## Part 1 General

### 1.1 REFERENCES

.1 Definitions:

.1 HVAC System: complete air duct system from outside air intake louvers to furthest air supply terminal unit and including:

.1 Rigid supply and return ductwork;

.2 Flexible ductwork;

.3 Mixing plenum boxes;

.4 Return air plenums including ceiling plenums;

.5 Cooling and heating coils and compartments;

.6 Condensate drain pans, eliminator blades and humidifiers;

.7 Fans, fan blades and fan housing;

.8 Filter housing and frames;

.9 Acoustically insulated duct linings;

.10 Diffusers, registers and terminal units;

.11 Dampers and controls;

.2 Reference Standards:

.1 National Air Duct Cleaners Association (NADCA)

.1 ACR Standard: Assessment, Cleaning and Restoration of HVAC Systems.

.2 North American Insulation Manufacturers Association (NAIMA)

.1 NAIMA, Cleaning Fibrous Glass Insulated Duct Systems - Recommended Practices.

.3 United States Environmental Protection Agency (US EPA)

.1 US EPA, 40 CFR Parts 152 and 156.

### 1.2 ACTION AND INFORMATIONAL SUBMITTALS

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

.2 Submit video survey and cleaning plan developed during Site evaluation.

.1 Ensure plan includes sequence of operation, identification of camera and cleaning apparatus insertion points and schedule for Work.

.3 Product Data:

.1 Submit manufacturer's printed product literature and data sheets for antimicrobial agents and include product characteristics, performance criteria and limitations.

.2 Provide two copies of WHMIS MSDS in accordance with Section 01 35 30 - Health and Safety and Section 01 35 43 - Environmental Procedures for antimicrobial agents or coatings.

.4 Submit verification of delivery of hazardous or toxic waste materials to contaminated waste facility, as described in PART 3 - CLEANING - Waste Management.

### 1.3 CLOSEOUT SUBMITTALS

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

.2 Post Cleaning Inspection Report: submit one copy of Final Inspection Report, including data collected, observations and recommendations as well as following information:

- .1 Name and address of facility;
- .2 Name and address of HVAC cleaning contractor;
- .3 Description of HVAC systems with drawings identifying systems cleaned;
- .4 Identification scheme for location points in systems that were inspected with accompanying notes describing methods of inspection or tests used;
- .5 Identification of points where samples were collected and type of analysis used for each collection;
- .6 Identification of each sample collected;
- .7 Comments complete with photographs of each sampling location and other observed system features;
- .8 Identify systems tested, observations, actions taken and recommendations for future maintenance.

.3 Submit verification of delivery of hazardous or toxic waste materials to contaminated waste facility.

### 1.4 EXTRA MATERIALS

.1 Extra Stock Materials:

- .1 Supply 4 extra filters for each HVAC System cleaned.
- .2 Ensure filters are correct match, size, type and configuration of existing HVAC Systems.

### 1.5 QUALITY ASSURANCE

.1 Contractor: 5 years minimum experience in work similar to or exceeding Work of this Section.

## Part 2 Products

### 2.1 ACCESS DOORS AND PANELS

.1 Equipment Access Doors and Panels: construct from same materials as equipment panelling complete with sealing gasket and positive locking device.

- .1 Size access doors and panels in equipment to allow for inspection and cleaning.

.2 Ductwork Access Doors: Refer to Section 23 33 00 Air Duct Accessories.

.3 Access Doors and Panels Acoustic Lining: Refer to Section 23 33 00 Air Duct Accessories.

### 2.2 SYSTEM FILTERS

.1 Supply and install new filters for each HVAC System cleaned.

### 2.3 AIR DUCT CLEANING EQUIPMENT

.1 Manually propelled full contact brushes:

.1 Ensure brushes are specifically manufactured and shaped to fit individual ducts, equipment and components of HVAC system.

.1 Ensure brushes are sized to fit various duct sizes in HVAC system.

.2 Ensure brushes make scrubbing motion and full contact with HVAC system interior surfaces to be cleaned.

.2 Brushes: manually propelled with integrally-mounted motor bristles.

.1 Ensure motor has capacity to continue to push brush after bristles are distorted.

.2 Replace worn and ineffective brushes when required.

### 2.4 HEPA FILTER EVACUATION FAN

.1 Evacuation Fan: includes fan, HEPA filter, flexible hose and motor capable of maintaining debris and particulates airborne in airstream until they reach evacuation fan and maintaining system under negative pressure.

.1 Ensure HEPA filters are clean and maintain evacuation fan and HEPA filter to run efficiently.

## Part 3 Execution

### 3.1 PREPARATION

.1 Close down HVAC system.

.2 Locate and identify externally visible HVAC system features which may affect cleaning process including:

.1 Control devices;

.2 Fire and smoke control dampers;

.3 Balancing dampers: indicate and record positions for resetting;

.4 Air volume control boxes: indicate and record positions for resetting;

.5 Fire alarm devices;

.6 Monitoring devices and controls;

.3 Cut openings in equipment panels and ductwork for access to system interior.

.4 Installation of Access Doors and Panels: install access doors and panels for equipment to facilitate system inspection and cleaning.

.1 Install access doors and panels for inspection and cleaning of equipment as follows:

.1 Heating and cooling coils;

.2 Fan units;

.3 Filters;

.4 Dampers;

.5 Sensors;

.5 Installation of Access Doors in Ductwork: Refer to Section 23 33 00 Air Duct Accessories.

.6 Remove and reinstall ceiling tiles to gain access to HVAC system as required.

.1 Replace ceiling tiles damaged or soiled by air duct cleaning procedures.

## 3.2 EXAMINATION / PRE-CLEANING INSPECTION

.1 Verification of Conditions:

.1 Make visual inspection of interior of HVAC system using remote controlled robotic camera.

.2 Insert camera at pre-established strategic locations to evaluate condition and cleanliness of HVAC systems and components.

.2 Evaluation and Assessment:

.1 Identify location and type of internal components.

.2 Identify extent of potential problems.

## 3.3 DUCT CLEANING

.1 Do duct cleaning in accordance with NADCA ACR Standard.

.2 Isolate and clean sections in zones to ensure that dirt deposits and debris from zone being cleaned does not pass through another zones which has already been cleaned.

.3 Ensure vacuum units and evacuation fans are securely in place before starting cleaning operation of isolated section of HVAC air duct system.

.4 Install HEPA filter evacuation fan at one end of zone section and insert full contact brushes at other end.

.5 Clean supply, exhaust, return, transfer ductwork and plenums, equipment and components.

.6 Energize brushes to travel from insertion point to HEPA filter evacuation fan.

.1 Pass brushes through sections as often as necessary to achieve required cleanliness.

.2 Change brush sizes as required to ensure positive contact with duct and component interiors.

.3 Clean corners and pockets where dirt and debris can accumulate.

.7 Clean equipment, components and other features in isolated zone before moving to next zone of HVAC air duct system.

.8 Clean diffusers, registers, louvers, and all other terminal units.

.9 Remove perforated supply diffusers from suspended tee-bar ceiling.

.1 Dismantle and clean perforated plates and supply diffuser duct collars.

.2 Re-assemble perforated plate diffusers and reconnect to HVAC system using supply diffuser duct collar after cleaning.

## 3.4 COMPONENTS AND EQUIPMENT CLEANING

.1 Brush and vacuum coils, air handling unit enclosures, and heat exchanger surfaces to achieve required cleanliness.

.2 When cleaning equipment and components by brushing and vacuuming is inappropriate or insufficient, dismantle and remove equipment or component.

.1 Pressure wash with water and cleaning solution until required cleanliness is achieved.

.2 Clean equipment and components in place only if there is no hazard to adjacent materials.

.3 Compressed air and manual cleaning is acceptable only for cleaning individual components and small areas as follows:

.1 Fan blades;

.2 Dampers;

.3 Turning vanes;

.4 Controls;

.5 Sensor bulbs;

.6 Fire alarms;

.7 Smoke detectors;

## 3.5 FIELD QUALITY CONTROL/FINAL INSPECTIONS

.1 Post Cleaning Inspection: carry out final inspection using visual inspection methods after final cleaning has been completed.

.1 Identify on HVAC system record drawings access points used for inspection and cleaning.

.2 Reset components including dampers and sensors, which have been disturbed during cleaning operations.

## 3.6 SYSTEM STARTUP

.1 Install new system filters after cleaning operations are completed.

.2 Cover each inspection opening with access door or panel and secure in place after inspection and cleaning are completed.

.3 Restart each HVAC system.

## 3.7 CLEANING

.1 Clean in accordance with Section 01 74 00 - Cleaning.

.1 Waste Management: In accordance with 01 74 21 Construction Waste Management.

**END OF SECTION**

## Part 1 General

### 1.1 SUMMARY

.1 Section Includes:

.1 Use of mechanical systems during construction.

### 1.2 USE OF SYSTEMS

.1 Use of new or existing permanent HVAC systems for supplying temporary heating, cooling or ventilation is not permitted.

## Part 2 Products

### 2.1 NOT USED

.1 Not Used.

## Part 3 Execution

### 3.1 NOT USED

.1 Not Used.

**END OF SECTION**

## Part 1 General

### 1.1 REFERENCES

.1 Canadian General Standards Board (CGSB)

.1 CAN/CGSB-1.181, Ready-Mixed Organic Zinc-Rich Coating.

.2 Canada Green Building Council (CaGBC)

.1 LEED Canada 2009 for Design and Construction, LEED Canada 2009 for Design and Construction Leadership in Energy and Environmental Design Green Building Rating System Reference Guide.

.3 Green Seal Environmental Standards (GSES)

.1 Standard GS-11, Environmental Standard for Paints and Coatings.

.4 National Fire Code of Canada (NFCC 2005)

### 1.2 ACTION AND INFORMATIONAL SUBMITTALS

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

.2 Product Data:

.1 Provide manufacturer's printed product literature, specifications and datasheets for piping and equipment and include product characteristics, performance criteria, physical size, finish and limitations.

.3 Sustainable Design Submittals:

.1 Submittals: in accordance with Section 01 47 15 - LEED Sustainable Requirements.

### 1.3 QUALITY ASSURANCE

.1 Sustainability Standards Certification:

.1 Low-Emitting Materials: provide listing of sealants and coatings used in the building, comply with VOC and chemical component limits in accordance with Section 01 47 15 - LEED Sustainable Requirements

### 1.4 DELIVERY, STORAGE AND HANDLING

.1 Deliver, store and handle materials in accordance with Section 01 60 00 - Common Product Requirements and with manufacturer's written instructions.

.2 Delivery and Acceptance Requirements:

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

.1 Waste Management: In accordance with 01 74 21 Construction Waste Management.

## Part 2 Products

### 2.1 MATERIAL

.1 Paint: zinc-rich to CAN/CGSB-1.181.

.1 Primers, paints and coating: in accordance with manufacturer's recommendations for surface conditions.

.2 Primer: maximum VOC limit in accordance with Section 01 47 15 - LEED Sustainable Requirements.

.3 Paints: maximum VOC limit in accordance with Section 01 47 15 - LEED Sustainable Requirements.

.2 Sealants: in accordance with Section 07 92 00 - Joint Sealants.

.1 Sealants: maximum VOC limit in accordance with Section 01 47 15 - LEED Sustainable Requirements.

.3 Adhesives: maximum VOC limit in accordance with Section 01 47 15 - LEED Sustainable Requirements

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

## Part 3 Execution

### 3.1 APPLICATION

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

### 3.2 CONNECTIONS TO EQUIPMENT

.1 In accordance with manufacturer's instructions unless otherwise indicated.

.2 Use valves and either unions or flanges for isolation and ease of maintenance and assembly.

.3 Use double swing joints when equipment mounted on vibration isolation and when piping subject to movement.

### 3.3 CLEARANCES

.1 Provide clearance around systems, equipment and components for observation of operation, inspection, servicing, maintenance and as recommended by manufacturer and related codes.

.2 Provide space for disassembly, removal of equipment and components without interrupting operation of other system, equipment, components.

### 3.4 DRAINS

.1 Install piping with grade in direction of flow except as indicated.

.2 Install drain valve at low points in piping systems, at equipment and at section isolating valves.

.3 Pipe each drain valve discharge separately to above floor drain.

.1 Discharge to be visible.

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

**3.5 AIR VENTS**

.1 Install automatic air vents at high points in the piping.

.2 Install isolating valve at each automatic air valve.

.3 Install drain piping to approved location and terminate where discharge is visible.

**3.6 DIELECTRIC COUPLINGS**

.1 General: compatible with system, to suit pressure rating of system.

.2 Locations: where dissimilar metals are joined.

.3 NPS 2 and under: isolating unions or bronze valves.

.4 Over NPS 2: isolating flanges.

**3.7 PIPEWORK INSTALLATION**

.1 Screwed fittings jointed with Teflon tape.

.2 Protect openings against entry of foreign material.

.3 Install to isolate equipment and allow removal without interrupting operation of other equipment or systems.

.4 Assemble piping using fittings manufactured to ANSI standards.

.5 Saddle type branch fittings may be used on mains if branch line is no larger than half size of main.

.1 Hole saw (or drill) and ream main to maintain full inside diameter of branch line prior to welding saddle.

.6 Install exposed piping, equipment, rectangular cleanouts and similar items parallel or perpendicular to building lines.

.7 Install concealed pipework to minimize furring space, maximize headroom, conserve space.

.8 Slope piping, except where indicated, in direction of flow for positive drainage and venting.

.9 Install, except where indicated, to permit separate thermal insulation of each pipe.

.10 Group piping wherever possible.

.11 Ream pipes, remove scale and other foreign material before assembly.

.12 Use eccentric reducers at pipe size changes to ensure positive drainage and venting.

.13 Provide for thermal expansion as indicated.

.14 Valves:

.1 Install in accessible locations.

.2 Remove interior parts before soldering.

.3 Install with stems above horizontal position unless indicated.

.4 Valves accessible for maintenance without removing adjacent piping.

.5 Install globe valves in bypass around control valves.

.6 Use ball or butterfly valves at branch take-offs for isolating purposes except where specified.

