

## **1.01 GENERAL**

- .1 Refer to Division 01 for the requirement regarding Commissioning.

## **1.02 RELATED SECTIONS**

- .1 Section 01 33 00 - Submittal Procedures
- .2 Section 01 78 00 - Closeout Submittals

## **1.03 EQUIPMENT LIST**

- .1 Complete list of equipment and materials to be used on this project and forming part of tender documents by adding manufacturer's name, model number and details of materials, and submit for approval.
- .2 Submit for approval at time of tender within 48 hours within 10 days after award of contract.

## **1.04 ALTERNATES**

- .1 The equipment listed on the project equipment schedules is the "basis of design equipment", the Contactor is permitted to find alternates to this equipment that meet the technical and quality requirements of the project specifications. If there are necessary changes to the building systems to accommodate these alternates, the changes must be coordinated and provided by the Contractor at no additional cost to the Contract.

## **1.05 TRIAL USAGE**

- .1 Departmental Representative may use equipment and systems for test purposes prior to acceptance. Supply labour, material, and instruments required for testing.
  - .1 Trial usage to apply to systems only after prior approval of Departmental Representative.

## **1.06 PROTECTION OF OPENINGS**

- .1 Protect equipment and systems openings from dirt, dust, and other foreign materials with materials appropriate to system.
- .2 Seal all ductwork openings with 6 mil plastic to protect it from dirt, dust, and foreign materials during the course of the day's installation. Further ensure that at the end of the day, all open joints are closed off. Tape all plastic with duct tape. Cover and protect all un-installed ductwork before it is installed.
- .3 Protect all existing ductwork to be re-used, closing off openings

with 6 mil plastic.

#### **1.07 PAINTING**

- .1 To Section 09 91 00 - Painting.
- .2 Prime and touch up marred finished paintwork to match original.
- .3 Restore to new condition, finishes which have been damaged too extensively to be merely primed and touched up.

#### **1.08 SPARE PARTS**

- .1 Furnish spare parts in accordance with Section 01 78 00 - Closeout Submittals as follows:
  - .1 One (1) set of belts for each piece of machinery.
  - .2 Three (3) sets of filters for each filter bank.
  - .3 Keys for vandal resistant outlets.

#### **1.09 SPECIAL TOOLS**

- .1 Provide one (1) set of special tools required to service equipment as recommended by manufacturers and in accordance with Section 01 78 00 - Closeout Submittals.
- .2 Furnish one (1) commercial quality grease gun, grease and adapters to suit different types of grease and grease fittings.

#### **1.10 DEMONSTRATION AND OPERATING AND MAINTENANCE INSTRUCTIONS**

- .1 Supply tools, equipment and personnel to demonstrate and instruct operating and maintenance personnel in operating, controlling, adjusting, troubleshooting and servicing of all systems and equipment during regular work hours, prior to acceptance.
- .2 Where specified elsewhere in Divisions 22 and 23, manufacturers to provide demonstrations and instructions.
- .3 In addition to where training is specified elsewhere in other divisions, factory trained personnel to provide on-site instruction in operation and maintenance as follows:
  - .1 Ventilation Systems - minimum eight (8) hours.
  - .2 Heating Systems - minimum eight (8) hours.
  - .3 Plumbing Systems - minimum four (4) hours.
  - .4 Control System - minimum eight (8) hours.
- .4 Use operation and maintenance manual, as-built drawings, audio visual aids, etc. as part of instruction materials.

### 1.11 CLOSEOUT SUBMITTALS

- .1 Provide operation and maintenance data for incorporation into manual specified in Section 01 78 00 - Closeout Submittals.
- .2 Operation and maintenance manual to be approved and final copies deposited with the Departmental Representative before final inspection.
- .3 Operation data to include:
  - .1 Control schematics for each system including environmental controls.
  - .2 Description of each system and its controls.
  - .3 Description of operation of each system at various loads together with reset schedules and seasonal variances.
  - .4 Operation instruction for each system and each component.
  - .5 Description of actions to be taken in event of equipment failure.
  - .6 Valves schedule and flow diagram.
  - .7 Colour coding chart.
- .4 Maintenance data to include:
  - .1 Servicing, maintenance, operation and troubleshooting instructions for each item of equipment and parts list.
  - .2 Data to include schedules of tasks, frequency, tools required and task time.
- .5 Performance data to include:
  - .1 Equipment manufacturer's performance data sheets with point of operation as left after commissioning is complete.
  - .2 Equipment performance verification test results.
  - .3 Special performance data as specified elsewhere.
  - .4 Testing, adjusting and balancing reports as specified in Section 2305 95 - Testing, Adjusting and Balancing.
- 6 Approvals:
  - .1 Submit copies of draft Operation and Maintenance Manual to the Departmental Representative for approval. Submission of individual data will not be accepted unless so directed by the Departmental Representative.
  - .2 Make changes as required and resubmit two (2) copies as directed by the Departmental Representative.
- .7 Additional data:
  - .1 Prepare and insert into operation and maintenance manual when need for same becomes apparent during demonstrations and instructions specified above.

### 1.12 SHOP DRAWINGS AND PRODUCT DATA

- .1 Submit shop drawings and product data in accordance with Section 01 33 00 - Submittal Procedures.
- .2 Shop drawings and product data to show:
  - .1 Mounting arrangements.
  - .2 Operating and maintenance clearances. eg. access door swing spaces.
  - .3 Installation requirements and procedures.
- .3 Shop drawings and product data to be 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 as to 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. Identify section and paragraph number.

### 1.13 CLEANING

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

### 1.14 PROJECT RECORD DRAWINGS

- .1 Site records:
  - .1 Departmental Representative will provide one (1) set of reproducible mechanical drawings. Provide sets of white prints as required for each phase of the work. Mark there on all changes as work progresses and as changes occur. This includes changes to existing mechanical systems, control systems and low voltage control wiring.
  - .2 On a weekly basis, transfer information to reproducibles, revising reproducibles to show all work as actually installed.
  - .3 Use different colour waterproof ink for each service.
  - .4 Make available for reference purposes and inspection at all times.
- .2 Project Record drawings:
  - .1 Prior to start of Testing, Adjusting and Balancing (TAB), finalize production of as-built drawings.
  - .2 Identify each drawing in lower right hand corner in letters at least 12 mm high as follows: "Project Record 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 TAB to be performed using Project Record drawings.
- .5 Submit completed reproducible Project Record drawings with Operating and Maintenance Manuals.
- .3 Submit copies of Project Record drawings for inclusion in final TAB report.

#### **1.15 WASTE MANAGEMENT AND DISPOSAL**

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

#### **1.16 ELECTRICAL**

- .1 Electrical Work to conform to Division 26 including the following:
  - .1 Starters, motor protection and manual control devices are specified and indicated in Division 26 except where otherwise indicated or specified. Wiring to packaged mechanical equipment is indicated on electrical drawings. Coordinate as required.
  - .2 Supplier and installer responsibility is indicated on electrical drawings and related mechanical responsibility as indicated on mechanical equipment schedules on mechanical drawings or in specifications.
  - .3 Control wiring 50 V and greater, specified and installed by Division 26. Control wiring 50 V or less, is responsibility of EMCS contractor, except as indicated elsewhere in the specifications.

#### **1.17 EQUIPMENT SUPPORTS**

- .1 Equipment supports supplied by equipment manufacturer specified elsewhere in Divisions 22 and 23.
- .2 Mount base mounted equipment on chamfered edge housekeeping pads, minimum of 150mm high and 100mm larger than equipment dimensions all around. Concrete specified in Section 03 30 00 - Cast-in-Place Concrete.

#### **1.18 MANUFACTURER'S REVIEW**

- .1 For all major pieces of equipment, it will be the responsibility of the Contractor to have the equipment supplier or his representative review all proposed connections, clearances, sizes, valves, breakers, etc. including wire and pipe sizes to his equipment before installation commences. At that time, inform the Departmental Representative of any changes required to make the equipment function satisfactorily.

- .2 Departmental Representative will provide the Contractor with a letter accepting all connections as proposed and where required, recommend necessary changes.
- .3 If any changes or additional material and labour are required to make the equipment function properly to capacity and the manufacturer has not pointed out this Work prior to commencement of Work, do the additional and/or corrective work at the expense of the equipment supplier.

#### **1.19 WARRANTIES**

- .1 Make good all defects other than normal wear and tear during the life of the warranty period specified in the General Conditions of the contract. Warrant all Work and install equipment to work quietly and satisfactorily and to accomplish the work for which it was installed during the life of the warranty. At any time during this period, make any necessary changes and adjustments, or replacements, to accomplish this at no additional cost to the Contract.
- .2 Submit warranties in maintenance manuals as specified in Section 01 33 00 and Section 01 78 00.

#### **1.20 TESTS**

- .1 Notice of Tests: Give written notice for a minimum of four (4) working days prior to the date when tests will be made.
- .2 Prior Tests: Concealed or insulated work must remain uncovered until completely tested and approved, but if construction schedule requires, arrange for prior tests on parts of system as approved.
- .3 Acceptance Tests: Conduct in presence of the Departmental Representative or representative of the authorities having jurisdiction.
- .4 Costs: Bear all costs in connection with tests conducted.
- .5 Certificates: Obtain acceptance certificates from the authorities having jurisdiction. Work is not considered complete until certificates have been delivered to the Departmental Representative.
- .6 Water Systems: Fill with water and hydraulically test at 1 ½ times system operating pressure or at 125 psig, whichever is greatest. Unless otherwise noted, maintain test pressures without loss for a four (4) hour period. Use valves to isolate equipment not rated for these pressures.

- .7 Test plumbing sanitary sewer, storm sewer and vent piping as required by National Building Code, Canadian Plumbing Code and Municipal Regulations.
- .8 Rest sanitary, storm and vent piping by sealing outlets and filling the system to the highest point with water. The water level must remain constant for a minimum of two (2) hours.
- .9 Hammer test all welded joints.

**END OF SECTION**

## **1 GENERAL**

### **1.01 REFERENCES**

- .1 Canadian General Standards Board (CGSB)
  - .1 CAN/CGSB 1.181-99, Organic Zinc Rich Coating.

## **2 PRODUCTS Not applicable.**

## **3 EXECUTION**

### **3.01 CONNECTIONS TO EQUIPMENT**

- .1 Make connections 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.
- .4 Maintain all minimum clearances required by the Canadian Electrical Code.
- .5 Minimum 750mm in front of VAV terminal units.
- .6 Maintain equipment and valves a maximum of 900mm above ceilings.

### **3.02 CLEARANCES**

- .1 Provide clearance around systems, equipment and components for observation of operation, inspection, servicing, maintenance and as recommended by manufacturer.
- .2 Provide space for disassembly, removal of equipment and components as recommended by manufacturer or as indicated (whichever is greater) without interrupting operation of other system, equipment, components.

### **3.03 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. Discharge to be visible.
- .4 Drain valves: NPS 3/4 ball valves unless indicated otherwise, with hose end male thread, cap and chain.

### **3.04 AIR VENTS**

- .1 Install manual air vents at high points in piping systems in areas within accessible mechanical spaces.
- .2 Install automatic air vent with isolating valve at each high point in finished areas.
- .3 Install drain piping on manual air vents to floor drain and terminate where discharge is visible.

### **3.05 PIPEWORK INSTALLATION**

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

- .12 Use eccentric reducers at pipe size changes to ensure positive drainage and venting.
- .13 Provide for thermal expansion.
- .14 Valves:
  - .1 Install in accessible locations.
  - .2 Remove interior parts before soldering.
  - .3 Install with stems above horizontal position unless otherwise indicated.
  - .4 Valves accessible for maintenance without removing adjacent piping.
  - .5 Install globe valves in bypass around control valves.
  - .6 Use ball or butterfly valves at branch takeoffs for isolating purposes except where otherwise 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.
- .15 Check Valves:
  - .1 Install silent check valves on discharge of pumps and in vertical pipes with downward flow and elsewhere as indicated.
  - .2 Install swing check valves in horizontal lines on discharge of pumps and elsewhere as indicated.
- .16 Install pipe straight and parallel to building lines.

### **3.06 SLEEVES**

- .1 General: Install where pipes pass through masonry, concrete structures, fire rated assemblies, dry-wall partitions and elsewhere as indicated.
- .2 Material: Schedule 40 black steel pipe (sheet metal acceptable for non-rated dry wall partitions).
- .3 Construction: Foundation walls and where sleeves extend above finished floors to have annular fins continuously welded on at mid-point.
- .4 Sizes: 6 mm minimum clearance between sleeve and un-insulated 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.
- .4 All mechanical room walls and wet areas above ground slab.
- .6 Sealing:
  - .1 Foundation walls and below grade floors: Fire retardant,  
waterproof non-hardening mastic.
  - .2 Elsewhere: Provide space for firestopping. Maintain fire  
rating integrity.
  - .3 Sleeves installed for future use: Fill with lime plaster or  
other easily removable filler.
  - .4 Allow for no contact between copper pipe or tube and  
sleeve.

### **3.07 ESCUTCHEONS**

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

### **3.08 PREPARATION FOR FIRESTOPPING**

- .1 Material and installation within annular space between pipes,  
ducts, insulation and adjacent fire separation to Section 07 84  
00 - Fire Stopping.
- .2 Un-insulated unheated pipes not subject to movement: No special  
preparation.
- .3 Un-insulated heated pipes subject to movement: Wrap with non-  
combustible smooth material to permit pipe movement without  
damaging firestopping material or installation.
- .4 Insulated pipes and ducts: Ensure integrity of insulation and  
vapour barriers.

### **3.09 FLUSHING OUT OF PIPING SYSTEMS**

- .1 Before start-up, clean interior of piping systems supplemented as  
specified in relevant sections of Division 22 and 23.
- .2 Preparatory to acceptance, clean and refurbish equipment and

leave in operating condition, including replacement of filters in piping systems.

### **3.10 PRESSURE TESTING OF EQUIPMENT**

- .1 Advise the Departmental Representative 72 hours minimum prior to performance of pressure tests.
- .2 Pipework: pressure test piping at either the main pressure, or 1.5 times the normal operating pressure, whichever is greater. Also refer to testing requirements specified in relevant sections of Divisions 22 and 23.
- .3 Maintain specified test pressure without loss for 4 hours minimum unless specified for longer period of time in relevant sections of Divisions 22 and 23.
- .4 Prior to tests, isolate equipment and other parts which are not designed to withstand test pressure or media.
- .5 Submit tests results to the Departmental Representative. Work to be carried out in off hours after 5 p.m., weekends or holidays.
- .6 Pay costs for repairs or replacement, retesting, and making good. Departmental Representative to determine whether repair or replacement is appropriate.
- .7 Insulate or conceal work only after review of tests by the Departmental Representative.

### **3.11 EXISTING SYSTEMS**

- .1 Connect into existing piping systems at times approved by the Departmental Representative. Work to be carried out off hours after 5 p.m., weekends or holidays.
- .2 Request written approval ten (10) days minimum, prior to commencement of work.
- .3 Be responsible for damage to existing plant by this work.
- .4 Conduct daily clean-up of existing areas.

**END OF SECTION**

## **Part 1      General**

### **1.1    RELATED SECTIONS**

- .1    Section 01 33 00 – Submittal Procedures
- .2    Section 23 05 01 – Mechanical General Requirements
- .3    Section 23 05 53 – Mechanical Identification

### **1.2    REFERENCES**

- .1    ASME B40.100-2013, Pressure Gauges and Gauge Attachments.
- .2    CAN/CGSB-14.4-M88, Thermometers, Liquid-in-Glass, Self-Indicating, Commercial/Industrial Type.
- .3    CAN/CGSB-14.5-M88, Thermometers, Bimetallic, Self-Indicating, Commercial/Industrial Type.

### **1.3    SHOP DRAWINGS AND PRODUCT DATA**

- .1    Submit shop drawings and product data in accordance with Section 01 33 00 – Submittal Procedures.
- .2    Submit manufacturer's product data for following items:
  - .1    Thermometers.
  - .2    Pressure gauges.
  - .3    Stop cocks.
  - .4    Wells.
  - .5    Snubbers.

### **1.4    MAINTENANCE DATA**

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

## **Part 2      Products**

### **2.1    GENERAL**

- .1    Thermometers and pressure gauges to operate at midpoint of scale or range.

