 Using thermal anemometer take readings 1.5 m above floor, 500 mm from sash, at centre, and left and right posts of fume hood.
 - .2 Take readings at 1 reading/second, recorded to obtain average, and maximum and minimum values over a duration of 20 seconds at each location.
 - .3 Ensure that project authority reduces excessive values to less than 50% of average face velocity before proceeding with further fume hood testing.
- .2 Visualization (smoke) tests:
 - .1 Extent of tests and performance criteria: to MD15128.

- .3 Face velocity and flow response test pass ratings: to MD15128 and ANSI/ASHRAE 110.
 - .1 Average face velocity for CAV bypass fume hoods: 0.5 m/s
 - .2 CAV bypass effectiveness at 150 mm sash opening; 1.25 m/s maximum average face velocity.
 - .3 Average face velocity for high performance fume hoods: 0.35 m/s, with no reading less than 0.25 m/s.
 - .4 VAV face velocity and flow response tests:
 - .1 Average face velocity at design sash position: 0.5 m/s
 - .2 Average face velocity with sash at 66% of design sash position: 0.5 m/s \pm 0.025 m/s
 - .1 Variation allowed for individual readings: \pm 20%
 - .3 Average face velocity with sash at 33% of design sash position: 0.5 m/s \pm 0.025 m/s.
 - .1 Variation allowed for individual readings: \pm 20%
 - .4 Response time: time to reach 90% of the average steady state value: within 5 seconds of initial sash movement
 - .5 Test for VAV minimum flow with sash closed: to ANSI/AIHA Z9.5 capable of maintaining 375 air changes per hour.
- .4 Tracer Gas tests:
 - .1 Performance criteria: to MD15128.
 - .2 Conduct tests at target average face velocity.
 - .3 Use approved tracer gas.
 - .4 Perform tests with probe at height of 560 mm above work surface.
 - .5 Leakage with sash at normal operating position:
 - .1 Average leakage: 0.05 ppm maximum.
 - .2 Peak reading: 0.25 ppm.
 - .6 Leakage with sash in fully open position:
 - .1 Average leakage: 0.05 ppm maximum.
 - .2 Peak reading: 0.25 ppm.
 - .7 Peripheral scan:
 - .1 Record significant peak readings and their locations.
 - .2 Record 30 second rolling averages.
 - .3 Maximum 0.25 ppm for any 30 second rolling average.
 - .4 Include readings in test report.
 - .8 Sash Movement Effect (SME), to determine potential for escape after movement of sash to ANSI/ASHRAE 110 procedures:
 - .1 Maximum 45 second rolling average: 0.05 ppm.
- .5 Conduct VAV Response Tests, Stability Tests and SME simultaneously for VAV fume hoods.

3.03 AS USED (AU) TESTS WITH LAB APPARATUS IN PLACE

- .1 Repeat smoke tests and velocity tests

3.04 FUME HOOD MONITOR AND ALARM TESTS

- .1 Fume Hood Monitor:
 - .1 Provide 3 point calibration.
 - .2 Ensure each monitor initiates alarms (audible, visual, and BMS) when unsafe velocity conditions occur.
 - .3 Ensure monitor readings are displayed in metres per second, to 2 decimal places.
- .2 Fume Hood Monitor/Alarm testing:
 - .1 Monitor accuracy test: ensure monitor is accurate within 5% of

- average face velocity.
- .2 Alarm enunciation test: ensure alarm occurs beyond $\pm 20\%$ of design flow set point.
- .3 Alarm response enunciation test: ensure alarm delay is 10 seconds maximum.

3.05 FUME HOOD STATIC PRESSURE TEST

- .1 With sash at design position and face velocity at target setting, fume hood static pressure: less than 62 Pa.

3.06 NOISE LEVEL TEST

- .1 With sash at design position and face velocity at target setting, noise level at working position in front of fume hood: less than 70 dBA.

3.07 VERIFICATION LABELS

- .1 Affix label to front of fume hood indicating verification, name of testing agency, and date.

3.08 COMMISSIONING - INTEGRATED SYSTEMS TESTS

- .1 Fume hood testing to commence only after laboratory HVAC systems are fully commissioned, including calibration of airflow controls, calibration of automatic temperature controls, balance of air supply, completion of duct traverse on each fume hood exhaust duct, and completion of an air balance of the total exhaust flow.
- .2 Test fume hoods in conjunction with complete laboratory integrated HVAC and exhaust systems commissioning testing including, room air flow patterns, temperature, humidity, pressurization, noise, and vibration.

3.09 REPORTS

- .1 Ensure test reports are signed by testing agency before submitting to Departmental Representative

3.10 CLEANING

- .1 Progress Cleaning: clean in accordance with Section 01 74 00 - Cleaning.
 - .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 74 00 - Cleaning.

3.11 PROTECTION

- .1 Protect adjacent materials from work associated with testing and maintenance of fume hoods.

END OF SECTION

1 GENERAL

1.01 REFERENCE STANDARDS

- .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, 1985.

1.02 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 months 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 72 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.

1.03 QUALITY ASSURANCE

- .1 Pre-Installation Meetings:
 - .1 Convene pre-installation meeting one week prior to beginning work
 - .1 Verify project requirements.
 - .2 Review installation and substrate conditions.
 - .3 Co-ordination with other building subtrades.
 - .4 Review manufacturer's installation instructions and warranty requirements.
 - .2 Health and Safety:
 - .1 Do construction occupational health and safety in accordance with Section 01 35 29.06 - Health and Safety Requirements.

2 PRODUCTS

2.01 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 months before anticipated start date.
- .4 Test instruments: calibrated and certificate of calibration deposited with Departmental Representative no more than 28 days before start of tests.

2.02 EQUIPMENT LEAKAGE TOLERANCES

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

3 EXECUTION

3.01 MANUFACTURER'S INSTRUCTIONS

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

3.02 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.

3.03 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 applicable systems not to exceed specified leakage rates per SMACNA standards and ductwork table.
- .3 Evaluation of test results to use surface area of duct and pressure in duct as basic parameters.

3.04 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.

3.05 FIELD QUALITY CONTROL

- .1 Performance Verification:
 - .1 Departmental Representative to witness tests and to verify reported results.
 - .2 To be certified by same TAB agency approved by Departmental Representative to undertake TAB on this project.

3.06 CLEANING

- .1 Upon completion and verification of performance of installation, remove surplus materials, excess materials, rubbish, tools and equipment.