.7 Install butterfly valves between weld neck flanges to ensure full compression of liner.

.8 Install ball valves for glycol service.

.15 Check Valves:

.1 Install silent check valves where indicated on plans.

## 3.8 SLEEVES

.1 General: install where pipes pass through masonry, concrete structures, fire rated assemblies, and as indicated.

.2 Material: schedule 40 black steel pipe.

.3 Construction: use annular fins continuously welded at mid-point at foundation walls and where sleeves extend above finished floors.

.4 Sizes: 6 mm minimum clearance between sleeve and uninsulated pipe or between sleeve and insulation.

.5 Installation:

.1 Concrete, masonry walls, concrete floors on grade: terminate flush with finished surface.

.2 Other floors: terminate 25 mm above finished floor.

.3 Before installation, paint exposed exterior surfaces with heavy application of zinc-rich paint to CAN/CGSB-1.181.

.6 Sealing:

.1 Foundation walls and below grade floors: fire retardant, waterproof non-hardening mastic.

.2 Elsewhere:

.1 Provide space for firestopping.

.2 Maintain fire rating integrity.

.3 Sleeves installed for future use: fill with lime plaster or other easily removable filler.

.4 Ensure no contact between copper pipe or tube and sleeve.

## 3.9 ESCUTCHEONS

.1 Install on pipes passing through walls, partitions, floors, and ceilings in finished areas.

.2 Construction: one piece type with set screws.

.1 Chrome or nickel plated brass or type 302 stainless steel.

.3 Sizes: outside diameter to cover opening or sleeve.

.1 Inside diameter to fit around pipe or outside of insulation if so provided.

## 3.10 PREPARATION FOR FIRE STOPPING

.1 Install firestopping within annular space between pipes, ducts, insulation and adjacent fire separation in accordance with Section 07 84 00 - Fire Stopping.

.2 Uninsulated unheated pipes not subject to movement: no special preparation.

.3 Uninsulated heated pipes subject to movement: wrap with non-combustible smooth material to permit pipe movement without damaging fires topping material or installation.

.4 Insulated pipes and ducts: ensure integrity of insulation and vapour barriers.

## 3.11 FLUSHING OUT OF PIPING SYSTEMS

.1 Flush system in accordance with Section 23 08 02 - Cleaning and Start-up of Mechanical Piping Systems.

.2 Before start-up, clean interior of piping systems in accordance with requirements of Section 01 74 00 - Cleaning supplemented as specified in relevant mechanical sections.

.3 Preparatory to acceptance, clean and refurbish equipment and leave in operating condition, including replacement of filters in piping systems.

## 3.12 PRESSURE TESTING OF EQUIPMENT AND PIPEWORK

.1 Advise Contract Administrator 48 hours minimum prior to performance of pressure tests.

.2 Pipework: test as specified in relevant sections of heating, ventilating and air conditioning work.

.3 Maintain specified test pressure without loss for 4 hours minimum unless specified for longer period of time in relevant mechanical sections.

.4 Prior to tests, isolate equipment and other parts which are not designed to withstand test pressure or media.

.5 Pay costs for repairs or replacement, retesting, and making good. Contract Administrator to determine whether repair or replacement is appropriate.

.6 Insulate or conceal Work only after approval and certification of tests.

## 3.13 CLEANING

.1 Clean in accordance with Section 01 74 00 - Cleaning.

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

.2 Waste Management: In accordance with 01 74 21 Construction Waste Management.

**END OF SECTION**

## Part 1 General

### 1.1 REFERENCES

.1 American Society of Mechanical Engineers (ASME)

.1 ASME B40.100, Pressure Gauges and Gauge Attachments.

.2 ASME B40.200, Thermometers, Direct Reading and Remote Reading.

.2 Canada Green Building Council (CaGBC)

.1 LEED Canada 2009 for Design and Construction, LEED Canada 2009 for Design and Construction Leadership in Energy and Environmental Design Green Building Rating System Reference Guide.

.3 Canadian General Standards Board (CGSB)

.1 CAN/CGSB-14.4, Thermometers, Liquid-in-Glass, Self Indicating, Commercial/Industrial Type.

.2 CAN/CGSB-14.5, Thermometers, Bimetallic, Self-Indicating, Commercial/Industrial Type.

.4 Efficiency Valuation Organization (EVO)

.1 International Performance Measurement and Verification Protocol (IPMVP)

.1 IPMVP Version.

.5 Green Seal Environmental Standards (GS)

.1 GS-11, Standard for Paints and Coatings.

.2 GS-36, Standard for Commercial Adhesives.

### 1.2 ACTION AND INFORMATIONAL SUBMITTALS

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

.2 Product Data:

.1 Submit manufacturer's instructions, printed product literature and data sheets for thermometers and pressure gauges and include product characteristics, performance criteria, physical size, finish and limitations.

.3 Sustainable Design Submittals:

.1 Submittals: in accordance with Section 01 47 15 - LEED Sustainable Requirements.

### 1.3 DELIVERY, STORAGE AND HANDLING

.1 Deliver, store and handle materials in accordance with Section 01 60 00 - Common Product Requirements and with manufacturer's written instructions.

.2 Delivery and Acceptance Requirements: deliver materials to Site in original factory packaging, labelled with manufacturer's name and address.

.3 Storage and Handling Requirements:

.1 Store thermometers and pressure gauges in accordance with manufacturer's recommendations in clean, dry, well-ventilated area.

.2 Store and protect thermometers and pressure gauges from damage.

.3 Replace defective or damaged materials with new.

.4 Waste Management: In accordance with 01 74 21 Construction Waste Management.

## Part 2 Products

### 2.1 GENERAL

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

.2 Ranges: as indicated.

### 2.2 DIRECT READING THERMOMETERS

.1 Industrial, variable angle type, mercury-free, liquid filled, 125 mm scale length

.1 Resistance to shock and vibration.

### 2.3 THERMOMETER WELLS

.1 Copper pipe: copper or bronze.

.2 Steel pipe: brass.

### 2.4 PRESSURE GAUGES

.1 112 mm, dial type: to ASME B40.100, Grade 2A, stainless steel bourdon tube having 0.5% accuracy full scale unless otherwise specified.

.2 Provide:

.1 Snubber for pulsating operation.

.2 Gasketted pressure relief back with solid front.

.3 Bronze stop cock.

## Part 3 Execution

### 3.1 EXAMINATION

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

.1 Visually inspect substrate in presence of Contract Administrator

.2 Inform Contract Administrator of unacceptable conditions immediately upon discovery.

.3 Proceed with installation only after unacceptable conditions have been remedied.

### 3.2 GENERAL

.1 Install thermometers and gauges so they can be easily read from floor or platform.

.1 If this cannot be accomplished, install remote reading units.

.2 Install between equipment and first fitting or valve.

**3.3 THERMOMETERS**

.1 Install in wells on piping. Include heat conductive material inside well.

.2 Install in locations as indicated and on inlet and outlet of:

.1 Heat exchangers.
.2 Water heating coils.
.3 Water boilers.

.3 Use extensions where thermometers are installed through insulation.

**3.4 PRESSURE GAUGES**

.1 Install in locations as follows:

.1 Suction and discharge of pumps.
.2 Upstream and downstream of PRV's.
.3 Upstream and downstream of control valves.
.4 Inlet and outlet of coils.
.5 Inlet and outlet of liquid side of heat exchangers.
.6 Outlet of boilers.
.7 In other locations as indicated.

.2 Use extensions where pressure gauges are installed through insulation.

**3.5 NAMEPLATES**

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

**3.6 CLEANING**

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

.1 Leave Work area clean at end of each day.

.2 Final Cleaning: upon completion remove surplus materials, rubbish, tools and equipment in accordance with Section 01 74 00 - Cleaning.

.3 Waste Management: In accordance with 01 74 21 Construction Waste Management.

**3.7 PROTECTION**

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

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

**END OF SECTION**

## Part 1 General

### 1.1 REFERENCES

.1 American National Standards Institute (ANSI)/American Society of Mechanical Engineers (ASME)

.1 ANSI/ASME B1.20.1, Pipe Threads, General Purpose (Inch).

.2 ANSI/ASME B16.18, Cast Copper Alloy Solder Joint Pressure Fittings.

.2 ASTM International

.1 ASTM A276, Standard Specification for Stainless Steel Bars and Shapes.

.2 ASTM B62, Standard Specification for Composition Bronze or Ounce Metal Castings.

.3 ASTM B283, Standard Specification for Copper and Copper Alloy Die Forgings (Hot-Pressed).

.4 ASTM B505/B505M, Standard Specification for Copper-Base Alloy Continuous Castings.

.3 Canada Green Building Council (CaGBC)

.1 LEED Canada 2009 for Design and Construction, LEED Canada 2009 for Design and Construction Leadership in Energy and Environmental Design Green Building Rating System Reference Guide.

.4 Manufacturers Standardization Society of the Valve and Fittings Industry, Inc. (MSS)

.1 MSS-SP-25, Standard Marking System for Valves, Fittings, Flanges and Unions.

.2 MSS-SP-80, Bronze Gate Globe, Angle and Check Valves.

.3 MSS-SP-110, Ball Valves, Threaded, Socket-Welding, Solder Joint, Grooved and Flared Ends.

### 1.2 ACTION AND INFORMATIONAL SUBMITTALS

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

.2 Product Data:

.1 Provide manufacturer's printed product literature and data sheets for equipment and systems and include product characteristics, performance criteria, physical size, finish and limitations.

.2 Submit WHMIS MSDS - Material Safety Data Sheets in accordance with Section 02 81 01 - Hazardous Materials.

.3 Shop Drawings:

.1 Submit data for valves specified in this Section.

.4 Sustainable Design Submittals:

.1 Submittals: in accordance with Section 01 47 15 - LEED Sustainable Requirements.

**1.3 CLOSEOUT SUBMITTALS**

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

**1.4 MAINTENANCE MATERIAL SUBMITTALS**

.1 Extra Materials/Spare Parts:

.1 Furnish following spare parts:

.1 Valve seats: one for every 10 valves each size, minimum 1.

.2 Discs: one for every 10 valves, each size. Minimum 1.

.3 Stem packing: one for every 10 valves, each size. Minimum 1.

.4 Valve handles: 2 of each size.

.5 Gaskets for flanges: one for every 10 flanged joints.

.2 Tools:

.1 Furnish special tools for maintenance of systems and equipment.

.2 Include following:

.1 Lubricant gun for expansion joints.

**1.5 DELIVERY, STORAGE AND HANDLING**

.1 Deliver, store and handle materials in accordance with Section 01 60 00 - Common Product Requirements and with manufacturer's written instructions.

.2 Delivery and Acceptance Requirements:

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

.3 Waste Management: In accordance with 01 74 21 Construction Waste Management.

**Part 2 Products**

**2.1 MATERIALS**

.1 Valves:

.1 Except for specialty valves, to be single manufacturer.

.2 Products to have CRN registration numbers.

.2 End Connections:

.1 Connection into adjacent piping/tubing:

.1 Steel pipe systems: screwed ends to ANSI/ASME B1.20.1.

.2 Copper tube systems: solder ends to ANSI/ASME B16.18.

.3 Lockshield Keys:

.1 Where lockshield valves are specified, provide 10 keys of each size: malleable iron cadmium plated.

.4 Silent Check Valves:

.1 NPS 2 and under:

.1 Body: cast high tensile bronze to ASTM B62 with integral seat.

.2 Pressure rating: Class 125.

.3 Connections: screwed ends to ANSI B1.20.1 and with hex. shoulders.

.4 Disc and seat: renewable rotating disc.

.5 Stainless steel spring, heavy duty.

.6 Seat: regrindable.

.5 Ball Valves:

.1 NPS 2 and under:

.1 Body and cap: cast high tensile bronze to ASTM B62.

.2 Pressure rating: Class125.

.3 Connections: screwed ends to ANSI B1.20.1 and with hexagonal shoulders, solder ends to ANSI.

.4 Stem: tamperproof ball drive.

.5 Stem packing nut: external to body.

.6 Ball and seat: replaceable stainless steel solid ball and Teflon seats.

.7 Stem seal: TFE with external packing nut.

.8 Operator: removable lever handle.

.6 Butterfly Valves:

.1 NPS 2 1/2 through NPS 6, with grooved ends.

.1 Body: cast bronze, with copper-tube dimensioned grooved ends.

.2 Disc: elastomer coated ductile iron with integrally cast stem.

.3 Operator: lever.

## Part 3 Execution

### 3.1 INSTALLATION

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

.2 Remove internal parts before soldering.

.3 Install valves with unions at each piece of equipment arranged to allow servicing, maintenance, and equipment removal.

### 3.2 CLEANING

.1 Clean in accordance with Section 01 74 00 - Cleaning.

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

.2 Waste Management: In accordance with 01 74 21 Construction Waste Management.

**END OF SECTION**

## Part 1 General

### 1.1 REFERENCES

.1 American Society of Mechanical Engineers (ASME)

.1 ASME B31.1, Power Piping.

.2 ASTM International

.1 ASTM A125, Standard Specification for Steel Springs, Helical, Heat-Treated.

.2 ASTM A307, Standard Specification for Carbon Steel Bolts and Studs, 60,000 PSI Tensile Strength.

.3 ASTM A563, Standard Specification for Carbon and Alloy Steel Nuts.

.3 Canada Green Building Council (CaGBC)

.1 LEED Canada 2009 for Design and Construction, LEED Canada 2009 for Design and Construction Leadership in Energy and Environmental Design Green Building Rating System Reference Guide.

.4 Factory Mutual (FM)

.5 Manufacturer's Standardization Society of the Valves and Fittings Industry (MSS)

.1 MSS SP58, Pipe Hangers and Supports - Materials, Design and Manufacture.

.2 MSS SP69, Pipe Hangers and Supports - Selection and Application.

.3 MSS SP89, Pipe Hangers and Supports - Fabrication and Installation Practices.