**2.2 DIRECT READING THERMOMETERS**

- .1 Industrial, variable angle type, aluminum case, graduated in C and F brass stem, liquid filled, 225 mm scale length: to CAN/CGSB 14.4.

**2.3 REMOTE READING THERMOMETERS**

- .1 112 mm diameter mercury activated dial type: to CAN/CGSB-14.5, stainless steel bourdon tube, accuracy within one scale division, brass movement, stainless steel capillary, stainless steel spiral armour, stainless steel bulb and polished brass or stainless steel case for wall mounting.

**2.4 INDUSTRIAL THERMOMETER WELLS**

- .1 Use copper, bronze, brass, or stainless steel to suit application, 3/4 NPT.
- .2 Provide extension to suit insulation thickness.

**2.5 PRESSURE GAUGES**

- .1 112 mm dia., dial type: to ANSI/ASME B40.100, Grade A, having 1% of full scale over middle half of range accuracy unless otherwise specified. Graduated in C and F.
- .2 Provide mini ball valve and:
  - .1 Snubber for pulsating operation.
  - .2 Diaphragm for corrosive service.

**Part 3 Execution****3.1 GENERAL**

- .1 Install so they can be easily read from floor or platform. If this cannot be accomplished, install remote reading units.
- .2 Provide engraved lamicoid nameplates as specified in Section 23 05 53, identifying medium.
- .3 Locate between equipment and first fitting or valve.

**3.2 THERMOMETERS**

- .1 Install in wells on all piping. Provide heat conductive material inside well.

- .2 Install in locations as indicated and on inlet and outlet of:
  - .1 Water heating coils.
  - .2 3-way mixing valves.
  - .3 Heat exchangers supply and return piping.
  - .4 Supply and return piping from main heating zones.
  - .5 Supply and return from chiller and each boiler.
  - .6 Discharge from domestic hot water tanks.
- .3 Use extensions on all thermometers wells and pressure gauges to allow for insulation thickness.

### 3.3 PRESSURE GAUGES

- .1 Install in following locations:
  - .1 Domestic and fire water entrance.
  - .2 Suction and discharge of pumps over 1/2 hp.
  - .3 Upstream and downstream of control valves.
  - .4 Inlet and outlet of water side of coils: provide pressure gauge cocks and taps for balancing/commissioning.
  - .5 Inlets and outlets of all heat exchangers.
  - .6 Inlet and outlet of each boiler and chiller.
- .2 Use extensions on all pressure gauge connections to permit mini-ball valve complete with snubber to be clear of insulation and jacket.

**END OF SECTION**

## **1 GENERAL**

### **1.01 RELATED SECTIONS**

- .1 Submittal Procedures: Section 01 33 00
- .2 Cast-in-Place Concrete: Section 03 30 00

### **1.02 REFERENCES**

- .1 American National Standards Institute/ American Society of Mechanical Engineers (ANSI/ASME)
  - .1 ANSI/ASME B31.1-2016, Power Piping, (SI Edition).
  - .2 ANSI/ASME B31.3-2016, Process Piping.
  - .3 ANSI/ASME B31.5-2016, Refrigeration Piping and Heat Transfer Components.
  - .4 ANSI/ASME B31.9-2014, Building Services Piping.
- .2 American Society for Testing and Materials (ASTM)
  - .1 ASTM A125-96(R2013), Specification for Steel Springs, Helical, Heat Treated.
  - .2 ASTM A307-2014, Specification for Carbon Steel Bolts and Studs, 60,000 PSI Tensile Strength.
  - .3 ASTM A563-15, Specification for Carbon and Alloy Steel Nuts.
- .3 Factory Mutual (FM)
- .4 Manufacturer's Standardization Society of the Valves and Fittings Industry (MSS)
  - .1 MSS SP58-2009, Pipe Hangers and Supports Materials, Design and Manufacture.
- .5 Underwriter's Laboratories of Canada (ULC).

### **1.03 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, B31.3, B31.5, B31.9 or MSS SP58.
- .3 Do not allow that supports, guides or anchors to transmit excessive quantities of heat to building structure.
- .4 Design hangers and supports to support systems under all 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 to be in accordance with MSS SP58.

#### **1.04 PERFORMANCE REQUIREMENTS**

- .1 Design supports, platforms, catwalks, hangers to withstand seismic events for location as per the National Building Code.

#### **1.05 SHOP DRAWINGS AND PRODUCT DATA**

- .1 Submit shop drawings and product data in accordance with Section 01 33 00.
- .2 Submit shop drawings and product data for following items:
  - .1 Bases, hangers and supports.
  - .2 Connections to equipment and structure.
  - .3 Structural assemblies.

#### **1.06 CLOSEOUT SUBMITTALS**

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

### **2 PRODUCTS**

#### **2.01 GENERAL**

- .1 Fabricate hangers, supports and sway braces in accordance with ANSI B31.1 and MSS SP58.
- .2 Use components for intended design purpose only. Do not use for rigging or erection purposes.

#### **2.02 PIPE HANGERS**

- .1 Finishes:
  - .1 Pipe hangers and supports: galvanized painted with zinc rich paint after manufacture.
  - .2 Use electroplating galvanizing process or hot dipped galvanizing process.
  - .3 Confirm 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: 9 mm UL listed, 13 mm FM approved.
- .2 Cold piping NPS 2 1/2 or greater, all hot piping: Malleable iron beam clamp, eye rod, jaws and extension with carbon steel retaining clip, tie rod, nuts and washers, UL listed, FM approved where required to MSS SP58.
- .3 Upper attachment structural: Suspension from upper flange of I-Beam.
  - .1 Cold piping NPS 2 maximum: Ductile iron top of beam C-clamp with hardened steel cup point setscrew, locknut and carbon steel retaining clip, UL listed FM approved where required to MSS SP58.
  - .2 Cold piping NPS 2 1/2 or greater, all hot piping: Malleable iron top of beam jaw clamp with hooked rod, spring washer, plain washer and nut UL listed, FM approved where required.
- .4 Upper attachment to concrete:
  - .1 Ceiling: Carbon steel welded eye rod, clevis plate, clevis pin and cotters with weld-less forged steel eye nut. Ensure eye 6 mm minimum greater than rod diameter.
  - .2 Concrete inserts: wedge shaped body with knockout protector plate UL listed FM approved where required to MSS SP58.
- .5 Shop and field fabricated assemblies:
  - .1 Trapeze hanger assemblies: MSS SP58.
  - .2 Steel brackets: MSS SP58.
  - .3 Sway braces for seismic restraint systems: to MSS SP58.
- .6 Hanger rods: threaded rod material to MSS SP58.
  - .1 Only subject hanger rods to tensile loading.
  - .2 Provide linkages where lateral or axial movement of pipework is anticipated.
  - .3 Do not use 22 mm or 28 mm rod.
- .7 Pipe attachments: material to MSS SP58.
  - .1 Attachments for steel piping: carbon steel galvanized.
  - .2 Attachments for copper piping: copper plated black steel.
  - .3 Use insulation saddles for hot pipework.
  - .4 Oversize pipe hangers and supports for insulated pipes.
- .8 Adjustable clevis: material to MSS SP58, UL listed FM approved, where required 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 SP58.

- .10 U-bolts: carbon steel to MSS SP58 with two (2) nuts at each end to ASTM A563.
  - .1 Finishes for steel pipework: galvanized.
  - .2 Finishes for copper, glass, brass or aluminum pipework: black with formed portion plastic coated or epoxy coated.
- .11 Pipe rollers: cast iron roll and roll stand with carbon steel rod to MSS SP58.

### **2.03 RISER CLAMPS**

- .1 Steel or cast iron pipe: galvanized black carbon steel to MSS SP58, type 42, UL listed FM approved where required.
- .2 Copper pipe: carbon steel copper plated to MSS SP58, type 42.
- .3 Bolts: to ASTM A307.
- .4 Nuts: to ASTM A563.

### **2.04 INSULATION PROTECTION SHIELDS**

- .1 Insulated cold piping:
  - .1 64 kg/m<sup>3</sup> density insulation plus insulation protection shield to: MSS SP58, 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 SP58.

### **2.05 EQUIPMENT SUPPORTS**

- .1 Fabricate equipment supports not provided by equipment manufacturer from structural grade steel meeting requirements of Section 05121. Submit calculations with shop drawings.

### **2.06 EQUIPMENT ANCHOR BOLTS AND TEMPLATES**

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

### **2.07 HOUSEKEEPING PADS**

- .1 For base mounted equipment: Concrete, at least 100 mm high, 50 mm larger all around than equipment, and with chamfered edges.
- .2 Concrete: to Section 03 30 00.

## **2.08 OTHER EQUIPMENT SUPPORTS**

- .1 From structural grade steel.
- .2 Submit structural calculations with shop drawings.

## **3 EXECUTION**

### **3.01 INSTALLATION**

- .1 Install in accordance with manufacturer's instructions and recommendations.
- .2 Vibration Control Devices:
  - .1 Install on piping systems at pumps, boilers, chillers, cooling towers, and elsewhere 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 be 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 four (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.

### **3.02 HANGER SPACING**

- .1 Plumbing piping: most stringent requirements of Canadian Plumbing Code
- .2 Fire protection: to the Canadian 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 Hydronic, steam, condensate, rigid, and flexible joint roll groove pipe: in accordance with table below, but not less than one hanger at joints.

Maximum Pipe Size Copper Size: NPS	NPS Maximum Spacing:	Steel Maximum Spacing:
up to 1-1/4	2.2 m	1.8 m
1-1/2	2.1 m	2.4 m
2	3.0 m	2.7 m
2-1/2	3.1 m	3.0 m
3	3.1 m	3.0 m
3-1/2	3.1 m	3.3 m
4	4.1 m	3.6 m
5	4.1 m	
6	5.1 m	
8	5.1 m	
10	6.6 m	
12	6.9 m	

- .6 Within 300 mm of each elbow.
- .7 Pipework greater than NPS 12: to MSS SP58.

### 3.03 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. Comprised of angel iron or c-channel.

### 3.04 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.

### **3.05 FINAL ADJUSTMENT**

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

**END OF SECTION**

## **1 GENERAL**

### **1.01 RELATED SECTIONS**

- .1 Submittal Procedures: Section 01 33 00
- .2 Painting: Section 09 91 00

### **1.02 REFERENCES**

- .1 Canadian Gas Association (CGA)
  - .1 CSA B149.1-2015, Natural Gas and Propane Installation Code.
- .2 Canadian General Standards Board (CGSB)
  - .1 CAN/CGSB1.60-97, Interior Alkyd Gloss Enamel.
  - .2 CAN/CGSB24.3-92, Identification of Piping Systems.
- .3 National Fire Protection Association
  - .1 NFPA 13-2013, Installation of Sprinkler Systems.
  - .2 NFPA 14-2013, Standpipe and Hose Systems.
- .4 CSA Z7396.1-2012, Medical Gas Piping Systems.

### **1.03 PRODUCT DATA**

- .1 Submit product data in accordance with Section 01 33 00.
- .2 Product data to include paint colour chips, other products specified in this section.

### **1.04 SAMPLES**

- .1 Submit samples in accordance with Section 01 33 00 - Submittal Procedures.
- .2 Samples to include nameplates, labels, tags, lists of proposed legends.

## **2 PRODUCTS**

### **2.01 MANUFACTURER'S EQUIPMENT NAMEPLATES**

- .1 Metal or plastic laminate nameplate mechanically fastened to each piece of equipment by manufacturer.
- .2 Lettering and numbers to be 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.

## 2.02 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 or white anodized aluminum, matte finish, with square corners, letters accurately aligned and machine engraved into core.
- .3 Sizes:
  - .1 Conform to following table:

#	mm	Lines	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.
  - .3 Use maximum of 25 letters/numbers per line.

## 2.03 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.

## 2.04 PIPING SYSTEMS GOVERNED BY CODES

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



.3 Standpipe and hose systems: to NFPA 14.

## 2.05 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, to 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 All other pipes: Pressure sensitive plastic-coated cloth or vinyl with protective overcoating, waterproof contact adhesive undercoating, suitable for ambient of 100%RH and continuous operating temperature of 150°C and intermittent temperature of 200°C.
- .7 Colours and Legends:
  - .1 Where not listed, obtain direction from the Departmental Representative.
  - .2 Colours for legends, arrows, to following

<u>Background colour</u>	<u>Legend, arrows</u>
Yellow	BLACK
Green	WHITE
Red	WHITE

.3 Background colour marking and legends for piping systems:

<u>Contents</u>	<u>Background colour</u>	<u>Legend</u>
** Add design temperature		
++ Add design temperature and pressured		
Domestic hot water supply	Green	DOM. HW SUPPLY
Dom. HWS recirculation	Green	DOM. HW CIRC
Domestic cold water supply	Green	DOM. CWS
Storm water	Green	STORM
Sanitary	Green	SAN
Plumbing vent	Green	SAN. VENT
Refrigeration suction	Yellow	REF. SUCTION
Refrigeration liquid	Yellow	REF. LIQUID
Refrigeration hot gas	Yellow	REF. HOT GAS

## 2.06 DUCTWORK IDENTIFICATION

- .1 50 mm high stenciled letters and directional arrows 150 mm long x 50 mm high.
- .2 Colours: Black, or coordinated with base colour to provide strong contrast.
- .3 Identify system: e.g. Supply AHU1, Exhaust F7.

## 2.07 VALVES, CONTROLLERS

- .1 Brass tags 12 mm diameter with 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.

## 2.08 CONTROLS COMPONENTS IDENTIFICATION

- .1 Identify all systems, equipment, components, controls, sensors with system nameplates specified in this Section. If no EMCS included in project, identification as per this section.
- .2 Inscriptions to include function and (where appropriate) failsafe position, component ID name.

## 2.09 LANGUAGE

- .1 Identification to be in English.
- .2 Use one nameplate, label, etc. for each language.

### **3 EXECUTION**

#### **3.01 TIMING**

- .1 Provide identification only after all painting specified in Section 09 91 00 - Painting, has been completed.

#### **3.02 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.

#### **3.03 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 in any way.

#### **3.04 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, dampers, etc. Where this is not possible, place identification as close as possible, preferably on upstream side.
- .9 Identification to be easily and accurately readable from usual operating areas and from access points.
  - .1 Position of identification to be 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.

### **3.05 VALVES, CONTROLLERS**

- .1 Valves and operating controllers, except at plumbing fixtures, radiation, or where in plain sight of equipment they serve: Secure tags with nonferrous chains or closed "S" hooks.
- .2 Install one (1) 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.

**END OF SECTION**

## **1 GENERAL**

### **1.01 SUMMARY**

- .1 TAB is used throughout this Section to describe the process, methods and requirements of testing, adjusting and balancing for HVAC.
- .2 TAB means to test, adjust and balance to perform in accordance with requirements of Contract Documents and to do other work as specified in this Section.
- .3 TAB agency will be present to assist the commissioning authority during the commissioning of HVAC systems. TAB agency will be responsible for measuring entering and leaving air temperature at all coils to calibrate EMCS and for setting the DHW balancing valves.

### **1.02 QUALIFICATIONS OF TAB PERSONNEL**

- .1 Submit names of personnel certified to AABC or NEBB to perform TAB to the Departmental Representative within 90 days of award of contract.
- .2 Provide documentation confirming qualifications, successful experience. TAB contractor must have a minimum of five (5) years' experience to AABC, NEBB or SMACNA.
- .3 Perform TAB in accordance with the requirements of standard under which TAB Firm's qualifications are approved:
  - .1 Associated Air Balance Council, (AABC) National Standards for Total System Balance, MN-1.
  - .2 National Environmental Balancing Bureau (NEBB) TABES, Procedural Standards for Testing, Adjusting, Balancing of Environmental Systems.
  - .3 Sheet Metal and Air Conditioning Contractors' National Association (SMACNA), HVAC TAB HVAC Systems - Testing, Adjusting and Balancing.
- .4 Recommendations and suggested practices contained in the TAB Standard: mandatory.
- .5 Use TAB Standard provisions, including checklists, and report forms to satisfy Contract requirements.
- .6 Use TAB standard for TAB, including qualifications for TAB Firm and Specialist and calibration of TAB instruments.