END OF SECTION

1 GENERAL

1.01 RELATED REQUIREMENTS

- .1 Section 23 31 13.02

1.02 REFERENCE STANDARDS

- .1 American Society of Heating, Refrigeration and Air Conditioning Engineers (ASHRAE)
 - .1 ANSI/ASHRAE/IESNA 90.1-04, SI; Energy Standard for Buildings Except Low-Rise Residential Buildings.
- .2 ASTM International Inc.
 - .1 ASTM B 209M-07, Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate (Metric).
 - .2 ASTM C 335-05a¹, Standard Test Method for Steady State Heat Transfer Properties of Pipe Insulation.
 - .3 ASTM C 411-05, Standard Test Method for Hot-Surface Performance of High-Temperature Thermal Insulation.
 - .4 ASTM C 449/C 449M-00, Standard Specification for Mineral Fiber-Hydraulic-Setting Thermal Insulating and Finishing Cement.
 - .5 ASTM C 547-07e¹, Standard Specification for Mineral Fiber Pipe Insulation.
 - .6 ASTM C 553-02e¹, Standard Specification for Mineral Fiber Blanket Thermal Insulation for Commercial and Industrial Applications.
 - .7 ASTM C 612-04e¹, Standard Specification for Mineral Fiber Block and Board Thermal Insulation.
 - .8 ASTM C 795-03, Standard Specification for Thermal Insulation for Use in Contact with Austenitic Stainless Steel.
 - .9 ASTM C 921-03a, 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.
- .5 Green Seal Environmental Standards (GSES)
 - .1 Standard GS-36-00, Commercial Adhesives.
- .6 South Coast Air Quality Management District (SCAQMD), California State
 - .1 SCAQMD Rule 1168-[A2005], Adhesive and Sealant Applications.
- .7 Thermal Insulation Association of Canada (TIAC): National Insulation Standards (2005).
- .8 Underwriters Laboratories of Canada (ULC)
 - .1 CAN/ULC-S102-03, Method of Test for Surface Burning Characteristics of Building Materials and Assemblies.
 - .2 CAN/ULC-S701-05, Standard for Thermal Insulation, Polystyrene, Boards and Pipe Covering.

1.03 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.

1.04 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.
- .3 Shop Drawings:
 - .1 Submit drawings where required.
- .4 Manufacturers' Instructions:
 - .1 Provide manufacture's written duct insulation jointing recommendations. and special handling criteria, installation sequence, cleaning procedures.

1.05 DELIVERY, STORAGE AND HANDLING

- .1 Deliver, store and handle in accordance with Section 01 61 00 - Common Product Requirements.
- .2 Deliver materials to site in original factory packaging, labelled with manufacturer's name, address and ULC markings.
- .3 Packaging Waste Management: remove for reuse in accordance with Section 01 74 19 - Waste Management and Disposal.

2 PRODUCTS

2.01 FIRE AND SMOKE RATING

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

2.02 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.

2.03 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: 0.50 mm sheet.
 - .3 Finish: Smooth
 - .4 Jacket banding and mechanical seals: 19 mm wide, 0.5 mm thick stainless steel.
 - .1 Stainless steel:
 - .5 Type: 304.
 - .6 Thickness: 0.25 mm sheet.
 - .7 Finish: Smooth
 - .8 Jacket banding and mechanical seals: 19 mm wide, 0.5 mm thick stainless steel.

2.04 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 Outdoor Vapour Retarder Mastic:
 - .1 Vinyl emulsion type acrylic, compatible with insulation.
 - .2 Reinforcing fabric: Fibrous glass, untreated 305 g/m².
- .6 Tape: self-adhesive, aluminum, 75 mm wide minimum.
- .7 Contact adhesive: quick-setting
- .8 Canvas adhesive: washable.
- .9 Tie wire: 1.5 mm stainless steel.

- .10 Banding: 19 mm wide, 0.5 mm thick stainless steel.
- .11 Facing: 25 mm stainless or galvanized steel hexagonal wire mesh stitched on one face of insulation with expanded metal lath on other face.
- .12 Fasteners: 4 mm diameter pins with 35 mm square clips, length to suit thickness of insulation.

3 EXECUTION

3.01 APPLICATION

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

3.02 PRE-INSTALLATION REQUIREMENTS

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

3.03 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 75 mm.
- .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 300 mm on centre in horizontal and vertical directions, minimum 2 rows each side.

3.04 DUCTWORK INSULATION SCHEDULE

- .1 Insulation types and thicknesses: conform to following table:

| | TIAC Code | Vapour Retarder | Thickness (mm) |
|--|-----------|-----------------|----------------|
| Rectangular cold and dual temperature supply air ducts | C-1 | yes | 50 |

| | | | |
|--|------|---------|------|
| Round cold and dual temperatir e supply air ducts | C-2 | yes | 50 |
| Rectangula r warm air ducts | C-1 | no | 25 |
| Round warm air ducts | C-1 | no | 25 |
| Supply, return and exhaust ducts exposed in space being served | | | none |
| Outside air ducts to mixing plenum | C-1 | yes | 25 |
| Mixing plenums | C-1 | yes | 25 |
| Exhaust duct between dampers and louvres | C-1 | no | 25 |
| Rectangula r ducts outside | C-1 | special | 50 |
| Round ducts outside | C-1 | special | 50 |
| Acoustical ly 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 |
| Outdoor, exposed to | CRF/3 | CRD/4 |

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DUCT INSULATION

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precipitation
Outdoor,
elsewhere

CRF/4

CRD/5

END OF SECTION

1 GENERAL

1.01 REFERENCE STANDARDS

- .1 American Society of Heating, Refrigeration and Air Conditioning Engineers (ASHRAE)
 - .1 ASHRAE Standard 90.1-01, 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-04, Standard Specification for Aluminum and Aluminum Alloy Sheet and Plate Metric.
 - .2 ASTM C 335-04], Standard Test Method for Steady State Heat Transfer Properties of Horizontal Pipe Insulation.
 - .3 ASTM C 411-04, Standard Test Method for Hot-Surface Performance of High-Temperature Thermal Insulation.
 - .4 ASTM C 449/C 449M-00, Standard Specification for Mineral Fiber-Hydraulic-Setting Thermal Insulating and Finishing Cement.
 - .5 ASTM C 533-2004, Calcium Silicate Block and Pipe Thermal Insulation.
 - .6 ASTM C 547-2003, Mineral Fiber Pipe Insulation.
 - .7 ASTM C 795-03, Standard Specification for Thermal Insulation for Use in Contact with Austenitic Stainless Steel.
 - .8 ASTM C 921-03a, 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) Jacketting Sheet, for Insulated Pipes, Vessels and Round Ducts
- .4 Department of Justice Canada (Jus)
 - .1 Canadian Environmental Assessment Act (CEAA), 1995, c. 37.
 - .2 Canadian Environmental Protection Act (CEPA), 1999, c. 33.
 - .3 Transportation of Dangerous Goods Act (TDGA), 1992, c. 34.
- .5 Health Canada/Workplace Hazardous Materials Information System (WHMIS)
 - .1 Material Safety Data Sheets (MSDS).
- .6 Manufacturer's Trade Associations
 - .1 Thermal Insulation Association of Canada (TIAC): National Insulation Standards (Revised 2004).
- .7 Underwriters' Laboratories of Canada (ULC)
 - .1 CAN/ULC-S102-03, Surface Burning Characteristics of Building Materials and Assemblies.
 - .2 CAN/ULC-S701-01, Thermal Insulation, Polystyrene, Boards and Pipe Covering.
 - .3 CAN/ULC-S702-1997, Thermal Insulation, Mineral Fibre, for Buildings
 - .4 CAN/ULC-S702.2-03, Thermal Insulation, Mineral Fibre, for Buildings, Part 2: Application Guidelines.

1.02 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.

1.03 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 one copy 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 12 mm 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 1 copy of systems supplier's installation instructions.