.6 Underwriter's Laboratories of Canada (ULC)

### 1.2 ACTION AND INFORMATIONAL SUBMITTALS

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

.2 Product Data:

.1 Provide manufacturer's printed product literature and data sheets for hangers and supports and include product characteristics, performance criteria, physical size, finish and limitations.

.3 Shop Drawings:

.1 Submit shop drawings for:

.1 Bases, hangers and supports.

.2 Connections to equipment and structure.

.3 Structural assemblies.

.4 Manufacturers' Instructions:

.1 Provide manufacturer's installation instructions.

.5 Sustainable Design Submittals:

.1 Submittals: in accordance with Section 01 47 15 - LEED Sustainable Requirements.

**1.3 CLOSEOUT SUBMITTALS**

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

**1.4 DELIVERY, STORAGE AND HANDLING**

.1 Deliver, store and handle materials in accordance with Section 01 60 00 - Common Product Requirements and with manufacturer's written instructions.

.2 Delivery and Acceptance Requirements:

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

.3 Waste Management: In accordance with 01 74 21 Construction Waste Management.

**Part 2 Products**

**2.1 SYSTEM DESCRIPTION**

.1 Design Requirements:

.1 Construct pipe hanger and support to manufacturer's recommendations utilizing manufacturer's regular production components, parts and assemblies.

.2 Base maximum load ratings on allowable stresses prescribed by ASME B31.1 or MSS SP58.

.3 Ensure that supports, guides, anchors do not transmit excessive quantities of heat to building structure.

.4 Design hangers and supports to support systems under conditions of operation, allow free expansion and contraction, prevent excessive stresses from being introduced into pipework or connected equipment.

.5 Provide for vertical adjustments after erection and during commissioning. Amount of adjustment in accordance with MSS SP58.

**2.2 SUSTAINABLE REQUIREMENTS**

.1 Materials and products in accordance with Section 01 47 15 - Sustainable Requirements: Construction.

**2.3 GENERAL**

.1 Fabricate hangers, supports and sway braces in accordance with MSS SP58.

**2.4 PIPE HANGERS**

.1 Finishes:

.1 Pipe hangers and supports: galvanized after manufacture.

.2 Use hot dipped galvanizing process.

.3 Ensure steel hangers do not come in contact with copper piping..

.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.

.1 Rod: 9 mm UL listed.

.2 Cold piping NPS 2 1/2 or greater, hot piping: malleable iron beam clamp, eye rod, jaws and extension with carbon steel retaining clip, tie rod, nuts and washers, UL listed.

.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.

.2 Cold piping NPS 2 1/2 or greater, hot piping: malleable iron top-of-beam jaw-clamp with hooked rod, spring washer, plain washer and nut UL listed.

.4 Upper attachment to concrete:

.1 Ceiling: carbon steel welded eye rod, clevis plate, clevis pin and cotters with weldless forged steel eye nut. Ensure eye 6 mm minimum greater than rod diameter.

.2 Concrete inserts: wedge shaped body with knockout protector plate UL listed to MSS SP69.

.5 Hanger rods: threaded rod material to MSS SP58:

.1 Ensure that hanger rods are subject to tensile loading only.

.2 Provide linkages where lateral or axial movement of pipework is anticipated.

.6 Pipe attachments: material to MSS SP58:

.1 Attachments for steel piping: carbon steel.

.2 Attachments for copper piping: copper plated black steel.

.3 Use insulation shields for hot pipework.

.4 Oversize pipe hangers and supports.

.7 Adjustable clevis: material to MSS SP69 UL listed, clevis bolt with nipple spacer and vertical adjustment nuts above and below clevis.

.1 Ensure "U" has hole in bottom for rivetting to insulation shields.

.8 Yoke style pipe roll: carbon steel yoke, rod and nuts with cast iron roll, to MSS SP69.

.9 U-bolts: carbon steel to MSS SP69 with 2 nuts at each end to ASTM A563.

.1 Finishes for steel pipework: galvanized.

.2 Finishes for copper, glass, brass or aluminum pipework: epoxy coated.

.10 Pipe rollers: cast iron roll and roll stand with carbon steel rod to MSS SP69.

## 2.5 RISER CLAMPS

.1 Steel or cast iron pipe: galvanized carbon steel to MSS SP58, type 42, UL listed.

.2 Copper pipe: carbon steel copper plated to MSS SP58, type 42.

.3 Bolts: to ASTM A307.

.4 Nuts: to ASTM A563.

**2.6 INSULATION PROTECTION SHIELDS**

.1 Insulated cold piping:

.1 64 kg/$m^3$ density insulation plus insulation protection shield to: MSS SP69, 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 SP69.

**2.7 CONSTANT SUPPORT SPRING HANGERS**

.1 Springs: alloy steel to ASTM A125, shot peened, magnetic particle inspected, with +/-5% spring rate tolerance, tested for free height, spring rate, loaded height and provided with Certified Mill Test Report (CMTR).

.2 Load adjustability: 10% minimum adjustability each side of calibrated load. Adjustment without special tools. Adjustments not to affect travel capabilities.

.3 Provide upper and lower factory set travel stops.

.4 Provide load adjustment scale for field adjustments.

.5 Total travel to be actual travel + 20%. Difference between total travel and actual travel 25 mm minimum.

.6 Individually calibrated scales on each side of support calibrated prior to shipment, complete with calibration record.

**2.8 EQUIPMENT ANCHOR BOLTS AND TEMPLATES**

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

**2.9 HOUSE-KEEPING PADS**

.1 Provide 100 mm high concrete housekeeping pads for base-mounted equipment; size pads 50 mm larger than equipment; chamfer pad edges.

.2 Concrete: to Section 03 30 00 - Cast-in-Place Concrete.

**Part 3 Execution**

**3.1 MANUFACTURER'S INSTRUCTIONS**

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

**3.2 INSTALLATION**

.1 Install in accordance with:

.1 Manufacturer's instructions and recommendations.

.2 Vibration Control Devices:

.1 Install on piping systems at pumps, boilers, chillers, cooling towers, and as indicated.

.3 Clamps on riser piping:

.1 Support independent of connected horizontal pipework using riser clamps and riser clamp lugs welded to riser.

.2 Bolt-tightening torques to industry standards.

.3 Steel pipes: install below coupling or shear lugs welded to pipe.

.4 Cast iron pipes: install below joint.

.4 Clevis plates:

.1 Attach to concrete with 4 minimum concrete inserts, one at each corner.

.5 Provide supplementary structural steelwork where structural bearings do not exist or where concrete inserts are not in correct locations.

.6 Use approved constant support type hangers where:

.1 Vertical movement of pipework is 13 mm or more,

.2 Transfer of load to adjacent hangers or connected equipment is not permitted.

.7 Use variable support spring hangers where:

.1 Transfer of load to adjacent piping or to connected equipment is not critical.

.2 Variation in supporting effect does not exceed 25 % of total load.

## 3.3 HANGER SPACING

.1 Plumbing piping: to Manitoba Plumbing Code.

.2 Fire protection: to applicable fire code.

.3 Gas and fuel oil piping: up to NPS 1/2: every 1.8 m.

.4 Copper piping: up to NPS 1/2: every 1.5 m.

.5 Flexible joint roll groove pipe: in accordance with table below for steel, but not less than one hanger at joints. Table listings for straight runs without concentrated loads and where full linear movement is not required.

.6 Within 300 mm of each elbow.

| Maximum Pipe Size : NPS | Maximum Spacing Steel | Maximum Spacing Copper |
|---|---|---|
| up to 1-1/4 | 2.4 m | 1.8 m |
| 1-1/2 | 3.0 m | 2.4 m |
| 2 | 3.0 m | 2.4 m |
| 2-1/2 | 3.7 m | 3.0 m |
| 3 | 3.7 m | 3.0 m |
| 3-1/2 | 3.7 m | 3.3 m |
| 4 | 3.7 m | 3.6 m |

| Maximum Pipe Size : NPS | Maximum Spacing Steel | Maximum Spacing Copper |
|---|---|---|
| 5 | 4.3 m | |
| 6 | 4.3 m | |
| 8 | 4.3 m | |
| 10 | 4.9 m | |
| 12 | 4.9 m | |

.7 Pipework greater than NPS 12: to MSS SP69.

## 3.4 HANGER INSTALLATION

.1 Install hanger so that rod is vertical under operating conditions.

.2 Adjust hangers to equalize load.

.3 Support from structural members. Where structural bearing does not exist or inserts are not in suitable locations, provide supplementary structural steel members.

## 3.5 HORIZONTAL MOVEMENT

.1 Angularity of rod hanger resulting from horizontal movement of pipework from cold to hot position not to exceed 4 degrees from vertical.

.2 Where horizontal pipe movement is less than 13 mm, offset pipe hanger and support so that rod hanger is vertical in the hot position.

## 3.6 FINAL ADJUSTMENT

.1 Adjust hangers and supports:

.1 Ensure that rod is vertical under operating conditions.

.2 Equalize loads.

.2 Adjustable clevis:

.1 Tighten hanger load nut securely to ensure proper hanger performance.

.2 Tighten upper nut after adjustment.

.3 C-clamps:

.1 Follow manufacturer's recommended written instructions and torque values when tightening C-clamps to bottom flange of beam.

.4 Beam clamps:

.1 Hammer jaw firmly against underside of beam.

## 3.7 FIELD QUALITY CONTROL

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

.2 Manufacturer's Field Services:

.1 Obtain written report from manufacturer verifying compliance of Work, in handling, installing, applying, protecting and cleaning of product and submit Manufacturer's Field Reports as described in PART 1 - ACTION AND INFORMATIONAL SUBMITTALS.

.2 Provide manufacturer's field services consisting of product use recommendations and periodic Site visits for inspection of product installation in accordance with manufacturer's instructions.

.3 Schedule Site visits, to review Work, as directed in PART 1 - QUALITY ASSURANCE.

.3 Verification requirements in accordance with Section 01 47 15 - Sustainable Requirements, include:

.1 Materials and resources.

.2 Storage and collection of recyclables.

.3 Construction waste management.

.4 Resource reuse.

.5 Recycled content.

.6 Local/regional materials.

.7 Certified wood.

.8 Low-emitting materials.

## 3.8 CLEANING

.1 Clean in accordance with Section 01 74 00 - Cleaning.

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

.2 Waste Management: In accordance with 01 74 21 Construction Waste Management.

**END OF SECTION**

## Part 1 General

### 1.1 SUMMARY

.1 Section Includes:

.1 Materials and requirements for the identification of piping systems, ductwork, valves and controllers, including the installation and location of identification systems.

.2 Sustainable requirements for construction and verification.

### 1.2 REFERENCES

.1 CSA/CGA B149.1, Natural Gas and Propane Installation Code.

.2 Canadian General Standards Board (CGSB)

.1 CAN/CGSB-1.60, Interior Alkyd Gloss Enamel.

.2 CAN/CGSB-24.3, Identification of Piping Systems.

.3 National Fire Protection Association (NFPA)

.1 NFPA 13, Standard for the Installation of Sprinkler Systems.

### 1.3 ACTION AND INFORMATIONAL SUBMITTALS

.1 Product Data:

.2 Submittals: in accordance with Section 01 33 00 - Submittal Procedures.

.3 Product data to include paint colour chips, other products specified in this section.

.4 Samples:

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

.2 Samples to include nameplates, labels, tags, lists of proposed legends.

### 1.4 QUALITY ASSURANCE

.1 Quality assurance submittals: submit following in accordance with Section 01 33 00 - Submittal Procedures.

.2 Health and Safety:

### 1.5 DELIVERY, STORAGE, AND HANDLING

.1 Packing, shipping, handling and unloading:

.1 Deliver, store and handle in accordance with Section 01 60 00 - Common Product Requirements.

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

.1 Waste Management: In accordance with 01 74 21 Construction Waste Management.

## Part 2 Products

### 2.1 SUSTAINABLE REQUIREMENTS

.1 Materials and products in accordance with Section 01 47 15 - Sustainable Requirements: Construction.

### 2.2 MANUFACTURER'S EQUIPMENT NAMEPLATES

.1 Metal or plastic laminate nameplate mechanically fastened to each piece of equipment by manufacturer.

.2 Lettering and numbers raised or recessed.

.3 Information to include, as appropriate:

.1 Equipment: manufacturer's name, model, size, serial number, capacity.

.2 Motor: voltage, Hz, phase, power factor, duty, frame size.

### 2.3 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] [white anodized aluminum], matte finish, with square corners, letters accurately aligned and machine engraved into core.

.3 Sizes:

.1 Conform to following table:

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

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

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

.4 Apply existing identification system to new work.

.5 Where existing identification system does not cover for new work, use identification system specified this section.

## 2.4 PIPING SYSTEMS GOVERNED BY CODES

.1 Identification:

.1 Natural gas: to CSA/CGA B149.1.

.2 Sprinklers: to NFPA 13.

## 2.5 IDENTIFICATION OF PIPING SYSTEMS

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

.2 Pictograms:

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

.3 Legend:

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

.4 Arrows showing direction of flow:

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

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

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

.5 Extent of background colour marking:

.1 To full circumference of pipe or insulation.

.2 Length to accommodate pictogram, full length of legend and arrows.

.6 Materials for background colour marking, legend, arrows:

.1 Pipes and tubing 20 mm and smaller: waterproof and heat-resistant pressure sensitive plastic marker tags.

.2 Other pipes: pressure sensitive [plastic-coated cloth] [vinyl] with protective overcoating, waterproof contact adhesive undercoating, suitable for ambient of 100% RH and continuous operating temperature of 150 degrees C and intermittent temperature of 200 degrees C.

.7 Colours and Legends:

.1 Where not listed, obtain direction from Contract Administrator.