- .7 Where instrument manufacturer calibration recommendations are more stringent than those listed in the TAB standard, use manufacturer's recommendations.
- .8 TAB Standard quality assurance provisions such as performance guarantees form part of this contract.
  - .1 For systems or system components not covered in TAB standard, use TAB procedures developed by TAB Specialist.
  - .2 Where new procedures and requirements are applicable to Contract requirements have been published or adopted by body responsible for TAB Standard used (AABC, NEBB, or SMACNA), requirements and recommendations contained in these procedures and requirements are mandatory.

### **1.03 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 so as 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.

### **1.04 EXCEPTIONS**

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

### **1.05 CO-ORDINATION**

- .1 Schedule time required for TAB (including repairs, re-testing) into project construction and completion schedule so as 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.

### **1.06 PRE-TAB REVIEW**

- .1 Review contract documents before project construction is started and confirm in writing to the 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 the Departmental Representative in writing all proposed procedures which vary from standard.
- .3 During construction, co-ordinate location and installation of TAB devices, equipment, accessories, measurement ports and fittings.

#### **1.07 START-UP**

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

#### **1.08 OPERATION OF SYSTEMS DURING TAB**

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

#### **1.09 START OF TAB**

- .1 Notify the Departmental Representative seven (7) days prior to start of TAB.
- .2 Start TAB when building is essentially completed, including:
  - .1 Installation of ceilings, doors, windows, other construction affecting TAB.
  - .2 Application of weather-stripping, sealing, caulking.
  - .3 Pressure, leakage, other tests specified elsewhere in other Divisions.
  - .4 Provisions for TAB installed and operational.
- .3 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.

#### **1.10 APPLICATION TOLERANCES**

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

#### **1.11 ACCURACY TOLERANCES**

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

#### **1.12 INSTRUMENTS**

- .1 Prior to TAB, submit to the Departmental Representative list of instruments to be 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 three (3) months of TAB. Provide certificate of calibration to the Departmental Representative.

#### **1.13 SUBMITTALS**

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

#### **1.14 PRELIMINARY TAB REPORT**

- .1 Submit for checking and approval of the 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.

#### **1.15 TAB REPORT**

- .1 Format to be in accordance with referenced standard.
- .2 TAB report to show results in SI units and to include:
  - .1 Project record drawings.
  - .2 System schematics.
- .3 Submit three (3) copies of TAB Report to the Departmental Representative for verification and approval, in English in D-ring binders, complete with index tabs. Submit electronic copy that includes the same information.

#### **1.16 VERIFICATION**

- .1 Reported results subject to verification by the Departmental Representative.
- .2 Provide manpower and instrumentation to verify up to 30% of reported results.
- .3 Number and location of verified results to be at discretion of the Departmental Representative.
- .4 Bear costs to repeat TAB as required to satisfaction of the Departmental Representative.

#### **1.17 SETTINGS**

- .1 After TAB is completed to satisfaction of the 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. Markings not to be eradicated or covered in any way.

#### **1.18 COMPLETION OF TAB**

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

## **1.19 AIR SYSTEMS**

- .1 Standard: TAB to be to most stringent of this section or TAB standards of AABC or NEBB.
- .2 Do TAB of systems, equipment, components, controls specified in other Divisions.
- .3 Qualifications: personnel performing TAB to be qualified to standards of AABC or NEBB.
- .4 Quality assurance: Perform TAB under direction of supervisor qualified to standards of AABC or NEBB.
- .5 Measurements: to include, but not limited to, following 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, amperage and volts for each stage of electrical heating coils.
- .6 Locations of equipment measurements to include, but not be limited to, following as appropriate:
  - .1 Inlet and outlet of dampers, filter, coil, humidifier, fan, other equipment causing changes in conditions.
  - .2 At controllers, controlled device.
- .7 Locations of systems measurements to include, but not be limited to, following as appropriate: Main ducts, main branch, sub-branch, run-out (or grille, register or diffuser).

## **2 PRODUCTS**

### **2.01 NOT USED**

- .1 Not applicable.

## **3 EXECUTION**

### **3.01 NOT USED**

- .1 Not applicable.

**END OF SECTION**

## **1 GENERAL**

### **1.01 RELATED SECTIONS**

- .1 Section 01 33 00 - Submittal Procedures.
- .2 Section 23 05 29 - Bases, Hangers and Supports.
- .3 Section 23 05 53 - Mechanical Identification.

### **1.02 REFERENCES**

- .1 American Society for Testing and Materials International, (ASTM)
  - .1 ASTM B209M-2014, Specification for Aluminum and Aluminum Alloy Sheet and Plate (Metric).
  - .2 ASTM C335-2010e1, Test Method for Steady State Heat Transfer Properties of Pipe Insulation.
  - .3 ASTM C449-07(R2013), Standard Specification for Mineral Fiber Hydraulic Setting Thermal Insulating and Finishing Cement.
  - .4 ASTM C553-2013, Specification for Mineral Fiber Blanket Thermal Insulation for Commercial and Industrial Applications.
  - .5 ASTM C612-2014, Specification for Mineral Fiber Block and Board Thermal Insulation.
  - .6 ASTM C921-10(2015), Standard Practice for Determining Properties of Jacketing Materials for Thermal Insulation.
- .2 Canadian General Standards Board (CGSB)
  - .1 CGSB 51GP52Ma-1989, Vapour Barrier, Jacket and Facing Material for Pipe, Duct and Equipment Thermal Insulation.
- .3 Thermal Insulation Association of Canada (TIAC): National Insulation Standards.
- .4 Underwriters Laboratories of Canada (ULC)
  - .1 CAN/ULC S102-2010, Surface Burning Characteristics of Building Materials and Assemblies.
  - .2 CAN/ULC S701-2011, 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" will mean "not concealed" as defined herein.
  - .3 Insulation systems insulation material, fasteners, jackets,

and other accessories.

- .2 TIAC Codes:
  - .1 CRD: Commercial Round Ductwork,
  - .2 CRF: Commercial Rectangular Finish.
  - .3 CEF: Commercial Rigid Insulation External Application.

#### **1.04 SHOP DRAWINGS**

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

#### **1.05 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 typewritten label beneath sample indicating service.

#### **1.06 MANUFACTURERS' INSTRUCTIONS**

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

#### **1.07 QUALIFICATIONS**

- .1 Installer: specialist in performing work of this section and qualified to standards of TIAC.

#### **1.08 DELIVERY, STORAGE AND HANDLING**

- .1 Deliver materials to site in original factory packaging, labelled with manufacturer's name, address.
- .2 Protect from weather and construction traffic.
- .3 Protect against damage from any source.
- .4 Store at temperatures and conditions recommended by manufacturer.

## **2 PRODUCTS**

### **2.01 FIRE AND SMOKE RATING**

- .1 In accordance with CAN/ULCS102:
  - .1 Maximum flame spread rating: 25.
  - .2 Maximum smoke developed rating: 50.

### **2.02 INSULATION**

- .1 Mineral fiber: as specified includes glass fiber, rock wool, slag wool.
- .2 Thermal conductivity ("k" factor) not to exceed specified values at 24 C mean temperature when tested in accordance with ASTM C335.
- .3 TIAC Code C1: Rigid mineral fiber board to ASTM C612, with factory applied vapour retarder jacket to CGSB 51GP52Ma (as scheduled in PART 3 of this Section).
- .4 TIAC Code C2: Mineral fiber blanket to ASTM C553 faced with factory applied vapour retarder jacket to CGSB 51GP52Ma (as scheduled in PART 3 of this section).
  - .1 Mineral fiber: to ASTM C553.
  - .2 Jacket: to CGSB 51GP52Ma.
  - .3 Maximum "k" factor: to ASTM C553.

### **2.03 JACKETS**

- .1 Canvas:
  - .1 220 gm/m<sup>2</sup> cotton, plain weave, treated with dilute fire retardant lagging adhesive to ASTM C921.
  - .2 Lagging adhesive: Compatible with insulation.
- .2 Aluminum:
  - .1 To ASTM B209 with moisture barrier as scheduled in PART 3 of this section.
  - .2 Thickness: 0.40 mm sheet.
  - .3 Finish: Stucco embossed or corrugated.
  - .4 Jacket banding and mechanical seals: 12 mm wide, 0.5 mm thick stainless steel.
- .3 Stainless steel:
  - .1 Type: 304 or 316 where additional corrosion protection is required.
  - .2 Thickness: 0.25 mm sheet.
  - .3 Finish: Corrugated or stucco embossed.
  - .4 Jacket banding and mechanical seals: 12mm wide, 0.5 mm thick stainless steel.

- .4 Self-adhesive weather barrier membrane:
  - .1 Flexible SBS modified membrane impermeable to air, moisture vapour and water. UV light resistant, flame free adhesion.

## **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 C449.
- .4 ULC Listed Canvas Jacket:
  - .1 220 gm/m<sup>2</sup> cotton, plain weave, treated with dilute fire retardant lagging adhesive to ASTM C921. Outdoor Vapour Retarder Mastic:
    - .1 Vinyl emulsion type acrylic, compatible with insulation.
    - .2 Reinforcing fabric: Fibrous glass, untreated 305 g/m<sup>2</sup>.
- .5 Tape: self-adhesive, aluminum, reinforced, 75 mm wide minimum.
- .6 Contact adhesive: quick-setting.
- .7 Canvas adhesive: washable.
- .8 Tie wire: 1.5 mm stainless steel.
- .9 Banding: 12 mm wide, 0.5 mm thick stainless steel.
- .10 Facing: 25 mm galvanized steel hexagonal wire mesh stitched on one face of insulation.
- .11 Fasteners: 4 mm diameter pins with 35 mm diameter or square clips, length to suit thickness of insulation.

## **3 EXECUTION**

### **3.01 PRE-INSTALLATION REQUIREMENTS**

- .1 Pressure testing of ductwork systems complete, witnessed and certified.
- .2 Surfaces clean, dry, free from foreign material.

### 3.02 INSTALLATION

- .1 Install in accordance with TIAC National Standards.
- .2 Apply materials in accordance with manufacturer's instructions and as indicated.
- .3 Use two layers with staggered joints when required nominal thickness exceeds 75 mm.
- .4 Maintain uninterrupted continuity and integrity of vapour retarder jacket and finishes.
  - .1 Hangers, supports to be outside vapour retarder jacket.
- .5 Supports, Hangers in accordance with Section 23 05 29 Bases, Hangers and Supports.
  - .1 Apply high compressive strength insulation where insulation may be compressed by weight of ductwork.
- .6 Fasteners: At 300 mm oc in horizontal and vertical directions, minimum two rows each side.

### 3.03 DUCTWORK INSULATION SCHEDULE

.1 Insulation types and thicknesses: Conform to following Table:			
	<u>TIAC</u> <u>Code</u>	<u>Vapour</u> <u>Retarder</u>	<u>Thickness</u> <u>(mm)</u>
Rectangular cold and dual temperature supply air ducts (incl. HRV SA) (exposed)	C1	Yes	50
Round cold and dual temperature supply air ducts (incl. HRV SA) (concealed)	C2	Yes	50
Rectangular warm air ducts (exposed)	C1	No	25
Round warm air ducts (exposed)	C1	No	25
Rectangular cold and dual temperature supply air ducts (incl. HRV SA) (concealed)	C2	Yes	25
Round cold and dual temperature supply air ducts (incl. HRV SA) (exposed)	C1	Yes	50
Rectangular warm air ducts (concealed)	C2	No	25

Round warm air ducts (concealed)	C2	No	25
Supply, return and exhaust ducts exposed in space being served	none		
Outside air ducts to mixing Plenum	C1	Yes	50
Intake and exhaust plenums	C1	Yes	50
Exhaust duct between dampers and louvers	C1	No	50
Rectangular ducts outside	C1	special	75
Round ducts outside	C1	special	75

- .2 Jackets: Exposed round ducts 600mm and larger, smaller sizes where subject to abuse:  
.1 Use TIAC code C1 insulation, scored to suit diameter of duct.  
.2 Finishes: Conform to following table:

	TIAC Code	
	Rectangular	Round
Indoor, concealed	None	None
Indoor, exposed within mechanical room	CRF/ Canvas	CRD/ Canvas
Indoor, exposed elsewhere	CRF/ Aluminum CRF/Self	CRD/ Aluminum CRD/Self
Outdoor, exposed	adhesive weather barrier membrane	adhesive weather barrier membrane

**END OF SECTION**



## **1 GENERAL**

### **1.01 RELATED SECTIONS**

- .1 Submittal Procedures: Section 01 33 00
- .2 Joint Sealants: Section 07 92 00
- .3 Mechanical Identification: Section 23 05 53

### **1.02 REFERENCES**

- .1 American Society for Testing and Materials (ASTM)
  - .1 ASTM B209M-2014, Specification for Aluminum and Aluminum Alloy Sheet and Plate Metric.
  - .2 ASTM C335-10e1, Test Method for Steady State Heat Transfer Properties of Horizontal Pipe Insulation
  - .3 ASTM C449/C449M-07(R2013), Standard Specification for Mineral Fibre Hydraulic Setting Thermal Insulating and Finishing Cement.
  - .4 ASTM C533-2013, Standard specification for Calcium Silicate Insulation Block and Pipe.
  - .5 ASTM C534-2016, Standard Specification for Preformed Elastomeric Cellular Thermal Insulation in Sheet and Tubular Form.
  - .6 ASTM C547-2015, Standard Specification for Mineral Fibre Pipe Insulation.
  - .7 ASTM C921-10(R2015), Practice for Determining the Properties of Jacketing Materials for Thermal Insulation.
- .2 Canadian General Standards Board (CGSB)
  - .1 CGSB 51GP52Ma-1989, Vapour Barrier, Jacket and Facing Material for Pipe, Duct and Equipment Thermal Insulation.
  - .2 CAN/CGSB51.53, Poly (Vinyl Chloride) Jacketting Sheet, for Insulated Pipes, Vessels and Round Ducts.
- .3 Manufacturer's Trade Associations
  - .1 Thermal Insulation Association of Canada (TIAC): National Insulation Standards.
- .4 Underwriters' Laboratories of Canada (ULC)
  - .1 CAN/ULC S102-10, Surface Burning Characteristics of Building Materials and Assemblies.
  - .2 CAN/ULC S701-11 Thermal Insulation, Polystyrene, Boards and Pipe Covering.
  - .3 CAN/ULC S702-09, Thermal Insulation, Mineral Fiber, for Buildings

### **1.03 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 CPF: Commercial Piping Finish.

### **1.04 SHOP DRAWINGS**

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

### **1.05 SAMPLES**

- .1 Submit samples in accordance with Section 01 33 00 - Submittal Procedures.

### **1.06 MANUFACTURER'S INSTRUCTIONS**

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

### **1.07 QUALIFICATIONS**

- .1 Installer to be specialist in performing work of this Section and qualified to standards of TIAC.

### **1.08 DELIVERY, STORAGE AND HANDLING**

- .1 Deliver materials to site in original factory packaging, labelled with manufacturer's name, address.
- .2 Protect from weather, construction traffic.
- .3 Protect against damage from any source.
- .4 Store at temperatures and conditions required by manufacturer.

## **2 PRODUCTS**

### **2.01 FIRE AND SMOKE RATING**

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

### **2.02 INSULATION**

- .1 Mineral fiber specified includes glass fiber, rock wool, slag wool.
- .2 Thermal conductivity ("k" factor) not to exceed specified values at 24°C mean temperature when tested in accordance with ASTM C335.
- .3 TIAC Code A2: Rigid moulded calcium silicate in sections and blocks, and with special shapes to suit project requirements.
  - .1 Insulation: to ASTM C533.
  - .2 Maximum "k" factor: to 0.075 W/m°C @ 500°C.
  - .3 Design to permit periodic removal and reinstallation.
- .4 TIAC Code A3: Rigid moulded mineral fiber with factory applied vapour retarder jacket.
  - .1 Mineral fiber: to CAN/ULCS702 and ASTM C547.
  - .2 Jacket: to CGSB 51GP52Ma.
  - .3 Maximum "k" factor: to CAN/ULCS702.
- .5 TIAC Code A6: Flexible unicellular tubular elastomer.
  - .1 Insulation: with vapour retarder jacket to ASTM C534.
  - .2 Jacket: to CGSB 51GP52Ma.
  - .3 Maximum "k" factor: 0.039 W/m - °C.
  - .4 To be certified by manufacturer to be free of potential stress corrosion cracking corrodants
  - .5 Flame spread index less than 25, and smoke developed index less than 50.
- .6 TIAC Code C2: Mineral fiber blanket faced with factory applied vapour retarder jacket (as scheduled in PART 3 of this section).
  - .1 Mineral fiber: to CAN/ULCS702.
  - .2 Jacket: to CGSB 51GP52Ma.
  - .3 Maximum "k" factor: to CAN/ULCS702.