1.04 DELIVERY, STORAGE AND HANDLING

- .1 Packing, shipping, handling and unloading:
 - .1 Deliver, store and handle in accordance with manufacturer's written instructions and Section 01 61 00 - Common Product Requirements.
 - .2 Deliver, store and handle materials in accordance with manufacturer's written instructions.
 - .3 Deliver materials to site in original factory packaging, labelled with manufacturer's name, address.
- .2 Storage and Protection:

- .1 Protect from weather, construction traffic.
- .2 Protect against damage.
- .3 Store at temperatures and conditions required by manufacturer.
- .3 Waste Management and Disposal:
 - .1 Construction/Demolition Waste Management and Disposal: separate waste materials in accordance with Section 01 74 19 - Waste Management and Disposal.
 - .2 Place excess or unused insulation and insulation accessory materials in designated containers.
 - .3 Divert unused metal materials from landfill to metal recycling facility approved by Departmental Representative.
 - .4 Dispose of unused adhesive material at official hazardous material collections site approved by Departmental Representative.

2 PRODUCTS

2.01 SUSTAINABLE REQUIREMENTS

- .1 Not Used

2.03 INSULATION 2.02 FIRE AND SMOKE RATING

- .1 In accordance with CAN/ULC-S102.
- .1 Maximum flame spread rating: 25.
- .2 Maximum smoke developed rating: 50.
- .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 and/or ASTM C 5 47.
 - .2 Maximum "k" factor: to CAN/ULC-S702.
- .4 TIAC Code A-3: rigid moulded mineral fibre with factory applied vapour retarder jacket.
 - .1 Mineral fibre: to CAN/ULC-S702 and/or ASTM C 5 47.
 - .2 Jacket: to CGSB 51-GP-52Ma.
 - .3 Maximum "k" factor: to CAN/ULC-S702 and/or ASTM C 547.
- .5 TIAC Code C-2: mineral fibre blanket faced with factory applied vapour retarder jacket (as scheduled in PART 3 of this section).
 - .1 Mineral fibre: to CAN/ULC-S702 and/or ASTM C 5 47.
 - .2 Jacket: to CGSB 51-GP-52Ma.
 - .3 Maximum "k" factor: to CAN/ULC-S702 and/or ASTM C 547.
- .6 TIAC Code A-6: flexible unicellular tubular elastomer.
 - .1 Insulation: with vapour retarder jacket.
 - .2 Jacket: to CGSB 51-GP-52Ma.
 - .3 Maximum "k" factor: to CAN/ULC-S702 and/or ASTM C 547.
 - .4 Certified by manufacturer: free of potential stress corrosion

cracking corrodants.

- .7 TIAC Code A-2: rigid moulded calcium silicate in sections and blocks, and with special shapes to suit project requirements.
 - .1 Insulation: to ASTM C 533.
 - .2 Maximum "k" factor: to CAN/ULC-S702 and/or ASTM C 547.
 - .3 Design to permit periodic removal and re-installation.

2.04 INSULATION SECUREMENT

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

2.05 CEMENT

- .1 Thermal insulating and finishing cement:
 - .1 Air drying on mineral wool, to ASTM C 449/C 449M.

2.06 VAPOUR RETARDER LAP ADHESIVE

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

2.07 INDOOR VAPOUR RETARDER FINISH

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

2.08 OUTDOOR VAPOUR RETARDER FINISH

- .1 Vinyl emulsion type acrylic, compatible with insulation.
- .2 Reinforcing fabric: fibrous glass, untreated 305 g/m².

2.09 JACKETS

- .1 Polyvinyl Chloride (PVC):
 - .1 One-piece moulded type and sheet to CAN/CGSB-51.53 with pre-formed shapes as required.
 - .2 Colours: to match adjacent finish paint by Departmental Representative.
 - .3 Minimum service temperatures: -20 degrees C.
 - .4 Maximum service temperature: 65 degrees C.
 - .5 Moisture vapour transmission: 0.02 perm.
 - .6 Thickness: 2 mm.
 - .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 and 120 gm/m² cotton, plain weave, treated with dilute fire retardant lagging adhesive to ASTM C 921.
- .2 Lagging adhesive: compatible with insulation.
- .3 Stainless steel:
 - .1 Type: 304.
 - .2 Thickness: 0.25 mm.
 - .3 Finish: corrugated.
 - .4 Joining: longitudinal and circumferential slip joints with 50 mm laps.
 - .5 Fittings: 0.5 mm thick die-shaped fitting covers with factory-attached protective liner.
 - .6 Metal jacket banding and mechanical seals: stainless steel, 19 mm wide, 0.5 mm thick at 300 mm spacing.

3 EXECUTION

3.01 MANUFACTURER'S INSTRUCTIONS

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

3.02 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.

3.03 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.

3.04 REMOVABLE, PRE-FABRICATED, INSULATION AND ENCLOSURES

- .1 Application: at expansion joints, primary flow measuring elements, flanges and unions at equipment.
- .2 Design: to permit movement of expansion joint and to permit periodic removal and replacement without damage to adjacent insulation.

- .3 Insulation:
 - .1 Insulation, fastenings and finishes: same as system.
 - .2 Jacket: PVC.

3.05 INSTALLATION OF ELASTOMERIC INSULATION

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

3.06 PIPING INSULATION SCHEDULES

- .1 Includes valves, valve bonnets, strainers, flanges and fittings unless otherwise specified.
- .2 TIAC Code: A-1.
 - .1 Securements: SS wire at 300 mm on centre.
 - .2 Seals: lap seal adhesive, lagging adhesive.
 - .3 Installation: TIAC Code 1501-H.
- .3 TIAC Code: A-3.
 - .1 Securements: SS wire at 300 mm on centre.
 - .2 Seals: VR lap seal adhesive, VR lagging adhesive.
 - .3 Installation: TIAC Code: 1501-C.
- .4 TIAC Code: A-6.
 - .1 Insulation securements: SS wire at 300 mm on centre.
 - .2 Seals: lap seal adhesive, lagging adhesive.
 - .3 Installation: TIAC Code: 1501.
- .5 TIAC Code: C-2 with without vapour retarder jacket.
 - .1 Insulation securements: SS wire at 300 mm on centre.
 - .2 Seals: lap seal adhesive, lagging adhesive.
 - .3 Installation: TIAC Code: 1501-C.
- .6 TIAC Code: A-2.
 - .1 Insulation securements: SS wire at 300 mm on centre.
 - .2 Seals: lap seal adhesive, lagging adhesive.
 - .3 Installation: TIAC Code: 1501-H.
- .7 Thickness of insulation as listed in following table.
 - .1 Run-outs to individual units and equipment not exceeding 4000 mm long.
 - .2 Do not insulate exposed runouts to plumbing fixtures, chrome plated piping, valves, fittings.