.2 Colours for legends, arrows: to following table:

| Background colour: | Legend, arrows: |
|---|---|
| Yellow | BLACK |
| Green | WHITE |
| Red | WHITE |

.3 Background colour marking and legends for piping systems:

| Contents | Background colour marking | Legend |
|---|---|---|
| Hot water heating supply | Yellow | HW HEATING SUPPLY |
| Hot water heating return | Yellow | HW HEATING RETURN |
| Glycol heating supply | Yellow | GLYCOL HEATING SUPPLY |
| Glycol heating return | Yellow | GLYCOL HEATING RETURN |
| Domestic hot water supply | Green | DOM. HW SUPPLY |
| Dom. HWS recirculation | Green | DOM. HW CIRC |
| Tempered water supply | Green | TW SUPPLY |
| Tempered water recirculation | Green | TW RETURN |
| 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 |
| Natural gas | to Codes | |
| Gas regulator vents | to Codes | |
| Fire protection water | Red | FIRE PROT. WTR |
| Sprinklers | Red | SPRINKLERS |

**2.6 IDENTIFICATION DUCTWORK SYSTEMS**

.1 50 mm high stencilled letters and directional arrows 150 mm long x 50 mm high.

.2 Colours: back, or co-ordinated with base colour to ensure strong contrast.

**2.7 VALVES, CONTROLLERS**

.1 [Brass] tags with 12 mm stamped identification data filled with black paint.

.2 Include flow diagrams for each system, of approved size, showing charts and schedules with identification of each tagged item, valve type, service, function, normal position, location of tagged item.

**2.8 CONTROLS COMPONENTS IDENTIFICATION**

.1 Identify all systems, equipment, components, controls, sensors with system nameplates specified in this section.

.2 Inscriptions to include function and (where appropriate) fail-safe position.

**2.9 LANGUAGE**

.1 Identification in English.

**Part 3 Execution**

**3.1 MANUFACTURER'S INSTRUCTIONS**

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

## 3.2 TIMING

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

## 3.3 INSTALLATION

.1 Perform Work in accordance with CAN/CGSB-24.3 except as specified otherwise.

.2 Provide ULC or CSA registration plates as required by respective agency.

.3 Identify systems, equipment to conform to PWGSC PMSS.

## 3.4 NAMEPLATES

.1 Locations:

.1 In conspicuous location to facilitate easy reading and identification from operating floor.

.2 Standoffs:

.1 Provide for nameplates on hot and/or insulated surfaces.

.3 Protection:

.1 Do not paint, insulate or cover.

## 3.5 LOCATION OF IDENTIFICATION ON PIPING AND DUCTWORK SYSTEMS

.1 On long straight runs in open areas in boiler rooms, equipment rooms, galleries, tunnels: at not more than 17 m intervals and more frequently if required to ensure that at least one is visible from any one viewpoint in operating areas and walking aisles.

.2 Adjacent to each change in direction.

.3 At least once in each small room through which piping or ductwork passes.

.4 On both sides of visual obstruction or where run is difficult to follow.

.5 On both sides of separations such as walls, floors, partitions.

.6 Where system is installed in pipe chases, ceiling spaces, galleries, confined spaces, at entry and exit points, and at access openings.

.7 At beginning and end points of each run and at each piece of equipment in run.

.8 At point immediately upstream of major manually operated or automatically controlled valves, and dampers. Where this is not possible, place identification as close as possible, preferably on upstream side.

.9 Identification easily and accurately readable from usual operating areas and from access points.

.1 Position of identification approximately at right angles to most convenient line of sight, considering operating positions, lighting conditions, risk of physical damage or injury and reduced visibility over time due to dust and dirt.

## 3.6 VALVES, CONTROLLERS

.1 Valves and operating controllers, except at plumbing fixtures, radiation, or where in plain sight of equipment they serve: Secure tags with non-ferrous chains or closed "S" hooks.

.2 Install one copy of flow diagrams, valve schedules mounted in frame behind non-glare glass where directed by Contract Administrator. Provide one copy (reduced in size if required) in each operating and maintenance manual.

.3 Number valves in each system consecutively.

## 3.7 FIELD QUALITY CONTROL

.1 Verification requirements in accordance with Section 01 47 15 - Sustainable Requirements, include:

.1 Materials and resources.

.2 Storage and collection of recyclables.

.3 Construction waste management.

.4 Resource reuse.

.5 Recycled content.

.6 Local/regional materials.

.7 Certified wood.

.8 Low-emitting materials.

## 3.8 CLEANING

.1 Proceed in accordance with Section 01 74 00 - Cleaning.

.1 Waste Management: In accordance with 01 74 21 Construction Waste Management.

**END OF SECTION**

## Part 1 General

### 1.1 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 This section includes the testing of all new fire dampers.

### 1.2 QUALIFICATIONS OF TAB PERSONNEL

.1 TAB: performed in accordance with the requirements of standard under which TAB Firm's qualifications are approved:

.1 Associated Air Balance Council, (AABC) National Standards for Total System Balance.

.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.

.2 Recommendations and suggested practices contained in the TAB Standard: mandatory.

.3 Use TAB Standard provisions, including checklists, and report forms to satisfy Contract requirements.

.4 Use TAB Standard for TAB, including qualifications for TAB Firm and Specialist and calibration of TAB instruments.

.5 Where instrument manufacturer calibration recommendations are more stringent than those listed in TAB Standard, use manufacturer's recommendations.

.6 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 TABB), requirements and recommendations contained in these procedures and requirements are mandatory.

### 1.3 PURPOSE OF TAB

.1 Test to verify proper and safe operation, determine actual point of performance, evaluate qualitative and quantitative performance of equipment, systems and controls at design, average and low loads using actual or simulated loads

.2 Adjust and regulate equipment and systems to meet specified performance requirements and to achieve specified interaction with other related systems under normal and emergency loads and operating conditions.

.3 Balance systems and equipment to regulate flow rates to match load requirements over full operating ranges.

**1.4 EXCEPTIONS**

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

**1.5 CO-ORDINATION**

.1 Schedule time required for TAB (including repairs, re-testing) into project construction and completion schedule to ensure completion before acceptance of project.

.2 Do TAB of each system independently and subsequently, where interlocked with other systems, in unison with those systems.

**1.6 PRE-TAB REVIEW**

.1 Review contract documents before project construction is started and confirm in writing to Contract Administrator adequacy of provisions for TAB and other aspects of design and installation pertinent to success of TAB.

.2 Review specified standards and report to Contract Administrator in writing proposed procedures which vary from standard.

.3 During construction, co-ordinate location and installation of TAB devices, equipment, accessories, measurement ports and fittings.

**1.7 START-UP**

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

.2 Follow special start-up procedures specified elsewhere in Division 23.

**1.8 OPERATION OF SYSTEMS DURING TAB**

.1 Operate systems for length of time required for TAB and as required by Contract Administrator for verification of TAB reports.

**1.9 START OF TAB**

.1 Notify Contract Administrator 7 days prior to start of TAB.

.2 Start TAB when building is essentially completed, including:

.3 Installation of ceilings, doors, windows, other construction affecting TAB.

.4 Application of weatherstripping, sealing, and caulking.

.5 Pressure, leakage, other tests specified elsewhere Division 23.

.6 Provisions for TAB installed and operational.

.7 Start-up, verification for proper, normal and safe operation of mechanical and associated electrical and control systems affecting TAB including but not limited to:

.1 Proper thermal overload protection in place for electrical equipment.

.2 Air systems:

.1 Filters in place, clean.

.2 Duct systems clean.

.3 Ducts, air shafts, ceiling plenums are airtight to within specified tolerances.

.4 Correct fan rotation.

.5 Fire, smoke, volume control dampers installed and open.

.6 Coil fins combed, clean.

.7 Access doors, installed, closed.

.8 Outlets installed, volume control dampers open.

.3 Liquid systems:

.1 Flushed, filled, vented.

.2 Correct pump rotation.

.3 Strainers in place, baskets clean.

.4 Isolating and balancing valves installed, open.

.5 Calibrated balancing valves installed, at factory settings.

.6 Chemical treatment systems complete, operational.

## 1.10 APPLICATION TOLERANCES

.1 Do TAB to following tolerances of design values:

.1 HVAC systems: plus 10 %, minus 5 %.

.2 Hydronic systems: plus or minus 5%.

## 1.11 ACCURACY TOLERANCES

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

## 1.12 INSTRUMENTS

.1 Calibrate in accordance with requirements of most stringent of referenced standard for either applicable system or HVAC system.

.2 Calibrate within 3 months of TAB.

## 1.13 ACTION AND INFORMATIONAL SUBMITTALS

.1 Submit, prior to commencement of TAB:

.2 Proposed methodology and procedures for performing TAB if different from referenced standard.

## 1.14 TAB REPORT

.1 Format in accordance with relevant standard.

.2 TAB report to show results in SI units and to include:

.1 Project record drawings.

.2 System schematics.

.3 Submit 1 copy of TAB Report to Contract Administrator for verification and approval, in English in D-ring binders, complete with index tabs.

**1.15 VERIFICATION**

.1 Reported results subject to verification by Contract Administrator

.2 Provide personnel and instrumentation to verify up to 30 % of reported results.

.3 Pay costs to repeat TAB as required to satisfaction of Contract Administrator.

**1.16 SETTINGS**

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

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

**1.17 COMPLETION OF TAB**

.1 TAB considered complete when final TAB Report received and approved by the Contract Administrator.

**1.18 AIR SYSTEMS**

.1 Standard: TAB to most stringent of TAB standards of AABC or ASHRAE.

.2 Do TAB of following systems, equipment, components, and controls:

.1 AHU-1, AHU-2 & AHU-3

.2 VAV-1 to VAV-9

.3 HRV-1, HRV-2 & HRV-3

.4 RF-1

.5 EF-1

.6 Verify and report outdoor air volumes for all ventilation systems.

.7 Provide readings for calibration of outdoor air flow stations. Coordinate with the controls contractor.

.8 Existing pool supply and return fan

.9 All supply grilles including supply grilles in existing pool.

.3 Test all fire dampers.

.4 Qualifications: personnel performing TAB to be current member in good standing 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, dew point), duct cross-sectional area, RPM, electrical power, voltage, noise, vibration.

.6 Locations of equipment measurements: to include, but not be limited to, following as appropriate:

.1 Inlet and outlet of dampers, grille, 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).

**1.19 OTHER TAB REQUIREMENTS**

.1 General requirements applicable to Work specified this paragraph:

.1 Qualifications of TAB personnel: as for air systems specified this section.

.2 Quality assurance: as for air systems specified this section.

.2 Zone pressure differences:

.1 Adjust HVAC systems, equipment, controls to establish specified air pressure differentials, with systems in every possible combinations of normal operating modes.

.2 Pressure differences shall be as follows:

.1 Splash pad (AHU-1) shall be negative pressure relative to outdoors.

.1 Differential Pressure: -0.05” to -0.02” w.c.

.2 MPR/Viewing Lobby (AHU-2) shall be positive relative to the splash pad.

.1 Differential Pressure: +0.02” to +0.05” w.c.

.3 Existing change rooms and washrooms (HRV-1) shall be positive relative to the splash pad.

.1 Differential Pressure: +0.02” to +0.05” w.c.

**1.20 WATER SYSTEMS**

.1 Do TAB on all hydronic systems including:

Flow balance of:

.1 Hydronic pumps PU-1 to PU-8

.2 Domestic pumps PU-9 & PU-10

.3 Hydronic boilers B-1 to B-4

.4 Reheat coils RHC-1 to RHC-12

.5 Preheat coils PHC-1 to PHC-3

.6 Pool water heat exchangers HX-1 & HX-2

.7 Cabinet unit heaters CUH-1

.2 Set water flows as noted. Obtain pump operating pressures, motor amperages and characteristics.

.3 Measure domestic water recirculation flow rates at all automatic flow balancing valves and record flows in balance report.

**Part 2 Products**

**2.1 NOT USED**

.1 Not used.

**Part 3 Execution**

**3.1 NOT USED**

.1 Not used.

**END OF SECTION**

## Part 1 General

### 1.1 REFERENCES

.1 Definitions:

.1 For purposes of this section:

.1 "CONCEALED" - insulated mechanical services and equipment in suspended ceilings and non-accessible chases and furred-in spaces.

.2 "EXPOSED" - means "not concealed" as previouslydefined.

.3 Insulation systems - insulation material, fasteners, jackets, and other accessories.

.2 TIAC Codes:

.1 CRD: Code Round Ductwork,

.2 CRF: Code Rectangular Finish.

.2 Reference Standards:

.1 American Society of Heating, Refrigeration and Air Conditioning Engineers (ASHRAE)

.1 ANSI/ASHRAE/IESNA 90.1, SI; Energy Standard for Buildings Except Low-Rise Residential Buildings.

.2 ASTM International Inc.

.1 ASTM B209M, Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate (Metric).

.2 ASTM C335, Standard Test Method for Steady State Heat Transfer Properties of Pipe Insulation.

.3 ASTM C411, Standard Test Method for Hot-Surface Performance of High-Temperature Thermal Insulation.

.4 ASTM C449/C449M, Standard Specification for Mineral Fiber-Hydraulic-Setting Thermal Insulating and Finishing Cement.

.5 ASTM C547, Standard Specification for Mineral Fiber Pipe Insulation.

.6 ASTM C553, Standard Specification for Mineral Fiber Blanket Thermal Insulation for Commercial and Industrial Applications.

.7 ASTM C612, Standard Specification for Mineral Fiber Block and Board Thermal Insulation.

.8 ASTM C795, Standard Specification for Thermal Insulation for Use in Contact with Austenitic Stainless Steel.

.9 ASTM C921, Standard Practice for Determining the Properties of Jacketing Materials for Thermal Insulation.

.3 Canadian General Standards Board (CGSB)

.1 CGSB 51-GP-52Ma-[89], Vapour Barrier, Jacket and Facing Material for Pipe, Duct and Equipment Thermal Insulation.

.4 Canada Green Building Council (CaGBC)

.1 LEED Canada 2009 for Design and Construction, LEED Canada 2009 for Design and Construction Leadership in Energy and Environmental Design Green Building Rating System Reference Guide.

.2 Green Seal Environmental Standards (GSES)

.3 Standard GS-36, Commercial Adhesives.

.4 South Coast Air Quality Management District (SCAQMD), California State

.5 SCAQMD Rule 1168, Adhesive and Sealant Applications.

.5 Thermal Insulation Association of Canada (TIAC): National Insulation Standards (2005).