### **2.03 INSULATION SECRETMENT**

- .1 Tape: Self-adhesive, aluminum, plain reinforced, 50 mm wide minimum.
- .2 Contact adhesive: Quick setting.

- .3 Canvas adhesive: Washable.
- .4 Tie wire: 1.5 mm diameter stainless steel.
- .5 Bands: Stainless steel, 19 mm wide, 0.5 mm thick.

#### **2.04 CEMENT**

- .1 Thermal insulating and finishing cement:
  - .1 Hydraulic setting or air drying on mineral wool, to ASTM C449/C449M.

#### **2.05 VAPOUR RETARDER LAP ADHESIVE**

- .1 Water based, fire retardant type, compatible with insulation.
- .2 For Type A6 insulation to manufacturer's recommendation.

#### **2.06 INDOOR VAPOUR RETARDER FINISH**

- .1 Vinyl emulsion type acrylic, compatible with insulation.
- .2 For Type A6 insulation to manufacturer's recommendation.

#### **2.07 OUTDOOR VAPOUR RETARDER FINISH**

- .1 Vinyl emulsion type acrylic, compatible with insulation.
- .2 For Type A6 insulation to manufacturer's recommendation.
- .3 Reinforcing fabric: Fibrous glass, untreated 305 g/m2.

#### **2.08 JACKETS**

- .1 Polyvinyl Chloride (PVC):
  - .1 One piece moulded type and sheet to CAN/CGSB51.53 with preformed shapes as required.
  - .2 Colours: to Section 23 05 53.
  - .3 Minimum service temperatures: 20 degrees C.
  - .4 Maximum service temperature: 65 degrees C.
  - .5 Moisture vapour transmission: 0.02 perm.
  - .6 Thickness: 1.0 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.
  - .8 Special requirements:
    - .1 Indoor: flame spread rating 25, smoke developed rating 50.
    - .2 Outdoor: UV rated material at least 1.0 mm thick.

- .2 Canvas:
  - .1 220gm/m<sup>2</sup> cotton, plain weave, treated with dilute fire retardant lagging adhesive to ASTM C921.
  - .2 Lagging adhesive: Compatible with insulation.
  - .3 Aluminum:
    - .1 To ASTM B209.
    - .2 Thickness: 0.40 mm sheet.
    - .3 Finish: Stucco embossed or 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.
  - .4 Stainless steel:
    - .1 Type: 304 or type 316 where additional corrosion protection is required.
    - .2 Thickness: 0.25 mm.
    - .3 Finish: Smooth corrugated or stucco embossed.
    - .4 Joining: Longitudinal and circumferential slip joints with 50 mm laps.
    - .5 Fittings: 0.5 mm thick die shaped fitting covers with factory attached protective liner.
    - .6 Metal jacket banding and mechanical seals: stainless steel, 19 mm wide, 0.5 mm thick at 300 mm spacing.

## **2.09 WEATHERPROOF CAULKING FOR JACKETS INSTALLED OUTDOORS**

- .1 Caulking: to Section 07 92 00 - Joint Sealants.

## **3 EXECUTION**

### **3.01 PRE-INSTALLATION REQUIREMENT**

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

### **3.02 INSTALLATION**

- .1 Install in accordance with TIAC National Standards.
- .2 Apply materials in accordance with manufacturer's instructions and this specification.
- .3 Use two (2) 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 Hangers, supports to be 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.

### **3.03 REMOVABLE, PRE-FABRICATED, INSULATION AND ENCLOSURES**

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

### **3.04 INSTALLATION OF ELASTOMERIC INSULATION**

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

### **3.05 PIPING INSTALLATION SCHEDULES**

- .1 Includes valves, valve bonnets, strainers, flanges and fittings unless otherwise specified.
- .2 TIAC Code: A2.
  - .1 Insulation securements: 18 ga SS wire or 12 mm x 0.51 mm SS bands at 300 mm oc.
  - .2 Seals: lap seal adhesive, lagging adhesive.
  - .3 Installation: TIAC Code: 1501H.
- .3 TIAC Code: A3.
  - .1 Securements: Tape at 300 mm oc.
  - .2 Seals: VR lap seal adhesive, VR lagging adhesive.
  - .3 Installation: TIAC Code: 1501C.
- .4 TIAC Code: A6.
  - .1 Insulation securements: as per manufacturer's recommendation.
  - .2 Seals: lap seal adhesive, lagging adhesive.
  - .3 Installation: TIAC Code: 1501CA.

- .5 TIAC Code: C2 with vapour retarder jacket.
  - .1 Insulation securements: 18 ga SS wire or 12 mm x 05 mm ss bands at 300 mm oc.
  - .2 Seals: lap seal adhesive, lagging adhesive.
  - .3 Installation: TIAC Code: 1501C.
- .6 Have thickness of insulation listed in the following table:
  - .1 Runouts to individual units and equipment not exceeding 4000 mm long.
  - .2 Do not insulate exposed runouts to plumbing fixtures, chrome plated piping, valves, fittings.

Application	Temp °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
Roof Drain Body		C2	25	25	25	25	25	25
Domestic HWS, HWR		A-3	25	25	25	38	38	38
Domestic CWS		A-3	25	25	25	25	25	25
Refrigerant Hot Gas, Liquid, Suction	4-13	A-6	25	25	25	25	25	25
Refrigerant Hot Gas, Liquid, Suction	below 4	A-6	25	25	25	25	25	25
Cooling Coil cond. Drain		A-3	25	25	25	25	25	25
Engine exhaust		A-2	65	65	65	75	90	90

- .7 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 A3 insulation compatible with insulation.
  - .5 Outdoors: Waterproof Aluminum or SS jacket.
  - .6 Finish attachments: SS screws or bands, at 150 mm oc.  
Seals: wing or closed.

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

**END OF SECTION**



## **1 GENERAL**

### **1.01 REFERENCES**

- .1 American Society of Mechanical Engineers (ASME)
  - .1 ASME B16.22-2013, Wrought Copper and Copper Alloy Solder - Joint Pressure Fittings.
  - .2 ASME B16.24-2016, Cast Copper Pipe Flanges and Flanged Fittings: Class 150, 300, 400, 600, 900, 1500 and 2500.
  - .3 ASME B16.26-2013, Cast Copper Alloy Fittings for Flared Copper Tubes.
  - .4 ASME B31.5-2013, Refrigeration Piping and Heat Transfer Components.
- .2 American Society for Testing and Materials International (ASTM)
  - .1 ASTM A 307-2014, Standard Specification for Carbon Steel Bolts and Studs, 60,000 PSI Tensile Strength.
  - .2 ASTM B 280-2016, Standard Specification for Seamless Copper Tube for Air Conditioning and Refrigeration Field Service.
- .3 Canadian Standards Association (CSA International)
  - .1 CSA B52-2013, Mechanical Refrigeration Code.
- .4 Environment Canada (EC)
  - .1 EPS 1/RA/1-96, Environmental Code of Practice for the Elimination of Fluorocarbon Emissions from Refrigeration and Air Conditioning Systems.
- .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 Submit WHMIS MSDS in accordance with Section 01 33 00. 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 DELIVERY, STORAGE AND HANDLING**

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

## **2 PRODUCTS**

### **2.01 TUBING**

- .1 Processed for refrigeration installations, deoxidized, dehydrated and sealed.
  - .1 Hard copper: to ASTM B 280, type B.
  - .2 Annealed copper: to ASTM B 280, with minimum wall thickness as per CSA B52 and ASME B31.5.

### **2.02 FITTINGS**

- .1 Service: design pressure 2070 kPa and temperature 121 degrees C.
- .2 Brazed:
  - .1 Fittings: wrought copper to ASME B16.22.
  - .2 Joints: silver solder, 15% Ag-80% Cu-5%P or copper-phosphorous, 95% Cu-5%P and non-corrosive flux.
- .3 Flanged:
  - .1 Bronze or brass, to ASME B16.24, Class 150 and Class 300.
  - .2 Gaskets: suitable for service.
  - .3 Bolts, nuts and washers: to ASTM A307, heavy series.

- .4 Flared:
  - .1 Bronze or brass, for refrigeration, to ASME B16.26.

## **2.03 PIPE SLEEVES**

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

## **2.04 VALVES**

- .1 22 mm and under: Class 500, 3.5 Mpa, globe or angle non-directional type, diaphragm, packless type, with forged brass body and bonnet, moisture proof seal for below freezing applications, brazed connections.
- .2 Over 22 mm: Class 375, 2.5 Mpa, globe or angle type, diaphragm, packless type, back-seating, cap seal, with cast bronze body and bonnet, moisture proof seal for below freezing applications, brazed connections.

## **3 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 GENERAL**

- .1 Install in accordance with CSA B52, EPS1/RA/1, ASME B31.5 and Section 23 05 05 - Installation of Pipework.

### **3.03 BRAZING PROCEDURES**

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

### **3.04 PIPING INSTALLATION**

- .1 General:
  - .1 Soft annealed copper tubing: bend without crimping or constriction. Hard drawn copper tubing: do not bend. Minimize use of fittings. Use hard drawn tubing in straight lengths other than as required at equipment connections.

- .2 Hot gas lines:
  - .1 Pitch at least 1:240 down in direction of flow to prevent oil return to compressor during operation.
  - .2 Provide trap at base of risers greater than 2400 mm high and at each 7600 mm thereafter.
  - .3 Provide inverted deep trap at top of risers.
  - .4 Provide double risers for compressors having capacity modulation.
    - .1 Large riser: install traps as specified.
    - .2 Small riser: size for 5.1 m/s at minimum load. Connect upstream of traps on large riser.

### **3.05 PRESSURE AND LEAK TESTING**

- .1 Close valves on factory charged equipment and other equipment not designed for test pressures.
- .2 Leak test to CSA B52 before evacuation to 2MPa and 1MPa on high and low sides respectively.
- .3 Test Procedure: build pressure up to 35 kPa with refrigerant gas on high and low sides. Supplement with nitrogen to required test pressure. Test for leaks with electronic or halide detector. Repair leaks and repeat tests.

### **3.06 FIELD QUALITY CONTROL**

- .1 Site Tests/Inspection:
  - .1 Close service valves on factory charged equipment.
- .2 Ambient temperatures to be at least 13 degrees C for at least 12 hours before and during dehydration.
- .3 Use copper lines of largest practical size to reduce evacuation time.
- .4 Use two-stage vacuum pump with gas ballast on 2nd stage capable of pulling 5Pa absolute and filled with dehydrated oil.
- .5 Measure system pressure with vacuum gauge. Take readings with valve between vacuum pump and system closed.
- .6 Triple evacuate system components containing gases other than correct refrigerant or having lost holding charge as follows:
  - .1 Twice to 14 Pa absolute and hold for 4 h.
  - .2 Break vacuum with refrigerant to 14 kPa.
  - .3 Final to 5 Pa absolute and hold for at least 12 h.
  - .4 Isolate pump from system, record vacuum and time readings until stabilization of vacuum.
  - .5 Submit test results to the Departmental Representative.

- .7 Charging:
  - .1 Charge system through filter-drier and charging valve on high side. Low side charging not permitted.
  - .2 With compressors off, charge only amount necessary for proper operation of system. If system pressures equalize before system is fully charged, close charging valve and start up. With unit operating, add remainder of charge to system.
  - .3 Re-purge charging line if refrigerant container is changed during charging process.
- .8 Checks:
  - .1 Make checks and measurements as per manufacturer's operation and maintenance instructions.
  - .2 Record and report measurements to the Departmental Representative.

### **3.07 CLEANING**

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

**END OF SECTION**

## **1 GENERAL**

### **1.01 RELATED SECTIONS**

- .1 Submittal Procedures: Section 01 33 00

### **1.02 REFERENCES**

- .1 American Society for Testing and Materials (ASTM)
  - .1 ASTM A480/A480M-16a, Specification for General Requirements for Flat-Rolled Stainless and Heat-Resisting Steel Plate, Sheet and Strip.
  - .2 ASTM A635/A635M-15, Specification for Steel, Sheet and Strip, Heavy Thickness Coils, Carbon, Hot Rolled.
  - .3 ASTM A653/A653M-15E1, Specification for Steel Sheet, Zinc Coated (Galvanized) or Zinc-Iron Alloy Coated (Galvannealed) by the Hot-Dip Process.
- .2 National Fire Protection Agency (NFPA)
  - .1 NFPA 90A-2015, Installation of Air Conditioning and Ventilating Systems.
  - .2 NFPA 90B-2015, Installation of Warm Air Heating and Air Conditioning Systems.
  - .3 NFPA 91-2015, Standard for Exhaust System for Air Conveying of Vapours, Gases, Mists, and Noncombustible Particle Solids.
  - .4 NFPA 96-2014, Standard for Ventilation Control and Fire Protection of Commercial Cooking Operations.
- .3 Sheet Metal and Air Conditioning Contractors' National Association (SMACNA)
  - .1 SMACNA HVAC Duct Construction Standards, Metal and Flexible.
  - .2 SMACNA HVAC Duct Leakage Test Manual.

### **1.03 SHOP DRAWINGS AND PRODUCT DATA**

- .1 Submit shop drawings and product data in accordance with Section 01 33 00 - Submittal Procedures.
- .2 Indicate following:
  - .1 Sealants.
  - .2 Tape.
  - .3 Proprietary Joints.

### **1.04 CERTIFICATE OF RATINGS**

- .1 Catalogue or published ratings shall be those obtained from tests carried out by manufacturer or independent testing agency

signifying adherence to codes and standards.

## **1.05 WASTE MANAGEMENT AND DISPOSAL**

- .1 Separate and recycle waste materials in accordance with municipal regulations and Section 01 74 21 - Construction/Demolition Waste Management and Disposal.

## **2 PRODUCTS**

### **2.01 SEAL CLASSIFICATION**

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

### **2.02 SEALANT**

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

### **2.03 TAPE**

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

### **2.04 DUCT LEAKAGE**

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

### **2.05 FITTINGS**

- .1 Fabrication: to SMACNA.
- .2 Radiused elbows:
  - .1 Rectangular: Centreline radius: 1.5 times width of duct.
  - .2 Round: smooth radius or five piece. Centreline radius: 1.5 times diameter.
- .3 Mitred elbows, rectangular:
  - .1 To 400 mm: with single thickness turning vanes.
  - .2 Over 400 mm: with double thickness turning vanes.

- .4 Branches:
  - .1 Rectangular main and branch: with radius on branch 1.5 times width of duct or 450 entry on branch.
  - .2 Round main and branch: enter main duct at 450 with conical connection.
  - .3 Provide volume control damper in branch duct near connection to main duct.
  - .4 Main duct branches: with volume control damper.
- .5 Transitions:
  - .1 Diverging: 200 maximum included angle.
  - .2 Converging: 300 maximum included angle.
- .6 Offsets:
  - .1 Full short radiused elbows as indicated.
- .7 Obstruction deflectors: maintain full cross-sectional area. Maximum included angles: as for transitions.

## **2.06 FIRE STOPPING**

- .1 Provide and install firestopping in accordance with section 07 84 00 - Fire Stopping.
- .2 Retaining angles around duct, on both sides of fire separation only if required by authority having jurisdiction.
- .3 Firestopping material and installation must not distort duct.

## **2.07 GALVANIZED STEEL**

- .1 Lock forming quality: to ASTM A653, 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.

## **2.08 STAINLESS STEEL**

- .1 To ASTM A480/A480M, Type 304.
- .2 Finish: No 4. finish on exposed side of duct in finished areas, No. 3 finish or lower where concealed.
- .3 Thickness, fabrication and reinforcement: to SMACNA.
- .4 Joints: to SMACNA and be continuous inert gas welded.



## 2.09 ALUMINUM

- .1 To SMACNA. Aluminum type: 3003H14.
- .2 Thickness, fabrication and reinforcement: to SMACNA.
- .3 Joints: to SMACNA and be continuous weld.

## 2.10 BLACK STEEL

- .1 To ASTM A635/A635M.
- .2 Thickness: 1.2 mm
- .3 Fabrication: ducts and fittings or SMACNA.
- .4 Reinforcement: to SMACNA.
- .5 Joints: continuous weld.