| Applic a-tion | Temp degree s C | TIAC code | Pipe sizes (NPS) and insulation thickness (mm) | | | | | |
|---|-----------------------|--------------|---|---------------|--------|-------------|----|----|
| | Run out | to 1 | 1 1/4 to 2 | 2 1/2 to 4 | 5 to 6 | 8 & over | | |
| Steam | up to 175 | A-1 | 38 | 50 | 65 | 75 | 90 | 90 |
| Steam, Satura ted and Super | over 175 | A-1 | 38 | 65 | 65 | 75 | 90 | 90 |

| | | | | | | | | |
|-----------------------------------|----------|-----|----|----|----|----|----|----|
| heated | | | | | | | | |
| Condensate | 60 - 94 | A-1 | 25 | 38 | 38 | 38 | 38 | 38 |
| Return Pumped | up to 94 | A-1 | 25 | 38 | 38 | 38 | 38 | 38 |
| Condensate return | | | | | | | | |
| Boiler Feed Water | | A-1 | 25 | 25 | 25 | 25 | 25 | 25 |
| Hot Water Heating | 60 - 94 | A-1 | 25 | 38 | 38 | 38 | 38 | 38 |
| Hot Water Heating | up to 59 | A-1 | 25 | 25 | 25 | 25 | 38 | 38 |
| Glycol Heating | 60 - 94 | A-1 | 25 | 38 | 38 | 38 | 38 | 38 |
| Glycol Heating | up to 59 | A-1 | 25 | 25 | 25 | 25 | 38 | 38 |
| Domestic HWS | | A-1 | 25 | 25 | 25 | 38 | 38 | 38 |
| Chilled Water | 4 - 13 | A-3 | 25 | 25 | 25 | 25 | 25 | 25 |
| Chilled Water | below 4 | A-3 | 25 | 25 | 38 | 38 | 38 | 38 |
| Domestic CWS | | A-3 | 25 | 25 | 25 | 25 | 25 | 25 |
| Domestic CWS with vapour retarder | | C-2 | 25 | 25 | 25 | 25 | 25 | 25 |
| Cooling Coil cond. drain | | C-2 | 25 | 25 | 25 | 25 | 25 | 25 |

.8 Finishes:

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

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surplus materials, excess materials, rubbish, tools and equipment.

END OF SECTION

1 GENERAL

1.01 RELATED REQUIREMENTS

- .1 Not Used

1.02 REFERENCE STANDARDS

- .1 ASME

1.03 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 pneumatic control system and include product characteristics, performance criteria, physical size, finish and limitations.
- .3 Shop Drawings:
 - .1 Submit drawings where required.
 - .2 Provide diagrams showing normal positions, model numbers, air piping and wiring layouts.
 - .3 Provide valve and damper schedule indicating size, configuration, capacity and locations. If size varies greater than 10%, obtain approval of Departmental Representative
- .4 Certificates: submit certificates signed by manufacturer certifying that materials comply with specified performance characteristics and physical properties.

1.04 CLOSEOUT SUBMITTALS

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

2 PRODUCTS

2.01 AIR PRESSURE GAUGES

- .1 At components and as indicated, minimum 40 mm diameter, with applicable range.

2.02 PILOT POSITIONERS

- .1 Full relay type: with interconnecting linkage for mechanical feedback on damper and valve operators acting in unison or sequenced from single controller.

2.03 VALVES

- .1 Pressure rating: as indicated.
- .2 Valve operators: spring return for "fail safe" in normally open or normally closed position, as indicated.
- .3 Water valves:
 - .1 Two-way: seated as indicated, equal percentage, linear, quick opening characteristics, as indicated.
 - .2 Three-way mixing: linear characteristics.
 - .3 Three-way diverting: linear characteristics as indicated.
 - .4 Flow rate and maximum pressure drop: as indicated.
- .4 Steam valves:
 - .1 Modified linear characteristics, with stainless steel seat for dead end service.
 - .2 Flow rate and inlet pressure as indicated.
 - .3 Flow rate and maximum pressure drop: as indicated.

2.04 DAMPERS

- .1 Operating type dampers are as existing

2.05 DAMPER OPERATORS

- .1 Dampers for fans: not required.
- .3 Provide spring return for "fail-safe" in normally open or normally closed position as indicated.
- .4 Size operators to control dampers against maximum pressure or dynamic closing pressure, whichever is greater.
- .5 Provide piston type operators with adjustable spring and stroke. Provide adjustable external stops to limit stroke in either direction.
- .6 Where pneumatic damper operators are connected into fire alarm system, provide additional control devices to allow dampers to respond and go to required position upon signal in less than 15 seconds.

2.06 IDENTIFICATION

- .1 Provide in accordance with Section 23 05 53 - Identification of HVAC Piping and Equipment.

2.07 CONTROL AIR TUBING

- .1 Plastic: flame retardant PVC tubing with minimum burst gauge pressure of 1.4 MPa at 80 degrees C.
- .2 Copper: type L complete with flared fittings.

3 EXECUTION

3.01 EXAMINATION

- .1 Verification of Conditions: verify that conditions of substrate previously installed under other Sections or Contracts are acceptable for pneumatic control system for HVAC installation in accordance with manufacturer's written instructions.

3.02 MANUFACTURER'S INSTRUCTIONS

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

3.03 INSTALLATION

- .1 Identify and code pneumatic tubing at every branch and at each piece of equipment and components.
- .2 Use copper tubing with flared fittings in following locations:
 - .1 Inaccessible areas.
 - .2 Where single lines travel from tube tray to instruments.
 - .3 Areas of heat above 80 degrees C.
 - .4 Mechanical rooms.
 - .5 Rooms where piping subject to damage.
 - .6 Adjacent to heating pipes passing through common sleeve.
 - .7 Where air pressures above 200 kPa.
 - .8 Where codes will not permit use of PVC.
 - .9 In fire rated walls and ceilings.
- .3 Run PVC tubing in cable trays or metal conduit as indicated. Use barb type fittings.
- .4 Follow building lines. Do not cover with insulation. Install drip legs and drains at low points.
- .6 Submit detail of damper motor location and support for review.
- .7 Install pilot positioners on operators.

3.04 FIELD QUALITY CONTROL

- .1 Start-Up and Adjustment:
 - .1 Upon completion of installation, test, adjust and regulate controls or safety equipment provided under this Section.
 - .2 Adjust and place in operating condition.

END OF SECTION

1 GENERAL

1.01 REFERENCE STANDARDS

- .1 American Society of Mechanical Engineers (ASME)
 - .1 ASME B16.5-03, Pipe Flanges and Flanged Fittings.
 - .2 ASME B16.18-01, Cast Copper Alloy Solder Joint Pressure Fittings.
 - .3 ASME B16.22-01, Wrought Copper and Copper Alloy Solder-Joint Pressure Fittings.
 - .4 ASME B18.2.1-96, Square and Hex Bolts and Screws Inch Series.
- .2 American Society for Testing and Materials International (ASTM)
 - .1 ASTM A 47/A 47M-99(2004), Standard Specification for Ferritic Malleable Iron Castings.
 - .2 ASTM A 53/A 53M-04, Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc Coated, Welded and Seamless.
 - .3 ASTM B 75M-99, Standard Specification for Seamless Copper Tube Metric.
 - .4 ASTM B 837-01, Standard Specification for Seamless Copper Tube for Natural Gas and Liquefied Petroleum (LP) Gas Fuel Distribution Systems.
- .3 Canadian Standards Association (CSA International)
 - .1 CSA W47.1-03, Certification of Companies for Fusion Welding of Steel.
- .4 Canadian Standards Association (CSA)/Canadian Gas Association (CGA)
 - .1 CAN/CSA B149.1HB-00, Natural Gas and Propane Installation Code Handbook.
 - .2 CAN/CSA B149.2-00, Propane Storage and Handling Code.
- .5 Health Canada/Workplace Hazardous Materials Information System (WHMIS)
 - .1 Material Safety Data Sheets (MSDS).