.6 Underwriters Laboratories of Canada (ULC)

.1 CAN/ULC-S102, Method of Test for Surface Burning Characteristics of Building Materials and Assemblies.

.2 CAN/ULC-S701, Standard for Thermal Insulation, Polystyrene, Boards and Pipe Covering.

## 1.2 ACTION AND INFORMATIONAL SUBMITTALS

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

.2 Product Data:

.1 Provide manufacturer's printed product literature and datasheets for duct insulation, and include product characteristics, performance criteria, physical size, finish and limitations.

.1 Description of equipment giving manufacturer's name, type, model, year and capacity.

.2 Details of operation, servicing and maintenance.

.3 Recommended spare parts list.

.3 Manufacturers' Instructions:

.1 Provide manufacture's written duct insulation jointing recommendations. and special handling criteria, installation sequence, cleaning procedures.

.4 Sustainable Design Submittals:

.1 Submittals: in accordance with Section 01 47 15 - LEED Sustainable Requirements.

## 1.3 QUALITY ASSURANCE

.1 Qualifications:

.1 Installer: specialist in performing Work of this section, and have at least 3 years successful experience in this size and type of project.

## 1.4 DELIVERY, STORAGE AND HANDLING

.1 Deliver, store and handle in accordance with Section 01 60 00 - Common Product Requirements.

.2 Deliver materials to Site in original factory packaging, labelled with manufacturer's name, address and ULC markings.

.3 Waste Management: In accordance with 01 74 21 Construction Waste Management.

## Part 2 Products

### 2.1 SUSTAINABLE REQUIREMENTS

.1 Materials and products in accordance with Section 01 47 15 - LEED Sustainable Requirements.

### 2.2 FIRE AND SMOKE RATING

.1 To CAN/ULC-S102:

.1 Maximum flame spread rating: 25.

.2 Maximum smoke developed rating: 50.

### 2.3 INSULATION

.1 Mineral fibre: as specified includes glass fibre, rock wool, slag wool.

.2 Thermal conductivity ("k" factor) not to exceed specified values at 24 degrees C mean temperature when tested in accordance with ASTM C335.

.3 PREMOLDED PIPE INSULATION

.1 Provide ULC Listed sectional fibreglass pipe insulation in compliance with ASTM C335-84 in pre-moulded sections 36” (900mm) long, split and ready for application complete with factory applied vapour seal jacket of vinyl coated foil Kraft laminate with reinforcing of open mesh glass fibre.

.2 Rigid board: 4.5 lbs/ft3 (72 kg/m3) density ULC listed glass fibre board with glass fibre reinforced aluminium foil vapour seal facing.

.4 REFRIGERANT PIPING INSULATION

.1 Fire retardant closed cell Armaflex, pre-formed for piping.

.5 DUCT INSULATION – INDOOR DUCTWORK

.1 The use of duct liner as thermal insulation is not allowed. Duct liner may be considered for acoustical purposes only. Special sound attenuators shall be used wherever required to eliminate fan noise. The University representative shall be contacted for approval.

.2 All duct insulation in mechanical rooms and on outside and mixed air ductwork, and also where subject to abuse or impact, shall be rigid fiberglass board, with a minimum density of 3 lb/ft3 and be covered with canvas and lagging. All other duct insulation shall be blanket type.

.6 DUCT INSULATION – EXTERIOR DUCTWORK

.1 A combination of exterior and interior duct insulation shall be used to insulate outdoor ductwork to achieve desired thermal resistance values.

.2 All duct insulation shall be rigid polyisocyanurate foam board on the exterior of the duct and rigid fiberglass board rated for use inside the air duct.

.3 Ductwork shall be jacketed with corrugated metal sheets and closures to maintain a water tight seal.

**2.4 JACKETS**

.1 Canvas:

.1 220 gm/$m^2$ cotton, plain weave, treated with dilute fire retardant lagging adhesive to ASTM C921.

.2 Lagging adhesive: compatible with insulation.

.1 Maximum VOC limit in accordance with Section 01 47 15 - LEED Sustainable Requirements.

.3 Aluminum:

.1 To ASTM B209 with moisture barrier as scheduled in PART 3 of this section.

.2 Thickness: 0.50 mm sheet.

.3 Finish: Corrugated.

.4 Jacket banding and mechanical seals: 19 mm wide, 0.5 mm thick stainless steel.

.1 Stainless steel:

.2 Type: 304.

.3 Thickness: 0.50 mm sheet.

.4 Finish: Smooth.

.5 Jacket banding and mechanical seals: 19 mm wide, 0.5 mm thick stainless steel.

**2.5 ACCESSORIES**

.1 Vapour retarder lap adhesive:

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

.1 Maximum VOC limit in accordance with Section 01 47 15 - LEED Sustainable Requirements.

.2 Tape: self-adhesive, aluminum, plain, 50 mm wide minimum.

.3 Contact adhesive: quick-setting

.1 Maximum VOC limit in accordance with Section 01 47 15 - LEED Sustainable Requirements.

.4 Canvas adhesive: washable.

.1 Maximum VOC limit in accordance with Section 01 47 15 - LEED Sustainable Requirements.

.5 Banding: 19 mm wide, 0.5 mm thick stainless steel.

.6 Fasteners: 2 mm diameter pins with 35 mm diameter clips, length to suit thickness of insulation.

## Part 3 Execution

### 3.1 APPLICATION

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

### 3.2 PRE-INSTALLATION REQUIREMENTS

.1 Pressure test ductwork systems complete, witness and certify.

.2 Ensure surfaces are clean, dry, free from foreign material.

### 3.3 INSTALLATION

.1 Install in accordance with TIAC National Standards.

.2 Apply materials in accordance with manufacturers instructions and as indicated.

.3 Use 2 layers with staggered joints when required nominal thickness exceeds 75 mm.

.4 Maintain uninterrupted continuity and integrity of vapour retarder jacket and finishes.

.1 Ensure hangers, and supports are outside vapour retarder jacket.

.5 Hangers and supports in accordance with Section 23 05 29 - Hangers and Supports for HVAC Piping and Equipment.

.1 Apply high compressive strength insulation where insulation may be compressed by weight of ductwork.

.6 Fasteners: install at 300 mm on centre in horizontal and vertical directions, minimum 2 rows each side.

### 3.4 DUCTWORK INSULATION SCHEDULE

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

| Duct System | Minimum Thermal Resistance (RSI) | Insulation | | Location of Insulation | Unit Thermal Resistance (RSI/25mm) | Insulation Thickness (mm) | Total Thermal Resistance (RSI) |
|---|---|---|---|---|---|---|---|
| | | Material | Type | | | | |
| **Indoor Ductwork** (*Temperature Difference = 5 to 22°C)* | | | | | | | |
| Supply Air - Headers and Plenums | 0.58 | Fiberglass | Board / Wrap | Exterior | 0.67 | 25 | 0.67 |
| Supply Air - Runouts | 0.58 | Fiberglass | Board / Wrap | Exterior | 0.67 | 25 | 0.67 |
| Return Air - Headers and Plenums | 0 | N/A | | | | - | |
| Return Air - Runouts | 0 | N/A | | | | - | |
| Exhaust/Relief Air - Indoor Headers and Plenums | 0 | N/A | | | | - | |
| **Indoor Ductwork** *(Temperature Difference = > 22°C)* | | | | | | | |
| Outdoor/Combustion Air - Indoor Headers and Plenums | 0.88 | Fiberglass | Board/Wrap | Exterior | 0.67 | 50 | 1.34 |
| **Exterior Ductwork** | | | | | | | |
| Supply Air - Exterior Headers and Plenums | 4.76 | - | - | Interior | - | - | 4.95 |
| | | Polyisocyanurate | Board | Exterior | 0.99 | 125 | |
| Return Air - Exterior Headers and Plenums | 4.76 | - | - | Interior | - | - | 5.48 |
| | | Polyisocyanurate | Board | Exterior | 0.99 | 125 | |

Notes: 1) Exterior ductwork carrying conditioned air needs to be insulated to same level as building wall.

2) Runouts are ducts that do not exceed 3 meters in length and connects to terminal grilles or diffusers.
3) Wrap shall be installed on ductwork less than 1200 mm wide. Board Insulation shall be installed on ductwork. greater than 1200 mm wide.
4) Insulate all exhaust/relief ducts 1800 mm back from outside wall.

.2 Exposed round ducts 600 mm and larger, smaller sizes where subject to abuse:

.1 Use TIAC code C-1 insulation, scored to suit diameter of duct.

.3 Finishes:

.1 All exposed, insulated ductwork shall be finished with a canvas jacket.

.2 All concealed, insulated ductwork shall have standard foil face finish.

.3 All insulated, outdoor ductwork shall be finished with an aluminum jacket.

## 3.5 CLEANING

.1 Clean in accordance with Section 01 74 00 - Cleaning.

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

.2 Waste Management: In accordance with 01 74 21 Construction Waste Management.

**END OF SECTION**

## Part 1 General

### 1.1 SUMMARY

.1 Section Includes:

.1 Thermal insulation for piping and piping accessories in commercial type applications.

.2 Sustainable requirements for construction and verification.

### 1.2 REFERENCES

.1 American Society of Heating, Refrigeration and Air Conditioning Engineers (ASHRAE)

.1 ASHRAE Standard 90.1, Energy Standard for Buildings Except Low-Rise Residential Buildings (IESNA co-sponsored; ANSI approved; Continuous Maintenance Standard).

.2 American Society for Testing and Materials International (ASTM)

.1 ASTM C335, Standard Test Method for Steady State Heat Transfer Properties of Horizontal Pipe Insulation.

.2 ASTM C547, Mineral Fiber Pipe Insulation.

.3 ASTM C921, Standard Practice for Determining the Properties of Jacketing Materials for Thermal Insulation.

.3 Canadian General Standards Board (CGSB)

.1 CGSB 51-GP-52Ma, Vapour Barrier, Jacket and Facing Material for Pipe, Duct and Equipment Thermal Insulation.

.2 CAN/CGSB-51.53, Poly (Vinyl Chloride) Jacketting Sheet, for Insulated Pipes, Vessels and Round Ducts

.4 Department of Justice Canada (Jus)

.1 Canadian Environmental Assessment Act (CEAA), 1995, c. 37.

.2 Canadian Environmental Protection Act (CEPA), 1999, c. 33.

.3 Transportation of Dangerous Goods Act (TDGA), 1992, c. 34.

.5 Health Canada/Workplace Hazardous Materials Information System (WHMIS)

.1 Material Safety Data Sheets (MSDS).

.6 Manufacturer's Trade Associations

.1 Thermal Insulation Association of Canada (TIAC): National Insulation Standards.

.7 Underwriters' Laboratories of Canada (ULC)

.1 CAN/ULC-S102, Surface Burning Characteristics of Building Materials and Assemblies.

.2 CAN/ULC-S701, Thermal Insulation, Polystyrene, Boards and Pipe Covering.

.3 CAN/ULC-S702, Thermal Insulation, Mineral Fibre, for Buildings

.4 CAN/ULC-S702.2, Thermal Insulation, Mineral Fibre, for Buildings, Part 2: Application Guidelines.

## 1.3 DEFINITIONS

.1 For purposes of this section:

.1 "CONCEALED" - insulated mechanical services in suspended ceilings and non-accessible chases and furred-in spaces.

.2 "EXPOSED" - will mean "not concealed" as specified.

.2 TIAC ss:

.1 CRF: Code Rectangular Finish.

.2 CPF: Code Piping Finish.

## 1.4 ACTION AND INFORMATIONAL SUBMITTALS

.1 Submittals: in accordance with Section 01 33 00 - Submittal Procedures.

.2 Product Data:

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

.1 Submit two copies of Workplace Hazardous Materials Information System (WHMIS) Material Safety Data Sheets (MSDS) in accordance with Section 01 33 00 - Submittal Procedures.

.3 Shop Drawings:

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

.4 Quality assurance submittals: submit following in accordance with Section 01 33 00 - Submittal Procedures.

.1 Certificates: submit certificates signed by manufacturer certifying that materials comply with specified performance characteristics and physical properties.

.2 Instructions: submit manufacturer's installation instructions.

## 1.5 QUALITY ASSURANCE

.1 Qualifications:

.2 Installer: specialist in performing Work of this Section, and have at least 3 years successful experience in this size and type of project.

.3 Health and Safety:

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

## 1.6 DELIVERY, STORAGE AND HANDLING

.1 Packing, shipping, handling and unloading:

.1 Deliver, store and handle in accordance with manufacturer's written instructions and Section 01 60 00 - Common Product Requirements.

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

.3 Deliver materials to Site in original factory packaging, labelled with manufacturer's name, address.

.2 Storage and Protection:

.1 Protect from weather, construction traffic.

.2 Protect against damage.

.3 Store at temperatures and conditions required by manufacturer.

.1 Waste Management: In accordance with 01 74 21 Construction Waste Management.

## Part 2 Products

### 2.1 SUSTAINABLE REQUIREMENTS

.1 Materials and products in accordance with Section 01 47 15 - Sustainable Requirements: Construction.

### 2.2 FIRE AND SMOKE RATING

.1 In accordance with CAN/ULC-S102.

.1 Maximum flame spread rating: 25.

.2 Maximum smoke developed rating: 50.

### 2.3 INSULATION

.1 Mineral fibre specified includes glass fibre, rock wool, slag wool.

.2 Thermal conductivity ("k" factor) not to exceed specified values at 24 degrees C mean temperature when tested in accordance with ASTM C335.

.3 TIAC Code A-1: rigid moulded mineral fibre without factory applied vapour retarder jacket.

.1 Mineral fibre: to CAN/ULC-S702.

.2 Maximum "k" factor: to CAN/ULC-S702.

.4 TIAC Code A-3: rigid moulded mineral fibre with factory applied vapour retarder jacket.

.1 Mineral fibre: to CAN/ULC-S702.

.2 Jacket: to CGSB 51-GP-52Ma.

.3 Maximum "k" factor: to CAN/ULC-S702.

.5 TIAC Code A-6: flexible unicellular tubular elastomer.