## 2.11 HANGERS AND SUPPORTS

- .1 Strap hangers: of same material as duct but next sheet metal thickness heavier than duct. Maximum size duct supported by strap hanger: 500 mm.
- .2 Hanger configuration: to SMACNA.
- .3 Hangers: galvanized steel angle with black steel rods to ASHRAE or SMACNA following table:

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

- .4 Upper hanger attachments:
  - .1 For concrete: manufactured concrete inserts.
    - .1 Acceptable manufacturers Myatt, Grinnell, Hunt.
  - .2 For steel joist: manufactured joist clamp steel plate washer.
    - .1 Acceptable manufacturers Myatt, Grinnell, Hunt.
  - .3 For steel beams: manufactured beam clamps:
    - .1 Acceptable manufacturers Myatt, Grinnell, Hunt.

### 3 EXECUTION

#### 3.01 GENERAL

- .1 Do work in accordance with NFPA 90A, NFPA 90B, and SMACNA.
- .2 Do not break continuity of insulation vapour barrier with hangers or rods. Insulate strap hangers 100 mm beyond insulated duct.
- .3 Support risers in accordance with SMACNA.
- .4 Install breakaway joints in ductwork on sides of fire separation. Do not place fire stopping material in expansion space between damper sleeve and fire partition.
- .5 Install proprietary manufactured flanged duct joints in accordance with manufacturer's instructions.
- .6 Manufacture duct in lengths and diameter to accommodate installation of acoustic duct lining.

#### 3.02 HANGERS

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

<u>Duct Size</u>	<u>Spacing</u>
(mm)	(mm)
to 1500	3000
1501 and over	2500

#### 3.03 WATERTIGHT DUCT

- .1 Provide watertight duct for:
  - .1 Fresh air intake.
  - .2 Minimum 3000 mm from duct mounted humidifier in all directions.
  - .3 As indicated.
- .2 Form bottom of horizontal duct without longitudinal seams. Solder or weld joints of bottom and side sheets. Seal other joints with duct sealer.
- .3 Slope horizontal branch ductwork down towards fume hoods served. Slope header ducts down toward risers.
- .4 Fit base of riser with 150 mm deep drain sump and NPS 1 ½ drain

connected, with deep seal trap and valve and discharging to open funnel drain or service sink or as approved by Departmental Representative.

### **3.04 SEALING AND TAPING**

- .1 Apply sealant to outside of joint to manufacturer's recommendations.
- .2 Bed tape in sealant and recoat with minimum of one coat of sealant to manufacturers recommendations. Sealant and tape to be applied to full perimeter of duct.

### **3.05 LEAKAGE TESTS**

- .1 In accordance with SMACNA HVAC Duct Leakage Test Manual.
- .2 Do leakage tests in sections.
- .3 Make trial leakage tests as instructed to demonstrate workmanship.
- .4 Install no additional ductwork until trial test has been passed.
- .5 Test section minimum of 30 m long with not less than three branch takeoffs and two 90 degree elbows.
- .6 Complete test before insulation or concealment.

**END OF SECTION**

## **1 GENERAL**

### **1.01 RELATED SECTIONS**

- .1 Submittal Procedures: Section 01 33 00

### **1.02 REFERENCES**

- .1 Sheet Metal and Air Conditioning Contractors' National Association (SMACNA)
  - .1 SMACNA HVAC Duct Construction Standards, Metal and Flexible.
  - .2 SMACNA HVAC Duct Leakage Test Manual.
- .2 ASTM E84-17, Standard Test Method for Surface Burning Characteristics of Building Materials.
- .3 ASTM D2412-11, Standard Test Method for Determination of External Loading Characteristics of Plastic Pipe by Parallel-Plate Loading.

### **1.03 SHOP DRAWINGS AND PRODUCT DATA**

- .1 Submit shop drawings and product data in accordance with Section 01 33 00 - Submittal Procedures.
- .2 Indicate following:
  - .1 Sealants.
  - .2 Tape.
  - .3 Proprietary Joints.

### **1.04 CERTIFICATE OF RATINGS**

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

### **1.05 WASTE MANAGEMENT AND DISPOSAL**

- .1 Separate and recycle waste materials in accordance with municipal regulations and Section 01 74 21 - Construction/Demolition Waste Management and Disposal.

## **2 PRODUCTS**

### **2.01 SEAL CLASSIFICATION**

- .1 Classification as follows:

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

## 2.02 UNDERGROUND DUCT

- .1 Complete duct system (including: plenums, round duct, run-outs, diffuser boots, etc.) must be from one manufacturer and be of the same material, construction and connection method throughout. Field made duct components are not acceptable.
- .2 Include the complete underground duct system including plenums and diffuser boots.
- .3 Unless otherwise noted, construct all duct and fittings as per SMACNA's Duct Construction Standards (+10 w.g.).
- .4 Provide elbows, duct, diffusers, plenum, clamp & gasket, boots, saddle registers, caulk, water gauge test and adapters as required by drawings for underground installation.
- .5 Ductwork to be HDPE, closed cell plastic material that is recyclable, does not emit volatile organic compounds, and conforms to ASTM D2412. Ductwork shall be resistant to mildew, mold (UL 181B), and radon gas (BSS 7239-88). Ductwork must not rust or crack under external stress or strain. Ductwork to have R -10equivalent thermal performance value without the use of external insulation.
- .6 Seal joints via gasket or bolts and sealant. Clamps and gaskets shall be used on ductwork without flanges. Clamps to be polyethylene with 410 stainless steel plates and stainless steel screws. Gaskets shall comprise of ¼" thick butyl rubber sealant tape with silver polyester facing that is water and UV resistant and shall not stain. Gaskets shall comply with ASTM-E84 for flame and smoke spread.
- .7 Flanged joints and duct branches to use a co-polymer adhesive caulking sealant that is water and UV resistant. Flanges shall be connected with stainless steel bolts.
- .8 Assembled ductwork must be able to maintain +/- 10" static pressure with no leakage.

- .9 Have assembled ductwork approved for installations 48" below flood plain elevation without water intrusion.
- .10 Have duct system installed by an AQC Industries' certified trained installer.
- .11 Fiberglass style ductwork or PVC coated galvanized steel ductwork will not be acceptable.
- .12 Duct system performance must exceed SMACNA's Leakage Class 3 requirements at the system design static pressure.
- .13 Duct system to carry a 10-year limited warranty.

### **3 EXECUTION**

#### **3.01 GENERAL**

- .1 Do work in accordance with manufacturer's written instructions, and SMACNA.
- .2 Backfilling material: sand.
- .3 Install proprietary manufactured flanged duct joints in accordance with manufacturer's instructions.

#### **3.02 LEAKAGE TESTS**

- .1 In accordance with SMACNA HVAC Duct Leakage Test Manual.
- .2 Do leakage tests in sections 24 hours after curing of sealant.
- .3 Make trial leakage tests as instructed to demonstrate workmanship.
- .4 Install no additional ductwork until trial test has been passed.
- .5 Test section minimum of 30 m long with not less than three branch takeoffs and two 90 degree elbows.
- .6 Complete test before insulation or concealment.

**END OF SECTION**

## **1 GENERAL**

### **1.01 REFERENCES**

- .1 American Society of Heating, Refrigeration and Air Conditioning Engineers (ASHRAE)
- .2 American Society for Testing and Materials International (ASTM)
  - .1 ASTM A653/A653M-2015E1, Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process.
  - .2 ASTM C423-09a, Test Method for Sound Absorption and Sound Absorption Coefficients by the Reverberation Room Method.
  - .3 ASTM E90-09, Test Method for Laboratory Measurement of Airborne Sound Transmission Loss of Building Partitions and Elements.
  - .4 ASTM E477-2013, Test Method for Measuring Acoustical and Airflow Performance of Duct Liner Materials and Prefabricated Silencers.
- .3 National Building Code of Canada (NBC), 2010.
- .4 Sheet Metal and Air Conditioning Contractors' National Association (SMACNA).

### **1.02 SHOP DRAWINGS**

- .1 Submit shop drawings in accordance with Section 01 33 00 - Submittal Procedures.
- .2 Provide separate shop drawings for each piece of attenuation equipment complete with product data.

### **1.03 PERFORMANCE RATING DATA**

- .1 Provide performance rating data, certified by a professional engineer or accredited test laboratory and supported by calculations and verified by test results in accordance with referenced standards as follows:
  - .1 Silencer: insertion loss, pressure drop at design conditions, generated noise level.
  - .2 Acoustic plenums: transmission loss and acoustical absorption.
  - .3 Acoustical performance measurements to be made in accordance with ASTM E477, ASTM E90 and ASTM C423, except where specified otherwise.

## **2 PRODUCTS**

### **2.01 ABSORPTION AND INSULATING MEDIA**

- .1 Acoustic quality, glass fiber, free of shot and odour; bacteria and fungus resistant; free of corrosion causing or accelerating agents; packed to density to meet performance requirements; and meet NBC fire requirements or requirements of authority having jurisdiction for duct lining.

## **3 EXECUTION**

### **3.01 INSTALLATION**

- .1 Install in accordance with manufacturer's instructions.
- .2 Noise flanking: where indicated, install in wall sleeve with uniform clearance around to ensure no contact of silencer with wall sleeve. Pack with flexible, non-hardening caulking on both sides of sleeves.
- .3 Instrument test ports: install at inlet and outlet to permit measurement of insertion loss and pressure loss.
- .4 Suspension: to manufacturer's instructions.

### **3.02 SITE VISIT**

- .1 Arrange for the supplier of equipment to visit site to confirm installation is in accordance with manufacturer's instructions and submit report to the Departmental Representative.
- .2 Make adjustments and corrections in accordance with written report.
- .3 Provide Departmental Representative with notice 24 h in advance of visit.

**END OF SECTION**



## **1 GENERAL**

### **1.01 RELATED SECTIONS**

- .1 Submittal Procedures: Section 01 33 00

### **1.02 REFERENCES**

- .1 Sheet Metal and Air Conditioning Contractors' National Association (SMACNA)
  - .1 SMACNA HVAC Duct Construction Standards Metal and Flexible.

### **1.03 PRODUCT DATA**

- .1 Submit product data in accordance with Section 01 33 00 - Submittal Procedures.
- .2 Indicate the following:
  - .1 Flexible connections.
  - .2 Duct access doors.
  - .3 Turning vanes.
  - .4 Instrument test ports.

### **1.04 CERTIFICATION OF RATINGS**

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

## **2 PRODUCTS**

### **2.01 GENERAL**

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

### **2.02 FLEXIBLE CONNECTIONS**

- .1 Frame: galvanized sheet metal frame 0.66 mm thick with fabric clenched by means of double locked seams.
- .2 Material:
  - .1 Fire resistant, self-extinguishing, neoprene coated glass fabric, temperature rated at minus 400C to plus 900 degrees C, density of 1.3 kg/m2.

## **2.03 ACCESS DOORS IN DUCTS**

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

## **2.04 TURNING VANES**

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

## **2.05 INSTRUMENT TEST PORTS**

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

## **2.06 SPIN-IN COLLARS**

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

### 3 EXECUTION

#### 3.01 INSTALLATION

- .1 Flexible Connections:
  - .1 Install in following locations:
    - .1 Inlets and outlets to supply air units and fans.
    - .2 Inlets and outlets of exhaust and return air fans.
    - .3 As indicated.
  - .2 Length of connection: 100 mm.
  - .3 Minimum distance between metal parts when system in operation: 75 mm.
  - .4 Install in accordance with recommendations of SMACNA.
  - .5 When fan is running:
    - .1 Ducting on sides of flexible connection to be in alignment.
    - .2 Allow for slack material in flexible connection.
- .2 Access doors and viewing panels:
  - .1 Size:
    - .1 600 mm x 600 mm for person size entry.
    - .2 450 mm x 450 mm for servicing entry.
    - .3 300 mm x 300 mm for viewing.
    - .4 As indicated.
  - .2 Locations:
    - .1 Fire and smoke dampers.
    - .2 Control dampers.
    - .3 Devices requiring maintenance.
    - .4 Required by code.
    - .5 Reheat coils.
    - .6 Elsewhere as indicated.
- .3 Instrument test ports:
  - .1 General:
    - .1 Install in accordance with recommendations of SMACNA and in accordance with manufacturer's instructions.
  - .2 Locate to permit easy manipulation of instruments.
  - .3 Install insulation port extensions as required.
  - .4 Locations.
    - .1 For traverse readings:
      - .1 Ducted inlets to roof and wall exhausters.
      - .2 Inlets and outlets of other fan systems.
      - .3 Main and submain ducts.
      - .4 And as indicated.
    - .2 For temperature readings:
      - .1 At outside air intakes.
      - .2 In mixed air applications in locations as approved by Department Representative.

- .3 At inlet and outlet of coils.
  - .4 Downstream of junctions of two converging air streams of different temperatures.
  - .5 And as indicated.
- .4 Turning vanes:
- .1 Install in accordance with recommendations of SMACNA and as indicated.

**END OF SECTION**

## **1 GENERAL**

### **1.01 RELATED SECTIONS**

- .1 Submittal Procedures: Section 01 33 00

### **1.02 REFERENCES**

- .1 Sheet Metal and Air Conditioning National Association (SMACNA)
  - .1 SMACNA HVAC Duct Construction Standards, Metal and Flexible.

### **1.03 PRODUCT DATA**

- .1 Submit product data in accordance with Section 01 33 00 - Submittal Procedures.
- .2 Indicate the following: dimensions, materials.

## **2 PRODUCTS**

### **2.01 GENERAL**

- .1 Manufacture to SMACNA standards.

### **2.02 SINGLE BLADE DAMPERS**

- .1 Of same material as duct, 0.8 mm up to 450 mm wide, 1.6 mm maximum up to 1200 mm wide, V-groove stiffened.
- .2 Size and configuration to recommendations of SMACNA, except maximum height 100 mm.
- .3 Locking quadrant with shaft extension to accommodate insulation thickness.
- .4 Inside and outside nylon or bronze end bearings.
- .5 Channel frame of same material as adjacent duct, complete with angle stop.

### **2.03 MULTI-BLADED DAMPERS**

- .1 Factory manufactured of material compatible with duct.
- .2 Opposed blade: configuration, metal thickness and construction to recommendations of SMACNA.
- .3 Maximum blade height: 100 mm.

- .4 Bearings: pin in bronze bushings or self-lubricating nylon.
- .5 Linkage: shaft extension with locking quadrant.
- .6 Channel frame of same material as adjacent duct, complete with angle stop.
- .7 Maximum leakage: 2% at 500 Pa.

### **3 EXECUTION**

#### **3.01 INSTALLATION**

- .1 Install where indicated.
- .2 Install in accordance with recommendations of SMACNA and in accordance with manufacturer's instructions.
- .3 For supply, return and exhaust systems, locate balancing dampers in each branch duct.
- .4 Runouts to registers and diffusers: located as close as possible to main ducts.
- .5 All dampers must be vibration free.
- .6 Confirm damper operators are observable and accessible.

**END OF SECTION**

## **1 GENERAL**

### **1.01 RELATED SECTIONS**

- .1 Submittal Procedures: Section 01 33 00
- .2 Closeout Submittals: Section 01 78 00
- .3 Duct Accessories: Section 23 33 00

### **1.02 REFERENCES**

- .1 American Society for Testing and Materials (ASTM)
  - .1 ASTM A653M-15E1, Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by Hot-Dip Process.

### **1.03 PRODUCT DATA**

- .1 Submit product data in accordance with Section 01 33 00 - Submittal Procedures.
- .2 Indicate the following:
  - .1 Performance data.
  - .2 Specifications.

### **1.04 CLOSEOUT SUBMITTALS**

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

### **1.05 CERTIFICATION OF RATINGS**

- .1 Catalogue or published ratings must be those obtained from tests carried out by manufacturer or those from an independent testing agency.

## **2 PRODUCTS**

### **2.01 MULTI-LEAF DAMPERS**

- .1 Opposed or parallel blade type as indicated.
- .2 Structurally formed steel or extruded aluminum, interlocking blades, complete with extruded vinyl seals, spring stainless steel side seals, structurally formed and welded galvanized steel or extruded aluminum frame.
- .3 Pressure fit self-lubricated bronze bearings.