1.02 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 for piping, fittings and equipment.
 - .2 Indicate on manufacturers catalogue literature following: valves.
 - .3 Submit WHMIS MSDS. Indicate VOC's for adhesive and solvents during application and curing.
- .3 Test Reports: submit certified test reports from approved independent testing laboratories indicating compliance with specifications for specified performance characteristics and physical properties.
- .4 Certificates: submit certificates signed by manufacturer certifying that materials comply with specified performance characteristics and physical properties.
- .5 Instructions: submit manufacturer's installation instructions.

- .6 Closeout Submittals: submit maintenance and engineering data for incorporation into manual specified in Section 01 78 00 - Closeout Submittals.

1.03 QUALITY ASSURANCE

- .1 Pre-Installation Meeting:
 - .1 Convene pre-installation meeting one week prior to beginning work
 - .1 Verify project requirements.
 - .2 Review installation and substrate conditions.
 - .3 Co-ordination with other building subtrades.
 - .4 Review manufacturer's installation instructions and warranty requirements.
- .2 Health and Safety:
 - .1 Do construction occupational health and safety in accordance with Section 01 35 29.06 - Health and Safety Requirements.

1.04 DELIVERY, STORAGE AND HANDLING

- .1 Waste Management and Disposal:
 - .1 Separate waste materials for reuse and recycling
 - .2 Remove from site and dispose of packaging materials at appropriate recycling facilities.

2 PRODUCTS

2.02 PIPE

- .1 Steel pipe: to ASTM A 53/A 53M, Schedule 40, seamless as follows:
 - .1 NPS 1/2 to 2, screwed.
 - .2 NPS2 1/2 and over, plain end.
- .2 Copper tube: to ASTM B 837.

2.03 JOINTING MATERIAL

- .1 Screwed fittings: pulverized lead paste.
- .2 Welded fittings: to CSA W47.1.
- .3 Flange gaskets: nonmetallic flat.
- .4 Brazing: to ASTM B 837.

2.04 FITTINGS

- .1 Steel pipe fittings, screwed, flanged or welded:
 - .1 Malleable iron: screwed, banded, Class 150.
 - .2 Steel pipe flanges and flanged fittings: to ASME B16.5.
 - .3 Welding: butt-welding fittings.
 - .4 Unions: malleable iron, brass to iron, ground seat, to ASTM A 47/A 47M.
 - .5 Bolts and nuts: to ASME B18.2.1.
 - .6 Nipples: schedule 40, to ASTM A 53/A 53M.

- .2 Copper pipe fittings, screwed, flanged or soldered:
 - .1 Cast copper fittings: to ASME B16.18.
 - .2 Wrought copper fittings: to ASME B16.22.
- .3 For connection of dissimilar materials, provide threaded pipe joints of steel body nut type dielectric unions with insulating gaskets.

2.05 VALVES

- .1 Provincial Code approved, lubricated ball type.

3 EXECUTION

3.01 MANUFACTURER'S INSTRUCTIONS

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

3.02 PIPING

- .1 Install in accordance with Section 23 05 05 - Installation of Pipework, applicable Provincial/Territorial Codes, CAN/CSA B149.1, CAN/CSA B149.2,, supplemented as specified.
- .2 Install drip points:
 - .1 At low points in piping system.
 - .2 At connections to equipment.

3.03 VALVES

- .1 Install valves with stems upright or horizontal unless otherwise approved by Departmental Representative.
- .2 Install valves at branch take-offs to isolate pieces of equipment, and as indicated.

3.04 FIELD QUALITY CONTROL

- .1 Test system in accordance with CAN/CSA B149.1 and requirements of authorities having jurisdiction.
- .2 Manufacturer's Field Services:
 - .1 Have manufacturer of products supplied under this Section review work involved in handling, installation/application, protection and cleaning of its products, and submit written reports, in acceptable format, to verify compliance of work with Contract.
 - .2 Provide manufacturer's field services, consisting of product use recommendations and periodic site visits for inspection of product installation, in accordance with manufacturer's instructions.
 - .3 Schedule site visits to review work at stages listed:
 - .1 After delivery and storage of products, and when

- preparatory work on which work of this Section depends is complete, but before installation begins.
- .2 During progress of work at 60% complete.
 - .3 Upon completion of work, after cleaning is carried out.
- .3 Obtain reports within 3 days of review and submit immediately to Departmental Representative.
- .5 Performance Verification:
- .1 Test entire gas piping system to ensure that it is gastight prior to putting into service. Prior to testing, purge the system, clean, and clear all foreign material. Test each joint with an approved gas detector, soap and water, or an equivalent nonflammable solution. Inspect and test each valve in conformance with API Std 598 and API Std 607. Test by filling the piping systems with air or an inert gas to withstand a minimum pressure of 3 pounds gauge for a period of not less than 10 minutes as specified in NFPA 54 without showing any drop in pressure. Protect equipment, pipe, and tube openings by closing with caps or plugs during installation. At the completion of all work, thoroughly clean the entire system. Flush internals of system with water of sufficient velocity and quantity to dislodge sediment or dirt. Purge system with compressed air after cleaning is complete.

3.05 ADJUSTING

- .1 Purging: purge after pressure test in accordance with CAN/CSA B149.1.
- .2 Pre-Start-Up Inspections:
 - .1 Check vents from regulators, control valves, terminate outside building in approved location, protected against blockage, damage.
 - .2 Check gas trains, entire installation is approved by authority having jurisdiction.

3.06 CLEANING

- .1 Cleaning: in accordance with CAN/CSA B149.1
- .2 Upon completion and verification of performance of installation, remove surplus materials, excess materials, rubbish, tools and equipment.

END OF SECTION

PART 1- GENERAL

1.1 APPLICABLE CODES AND STANDARDS

- .1 SMACNA HVAC Duct Construction Standards - Metal and Flexible, 3rd Edition.
- .2 SMACNA HVAC Air Duct Leakage Test Manual, 2012, 2nd Edition.
- .3 Conform to;
- .4 NFPA 90A - Installation of air conditioning and ventilating systems.
- .5 NFPA 90B - Installation of warm air heating and air conditioning systems.
- .6 Letter and number designations, shown as "CR3-16" etc., are taken from ASHRAE Duct Fitting Data Base. (DFDB)
- .7 ASTM A525 Specification for General Requirements for Steel Sheet, Zinc Coating (Hot Dipped galvanized)
- .8 ASTM A480 Specification for General requirements for Flat Rolled Plate, Sheet, and Strip
- .9 ASTM A621 Specification for Steel Sheet and Strip Carbon Hot Rolled Drawing Quality

1.2 SHOP DRAWINGS AND SUBMITTALS

- .1 Product Data: submit manufactures' product data and catalogue literature for:
 - .1 Sealants.
 - .2 Tape.
 - .3 Proprietary Joints.
 - .4 Hardware
- .2 Submit field/fabrication drawings at 1:50 or larger scale, with piping, ductwork, and fittings in double line format, to show;
 - .1 Arrangements in congested areas,
 - .2 Where installation proposed deviates from layout shown, and
 - .3 Where installation requires joints for field assembly in welded duct construction.
- .3 For greater clarity, do not submit field/fabrication drawings for other areas of the Work.
 - .1 Submit schedules and details to show;
 - 1. Fabrication details of
 - .1 Connections to risers in duct shafts
 - .2 Balancing damper construction,
 - .3 Fittings where geometry contemplated is different from that specified.
 - 2. In chart form
 - .1 Duct system pressure class,
 - .2 Duct sheet gauges,

- .3 Joint types and application criteria,
- .4 Location criteria and dimensions for bracing, stiffeners and balancing dampers
- .5 Duct leakage class, and
- .6 Extent of sealing.