.1 Insulation: with vapour retarder jacket.

.2 Jacket: to CGSB 51-GP-52Ma.

.3 Certified by manufacturer: free of potential stress corrosion cracking corrodants.

**2.4 INSULATION SECUREMENT**

.1 Tape: self-adhesive, 50 mm wide minimum.

.2 Contact adhesive: quick setting.

.3 Canvas adhesive: washable.

**2.5 VAPOUR RETARDER LAP ADHESIVE**

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

**2.6 INDOOR VAPOUR RETARDER FINISH**

.1 Vinyl emulsion type acrylic, compatible with insulation.

**2.7 OUTDOOR VAPOUR RETARDER FINISH**

.1 Vinyl emulsion type acrylic, compatible with insulation.

.2 Reinforcing fabric: fibrous glass, untreated 305 g/$m^2$.

**2.8 JACKETS**

.1 Polyvinyl Chloride (PVC):

.1 One-piece moulded type and sheet to CAN/CGSB-51.53 with pre-formed shapes as required.

.2 Colours: Confirm with Contract Administrator.

.3 Minimum service temperatures: -20 degrees C.

.4 Maximum service temperature: 65 degrees C.

.5 Moisture vapour transmission: 0.02 perm.

.6 Fastenings:

.1 Use solvent weld adhesive compatible with insulation to seal laps and joints.

.2 Tacks.

.3 Pressure sensitive vinyl tape of matching colour.

.7 Special requirements:

.1 Outdoor: UV rated material at least 0.5 mm thick.

**Part 3 Execution**

**3.1 MANUFACTURER'S INSTRUCTIONS**

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

**3.2 PRE-INSTALLATION REQUIREMENT**

.1 Pressure testing of piping systems and adjacent equipment to be complete, witnessed and certified.

.2 Surfaces clean, dry, free from foreign material.

## 3.3 INSTALLATION

.1 Install in accordance with TIAC National Standards.

.2 Apply materials in accordance with manufacturers instructions and this specification.

.3 Use two layers with staggered joints when required nominal wall thickness exceeds 75 mm.

.4 Maintain uninterrupted continuity and integrity of vapour retarder jacket and finishes.

.1 Install hangers, supports outside vapour retarder jacket.

.5 Supports, Hangers:

.1 Apply high compressive strength insulation, suitable for service, at oversized saddles and shoes where insulation saddles have not been provided.

## 3.4 REMOVABLE, PRE-FABRICATED, INSULATION AND ENCLOSURES

.1 Application: at valves, primary flow measuring elements and flanges. Do not insulate unions at equipment on hot piping. Cold piping systems shall have no un-insulated sections.

.2 Design: to permit periodic removal and replacement without damage to adjacent insulation.

.3 Insulation:

.1 Insulation, fastenings and finishes: same as system.

.2 Jacket: PVC.

## 3.5 INSTALLATION OF ELASTOMERIC INSULATION

.1 Insulation to remain dry. Overlaps to manufacturers instructions. Ensure tight joints.

.2 Provide vapour retarder as recommended by manufacturer.

## 3.6 PIPING INSULATION SCHEDULES

.1 Includes valves, valve bonnets, strainers, flanges and fittings unless otherwise specified.

.2 Thickness of insulation as listed in following table.

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

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

| Type of System | Design Operating Temperature Range (°C) | Thermal Conductivity of Insulation | | Nominal Pipe Diameter | | | | |
|---|---|---|---|---|---|---|---|---|
| | | Conductivity Range W/m·°C) | Mean Rating Temperature (°C) | Runouts ≤ 50 | ≤ 25 | 32 to 50 | 63 to 100 | ≥ 125 |
| | | | | Minimum Thickness of Piping Insulation | | | | |
| Heating Systems (hot water, glycol, steam, steam condensate, etc.) | > 177 | 0.046 - 0.049 | 121 | 38 | 63 | 63 | 75 | 88 |
| | 122 - 177 | 0.042 - 0.045 | 93 | 38 | 50 | 63 | 63 | 88 |
| | 94 - 121 | 0.039 - 0.043 | 65 | 25 | 38 | 38 | 50 | 50 |
| | 61 - 93 | 0.036 - 0.042 | 52 | 25 | 25 | 25 | 38 | 38 |
| | 46 - 60 | 0.035 - 0.040 | 38 | 25 | 25 | 25 | 25 | 38 |
| | < 5 | 0.033 - 0.039 | 24 | 25 | 25 | 38 | 38 | 38 |
| Rain Water Leaders | - | 0.035 - 0.040 | 25 | 25 | 25 | 25 | 25 | 25 |
| Domestic Water Systems | | | | | | | | |
| *Conditioned Space* | | | | | | | | |
| Hot Water | - | 0.035 - 0.040 | 38 | 25 | 25 | 25 | 38 | 38 |
| Tempered Water | - | 0.035 - 0.040 | 38 | 25 | 25 | 25 | 38 | 38 |
| Hot Water Recirculation | - | 0.035 - 0.040 | 38 | 25 | 25 | 25 | 38 | 38 |
| Tempered Water Recirculation | - | 0.035 - 0.040 | 38 | 25 | 25 | 25 | 38 | 38 |
| *Un-Conditioned Space* | | | | | | | | |
| Sanitary Sewer | - | 0.046 - 0.049 | 38 | 38 | 63 | 63 | 75 | 88 |
| | | | | | | | | |

.3 Finishes:

.1 Exposed in mechanical rooms and janitors room: PVC jacket.

.2 Exposed in occupied spaces: PVC jacket, painted.

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

.4 Exposed, outdoors: PVC jacket with UV protection.

## 3.7 FIELD QUALITY CONTROL

.1 Verification requirements in accordance with Section 01 47 15 - Sustainable Requirements, include:

.1 Materials and resources.

.2 Storage and collection of recyclables.

.3 Construction waste management.

.4 Resource reuse.

.5 Recycled content.

.6 Local/regional materials.

.7 Certified wood.

.8 Low-emitting materials.

**3.8 CLEANING**

.1 Proceed in accordance with Section 01 74 00 - Cleaning.

.1 Waste Management: In accordance with 01 74 21 Construction Waste Management.

**END OF SECTION**

## Part 1 General

### 1.1 REFERENCES

.1 American Society for Testing and Materials International (ASTM)

.1 ASTM E202, Standard Test Methods for Analysis of Ethylene Glycols and Propylene Glycols.

### 1.2 CLEANING AND START-UP OF MECHANICAL PIPING SYSTEMS

.1 In accordance with Section 23 08 02 - Cleaning and Start-up of Mechanical Piping Systems.

### 1.3 HYDRONIC SYSTEMS - PERFORMANCE VERIFICATION (PV)

.1 Perform hydronic systems performance verification after cleaning is completed and system is in full operation.

.2 When systems are operational, perform following tests:

.1 Conduct full scale tests at maximum design flow rates, temperatures and pressures for continuous consecutive period of 48 hours to demonstrate compliance with design criteria.

.2 Verify performance of hydronic system circulating pumps as specified, recording system pressures, temperatures, fluctuations by simulating maximum design conditions and varying.

.1 Pump operation.

.2 Boiler operation.

.3 Control pressure failure.

.4 Maximum heating demand.

.5 Boiler failure.

.6 Outdoor reset. Re-check heat exchanger output supply temperature at 100% and 50% reset, maximum water temperature.

### 1.4 HYDRONIC SYSTEM CAPACITY TEST

.1 Perform hydronic system capacity tests after:

.1 TAB has been completed

.2 Verification of operating, limit, safety controls.

.3 Verification of primary and secondary pump flow rates.

.4 Verification of accuracy of temperature and pressure sensors and gauges.

.2 Calculate system capacity at test conditions.

.3 Using manufacturer's published data and calculated capacity at test conditions, extrapolate system capacity at design conditions.

.4 When capacity test is completed, return controls and equipment status to normal operating conditions.

.5 Submit sample of system water to approved testing agency to determine if chemical treatment is correct. Include cost.

.6 Heating system capacity test:

.1 Perform capacity test when ambient temperature is within 10% of design conditions. Simulate design conditions by:

.1 Increasing OA flow rates through heating coils (in this case, monitor heating coil discharge temperatures to ensure that coils are not subjected to freezing conditions) or

.2 Reducing space temperature by turning of heating system for sufficient period of time before starting testing.

.2 Test procedures:

.1 Open fully heat exchanger, heating coil and radiation control valves.

.2 With boilers on full firing and hot water heating supply temperature stabilized, record flow rates and supply and return temperatures simultaneously.

.3 Conduct flue gas analysis test on boilers at full load and at low fire conditions.

## 1.5 GLYCOL SYSTEMS

.1 Test to prove concentration will prevent freezing to minus 40 degrees C Test inhibitor strength and include in procedural report. Refer to ASTM E202.

## 1.6 GASEOUS FUEL SYSTEMS

.1 Operation tests:

.1 Measure gas pressure at gas meter outlet and at burner manifold.

.2 Verify details of temperature and pressure compensation at meter.

.3 Verify settings, operation, venting of high and low pressure cut-outs, alarms.

.4 Check terminals of vents for gas pressure regulators.

## 1.7 POTABLE WATER SYSTEMS

.1 When cleaning is completed and system filled:

.1 Verify performance of equipment and systems as specified elsewhere in Division 23.

.2 Check for proper operation of water hammer arrestors. Run one outlet for 10 seconds, then shut of water immediately. If water hammer occurs, replace water hammer arrestor or recharge air chambers. Repeat for each outlet and flush valve.

.3 Confirm water quality consistent with supply standards, verifying that no residuals remain resulting from flushing and/or cleaning.

## 1.8 WET PIPE SPRINKLER SYSTEM

.1 Cleaning, testing, start-up, performance verification of equipment, systems, components, and devices is specified elsewhere in Division 23.

.2 Verification of controls, detection devices, alarm devices is specified Division 26.

.3 Verify operation of interlocks between HVAC systems and fire alarm systems.

**1.9 SANITARY AND STORM DRAINAGE SYSTEMS**

.1 Ensure that traps are fully and permanently primed.

.2 Ensure that fixtures are properly anchored, connected to system.

.3 Operate flush valves, tank and operate each fixture to verify drainage and no leakage.

**1.10 REPORTS**

.1 In accordance with Section 01 91 13 - General Commissioning (Cx) Requirements: Reports, supplemented as specified herein.

**1.11 TRAINING**

.1 In accordance with Section 01 91 13 - General Commissioning (Cx) Requirements: Training of O M Personnel, supplemented as specified herein.

## Part 2 Products

**2.1 NOT USED**

.1 Not Used.

## Part 3 Execution

**3.1 NOT USED**

.1 Not Used.

**END OF SECTION**

## Part 1 General

### 1.1 SUMMARY

.1 Section Includes:

.1 Procedures and cleaning solutions for cleaning mechanical piping systems.

### 1.2 REFERENCES

.1 American Society for Testing and Materials International (ASTM)

.1 ASTM E202, Standard Test Methods for Analysis of Ethylene Glycols and Propylene Glycols.

.2 Health Canada/Workplace Hazardous Materials Information System (WHMIS)

.1 Material Safety Data Sheets (MSDS).

### 1.3 ACTION AND INFORMATIONAL SUBMITTALS

.1 Product Data:

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

.2 Quality assurance submittals: submit following in accordance with Section 01 33 00 - Submittal Procedures.

### 1.4 QUALITY ASSURANCE

.1 Health and Safety:

.1 Do construction occupational health and safety in accordance with Section 01 35 30 - Health and Safety.

### 1.5 DELIVERY, STORAGE, AND HANDLING

.1 Packing, shipping, handling and unloading:

.1 Deliver, store and handle in accordance with manufacturer's written instructions and Section 01 60 00 - Common Product Requirements.

.1 Waste Management: In accordance with 01 74 21 Construction Waste Management.

## Part 2 Products

### 2.1 SUSTAINABLE REQUIREMENTS

.1 Materials and products in accordance with Section 01 47 15 - Sustainable Requirements: Construction.

### 2.2 CLEANING SOLUTIONS

.1 Tri-sodium phosphate: 0.40 kg per 100 L water in system.

.2 Sodium carbonate: 0.40 kg per 100 L water in system.

.3 Low-foaming detergent: 0.01 kg per 100 L water in system.

## Part 3 Execution

### 3.1 MANUFACTURER'S INSTRUCTIONS

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

### 3.2 CLEANING HYDRONIC AND STEAM SYSTEMS

.1 Timing: systems operational, hydrostatically tested and with safety devices functional, before cleaning is carried out.

.2 Cleaning Agency:

.1 Retain qualified water treatment specialist to perform system cleaning.

.3 Install instrumentation such as flow meters, orifice plates, pitot tubes, flow metering valves only after cleaning is certified as complete by water treatment specialist.

.4 Cleaning procedures:

.1 Provide detailed report outlining proposed cleaning procedures at least 4 weeks prior to proposed starting date. Report to include:

.1 Cleaning procedures, flow rates, elapsed time.

.2 Chemicals and concentrations used.

.3 Inhibitors and concentrations.

.4 Specific requirements for completion of work.

.5 Special precautions for protecting piping system materials and components.

.6 Complete analysis of water used to ensure water will not damage systems or equipment.

.5 Conditions at time of cleaning of systems:

.1 Systems: free from construction debris, dirt and other foreign material.

.2 Control valves: operational, fully open to ensure that terminal units can be cleaned properly.

.3 Strainers: clean prior to initial fill.

.4 Install temporary filters on pumps not equipped with permanent filters.

.5 Install pressure gauges on strainers to detect plugging.

.6 Report on Completion of Cleaning:

.1 When cleaning is completed, submit report, complete with certificate of compliance with specifications of cleaning component supplier.

.7 Hydronic Systems:

.1 Fill system with water, ensure air is vented from system.

.2 Fill expansion tanks 1/3 to 1/2 full, charge system with compressed air to at least 35 kPa (does not apply to diaphragm type expansion tanks).

.3 Use water metre to record volume of water in system to +/- 0.5%.

.4 Add chemicals under direct supervision of chemical treatment supplier.