- .4 Linkage: plated steel tie rods, brass pivots and plated steel brackets, complete with plated steel control rod.
- .5 Performance:
  - .1 Leakage: in closed position to be less than 2% of rated air flow at 500 Pa differential across damper.
  - .2 Pressure drop: at full open position to be less than 25 Pa differential across damper at 10 m/s.
- .6 Insulated aluminum dampers:
  - .1 Frames: insulated with extruded polystyrene foam with RSI factor of 5.0.
  - .2 Blades: constructed from aluminum extrusions with internal hollows insulated with polyurethane or polystyrene foam, RSI factor of 5.0.

## **2.02 DISC TYPE DAMPERS**

- .1 Frame: insulated brake formed, welded, 1.6 mm thick, galvanized steel to ASTM A 653M.
- .2 Disc: insulated spin formed, 1.6 mm thick, galvanized steel to ASTM A 653M.
- .3 Gasket: extruded neoprene, field replaceable, with ten (10) year warranty.
- .4 Bearings: roller self-lubricated and sealed.
- .5 Operator: compatible with damper, linear stroke operator, spring loaded actuator, zinc aluminum foundry alloy casting cam follower.
- .6 Performance:
  - .1 Leakage: in closed position to be less than 2 % of rated air flow at 500 Pa pressure differential across damper.
  - .2 Pressure drop: at full open position to be less than 25 Pa differential across damper at 10 m/s.

## **2.03 BACK DRAFT DAMPERS**

- .1 Automatic gravity operated, multi leaf, aluminum or steel construction with nylon bearings, center pivoted, spring assisted or counterweighted.

## **2.04 RELIEF DAMPERS**

- .1 Automatic multi-leaf steel or aluminum dampers with ball bearing center pivoted and Counterweights set to open as indicated.



### **3 EXECUTION**

#### **3.01 INSTALLATION**

- .1 Install where indicated.
- .2 Install in accordance with recommendations of SMACNA and manufacturer's instructions.
- .3 Seal multiple damper modules with silicon sealant.
- .4 Install access door adjacent to each damper. See Section 23 33 00.
- .5 Confirm dampers are observable and accessible.

**END OF SECTION**

## **1 GENERAL**

### **1.01 RELATED SECTIONS**

- .1 Submittal Procedures: Section 01 33 00
- .2 Closeout Submittals: Section 01 78 00
- .3 Duct Accessories: Section 23 33 00

### **1.02 REFERENCES**

- .1 American National Standards Institute/National Fire Protection Association (ANSI/NFPA)
  - .1 ANSI/NFPA 90A-2015, Installation of Air Conditioning and Ventilating Systems.
- .2 Underwriters Laboratories of Canada (ULC)
  - .1 CAN/ULC S112-10, Fire Test of Fire Damper Assemblies.
  - .2 CAN/ULC S112.2-07, Fire Test of Ceiling Firestop Flap Assemblies.
  - .3 ULC S505-1974, Fusible Links for Fire Protection Service.

### **1.03 PRODUCT DATA**

- .1 Submit product data in accordance with Section 01 33 00 - Submittal Procedures.
- .2 Indicate the following:
  - .1 Fire dampers.
  - .2 Smoke dampers.
  - .3 Fire stop flaps.
  - .4 Operators.
  - .5 Fusible links.
  - .6 Design details of breakaway joints.

### **1.04 CLOSEOUT SUBMITTALS**

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

### **1.05 EXTRA MATERIALS**

- .1 Provide maintenance materials in accordance with Section 01 78 00 - Closeout Submittals.
- .2 Provide following:
  - .1 Six (6) fusible links of each type.

## **1.06 CERTIFICATE OF RATINGS**

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

## **2 PRODUCTS**

### **2.01 FIRE DAMPERS**

- .1 Fire dampers: arrangement Type B or C, blades out of air stream listed and bear label of ULC, meet requirements of provincial fire authority and ANSI/NFPA 90A. Fire damper assemblies to be fire tested in accordance with CAN/ULC S112. Minimum rating 1 ½ hours, dynamically rated.
- .2 Mild steel, factory fabricated for fire rating requirement to maintain integrity of fire wall and/or fire separation.
- .3 Top hinged: offset, round or square; multi-blade hinged or interlocking type; roll door type; or guillotine type; sized to maintain full duct cross section.
- .4 Fusible link actuated, weighted to close and lock in closed position when released or having negator spring closing operator for multi-leaf type or roll door type in horizontal position with vertical air flow.
- .5 Retaining angle iron frame, 40 mm x 40 mm x 3 mm, on full perimeter of fire damper, on both sides of fire separation being pierced.

### **2.02 SMOKE DAMPERS**

- .1 ULC or UL listed and labelled.
- .2 Normally closed reverse action smoke vent (S/DRASV): folding blade type, opening by gravity upon detection of smoke, and/or from remote alarm signalling device actuated by an electro thermal link. Two flexible stainless steel blade edge seals to provide required constant sealing pressure.
- .3 Normally open smoke/seal (S/DSSSD): folding blade type, closing when actuated by means of electro thermal link and/or from remote alarm signalling device. Blade edge seals of flexible stainless steel shall provide required constant sealing pressure. Stainless steel negator springs with locking devices shall ensure positive closure for units mounted horizontally in vertical ducts.

- .4 Motorized (S/DM): folding blade type, normally open with power on. When power is interrupted damper shall close automatically. Both damper and damper operator shall be ULC listed and labelled.
- .5 Electro thermal link (S/DETL): dual responsive fusible link which melts when subjected to local heat of 74 °C and from external electrical impulse of low power and short duration; ULC or UL listed and labelled.

### **2.03 COMBINATION FIRE AND SMOKE DAMPERS**

- .1 Damper: similar to smoke dampers specified above.
- .2 Combined actuator: electrical control system actuated from smoke sensor or smoke detection system and from fusible link.

### **2.04 FIRE STOP FLAPS**

- .1 Fire smoke flaps: ULC listed and labelled and fire tested in accordance with CAN/ULC-S112.2.
- .2 Construct of minimum 1.5 mm thick sheet steel with 1.6 mm thick non-asbestos ULC listed insulation and corrosion-resistant pins and hinges.
- .3 Flaps to be held open with fusible link conforming to ULC S505V and close at 74 °C.

## **3 EXECUTION**

### **3.01 INSTALLATION**

- .1 Install in accordance with ANSI/NFPA 90A and in accordance with conditions of ULC listing.
- .2 Maintain integrity of fire separation.
- .3 After completion and prior to concealment obtain approvals of complete installation from authority having jurisdiction.
- .4 Install access door adjacent to each damper. See Section 23 33 00.
- .5 Co-ordinate with installer of fire stopping.
- .6 Confirm access doors/panels, fusible links, damper operators are easily observed and accessible.
- .7 Install break-away joints of approved design on each side of fire separation.

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**END OF SECTION**

## **1 GENERAL**

### **1.01 REFERENCES**

- .1 Section 01 33 00 - Submittal Procedures.

### **1.02 REFERENCES**

- .1 National Fire Protection Association (NFPA)
  - .1 NFPA 90A-2015, Installation of Air Conditioning and Ventilating Systems.
  - .2 NFPA 90B-2015, Installation of Warm Air Heating and Air Conditioning Systems.
- .2 Sheet Metal and Air Conditioning Contractors' National Association (SMACNA)
  - .1 SMACNA 1966-2006, HVAC Duct Construction Standards Metal and Flexible.
- .3 Underwriter's Laboratories of Canada (ULC)
  - .1 CAN/ULC S110-13, Fire Tests for Air Ducts.
  - .2 UL 181-2013, Factory Made Air Ducts and Connectors.

### **1.03 PRODUCT DATA**

- .1 Submit product data in accordance with Section 01 33 00 - Submittal Procedures.
- .2 Indicate the following:
  - .1 Thermal properties.
  - .2 Friction loss.
  - .3 Acoustical loss.
  - .4 Leakage.
  - .5 Fire rating.

### **1.04 CERTIFICATION OF RATINGS**

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

### **1.05 SAMPLES**

- .1 Submit samples with product data of different types of flexible duct being used in accordance with Section 01 33 00 - Submittal Procedures.

## 2 PRODUCTS

### 2.01 GENERAL

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

### 2.02 METALLIC - ACOUSTIC INSULATED

- .1 Non-collapsible, coated mineral base perforated fabric type helically supported by and mechanically bonded to steel wire with factory applied flexible glass fibre acoustic insulation and encased in aluminum foil and Mylar laminate vapour barrier.
- .2 Performance:
  - .1 Factory tested to 3 kPa without leakage.
  - .2 Maximum relative pressure drop coefficient: 3.
  - .3 Acoustical performance: Minimum attenuation (dB/m) to following table:

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

## 3 EXECUTION

### 3.01 DUCT INSTALLATION

- .1 Install in accordance with: NFPA 90A and NFPA 90B SMACNA.
- .2 Do trial test to demonstrate workmanship.
- .3 Use for minimum 0.9m and maximum 1.5m between ceiling mounted diffusers and branch ducts on supply duct systems only. Do not use for exhaust air duct systems.
- .4 Flexible duct to have no more than a 15 degree offset and have a minimum of two (2) hangers.

END OF SECTION

## **1 GENERAL**

### **1.01 RELATED SECTIONS**

- .1 General Commissioning Requirements: Section 01 91 13
- .2 Duct Accessories: Section 23 33 00

### **1.02 REFERENCES**

- .1 AMCA 99-2010, Standards Handbook.
- .2 ANSI/AMCA 210/ASHRAE 51-2007, Laboratory Methods of Testing Fans for Rating.
- .3 ANSI/AMCA 300-08, Reverberant Room Method for Sound Testing of Fans.
- .4 ANSI/AMCA 301-2014, Methods for Calculating Fan Sound Ratings from Laboratory Test Data.
- .5 CGSB 1.181M-99, Coating, Zinc Rich, Organic, Ready Mixed.
- .6 NEMA ICS 7.1-2006, Safety Standard for Construction and Guide for Selection, Installation and Operation of Adjustable Speed Drive Systems.
- .7 American Bearing Manufacturers Association (ABMA).

### **1.03 SHOP DRAWINGS AND PRODUCT DATA**

- .1 Submit shop drawings and product data in accordance with Section 01 33 00 - Submittal Procedures.
- .2 Provide:
  - .1 Fan performance curves showing point of operation, BHP and efficiency.
  - .2 Sound rating data at point of operation.
  - .3 Dimensional data.
  - .4 Installation procedures.
- .3 Indicate:
  - .1 Motors, sheaves, bearings, shaft details.
  - .2 Minimum performance achievable with variable speed controllers and variable inlet vanes as appropriate, dimensions, installation procedure.



#### **1.04 CLOSEOUT SUBMITTALS**

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

#### **1.05 EXTRA MATERIALS**

- .1 Provide maintenance materials in accordance with Section 01 33 00 - Submittal Procedures.
  - .1 Spare parts to include:
    - .1 Matched sets of belts.
    - .2 Furnish list of individual manufacturer's recommended spare parts for equipment such as bearings and seals, and addresses of suppliers, together with list of specialized tools necessary for adjusting, repairing or replacing, for placement into operating manual.

#### **1.06 MANUFACTURED ITEMS**

- .1 Catalogued or published ratings must be those obtained from tests carried out by manufacturer or from independent testing agency signifying adherence to codes and standards in force.

#### **1.07 WARRANTY**

- .1 Provide warranty for parts and labour for one (1) year following project Substantial Completion.

### **2 PRODUCTS**

#### **2.01 FANS GENERAL**

- .1 Capacity: flow rate, static pressure, bhp, efficiency, revolutions per minute, power, model, size, sound power data and as indicated on schedule.
- .2 Fans: statically and dynamically balanced, constructed in conformity with AMCA 99.
- .3 Sound ratings: comply with AMCA 301, tested to AMCA 300. Unit shall bear AMCA certified sound rating seal.
- .4 Performance ratings: based on tests performed in accordance with ANSI/AMCA 210, and ANSI/ASHRAE 51. Unit must bear AMCA certified rating seal, except for propeller fans smaller than 300 mm diameter.
- .5 Open drip proof outside of air stream.
- .6 Motors: sizes as specified.

- .7 Accessories and hardware: matched sets of V-belt drives, adjustable slide rail motor bases, belt guards, coupling guards, fan inlet and/or outlet safety screens as indicated.
- .8 Factory primed before assembly in colour standard to manufacturer.
- .9 Scroll casing drains: as indicated.
- .10 Bearing lubrication systems plus extension lubrication tubes where bearings are not easily accessible.
- .11 Flexible connections: to Section 23 33 00 - Duct Accessories.

## **2.02 CENTRIFUGAL FANS**

- .1 Fan wheels:
  - .1 Welded steel or aluminum construction.
  - .2 Maximum operating speed of centrifugal fans not more than 40 % of first critical speed.
  - .3 Air foil or backward inclined blades, as indicated.
- .2 Bearings: air handling quality, heavy duty, split pillow block, flange mounted grease lubricated ball or roller self-aligning type with oil retaining, dust excluding seals and a certified minimum rated life to ABMA L10 of 100,000 hours.
- .3 Housings:
  - .1 Volute with inlet cones: fabricated steel for wheels 300 mm or greater, cast iron, or steel, for smaller wheels, braced, and with welded supports.
  - .2 For horizontally and vertically split housings provide flanges on each section for bolting together, with gaskets of non-oxidizing nonflammable material.
  - .3 Provide bolted latched airtight access doors with handles.

## **2.03 CEILING FANS**

- .1 As shown on drawings and in schedule.
- .2 Sustainability Characteristics: fan to possess the ENERGY STAR Most Efficient 2015 designation. The bamboo fan assembly, as a system, must be built pursuant to environmental and sustainability standards of the Forest Stewardship Council.
- .3 Quality: fan to display good workmanship in all aspects of its construction. Field balancing of the airfoils must not be necessary.
- .4 Colors and Materials: Airfoil materials and colors to be selected by the Departmental Representative.

- .5 Optional Accessories:
  - .1 Wall-mounted controller (in addition to the standard remote control).
- .6 Universal Mounting system:
  - .1 Universal mount must be suitable for flat or sloped ceilings.
  - .2 Equip the fan with a mounting bracket, canopy, mounting ball and wedge, extension tubes, wiring cover, motor hub, and mounting hardware.
  - .3 Include an extension tube with the fan as indicated.
  - .4 Fan to be available with a diameter of 1.3 m (52"), 1.5 m (60"), or 2.1 m (84") as indicated.
- .7 Equip the fan with three (3) airfoils spanning a total diameter of 1.3 m (52"), 1.5 m (60"), or 2.1 m (84"), as indicated. Airfoils to be available in the following materials: Bamboo or Aluminum polished finish. Aluminum airfoils must be damp-rated for use in covered outdoor spaces.
- .8 Motor:
  - .1 Fan to have an electronically commutated motor (ECM) rated for 100-240 VAC, single-phase.
  - .2 Motor to draw 1.41-52 watts depending on the speed at which the fan is operated and if a light is installed.
  - .3 Provide fan designed for continuous operation in ambient temperatures of 32-104°F (0-40°C), and a humidity range of 20-90% (non-condensing).
  - .4 Fan's motor unit and motor unit trim to be available in the following finishes:
    - .1 Fans with Caramel Bamboo airfoils: White, black, satin nickel, or oil-rubbed bronze.
    - .2 Fans with Cocoa Bamboo airfoils: Black, satin nickel, or oil-rubbed bronze.
    - .3 Fans with aluminum airfoils: Black or white.
- .9 Safety Cable:
  - .1 Equip fan with a safety cable that provides an additional means of securing the fan assembly to the building structure. Safety cable to be 1.5 mm in diameter and fabricated of aircraft steel. Field construction of safety cables is not permitted.
- .10 Wall Control:
  - .1 Equip fan with a wireless wall control in addition to the standard remote control, as specified by the Departmental Representative.
  - .2 Wall Control to include temperature, humidity, and motion sensors.
  - .3 The user must be able to group the wall control with one or

- more fans for simultaneous control of fan speed.
- .4 Wall control buttons to control the fan (on/off and variable speed).

## **2.04 GRAVITY VENTILATORS**

- .1 Housings: spun aluminum.
- .2 Roof curb, 350 mm high, continuous curb gaskets, cadmium plated or stainless steel securing bolts and screws, and special mated sound insulating 350 mm high curbs where indicated. Hinge curb plate for access to internals for maintenance.
- .3 As indicated.