1.3 RECORD DRAWINGS

- .1 As work progresses, mark-up field drawings and submit as part of record of "As-Built" conditions.

1.4 QUALITY ASSURANCE

- .1 Certification of Ratings.
- .2 Catalogue or published ratings shall be those obtained from tests carried out by manufacturer or independent testing agency signifying adherence to codes and standards.

1.5 DELIVERY, STORAGE AND HANDLING

- .1 Protect exposed ductwork on site from damage, dust and debris. Cover unused ductwork, and fittings while being stored. Cover open ends of ductwork and fittings with plastic sheeting after installation and while being stored to protect from construction dust and damage. Installed absorptive material to protect from moisture damage.

PART 2- PRODUCTS

2.1 GENERAL

- .1 Construction: round.
 - .1 Ducts: factory fabricated, spiral wound, with matching fittings and specials to SMACNA.
 - .2 Transverse joints up to 900 mm: slip type with tape and sealants.
 - .3 Fittings:
 - 1. Elbows: smooth radius. Centreline radius: 1.5 x diameter.
 - 2. Branches: conical transition with conical branch at 45 degrees and 45 degrees elbow.
- .2 Construction: rectangular:
 - .1 Ducts: Provide external reinforcing to SMACNA.
 - .2 Transverse joints: proprietary duct joints SMACNA seal Class A.
 - .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.

2.2 MATERIALS

- .1 Galvanized steel:
 - .1 Lock forming quality to ASTM A525, G90 zinc coating. Satin coat steel for painted surfaces.
- .2 Stainless Steel:
 - .1 Type 304L Flat Rolled Plate, Sheet and Strip
 - .2 Fully welded construction for zero leakage.
- .3 Seal Classification:
 - .1 Refer to Schedule on ductwork Drawings
 - .2 Class A: longitudinal seams, transverse joints, duct wall penetrations and connections made airtight with sealant and tape.

2.3 GALVANIZED STEEL

- .1 Lock forming quality: G90 zinc coating.
- .2 Thickness, fabrication and reinforcement: to SMACNA.
- .3 Joints: to SMACNA or proprietary manufactured duct joint. Proprietary manufactured flanged duct joint to be considered to be a class A seal.

2.4 STAINLESS STEEL

- .1 Supply ductwork as indicated using type 304L stainless steel sheets with longitudinal joints.
 - .1 Anneal stainless steel sheets before welding. For circular ducts roll sheets circular and weld flush. Provide integral 2 mm flanges on abutting ends of manufactured ducts.
- .2 Continuously weld all joints using Tungsten Inert Gas arc (GTAW) process without burning parent metal, using filler rods type ER308L as specified in CSA W48. Grind smooth and polish all joints.
- .3 Construction:
 - .1 Construct ductwork from following thicknesses of stainless steel sheet
 - 1. Rectangular ducts 1.3 mm minimum.
 - 2. Circular ducts up to 500 mm diameter 0.8 mm minimum.
 - 3. Circular ducts over 500 mm diameter 1.0 mm minimum.
- .4 Reinforce rectangular ducts with stainless steel angle frames at 1200 mm on centres 40 x 40 x 3 mm up to 900 mm maximum dimension and 50 x 50 x 6 mm for larger ducts.

2.5 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

2.6 TAPE

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

2.7 DUCT LEAKAGE

- .1 In accordance with SMACNA HVAC Air Duct Leakage Test Manual. See section 3.3 Leak Testing for more information.
- .2 In accordance with SMACNA Seal Class as specified on Ductwork Tables in drawing package.

2.8 PRESSURE CLASS

- .1 In accordance with Ductwork Tables shown in Drawing package

2.9 FIRE RATED DUCT WRAP INSULATION

- .1 Fire rating: 2 hrs or as shown.
- .2 ULC/Warnock Hersey/ETI listed:
 - .1 Maximum flame spread and smoke development rating: 25/50, to ULC-S102.
 - .2 2 hr ventilation duct: CAN/ISO 6944, or CAN/ULC-S101
- .3 Material: foil encapsulated, fireproof insulation blanket

2.10 PROPRIETARY MANUFACTURED FLANGED DUCT JOINTS

- .1 Material to match that of ductwork being joined.

2.11 BACKDRAFT DAMPERS

- .1 Frames shall be minimum 60 mm deep x 25 mm and no less than 1.5 mm in thickness, mill finish extruded aluminum with mounting flanges on both sides of frame. Frame to be assembled using plated steel mounting fasteners.
- .2 Blades shall be extruded aluminum profiles and shall not be less than 1.5 mm in thickness.
- .3 Blade and frame seals shall be of extruded silicone and shall be secured in an integral slot within the aluminum extrusions. Blade and frame seals are to be mechanically fastened to eliminate shrinkage and movement over the life of the damper. Adhesive or clip-on type blade seals are not acceptable.
- .4 Maintenance-free bearings system rotating on 12 mm aluminum pivot points.
- .5 Linkage system shall consist of hard alloy aluminum crank arms fastened to aluminum pivot rods and shall be doubly secured within channel running along top of blade. Large diameter 8.73 mm hard alloy aluminum linkage rod shall connect the crank arms by means of a zinc-plated steel trunnion.
- .6 Cup point trunnion set screw shall create a compression hard spot where it secures to the linkage rod for a slip-proof grip.
- .7 Trunnions shall be zinc-plated to provide a hard, smooth and long-lasting rotating surface.
- .8 Air leakage through a 610 mm x 610 mm back draft damper shall not exceed 21.95 l/s/m² against 250 Pa differential static pressure at standard air. Standard air leakage data to be certified under a Certified Ratings Program.

2.12 ACCESS DOORS

- .1 Material: Minimum 24 gauge metal, matching material specified for duct.
- .2 Pressure Rating: Suitable for duct pressure classifications shown.

| Duct Width | Door length x Width | No. Required |
|--------------------|---------------------|--------------|
| 450 mm and Smaller | 300 mm x 300 mm | 1 |
| 500 mm to 1200 mm | 450 mm x 450 mm | 1 |
| 1250 mm and larger | 450 mm x 450 mm | 2 |

- .3 Hardware:
 - .1 Hinges: Wrought steel, zinc plated; brass pins; sized to suit door; minimum two per door.
 - .2 Fasteners: Brass, window sash type; minimum two per door.
 - .3 Pull: Brass; minimum one per door on suction side of fan.
- .4 Reinforce doors with flat or angle iron stiffening frame to avoid racking. Make doors on insulated ductwork of double panel construction with an acceptable type insulated filler not less than 25mm thick. Frame out duct openings with a continuous reinforcing bar or angle against which door shall close. At insulated ducts, provide an extended metal collar flush with butt face of insulation. Attach gaskets to bar or angle with flameproof adhesive for airtight construction. Attach low pressure doors with at least two hinges.