.5 Closed loop systems: circulate system cleaner at 60 degrees C for at least 36 h. Drain as quickly as possible. Refill with water and inhibitors. Test concentrations and adjust to recommended levels.

.6 Flush velocity in system mains and branches to ensure removal of debris. System pumps may be used for circulating cleaning solution provided that velocities are adequate.

.7 Add chemical solution to system.

.8 Establish circulation, raise temperature slowly to maximum design. Circulate for 12 h, ensuring flow in all circuits. Remove heat, continue to circulate until temperature is below 38 degrees C. Drain as quickly as possible. Refill with clean water. Circulate for 6 h at design temperature. Drain and repeat procedures specified above. Flush through low point drains in system. Refill with clean water adding to sodium sulphite (test for residual sulphite).

.8 Glycol Systems:

.1 In addition to procedures specified above perform specified procedures.

.2 Test to prove concentration will prevent freezing to minus 40 degrees C. Test inhibitor strength and include in procedural report. Refer to ASTM E202.

## 3.3 START-UP OF HYDRONIC SYSTEMS

.1 After cleaning is completed and system is filled:

.1 Establish circulation and expansion tank level, set pressure controls.

.2 Ensure air is removed.

.3 Check pumps to be free from air, debris, possibility of cavitation when system is at design temperature.

.4 Dismantle system pumps used for cleaning, inspect, replace worn parts, install new gaskets and new set of seals.

.5 Clean out strainers repeatedly until system is clean.

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

.7 Repeat with water at design temperature.

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

.9 Bring system up to design temperature and pressure slowly

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

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

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

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

.14 Check operation of drain valves.

.15 Adjust valve stem packings as systems settle down.

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

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

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

## 3.4 FIELD QUALITY CONTROL

.1 Verification requirements in accordance with Section 01 47 15 - Sustainable Requirements, include:

.1 Materials and resources.

.2 Storage and collection of recyclables.

.3 Construction waste management.

.4 Resource reuse.

.5 Recycled content.

.6 Local/regional materials.

.7 Certified wood.

.8 Low-emitting materials.

## 3.5 CLEANING

.1 Proceed in accordance with Section 01 74 00 - Cleaning.

.1 Waste Management: In accordance with 01 74 21 Construction Waste Management.

**END OF SECTION**

## Part 1 General

### 1.1 RELATED REQUIREMENTS

.1 Section 01 47 15 - Sustainable Requirements

.2 Section 01 74 21 – Construction/Demolition Waste Management

### 1.1 GENERAL

.1 All drawings and all sections of the specifications shall apply to and form an integral part of this section. Refer to sections on AHU's, HRV's, etc to obtain information on their own packaged controls.

.2 Wherever words "shall be capable of" appear in specifications, interpret as meaning that; where feature or performance referred to is being applied, that feature or performance shall be provided. Where feature or performance is not applied now, but will be applied in future, system shall be provided with all necessary central hardware and software required to support that feature or performance, with only addition of field hardware being required at that future time.

.3 Controls contractor shall have minimum 5 years' experience in related Work.

.4 Technical assessment of proposed system will be made as part of our selection criteria.

.5 Controls contractor provides actuators for all motorized dampers in accordance with this section.

.6 **The facility has an existing Johnson Controls Metasys system. All new equipment or systems are to be added to the existing system.**

### 1.2 SCOPE OF SERVICE

.3 The contractor is to have the expertise to install a new DDC system for the new equipment.

.4 Provide a fully commissioned DDC system and documentation.

.5 The Contractor shall provide the necessary engineering, installation, supervision, equipment, commissioning and programming for a complete and fully operational system including but not limited to:

.1 Provide control shop drawings.

.2 Provide a network of Direct Digital Control (DDC) panels (if required).

.3 Provide all wells, sensors, interface devices, automatic control valves, VAV controllers, control dampers, transducers, relays, dampers, damper actuators, wiring, conduit raceways and piping.

.4 Provide graphics software, system software, and any third party software required to meet the intent of these specifications.

.5 Provide labelling of the DDC controls system.

.6 Provide labour and supervision for installation, calibration, checkouts and commissioning of systems. Coordinate with air balancing contractor for calibration of outdoor air flow stations.

.7 Provide all application, database and graphic programming.

.8 Provide shop drawings, training manuals and as-built drawings.

.9 Provide operator training. 8 hrs of training required (or 2 x 4 hr sessions).

.10 Provide a one-year warranty on all components.

.11 Provide one year of maintenance.

.12 Provide all the necessary software and interface devices for DDC based control of the points listed in the points list and the systems described in the sequences of operation.

## 1.3 SCOPE OF WORK

.1 Includes the design, supply, installation, commissioning, and training for a complete DDC control system for control and/or monitoring of the following equipment.

1. Air handing unit AHU-1 and associated gas heating system, DX cooling and dehumidification, heat pipe, motorized dampers and variable frequency drives (VFD).
2. Air handing unit AHU-2 and associated gas heating system, DX cooling and motorized dampers.
3. Air handing unit AHU-3 and associated return fan RF-1, hydronic heating coil and motorized dampers.
4. HRV-1 & HRV-2 and associated hydronic preheat coils, reheat coils and motorized dampers.
5. Boilers B-1 & B-2 and associated circulation pumps, heat exchangers and control valves. Boilers will be controlled by packaged controls.
6. Boilers B-3 & B-4 and associated circulation pumps, heating coils and control valves. Boilers will be controlled by packaged controls.

2. All motorized dampers, actuators, control valves and devices required by this Section.

3. VFD’s for AHU-3 supplied by electrical. Refer to electrical specifications for VFD requirements.

4. The controls contractor shall be responsible for mounting and wiring all remote-mounted sensors and controls supplied with vendor-supplied equipment including the AHU.

5. Graphics are required for each system – see Control Schematics.

**1.4 SUBMITTALS**

.6 Product Data:

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

**Part 2 Products**

**2.1 MATERIALS**

.1 All products used in this project installation shall be new and currently under manufacture and shall have been applied in similar installations for a minimum of two years. This installation shall not be used as a test site for any new products unless explicitly approved by the Contract Administrator in writing. Spare parts shall be available for at least five years after completion of this Contract.

**2.2 COMMUNICATION**

.1 All control products provided for this project shall be compatible with the existing Johnson Controls Metasys system.

.2 The contractor shall provide all communication media, connectors, repeaters, hubs, and routers necessary for the network.

.3 All controllers shall have a communication port for connections with the operator interfaces using the Metasys system.

.4 Communication services over the network shall result in operator interface and value passing that is transparent to the network architecture as follows:

.1 Connection of an operator interface device to any one controller on the network will allow the operator to interface with all other controllers as if that interface were directly connected to the other controllers. Data, status information, reports, system software, custom programs, etc., for all controllers shall be available for viewing and editing from any one controller on the network.

.2 All database values (e.g., objects, software variables, custom program variables) of any one controller shall be readable by any other controller on the network. This value passing shall be automatically performed by a controller when a reference to an object name not located in that controller is entered into the controller’s database. An operator/installer shall not be required to set up any communication services to perform network value passing.

.3 The time clocks in all controllers shall be automatically synchronized daily via the network. An operator change to the time clock in any controller shall be automatically broadcast to all controllers on the network.

.4 The network shall have the following minimum capacity for future expansion:

.1 Each building controller shall have routing capacity for 50 controllers.

.2 The building controller network shall have capacity for 50 building controllers.

.3 The system shall have an overall capacity for 12,500 building controller, custom application controller, and application specific controller input/output objects.

## 2.3 OPERATOR INTERFACE

.1 Operator Interface. Existing Metasys system is web-based. Through an internet connection, a workstation shall be able to access all information in the system.

.2 System Software

.1 System Graphics. Provide graphics for all systems noted under Section 1.2 of this specification. Graphics shall be similar to existing graphics.

## 2.4 CONTROLLER SOFTWARE

.1 Furnish the following applications software for building and energy management. All software applications shall reside and operate in the system controllers. Editing of applications shall occur at the operator workstation.

.2 System Security

.1 User access shall be secured using individual security passwords and user names.

.2 Passwords shall restrict the user to the objects, applications, and system functions as assigned by the system manager.

.3 User Log On/Log Off attempts shall be recorded.

.4 The system shall protect itself from unauthorized use by automatically logging off following the last keystroke. The delay time shall be user-definable.

.3 Scheduling. Provide the capability to schedule each object or group of objects in the system. Each schedule shall consist of the following:

.1 Weekly Schedule. Provide separate schedules for each day of the week. Each of these schedules should include the capability for start, stop, optimal start, optimal stop, and night economizer. Each schedule may consist of up to 10 events. When a group of objects are scheduled together, provide the capability to adjust the start and stop times for each member.

.2 Exception Schedules. Provide the ability for the operator to designate any day of the year as an exception schedule. Exception schedules may be defined up to a year in advance. Once an exception schedule is executed, it will be discarded and replaced by the standard schedule for that day of the week.

.3 Holiday Schedules. Provide the capability for the operator to define up to 99 special or holiday schedules. These schedules may be placed on the scheduling calendar and will be repeated each year. The operator shall be able to define the length of each holiday period.

.4 System Coordination. Provide a standard application for the proper coordination of equipment. This application shall provide the operator with a method of grouping together equipment based on function and location. This group may then be used for scheduling and other applications.

.5 Binary Alarms. Each binary object shall be set to alarm based on the operator-specified state. Provide the capability to automatically and manually disable alarming.

.6 Analog Alarms. Each analog object shall have both high and low alarm limits. Alarming must be able to be automatically and manually disabled.

.7 Alarm Reporting. The operator shall be able to determine the action to be taken in the event of an alarm. Alarms shall be routed to the appropriate workstations based on time and other conditions. An alarm shall be able to start programs, print, be logged in the event log, generate custom messages, and display graphics.

.8 Remote Communication. The system shall have the ability to dial out in the event of an alarm using BACnet or PTP.

.9 Maintenance Management. The system shall monitor equipment status and generate maintenance messages based upon user-designated run-time, starts, and/or calendar date limits.

.10 Sequencing. Provide application software based upon the sequences of operation specified to properly sequence chillers, boilers, and pumps.

.11 PID Control. A PID (proportional-integral-derivative) algorithm with direct or reverse action and anti-windup shall be supplied. The algorithm shall calculate a time-varying analog value that is used to position an output or stage a series of outputs. The controlled variable, set point, and PID gains shall be user-selectable.

.12 Staggered Start. This application shall prevent all controlled equipment from simultaneously restarting after a power outage. The order in which equipment (or groups of equipment) is started, along with the time delay between starts, shall be user-selectable.

.13 Anti-Short Cycling. All binary output objects shall be protected from short cycling. This feature shall allow minimum on-time and off-time to be selected.

.14 On/Off Control with Differential. Provide an algorithm that allows a binary output to be cycled based on a controlled variable and set point. The algorithm shall be direct-acting or reverse-acting and incorporate an adjustable differential.

.15 Run-Time Totalization. Provide software to totalize run-times for all binary input objects. A high runtime alarm shall be assigned, if required, by the operator.

## 2.5 BUILDING CONTROLLERS

.1 General. Provide an adequate number of building controllers to achieve the performance specified in the Part 1 Article on “System Performance.” Each of these panels shall meet the following requirements.

.1 The Building Automation System shall be composed of one or more independent, standalone, microprocessor-based building controllers to manage the global strategies described in the System Software section.

.2 The building controller shall have sufficient memory to support its operating system, database, and programming requirements.

.3 Data shall be shared between networked building controllers.

.4 The operating system of the building controller shall manage the input and output communication signals to allow distributed controllers to share real and virtual object information and allow for central monitoring and alarms.

.5 Controllers that perform scheduling shall have a real-time clock.

.6 The building controller shall continually check the status of its processor and memory circuits. If an abnormal operation is detected, the controller shall

.1 Assume a predetermined failure mode,

.2 Generate an alarm notification.

.7 The Building Controller shall communicate with other BACnet devices on the network using the Read (Execute and Initiate) and Write (Execute and Initiate) services as defined in ASHRAE Standard 135-1995 for BACnet.

.2 Communication.

.1 Each building controller shall reside on a BACnet network using the ISO 8802-3 (Ethernet) Data Link/Physical layer protocol. Each building controller also shall perform BACnet routing if connected to a network of custom application and application specific controllers.

.2 The controller shall provide a service communication port using BACnet Data Link/Physical layer protocol for connection to a portable operator's terminal.

.3 Environment. Controller hardware shall be suitable for the anticipated ambient conditions.

.1 Controllers used outdoors and/or in wet ambient conditions shall be mounted within waterproof enclosures and shall be rated for operation at minus 40°C to 65°C (-40°F to 150°F).

.2 Controllers used in conditioned space shall be mounted in dust-proof enclosures and shall be rated for operation at 0°C to 50°C (32°F to 120°F).

.4 Keypad. A local keypad and display shall be provided. The keypad shall be provided for interrogating and editing data. An optional system security password shall be available to prevent unauthorized use of the keypad and display. If the manufacturer does not provide this keypad and display, provide a portable operator terminal.

.5 Serviceability. Provide diagnostic LEDs for power, communication, and processor. All wiring connections shall be made to field-removable, modular terminal strips or to a termination card connected by a ribbon cable.

.6 Memory. The building controller shall maintain all BIOS and programming information in the event of a power loss for at least 72 hours.

.7 Immunity to power and noise. Controller shall be able to operate at 90% to 110% of nominal voltage rating and shall perform an orderly shutdown below 80% nominal voltage. Operation shall be protected against electrical noise of 5 to 120 Hz and from keyed radios up to 5 W at 1 m (3 ft).

## 2.6 CUSTOM APPLICATION CONTROLLERS

.1 General. Provide an adequate number of Custom Application Controllers to achieve the performance specified in the Part 1 Article on "System Performance." Each of these panels shall meet the following requirements.

.1 The custom application controller shall have sufficient memory to support its operating system, database, and programming requirements.

.1 Data shall be shared between networked custom application controllers.

.2 The operating system of the controller shall manage the input and output communication signals to allow distributed controllers to share real and virtual object information and allow central monitoring and alarms.