## **3 EXECUTION**

### **3.01 CEILING FAN PREPARATION**

- .1 The fan location must have an appropriate ceiling-mounted outlet box marked, "Acceptable for Fan Support." If there is not an appropriate outlet box already installed at the location, one must be installed on a ceiling joist or beam and be properly wired. Additional mounting options may be available. Consult the installation guide for additional details.
- .2 The fan location must be free from obstacles such as lights, cables, or other building components.
- .3 Check the fan location for proper electrical requirements. Consult the installation guide for appropriate circuit requirements.

### **3.02 CEILING FAN INSTALLATION**

- .1 Install the fan according to the manufacturer's installation guide, which includes acceptable mounting methods.
- .2 Required Distances:
  - .1 For 1.5 m and 1.3 m fans, the airfoils must be at least 2.1 m above the floor.
  - .2 For 2.1 m fans, the airfoils must be at least 2.4 m above the floor.
  - .3 The airfoils must have at least 0.6 m clearance from all obstructions.
  - .4 The fan must be within a 9.1 m radius of where the mobile digital device will be used for control. (Line-of-sight obstructions may create a smaller maximum range.)
  - .5 Do not locate fan where it will be subjected to rain or continuous wind gusts, or in close proximity to the outputs

of HVAC systems or radiant heaters. Consult the installation guide for additional details.

### **3.03 FAN INSTALLATION**

- .1 Install fans as indicated, complete with flexible electrical leads and flexible connections in accordance with Section 23 33 00 - Duct Accessories.
- .2 Provide sheaves and belts required for final air balance.
- .3 Bearings and extension tubes to be easily accessible.
- .4 Access doors and access panels to be easily accessible.
- .5 Provide installation in strict accordance with manufacturer's recommendations.
- .6 Grease fan bearing prior to operation.

### **3.04 COMMISSIONING**

- .1 Do commissioning in accordance with Section 01 91 13 - Commissioning General Requirements.

**END OF SECTION**

## **1 GENERAL**

### **1.01 RELATED SECTIONS**

- .1 Submittal Procedures: Section 01 33 00
- .2 Closeout Submittals: Section 01 78 00

### **1.02 PRODUCT DATA**

- .1 Submit product data in accordance with Section 01 33 00 - Submittal Procedures.
- .2 Indicate the following:
  - .1 Capacity.
  - .2 Throw and terminal velocity.
  - .3 Noise criteria.
  - .4 Pressure drop.
  - .5 Neck velocity.

### **1.03 SAMPLES**

- .1 Submit samples in accordance with Section 01 33 00 - Submittal Procedures.

### **1.04 CERTIFICATIONS**

- .1 Catalogued or published ratings must be those obtained from tests carried out by manufacturer or from independent testing agency signifying adherence to codes and standards.

### **1.05 EXTRA MATERIALS**

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

## **2 PRODUCTS**

### **2.01 GENERAL**

- .1 To meet capacity, pressure drop, terminal velocity, throw, noise level, neck velocity.
- .2 Frames:

- .1 Full perimeter gaskets.
- .2 Plaster frames where set into plaster or gypsum board.
- .3 Concealed fasteners.
- .3 Concealed manual volume control damper operators as indicated.
- .4 Colour: standard or as directed by the Departmental Representative.

## **2.02 MANUFACTURED UNITS**

- .1 Grilles, registers and diffusers of same generic type, products of one manufacturer.

## **2.03 SUPPLY GRILLES AND REGISTERS**

- .1 See Schedule.

## **2.04 RETURN AND EXHAUST GRILLES AND REGISTERS**

- .1 See Schedule.

## **2.05 DIFFUSERS**

- .1 See Schedule.

## **2.06 LINEAR GRILLES**

- .1 See Schedule.

# **3 EXECUTION**

## **3.01 INSTALLATION**

- .1 Install in accordance with manufacturer's instructions.
- .2 Install with flat head stainless steel or cadmium plated screws in countersunk holes where fastenings are visible.
- .3 Provide concealed safety chain on each grille, register and diffuser in gymnasium and similar game rooms and elsewhere.

**END OF SECTION**

## **1 GENERAL**

### **1.01 REFERENCES**

- .1 American National Standards Institute (ANSI)/ National Fire Protection Association (NFPA)
  - .1 ANSI/NFPA 96-2014, Standard for Ventilation Control and Fire Protection of Commercial Cooking Operations.
- .2 American Society for Testing and Materials (ASTM)
  - .1 ASTM E90-09, Method for Laboratory Measurement of Airborne Sound Transmission Loss of Building Partitions and Elements.
- .3 Sheet Metal and Air Conditioning Contractors' National Association (SMACNA)
- .4 Society of Automotive Engineers (SAE)

### **1.02 PRODUCT DATA**

- .1 Submit product data in accordance with Section 01 33 00 - Submittal Procedures.
- .2 Indicate the following:
  - .1 Pressure drop.
  - .2 Face area.
  - .3 Free area.
  - .4 Dimensions.

### **1.03 TEST REPORTS**

- .1 Submit certified data from independent laboratory substantiating acoustic and aerodynamic performance to ASTM E90.

### **1.04 CERTIFICATION OF RATINGS**

- .1 Catalogued or published ratings to be those obtained from tests carried out by manufacturer or those ordered by him from independent testing agency signifying

## **2 PRODUCTS**

### **2.01 FIXED LOUVRES - ALUMINUM**

- .1 Construction: welded with exposed joints ground flush and smooth.
- .2 Material: extruded aluminum alloy 6063T5.



- .3 Blade: drainable, with stormproof pattern with centre watershed in blade, reinforcing bosses and maximum blade length of 1500mm.
- .4 Frame, head, sill and jamb: 150 mm deep one piece extruded aluminum, minimum 3 mm thick with approved caulking slot, integral to unit. Flanged frame or flush frame as indicated.
- .5 Mullions: at 1500 mm maximum centres.
- .6 Fastenings: stainless steel with nuts and resilient neoprene washers between aluminum and head of bolt, or between nut, ss washer and aluminum body.
- .7 Screen: 12 mm on exhaust and intake mesh, 2 mm diam wire aluminum birdscreen on inside face of louvres in formed U-frame.
- .8 Finish: factory applied enamel, or anodized as indicated. Colour: to Engineer's approval.

### **3 EXECUTION**

#### **3.01 INSTALLATION**

- .1 In accordance with manufacturer's and SMACNA recommendations.
- .2 Reinforce and brace as indicated.
- .3 Anchor securely into opening. Seal with caulking to achieve weather tightness.

**END OF SECTION**

## **1 GENERAL**

### **1.01 SUMMARY**

- .1 Section Includes:
  - .1 Materials and application of electric duct heaters.

### **1.02 RELATED SECTIONS**

- .1 Section 01 33 00 - Submittal Procedures.
- .2 Section 01 91 13 - General Commissioning (Cx) Requirements
- .3 Section 26 05 00 - Common Work Results - Electrical.

### **1.03 REFERENCES**

- .1 Canadian Standards Association (CSA International)
  - .1 CSA C22.2 No. 46-13, Electric Air-Heaters.
- .2 Department of Justice Canada (Jus.)
  - .1 Canadian Environmental Protection Act (CEPA)
- .3 Transport Canada (TC)
  - .1 Transportation of Dangerous Goods Act (TDGA)

### **1.04 SUBMITTALS**

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

## **2 PRODUCTS**

### **2.01 DUCT HEATERS**

- .1 Duct heaters: flange type or insert type.
- .2 To carry CSA Approval.
- .3 Elements:
  - .1 Open coil elements of nickel-chrome resistance wire.
  - .2 Coils machine crimped into stainless steel terminals extending at least 25mm into the air stream.
  - .3 All terminal hardware shall be stainless steel.
  - .4 Coils shall be supported by ceramic bushings staked into the supporting brackets.
- .4 Frames: Heater frames and boxes to be corrosion resistant steel.
- .5 Terminal box:
  - .1 NEMA 1 general purpose enclosure.
  - .2 Hinged, latching cover.
  - .3 Multiple concentric knockouts to accept field wiring.
  - .4 Terminal blocks to accommodate field wiring.
  - .5 All internal wiring to be complete with 105°C rated insulation.
- .6 Ratings:
  - .1 Heaters to be rated for voltage, phase, and KW capacity as indicated in schedule on drawings.
  - .2 All three phase heaters to have equal, balanced, three phase stages.
  - .3 Supply heaters with size and quantity of fixed and proportional heating stages as indicated in schedule.
- .7 Controls:
  - .1 Factory mounted and wired in control box. Use terminal blocks for power and control wiring.
  - .2 Controls to include:
    - .1 Magnetic contactors.
    - .2 Fixed differential pressure switch.
    - .3 Manual and automatic reset high limit.
    - .4 Control transformers.
    - .5 Solid state relays.
    - .6 Door interlocked disconnect switch (non-fused).
    - .7 HRC load fuses.
    - .8 Electronic hybrid step controller.
    - .9 Heater to be controlled by 0 - 10 VDC or 4-20mA remote control signal from the building automation system supplied and installed by the EMCS contractor.
  - .3 Performance: see schedule.

- .4 Provide heater complete with protective screens on inlet/outlet.

### **3 EXECUTION**

#### **3.01 INSTALLATION**

- .1 Make power and control connections in accordance with CSA C22.2 No.46. Install in accordance with manufacturer's instructions.

#### **3.02 COMMISSIONING**

- .1 Perform tests in accordance with Section 01 91 13 - General Commissioning (Cx) Requirements and Section 26 05 00 - Common Work Results - Electrical.

**END OF SECTION**

## **1 GENERAL**

### **1.01 RELATED SECTIONS**

- .1 Section 01 33 00 - Submittal Procedures.
- .2 Section 01 74 21 - Construction/Demolition Waste Management and Disposal.
- .3 Section 01 78 00 - Closeout Submittals
- .4 Section 01 91 13 - Commissioning General Requirements.
- .5 Section 09 91 00 - Painting.
- .6 Section 23 33 00 - Duct Accessories.
- .7 Section 23 33 15 - Dampers Operating.
- .8 Section 23 34 00 - Commercial Fans.

### **1.02 REFERENCES**

- .1 ANSI/NFPA
  - .1 ANSI/NFPA90A-2015, Standard for the Installation of Air Conditioning and Ventilating Systems.
- .2 Canadian General Standards Board (CGSB)
  - .1 CGSB 1.181-99, Ready Mixed Organic Zinc Rich Coating.
- .3 Sheet Metal and Air-Conditioning Contractors' National Association (SMACNA).
- .4 Canadian Standards Association
  - .1 CSA B52-14 Mechanical Refrigeration Code.
  - .2 CAN/CSA C22.2 No. 236-15, Heating and Cooling Equipment.
- .5 American Bearing Manufacturer's Association
  - .1 ANSI/ABMA 9:2015 Load Ratings and Fatigue Life for Ball Bearings.
  - .2 ANSI/ABMA 11:2014 Load Ratings and Fatigue Life for Roller Bearings.
- .6 Air Movement and Control Association
  - .1 AMCA 300-2014 Reverberant Room Method for Sound Testing of Fans.
- .7 American Society of Heating Refrigeration and Air-Conditioning Engineers.

- .1 ASHRAE 68-1997, Laboratory Method of Testing to Determine the Sound Power in a Duct.
- .2 ASHRAE 90.1-2016, Standard 90.1-2016 (I-P Edition) -- Energy Standard for Buildings Except Low-Rise Residential Buildings.
- .8 National Electrical Manufacturer's Association
  - .1 NEMA MG1-2014 Motors and Generators.
  - .2 NEMA ICS 71 Safety Standards for Construction and Guide for Selection, Installation and Operation of Adjustable Speed Drive Systems.
- .9 Provincial Boiler Pressure Vessel and Compressed Gas Regulations.

#### **1.03 SHOP DRAWINGS AND PRODUCT DATA**

- .1 Submit shop drawings and product data in accordance with Section 01 33 00 - Submittal Procedures.
- .2 Indicate following:
  - .1 Construction specifications, dimensions, weights, fans, motors, vibration isolation, coils, capacities, curves, filter housings, filters, mixing boxes, dampers. Controls actuators, accessories installation procedures, and control wiring diagrams.

#### **1.04 CLOSEOUT SUBMITTALS**

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

#### **1.05 EXTRA MATERIALS**

- .1 Provide maintenance materials in accordance with Section 01 78 00 - Closeout Submittals.
- .2 Furnish list of individual manufacturer's recommended spare parts for equipment such as bearings and seals, and addresses of suppliers, together with list of specialized tools necessary for adjusting, repairing or replacing, for placement into operating manual.
- .3 Provide one (1) set of filters for start-up, one set for commissioning, and one (1) spare set of filters for each unit.

#### **1.06 WARRANTY**

- .1 Provide extended parts and labour warranty for five (5) years from the Substantial Performance Completion date.

## **1.07 CERTIFICATIONS**

- .1 Air handling units to be cETLus safety listed to conform to UL Standard 1995 and CAN/CSA C22.2 No. 236.
- .2 Conform to the Performance Rating of Air- to-Air Heat Exchangers for. Energy Recovery certification program, AHRI Standard 1060.
- .3 Heating and cooling coils to be certified in accordance with the forced circulation air cooling and air heating coils certification program, AHRI Standard 410.
- .4 Heat recovery devices must be certified to ANSI/AHRI 1060.

## **2 PRODUCTS**

### **2.01 GENERAL**

- .1 Factory assembled components to form units supplying air at design conditions as indicated.

### **2.02 MANUFACTURED ITEMS**

- .1 Catalogued or published ratings must be those obtained from tests carried out by manufacturer or those ordered by him from independent testing agency signifying adherence to codes and standards in force.
- .2 Air-to-Air Energy Recovery Ventilators to be fully assembled at the factory and consist of a fixed-plate cross-flow heat exchanger with no moving parts, an insulated cabinet, filter assemblies for both intake and exhaust air, enthalpy core, supply air blower assembly, exhaust air blower assembly and electrical control box with all specified components and internal accessories factory installed and tested and prepared for single-point high voltage connection. Entire unit with the exception of field-installed components must be assembled and test operated at the factory.
- .3 HRV supplier to confirm dimensions for use of their equipment in the space available.
- .4 Acoustics: Sound power levels (dB) for the unit will be controlled by the use of sound attenuating material inside the HRV casing and proper fan selection/mounting. Provide the necessary sound treatment to meet acceptable noise levels as required. Submit unit sound power for comparison with the basis of design equipment.

## 2.03 FANS

- .1 To Section 23 34 00 - Commercial Fans.
- .2 Blower motors to be Premium Efficiency, EISA compliant for energy efficiency. Blower motors to be totally enclosed (TEFC) and supplied with factory installed motor starters. Belt drive motors shall be provided with adjustable pulleys and motor mounts allowing for blower speed adjustment, proper motor shaft orientation and proper belt tensioning. Provide electrically commutated motors (ECM) where indicated.
- .3 Select fans to achieve the unit supply and return airflows specified on the equipment schedules. Account for losses within the equipment, i.e. leakage and purge at the heat recovery device, as required.

## 2.04 Casing

- .1 Materials: Formed double wall insulated metal cabinet, fabricated to permit access to internal components for maintenance.
- .2 Outside casing: 20 gauge, galvanized (G90) steel meeting ASTM A653 for components that do not receive a painted finish.
- .3 Access doors to be hinged with airtight closed cell foam gaskets. Door pressure taps, with captive plugs, shall be provided for cross-core pressure measurement allowing for accurate airflow measurement.
- .4 Unit shall have factory-installed duct flanges on all duct openings.
- .5 Cabinet Insulation: Unit walls and doors shall be insulated with 1 inch, 4 pound density, foil/scrim faced, high density fiberglass board insulation, providing a cleanable surface and eliminating the possibility of exposing the fresh air to glass fibers, and with a minimum R-value of 4.3 (hr-ft<sup>2</sup>-°F/BTU).
- .6 Enthalpy core: Energy recovery core to be of the total enthalpy type, capable of transferring both sensible and latent energy between airstreams. Latent energy transfer shall be accomplished by direct water vapor transfer from one airstream to the other, without exposing transfer media in succeeding cycles directly to the exhaust air and then to the fresh air. The energy recovery core shall be designed and constructed to permit cleaning and removal for servicing. The energy recovery core must have a ten year warranty. Performance criteria to be as specified in AHRI Standard 1060.