2.13 INSTRUMENT TEST PORTS

- .1 Construction:
 - .1 1.6mm thick steel body zinc plated after manufacture,
 - .2 Chain secured neoprene expansion plug with cam lock handle,
 - .3 28mm minimum inside diameter, length to suit insulation thickness,
 - .4 Neoprene mounting gasket: flat for rectangular duct and moulded for round duct

2.14 FLEXIBLE CONNECTIONS

- .1 Vinyl Super Duty Fabric. Minimum lateral movement of 38mm, minimum elongation or compression of 30mm.
 - .1 Sloped to base of riser where horizontal run is more than 3m, with NPS $\frac{3}{4}$ drain connection from low points in bottom of duct, trapped and piped to drain.

2.15 FITTINGS

- .1 Fabrication: to SMACNA.
- .2 Rectangular.
 - .1 Elbows are to installed as shown, or if not shown, in order of preference as follows:

1. CR3-1, with throat radius 0.75 times duct width, and full heel radius.
 2. rectangular reducing elbow with throat radius equal to 0.75 times radial duct dimension of larger duct, and heel radius equal to throat radius plus radial duct dimension of smaller duct (SMACNA HVAC FIG 2-2 Type RE-5),
 3. 150 mm throat radius with full heel radius, CR3-3,4, or 5 and full radius single thickness splitter vanes,
 4. 75 mm throat radius with full heel radius, CR3-3,4, or 5 and full radius single thickness splitter vanes,
 5. square throat, square heel, 115 mm radius heel vane and 80 mm spaced double thickness turning vanes with 115 mm radius of curvature, CR3-16,
 6. square throat, square heel, 115 mm radius heel vane and 80 mm spaced single thickness turning vanes with 115 mm radius of curvature and 1.625 in long trailing edges, CR3-13.
- .2 Wye and tee branches (supply systems):
1. Where flow divides at high pressure and high velocity SR5-1(parallel flow branch)
 2. Where round branch is taken from rectangular main followed by transition fitting SR5-12.(spin-in collar- flared)
 3. Where rectangular branch is taken from rectangular main followed by a transition fitting SR5-13. (shoe)
 4. Where flow divides from rectangular duct into round diffuser neck followed by a transition fitting SR5-11
 5. Where flow divides in a "bull nose tee" SR5-14. (dovetail symmetrical wye) $Q_b = (0.35 \text{ to } 0.65) \text{ times } Q_c$.
- .3 Wye and tee branches (return/exhaust systems):
1. Where flow combines at high pressure and high velocity ER5-1 (parallel flow branch)
 2. Where equal flows are combined in "bull nose tee" configuration. ER5-4 (dovetail symmetrical wye)
 3. Where small rectangular branch is combined with large main ER5-3 (shoe)
 4. Where small round or rectangular duct is connected into main at right angles to main flow direction ER5-2 (spin in collar - straight, or dovetail collar)
- .4 Transitions (Rectangular and Round):
1. converging: maximum angle between ductside and direction of flow: 20
 2. diverging: maximum angle between ductside and direction of flow: 15
- .5 Offsets:
1. single offset in single plane, less than duct height, made up with two 45 elbows of type selected as above.
 2. single offset, of greater displacement, made up with 90 elbows of type selected as above.

-
- 3. double offset in single plane, less than duct height, made up with four 45 elbows of type selected as above.
 - 4. double offset in single plane, of greater displacement than duct height, made up with 90 elbows of type selected as above
 - .6 First elbow on discharge side of fan:
 - 1. unvaned elbow, CR3-1, with throat radius 0.75 times duct width, and full heel radius, arrangement SR7-5 or 9 with L Le.
 - .7 Obstructions passing through duct:
 - 1. Not permitted.
 - .3 Round:
 - .1 30 round elbow:
 - 1. up to 300 mm: die stamped,
 - 2. 350 mm and larger: 2-gore
 - .2 45 round elbow:
 - 1. up to 300 mm: die stamped,
 - 2. 350 mm and larger: 3-gore.
 - .3 60 round elbow:
 - 1. up to 300 mm: die stamped,
 - 2. 350 mm and larger: 4-gore.
 - .4 90 round elbow:
 - 1. up to 200 mm: die stamped with centreline radius equal to 1.5 times duct diameter,
 - 2. from 225 mm to 350 mm: pleated with centreline radius equal to 1.5 times duct diameter
 - 3. from 375 mm to 900 mm: 9-gore elbow with centreline radius equal to 2.5 times duct diameter,
 - 4. (950 mm and larger: 7-gore elbow with centreline radius equal to 2.5 times duct diameter.
 - .5 Wye branches:
 - 1. downstream of supply fan: wye branch SD5-2, plus 45 elbow,
 - 2. downstream of terminal boxes, and return or exhaust: wye branch SD5-1, plus 45 elbow.
 - .6 Tee branch (supply):
 - 1. downstream of supply fan: tapering tee SD5-12,
 - 2. downstream of terminal boxes: conical tee SD5-10.
 - .7 Tee branch (return/exhaust):
 - 1. converging branches, where main and branch are of similar size: tapering 45 lateral SD5-2 and 45 elbow,
 - 2. converging flow where branch is small: tapering tee SD5-12.

2.16 HANGERS AND SUPPORTS

- .1 Hangers and Supports: in accordance with Section 20 05 29 Hangers and Supports, but also these items below.
- .2 Duct side up to maximum 500 mm supported with strap hangers of same material as duct but one sheet metal thickness heavier.
- .3 Extend strap hangers down duct side and turn under 50 mm fastening securely to side and underside of duct.
- .4 Duct side greater than 500 mm supported with trapeze hangers constructed from same material of duct steel angle with steel rods in accordance with following table;
- .5 Hanger configuration: to SMACNA.
- .6 Hangers: black steel angle with black steel rods to the 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 |

- .7 Provide additional hangers to comply with required building codes and standards.
- .8 Maximum hanger spacing: 2.4 m on centre.
- .9 Upper hanger attachments;
 - .1 In new concrete: manufactured concrete inserts.
 - .2 For steel joist: galvanized joist clamps or steel plate washer.
 - .3 For steel beams: galvanized beam clamps.

2.17 FIRE DAMPERS AND SLEEVES

- .1 Floors, and Walls:
 - .1 Intumescent type, rigid galvanized steel frame with minimum 2 hour fire rating.
 - .2 Standard of Acceptance:
- .2 Fire Damper Sleeves: Damper manufacturer's metal sleeve with mounting angles, for matching assembly.

PART 3- EXECUTION

3.1 INSTALLATION

- .1 Assemble, mount, and seal ductwork systems. Install duct and plenum mounted equipment in accordance with manufacturer's recommendations.