- .7 Control center/connections: Energy Recovery Ventilator shall have an electrical control center where all high and low voltage connections are made. Construct control center to permit single-point high voltage power supply connections to the non-fused disconnect(s). Refer to the equipment schedule and controls details for additional information.
- .8 Passive Frost Control: ERV core to perform without condensing or frosting under normal operating conditions (defined as outside temperatures above -10°F and inside relative humidity below 40%). Occasional more extreme conditions must not affect the usual function, performance or durability of the core.
- .9 Filters (SA and EA): as indicated.

## **2.05 ENERGY RECOVERY**

- .1 Equip unit with energy recovery component using fixed-plate cross-flow construction and no moving parts.
- .2 No condensate drain pans or drains will be allowed and unit must be capable of operating in both winter and summer conditions without generating condensate.
- .3 The heat recovery core shall be capable of transferring both sensible and latent energy between airstreams. Latent energy transfer shall be accomplished by direct water vapor transfer from one airstream to the other, without exposing transfer media in succeeding cycles directly to the exhaust air and then to the fresh air.

## **2.06 ELECTRICAL**

- .1 Fan motors to be manufacturer provided and installed, Totally Enclosed Fan Cooled premium efficiency (meets or exceeds EPAct requirements), 1750 RPM, single speed, suitable for operation with a Variable Frequency Drive. Refer to the equipment schedule and controls details for additional information.
- .2 Unit(s) to be ETL and ETL-Canada listed by Intertek Testing Services, Inc. Units must conform to bi-national standard ANSI/UL Standard 1995/CSA Standard C22.2 No. 236.
- .3 VFD's: Where indicated, provide factory installed and wired VFD's as per Division 25. Provide independent blower control where indicated.
- .4 Manufacturer to provide ASHRAE 90.1 Energy Efficiency equation details for individual equipment to assist Building Engineer for calculating system compliance.

### **3 EXECUTION**

#### **3.01 INSTALLATION**

- .1 Fabricate to provide smooth air flow through all components. Limit air leakage to 1 % of rated air flow at 2.5 kPa suction pressure.
- .2 Apply sealer into all seams prior to assembly. Secure toe angles continuous along entire length of assembly.
- .3 Install in accordance with manufacturer's Installation and Maintenance instructions.
- .4 Do not operate units for any purpose, temporary or permanent, until ductwork is clean, filters are in place, bearings lubricated, and fan has been test run under observation.

#### **3.02 COMMISSIONING**

- .1 Manufacturer's representative to provide one day on site per unit for start- up and one day for commissioning to Section 01 91 13 - Commissioning General Requirements.

#### **3.03 EXTRA MATERIALS**

- .1 Provide three (3) sets of filters.

**END OF SECTION**

## **1 GENERAL**

### **1.01 REFERENCES**

- .1 Air-Conditioning and Refrigeration Institute (ARI)
  - .1 ARI 210/240-2008, Performance Rating for Unitary Air Conditioning and Air-Source Heat Pump Equipment.
- .2 American National Standards Institute/Air-Conditioning and Refrigeration Institute (ANSI/ARI)
  - .1 ANSI/ARI 320-98, Water-Source Heat Pumps.
- .3 American National Standards Institute/National Fire Protection Association (ANSI/NFPA)
  - .1 ANSI/NFPA 90A-2018, Installation of Air Conditioning and Ventilating Systems.
- .4 American Society of Heating, Refrigeration and Air-Conditioning Engineers (ASHRAE)
  - .1 ASHRAE Standard 15-2010, Safety Standard for Mechanical Refrigeration.
- .5 Canadian Standards Association (CSA)
  - .1 CSA C22.1-15, Canadian Electrical Code.
  - .2 CAN/CSA C446- Series- 02(R2007), Consolidated - Design and Installation of Energy Systems.
  - .3 CAN/CSA C13256-1-2001, Water Source Heat Pumps - Test and Rating Performance.
- .6 Environment Canada
  - .1 EPS 1/RA/2-1996, Code of Practice for the Reduction of Chlorofluorocarbon Emissions from Refrigeration and Air Conditioning Systems.
  - .2 Environment Canada-1994, Ozone-Depleting Substances Alternatives and Suppliers List.

### **1.02 SHOP DRAWINGS AND PRODUCT DATA**

- .1 Submit shop drawings in accordance with Sections 01 33 00.
- .2 Indicate:
  - .1 Capacities.
  - .2 ARI Ratings.
  - .3 Sound Power levels.
  - .4 Installation instructions.
  - .5 Start-up Instructions.
  - .6 O&M, Instructions.
  - .7 Refrigerant pipe routing and sizes.

.8 Control system details.

### **1.03 SYSTEM DESCRIPTION**

- .1 The simultaneous heating and cooling Variable Refrigerant Flow (VRF) systems to consist of an outdoor unit, high efficiency heat recovery units designed for minimum piping and maximum design flexibility, indoor units, and controls by the equipment manufacturer. Every indoor unit must be independently capable of operating in either heating or cooling mode regardless of the mode of other indoor units. The system shall be capable of changing mode of individual indoor units (cooling to heating or heating to cooling) within a maximum time of 5 minutes to ensure indoor temperature can be properly maintained. Supervisory controls will be via Delta BacNET system through a BacNET interface. Provide and install software and all necessary accessories to permit maintenance and trouble shooting.

### **1.04 QUALITY ASSURANCE**

- .1 Units to be manufactured in a facility registered to ISO 9001 and ISO14001 which is a set of standards applying to environmental protection set by the International Standard Organization (ISO).
- .2 Provide wiring in accordance with the CSA C22.1.
- .3 The units must be listed by Electrical Testing Laboratories (ETL) or ULC and bear the ETL or ULC label.

### **1.05 STORAGE AND HANDLING**

- .1 Store VRF equipment protected from weather, extreme temperature, etc. as suggested by the manufacturer. Move and lift VRF equipment as suggested by the manufacturer.

### **1.06 WARRANTY**

- .1 VRF equipment must be warranted by the manufacturer's limited warranty for a period of one year from date of installation or 18 months from the project substantial completion. An extended warranty including one (1) additional year parts and labour and five (5) additional years compressor shall be granted upon submission to the manufacturer and acceptance by the manufacturer of proper installation with documentation including:
  - .1 Selection output and layout of the VRF system.
  - .2 60 minutes of operational history upon commissioning from the VRF service tool.
  - .3 Completed commissioning report as per the VRF equipment manufacturer.

- .2 During this period, repair or replace any part failing to function properly due to faulty workmanship or material at the VRF equipment manufacturer's discretion and shall all associated include labor.
- .3 Have the VRF system installed by a licensed mechanical contractor trained by the VRF equipment manufacturer or certified manufacturer's agent.
- .4 Have commissioning and start-up performed by the manufacturer or certified manufacturer's agent. Allow one day (separate from start-up) for functional testing as part of commissioning.

## **2 PRODUCTS**

### **2.01 SIMULTANEOUS HEATING AND COOLING OUTDOOR UNIT**

- .1 General:
  - .1 Use the outdoor units with VRF components of the same manufacturer consisting of the outdoor unit, high efficiency heat recovery units, indoor units, factory designed and supplied Y-branches, and controls.
  - .2 System components to be of the same manufacturer or as recommended by the manufacturer of the VRF equipment.
  - .3 Unit control boards must perform all functions required to effectively and efficiently operate the VRF system and communicate in a daisy chain configuration from outdoor unit to heat recovery and indoor units via RS485.
  - .4 The outdoor units must be completely factory assembled, piped and wired. Dual and triple frame outdoor units will be field piped with factory designed and supplied Y-branch kits to manifold them together into a single refrigerant circuit.
  - .5 Have each outdoor unit run tested at the factory.
  - .6 The sum of connected nominal capacity of all indoor air handlers shall range from 50% to 130% of outdoor unit nominal capacity to ensure the VRF system will have sufficient capacity to handle the building space loads at peak design.
  - .7 Outdoor units to have a tested sound rating no higher than 65 dB(A) per outdoor unit frame tested per KSA0701. Note that this level is for the entire two module unit.
  - .8 All refrigerant lines from the outdoor unit to the heat recovery unit and from the heat recovery unit to the indoor units shall be field insulated using ACR copper pipe and in strict accordance with the equipment manufacturer's recommendations.
  - .9 The outdoor units must have an accumulator.
  - .10 The outdoor units must have a high pressure safety switch.

- .11 The outdoor units shall have over-current protection.
  - .12 The outdoor units shall use a brazed plate sub-cooling heat exchanger.
  - .13 The outdoor units shall have the ability to operate at elevations indicated.
  - .14 The outdoor units shall allow up to a total equivalent refrigerant piping length of 225m.
  - .15 The maximum length from outdoor unit to indoor unit shall be up to 40m without traps.
  - .16 The outdoor units shall be capable of operating in heating only mode down to -4F and up to 61F ambient wet bulb without additional low ambient controls.
  - .17 The outdoor units shall be capable of operating in cooling only mode down to 21F and up to 110F ambient dry bulb.
  - .18 The outdoor units shall be capable of operating in simultaneous heating and cooling mode down to 14F and up to 86F ambient dry bulb.
  - .19 The outdoor units shall have an oil separator for each compressor and controls to ensure sufficient oil supply is maintained for the compressor.
  - .20 Shall use R410A refrigerant.
  - .21 Each outdoor unit frame shall have a removable inspection panel no greater than 6 inches tall or 12 inches wide to allow access to service tool connection, DIP switches, auto addressing and error codes.
  - .22 Outdoor units shall include a factory-applied anti-corrosion coating for use in this exposed coastal environment.
  - .23 The equipment manufacturer will determine the final refrigerant pipe routing and sizing in order to ensure that the system meets their equipment requirements.
- .2 Frame:
- .1 Shall be constructed with galvanized steel, bonderized and be finished with powder coat baked enamel paint. Aluminum, mill finish is also acceptable.
- .3 Compressor:
- .1 All 208V, 3-phase outdoor unit frames shall be equipped with one hermetic digitally controlled inverter driven scroll compressor and one hermetic constant speed scroll compressor.
  - .2 A crankcase heater shall be factory mounted on all compressors.
  - .3 The outdoor unit compressor shall have an inverter to modulate capacity. The frequency of the inverter compressor shall be completely variable from 25 to 105Hz.
  - .4 The compressor shall be equipped with an internal thermal overload.

- .5 The compressor shall be mounted to avoid the transmission of vibration.
- .4 Fan:
  - .1 All outdoor unit frames shall be furnished with two direct drive, variable speed propeller type fans.
  - .2 All fan motors shall have inherent protection, have permanently lubricated bearings, and be variable speed with a maximum speed up to 950 rpm.
  - .3 All fans shall be provided with a raised guard to limit contact with moving parts.
  - .4 The outdoor unit shall have vertical discharge airflow.
  - .5 Outdoor unit shall have a static pressure capability up to 0.16 inches wg to accommodate additional external static pressure introduced by the air guide.
- .5 Coil:
  - .1 The outdoor coil shall be of nonferrous construction with louvered fins on copper tubing.
  - .2 Coil fins to have a factory applied corrosion resistant material with hydrophilic coating. The unit shall meet the specified capacities with a provision for this corrosion protection.
  - .3 Protect the coil with an integral metal guard.
  - .4 Refrigerant flow from the outdoor unit shall be controlled by means of a digitally controlled inverter driven scroll compressor.
- .6 Electrical:
  - .1 The outdoor unit electrical power shall be 208/230V, 60 Hz, 3 phase.
  - .2 The outdoor unit must be capable of operation within voltage limits of +/- 10% rated voltage.
  - .3 The outdoor unit will be controlled by integral microprocessors.
  - .4 The control circuit between the indoor units, heat recovery box and the outdoor unit shall be 24VDC completed using a 2-conductor, stranded, shielded cable for the daisy chain communication.
- .7 Controls:
  - .1 Heat Pump and Heat Recovery units to be factory wired with necessary electrical control components, integral microprocessors, printed circuit boards, thermistors, sensors, terminal blocks, and lugs for power wiring. The control circuit between the indoor units, heat recovery unit and the outdoor unit shall be 24VDC completed using a two- conductor, stranded, and shielded cable for the RS-485 daisy chain communication. Microprocessor-based algorithms shall provide component protection, soft-start capability,

refrigeration system pressure, temperature, defrost, and ambient control. Provide central controller with touch screen interface to provide central system control of all indoor and outdoor units. Provide BacNET interface for integrating the heat pump system into the building DDC system as indicated on controls drawings. Refer to the controls drawing for additional requirements.

## **2.02 HEAT RECOVERY UNITS FOR SIMULTANEOUS HEATING AND COOLING SYSTEMS**

- .1 Provide heat recovery units (or 'BC box') designed for use with VRF equipment of the same manufacturer.
- .2 Heat recovery units shall have factory installed control boards that interface to the VRF equipment controls system and shall perform all functions to effectively and efficiently control the simultaneous heating and cooling VRF system.
- .3 Heat recovery units must be completely factory assembled, internally piped and wired.
- .4 Have heat recovery units run tested at the factory.
- .5 Provide heat recovery units designed for indoor installation.
- .6 Shall use R410A refrigerant.
- .7 All refrigerant lines from the outdoor unit to the indoor units shall be field insulated.
- .8 Heat recovery units shall allow multiple indoor units to be connected as indicated on drawings.
- .9 Heat recovery units will be permitted to be piped in series or parallel to minimize material cost and labor.
- .10 Heat Recovery Unit Construction:
  - .1 The heat recovery unit housing shall be galvanized steel.
  - .2 Each heat recovery unit shall contain piping, valves and controls to divert refrigerant for optimum efficiency.
  - .3 Heat recovery units shall be internally insulated.
- .11 Refrigerant System:
  - .1 R410A refrigerant shall be required for all VRF equipment and components including indoor units, outdoor units, refrigerant piping, valves, Y- branches, heat recovery units, etc. as applicable.
- .12 Refrigerant valves:
  - .1 Each port shall be circuited with two 2-position solenoid valves to control refrigerant flow path.



- .2 Isolation valves shall be field supplied and installed for ease of service to the heat recovery unit without evacuating the entire system refrigerant charge.
- .3 Shall be designed for use with R410A.
- .13 Electrical:
  - .1 The heat recovery box electrical power shall be 208/230V, 1 phase, 60 Hz.
  - .2 All units must be capable of satisfactory operation within +/-10% of nominal voltage.
  - .3 The heat recovery unit will be controlled by integral microprocessors from the main control in the outdoor unit.
  - .4 The control circuit between the indoor units, heat recovery box and the outdoor unit shall be 24VDC completed using a 2-conductor, stranded and shielded cable for the daisy chain communication.
- .14 Controls:
  - .1 Heat Recovery units to include factory installed control boards and integral microprocessors that communicate with the main control board in the outdoor unit and interface with the VRF equipment controls system. The control circuit between the indoor units, Heat Recovery unit, and the outdoor unit shall be a field wired system, 24VDC using a two conductor, stranded and shielded cable for the RS-485 daisy chain communication. Install wiring in strict accordance with the manufacturers' recommendations. Refer to the controls drawing for additional requirements.

## 2.03 FAN COILS

- .1 Ceiling concealed, low static, horizontal draw through for ducted installation.
- .2 Refer to schedule on drawing for performance.
- .3 Unit shall be complete with refrigerant coils, fan, motor, belt drives, drain pan, condensate lift pump and filter.
- .4 Unit shall include single point power connection and NEMA 1 electrical/controls enclosure with terminal strip for electrical termination.
- .5 Provide wired wall controllers for each zone (sometimes multiple fan coils) as indicated on drawings and controls schematics. Provide ability to control fan speed, temperature, mode,
- .6 Provide external heater adaptor giving the ability to send enable/disable signal to auxiliary electric heat.

### **3 EXECUTION**

#### **3.01 INSTALLATION**

- .1 Install where indicated and in accordance with manufacturer's instructions.
- .2 Nothing to obstruct ready access to all components or to prevent removal of components for servicing.

#### **3.02 START-UP**

- .1 Manufacturer to certify installation.
- .2 Manufacturer to test and start up units and certify performance.
- .3 Manufacturer to provide verbal, video, and written instructions to operating personnel.
- .4 Submit written report to Owner's Representative as defined in Division 01 as pre-functional testing.
- .5 Allow one day on site for functional testing as defined in section 01 91 13 - Commissioning General Requirements.

**END OF SECTION**