- .2 Suspend ducts securely, so that under conditions of operation, there will be no vibration.
- .3 Provide openings in ductwork where required to accommodate thermometers and controllers. Provide pivot tube openings where required for testing of systems.
- .4 Holes in Ductwork:
 - .1 Where ducts are insulated, neatly cut a 75mm wide strip of insulation away from hole site.
 - .2 Drill holes in ducts, casings and plenums not exceeding 300mm OC in locations as directed by Balancing Agency.
 - .3 Use snap-in plugs for low and medium pressure systems with material gauges of 14 through 26.
 - .4 Use instrument test holes for HEPA filter casings, high pressure and Class 1 systems, and all other low and medium pressure system applications.
 - .5 Reinstall cut away insulation and cover with 100mm wide duct tape. Identify plug and instrument hole locations on insulated ducts as "test holes" for future reference and use.
- .5 Locate ducts with sufficient space around equipment to allow normal operating and maintenance activities.
- .6 Install turning vanes of standard construction in duct elbows where center line radius is less than 1.25 times width of duct.
- .7 Provide gravity backdraft dampers on all exhaust air outlets to outdoor and exhaust fans where motorized dampers are not indicated, and where shown on drawings.
- .8 Set plenum doors 150 to 300mm above floor. Arrange door swings so that fan static pressure holds door in closed position.
- .9 Connect ducts to fans with flexible sleeves.
- .10 Do not use elbows or flexible ductwork within 3 inlet diameters of the inlet-to-air terminal units.
- .11 Do not use flexible duct to form elbows or turns exceeding 90 degrees. Use rigid metal duct for such applications.
- .12 Hanging from steel roof or floor decks is approved only when there is at least 100mm of concrete over deck. Provide supplementary or structural steel as required for seismic and structural support.
- .13 During construction, provide temporary closures of metal or taped polyethylene on open ductwork, to prevent construction dust from entering ductwork system.
- .14 Install mechanical duct connection systems in strict conformance with manufacturer's instructions. Over tightening of corner piece nuts and bolts may cause leakage in excess of allowable levels.
- .15 Install fire dampers in duct extension sleeves and with perimeter angles and breakaway fittings in accordance with manufacturer's instructions and SMACNA details. Provide control wiring for smoke dampers back to auxiliary contacts in fan starter.

- .16 Install access doors at plenums, automatic dampers, temperature and humidity sensors in fan discharges, control devices, fire dampers, smoke dampers, smoke detectors and other locations where shown. Locate doors on duct sidewalls.
- .17 Cut, fit and install blank out panels at portions of louvers not used. Seal seams, perimeter, cut-outs and duct connection. Provide angle closure collars where ducts meet blank out panels.
- .18 Locate pressure relief doors between fan and first fire damper. Provide multiple doors when required to match system capacity. Select doors based on capacity and settings to match duct construction classification shown.

3.2 LEAK TESTING

- .1 All ductwork shall be leak tested. Refer to schedule on drawings. Leakage Test Pressure to be at least 1.0 times the Pressure Rating as shown in the Ductwork Tables shown in the drawing package.
- .2 Conduct test in accordance with Associated Air Balance Council (AABC) recommended procedures.
- .3 Leak test supply and exhaust air ductwork. Maximum allowable leakage shall be one percent of total air volume.
- .4 Leak test laboratory exhaust air ductwork. Maximum allowable leakage shall be per SMACNA procedures.
- .5 Test each system as a whole or in segments as required by progress of work. Use test pressure of pressure-velocity classifications shown, unless otherwise noted.
- .6 Prior to testing, manually remove debris from inside equipment, plenums and ductwork. Do not use fans to remove debris. Verify that duct mounted equipment, accessories and components are installed complete, including access doors as specified. Set fire and smoke dampers in their proper position with "Fire Links" or other devices required for operation, in place and set.
- .7 Pressure test completed ductwork system before ductwork is insulated and concealed. Retest systems found to be incomplete during initial test.
- .8 If tests show ductwork system leakage is greater than allowed, reseal and retest until allowable leakage is not exceeded.
- .9 If, by test, pressure drop across ductwork fittings and duct mounted devices furnished under other Sections exceeds by 10 percent the pressure drop ratings listed in SMACNA HVAC Duct System Design, inspect inside ductwork fittings and devices, and report findings to Departmental Representative. If fittings and devices do not have access doors, cut inspection openings in ductwork, and provide airtight access covers secured with sheet metal screws. Repair or replace fittings and devices, and retest until allowable pressure drop is not exceeded.

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 DUCT CLEANING

- .1 Cleaning to be performed by agent specializing in this field of work, be a member in good standing with National Air Duct Cleaners Association (NADCA), and to comply with NADCA standards.
- .2 Clean new horizontal and vertical ducts (supply, return, exhaust, transfer), as well as, existing supply and return ductwork connected to new fan systems.
- .3 Clean ductwork using high powered vacuum system, hand tools and mechanical brushing systems such that metal surfaces are visibly clean.
- .4 Reset balancing dampers to original settings if moved during work. Have TAB Agent confirm damper settings.
- .5 Maintain set of drawings on site, coloured each day during cleaning to indicate extent of duct cleaning completed.
- .6 Submit a written report, verified by TAB Agent, identifying extent of duct system cleaning and certifying that NADCA standards have been met.

END OF SECTION 23 31 13

1 GENERAL

1.01 RELATED REQUIREMENTS

- .1 Section 23 05 29.

1.02 REFERENCE STANDARDS

Not used.

1.03 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 fan coil units and include product characteristics, performance criteria, physical size, finish and limitations.
 - .2 Product data to include:
 - .1 Filters, fan accessibility.
 - .2 Suspension of cabinet.
 - .3 Thermostat, transformer, controls where integral.
 - .4 kW rating, voltage, phase.
 - .5 Cabinet material thicknesses.
- .3 Shop Drawings:
 - .1 Submit drawings where required.
- .4 Certificates: submit certificates signed by manufacturer certifying that materials comply with specified performance characteristics and physical properties.

1.04 DELIVERY, STORAGE AND HANDLING

- .1 Deliver, store and handle materials in accordance with Section 01 61 00 - Common Product Requirements.
- .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 in dry location and in accordance with manufacturer's recommendations in clean, dry, well-ventilated area.
 - .2 Store and protect fan coil units from nicks, scratches, and blemishes.
 - .3 Replace defective or damaged materials with new.

2 PRODUCTS

2.01 FAN COIL UNITS

- .1 Cabinet: steel, 1.2 mm thick, ceiling mounting, recessed. Front inlet/ front outlet.
- .2 Elements: stainless steel sheathed with corrosion protected aluminum fins covering full length of element.
- .3 Blower motors: single phase, ECM motor.
- .4 Wall mounted thermostats: see drawings.
- .5 Fan delay switch.
- .6 Fresh air duct adapter.
- .7 Filter: replaceable.
- .8 Trim for flush installation.
- .9 Finish: 3 stage phosphatized treatment followed by enamel.
- .10 Assembly fully wired to one outlet location.
- .11 Multiple knockouts for up to 38 mm diameter conduit.
- .12 Complete with condensate discharge pump if required for drainage.

3 EXECUTION

3.01 EXAMINATION

- .1 Verification of Conditions: verify that conditions of substrate previously installed under other Sections or Contracts are acceptable for fan coil units 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.

3.02 INSTALLATION

- .1 Hang units.
- .2 Make electrical and control connections.

3.03 FIELD QUALITY CONTROL

- .1 Perform tests in accordance with Section 26 05 00 - Common Work Results for Electrical.

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END OF SECTION