.3 Controllers that perform scheduling shall have a real-time clock.

.4 The custom application controller shall continually check the status of its processor and memory circuits. If an abnormal operation is detected, the controller shall

.1 Assume a predetermined failure mode and

.2 Generate an alarm notification.

.5 The custom application controller shall communicate with other BACnet devices on the network using the Read (Execute and Initiate) and Write (Execute and Initiate) services as defined in ASHRAE Standard 135-1995 for BACnet.

.2 Communication.

.1 Each custom application controller shall reside on a BACnet network using the MS/TP Data Link/Physical layer protocol.

.2 The controller shall provide a service communication port using BACnet Data Link/Physical layer protocol for connection to a portable operator's terminal.

.3 Environment. Controller hardware shall be suitable for the anticipated ambient conditions.

.1 Controllers used outdoors and/or in wet ambient conditions shall be mounted within waterproof enclosures and shall be rated for operation at minus 40°C to 65°C (-40°F to 150°F).

.2 Controllers used in conditioned space shall be mounted in dustproof enclosures and shall be rated for operation at 0°C to 50°C (32°F to 120°F).

.4 Serviceability. Provide diagnostic LEDs for power, communication, and processor. All wiring connections shall be made to field-removable, modular terminal strips or to a termination card connected by a ribbon cable.

.5 Memory. The custom application controller shall maintain all BIOS and programming information in the event of a power loss for at least 72 hours.

.6 Immunity to power and noise. Controller shall be able to operate at 90% to 110% of nominal voltage rating and shall perform an orderly shutdown below 80% nominal voltage. Operation shall be protected against electrical noise of 5 to 120 Hz and from keyed radios up to 5 W at 1 m (3 ft).

## 2.7 APPLICATION SPECIFIC CONTROLLERS

.1 General. Application specific controllers (ASCs) are microprocessor-based DDC controllers, which through hardware or firmware design are dedicated to control a specific piece of equipment. They are not fully user-programmable but are customized for operation within the confines of the equipment they are designed to serve. Application specific controllers shall communicate with other BACnet devices on the network using the Read (Execute) service as defined in ASHRAE Standard 135-1995 for BACnet.

.1 Each ASC shall be capable of stand-alone operation and shall continue to provide control functions without being connected to the network.

.2 Each ASC will contain sufficient I/O capacity to control the target system.

.2 Communication.

.1 The controller shall reside on a BACnet network using the MS/TP Data Link/Physical layer protocol. Each network of controllers shall be connected to one building controller.

.2 Each controller shall have a BACnet Data Link/Physical layer compatible connection for a laptop computer or a portable operator's tool. This connection shall be extended to a space temperature sensor port if required.

.3 Environment. The hardware shall be suitable for the anticipated ambient conditions.

.1 Controllers used outdoors and/or in wet ambient conditions shall be mounted within waterproof enclosures and shall be rated for operation at minus 40°C to 65°C (-40°F to 150°F).

.2 Controllers used in conditioned space shall be mounted in dust-proof enclosures and shall be rated for operation at 0°C to 50°C (32°F to 120°F).

.4 Serviceability. Provide diagnostic LEDs for power, communication, and processor. All wiring connections shall be made to field-removable, modular terminal strips or to a termination card connected by a ribbon cable.

.5 Memory. The application specific controller shall use non-volatile memory and maintain all BIOS and programming information in the event of a power loss.

.6 Immunity to power and noise. Controllers shall be able to operate at 90% to 110% of nominal voltage rating and shall perform an orderly shutdown below 80%. Operation shall be protected against electrical noise of 5-120 Hz and from keyed radios up to 5 W at 1 m (3 ft).

.7 Transformer. Power supply for the ASC must be rated at a minimum of 125% of ASC power consumption and shall be of the fused or current limiting type.

## 2.8 INPUT/OUTPUT INTERFACE

.1 Hardwired inputs and outputs may tie into the system through building, custom application, or application specific controllers.

.2 All input points and output points shall be protected such that shorting of the point to itself, to another point, or to ground will cause no damage to the controller. All input and output points shall be protected from voltage up to 24 V of any duration, such that contact with this voltage will cause no damage to the controller.

.3 Universal type input/output points shall be designated (in software) as either a binary or analog type point with appropriate properties. Application specific controllers are exempted from this requirement.

.4 Binary inputs shall allow the monitoring of On/Off signals from remote devices. The binary inputs shall provide a wetting current of at least 12 mA to be compatible with commonly available control devices and shall be protected against the effects of contact bounce and noise. Binary inputs shall sense “dry contact” closure without external power (other than that provided by the controller) being applied.

.5 Pulse accumulation input objects. This type of object shall conform to all the requirements of binary input objects and also accept up to 10 pulses per second for pulse accumulation.

.6 Analog inputs shall allow the monitoring of low-voltage (0 to 10 VDC), current (4 to 20 mA), or resistance signals (thermistor, RTD). Analog inputs shall be compatible with—and field configurable to— commonly available sensing devices.

.7 Binary outputs shall provide for On/Off operation or a pulsed low-voltage signal for pulse width modulation control. Binary outputs on building and custom application controllers shall have three-position (On/Off/Auto) override switches and status lights. Outputs shall be selectable for either normally open or normally closed operation.

.8 Analog outputs shall provide a modulating signal for the control of end devices. Outputs shall provide either a 0 to 10 VDC or a 4 to 20 mA signal as required to provide proper control of the output device. Analog outputs on building or custom application controllers shall have status lights and a two-position (AUTO/MANUAL) switch and manually adjustable potentiometer for manual override. Analog outputs shall not exhibit a drift of greater than 0.4% of range per year.

.9 System Object Capacity. The system size shall be expandable to at least twice the number of input/output objects required for this project. Additional controllers (along with associated devices and wiring) shall be all that is necessary to achieve this capacity requirement. The operator interfaces installed for this project shall not require any hardware additions or software revisions in order to expand the system.

## 2.9 POWER SUPPLIES AND LINE FILTERING

.1 Control transformers shall be CSA approved. Furnish Class 2 current-limiting type or furnish over-current protection in both primary and secondary circuits for Class 2 service in accordance with CEC requirements. Limit connected loads to 80% of rated capacity.

.2 Provide transient voltage and surge suppression for all workstations and controllers either internally or as an external component.

## 2.10 AUXILIARY CONTROL DEVICES

.1 Motorized control dampers, unless otherwise specified elsewhere, shall be as follows:

.1 Control dampers shall be the parallel or opposed blade type as below or as scheduled on drawings.

.1 Outdoor and/or return air mixing dampers shall be parallel blade, arranged to direct airstreams toward each other.

.2 Other modulating dampers shall be the opposed blade type.

.3 Two-position shutoff dampers on exhaust and air intake applications shall have insulated blades and may be parallel or opposed blade type with blade and side seals. See control drawings for locations of these dampers and damper specifications for details.

.2 Damper frames shall be 13 gauge galvanized steel channel or 1/8 in. extruded aluminum with reinforced corner bracing.

.3 Damper blades shall not exceed 20 cm (8 in.) in width or 125 cm (48 in.) in length. Blades are to be suitable for medium velocity performance (10 m/s [2000 fpm]). Blades shall be not less than 16 gauge.

.4 Damper shaft bearings shall be as recommended by manufacturer for application, oil impregnated sintered bronze or better.

.5 All blade edges and top and bottom of the frame shall be provided with replaceable butyl rubber or neoprene seals. Side seals shall be spring-loaded stainless steel. The blade seals shall provide for a maximum leakage rate of 50 L/s·m2 (10 cfm per ft2) at 1000 Pa (4 in. w.g.) differential pressure. Provide airfoil blades suitable for a wide-open face velocity of 7.5 m/s (1500 fpm).

.6 Individual damper sections shall not be larger than 125 cm × 150 cm (48 in. × 60 in.). Provide a minimum of one damper actuator per section.

.7 Modulating dampers shall provide a linear flow characteristic where possible.

.8 Motorized dampers shall be installed next to duct access doors for ease in maintenance.

.2 Electric damper/valve actuators.

.1 The actuator shall have mechanical or electronic stall protection to prevent damage to the actuator throughout the rotation of the actuator.

.2 Where shown, for power-failure/safety applications, an internal mechanical, spring-return mechanism shall be built into the actuator housing.

.3 Proportional actuators shall accept a 0 to 10 VDC or 0 to 20 mA control signal and provide a 2 to 10 VDC or 4 to 20 mA operating range.

.4 All 24 VAC/VDC actuators shall operate on Class 2 wiring

.5 All non-spring-return actuators shall have an external manual gear release to allow manual positioning of the damper when the actuator is not powered. Spring-return actuators with more than 7 Nm (60 in.-lb) torque capacity shall have a manual crank for this purpose.

.3 Control valves.

.1 Control valves shall be two-way or three-way type for two-position or modulating service as shown. Perimeter radiators shall have pneumatic (non-DDC) two-position valves, AHU coils shall have modulating electric (DDC) valves and reheat coil valves shall be two-position electric (DDC) valves.

.2 Close-off (differential) Pressure Rating: Valve actuator and trim shall be furnished to provide the following minimum close-off pressure ratings:

.1 Water Valves:

.1 Two-way: 150% of total system (pump) head.

.2 Three-way: 300% of pressure differential between ports A and B at design flow or 100% of total system (pump) head.

.3 Water Valves:

.1 Body and trim style and materials shall be in accordance with manufacturer's recommendations for design conditions and service shown, with equal percentage ports for modulating service.

.2 Sizing Criteria:

.1 Two-position service: Line size.

.1 Two-way modulating service: Pressure drop shall be equal to 50% of the pressure difference between supply and return mains, or 5 psi, maximum.

.2 Three-way modulating service: Pressure drop equal to twice the pressure drop through the coil exchanger (load), 35 kPa (5 psi) maximum.

.3 Valves ½ in. through 2 in. shall be bronze body or cast brass ANSI Class 250, spring-loaded, PTFE packing, quick opening for two-position service. Two-way valves to have replaceable composition disc or stainless steel ball.

.4 Valves 2½ in. and larger shall be cast iron ANSI Class 125 with guided plug and PTFE packing.

.3 Water valves shall fail normally open or closed, as scheduled on plans, or as follows:

.1 Water zone valves—normally open preferred.

.2 Heating coils in air handlers—normally open.

.3 Other applications—as scheduled or as required by sequences of operation.

.4 Binary Temperature Devices

.1 Low-voltage space thermostat shall be 24 V, bimetal-operated, mercury-switch type, with either adjustable or fixed anticipation heater, concealed setpoint adjustment, 13°C to 30°C (55°F to 85°F) set point range, 1°C (2°F) maximum differential, and vented ABS plastic cover.

.2 Line-voltage space thermostat shall be bimetal-actuated, open contact type, or bellows-actuated, enclosed, snap-switch type or equivalent solid-state type, with heat anticipator, CSA approved for electrical rating, concealed setpoint adjustment, 13°C to 30°C (55°F to 85°F) setpoint range, 1°C (2°F) maximum differential, and vented ABS plastic cover.

.3 Low-limit thermostats. Low-limit air stream thermostats shall be CSA approved, vapor pressure type, with an element of 6 m (20 ft) minimum length. Element shall respond to the lowest temperature sensed by any 30 cm (1 ft) section. The low-limit thermostat shall be manual reset only.

.5 Temperature sensors.

.1 Temperature sensors shall be Resistance Temperature Device (RTD) or thermistor.

.2 Duct sensors shall be single point or averaging. Averaging sensors shall be a minimum of 1.5 m (5 ft) in length per 1 $m^2$ (10 $ft^2$) of duct cross section.

.3 Immersion sensors shall be provided with a separable stainless steel well. Pressure rating of well is to be consistent with the system pressure in which it is to be installed. The well must withstand the flow velocities in the pipe.

.4 Space sensors shall be equipped with set point adjustment, override switch, display, and/or communication port.

.5 Provide matched temperature sensors for differential temperature measurement.

.6 Flow switches.

.1 Flow-proving switches shall be either paddle or differential pressure type, as shown.

.2 Paddle type switches (water service only) shall be CSA approved, SPDT snap-acting with pilot duty rating (125 VA minimum) and shall have adjustable sensitivity with NEMA 1 enclosure unless otherwise specified.

.3 Differential pressure type switches (air or water service) shall be CSA approved, SPDT snap-acting, pilot duty rated (125 VA minimum), NEMA 1 enclosure, with scale range and differential suitable for intended application or as specified.

.7 Relays.

.1 Control relays shall be CSA approved plug-in type with dust cover and LED "energized" indicator. Contact rating, configuration, and coil voltage shall be suitable for application.

.2 Time delay relays shall be CSA approved solid-state plug-in type with adjustable time delay. Delay shall be adjustable ±200% (minimum) from set point shown on

plans. Contact rating, configuration, and coil voltage shall be suitable for application. Provide NEMA 1 enclosure when not installed in local control panel.

.3 Override timers.

.1 Override timers shall be spring-wound line voltage, CSA approved, with contact rating and configuration as required by application. Provide 0-to-6-hour calibrated dial unless otherwise specified. Timer shall be suitable for flush mounting on control panel face and located on local control panels or where shown.

.8 Current switches.

.1 Current-operated switches shall be self-powered, solid-state with adjustable trip current. The switches shall be selected to match the current of the application and output requirements of the DDC system.

.9 Pressure transducers.

.1 Transducer shall have linear output signal. Zero and span shall be field adjustable.

.2 Transducer sensing elements shall withstand continuous operating conditions of positive or negative pressure 50% greater than calibrated span without damage.

.3 Water pressure transducer shall have stainless steel diaphragm construction, proof pressure of 150 psi minimum. Transducer shall be complete with 4 to 20 mA output, required mounting brackets, and block and bleed valves.

.4 Water differential pressure transducer shall have stainless steel diaphragm construction, proof pressure of 150 psi minimum. Overrange limit (differential pressure) and maximum static pressure shall be 300 psi. Transducer shall be complete with 4 to 20 mA output, required mounting brackets, and five-valve manifold.

.10 Differential pressure type switches (air or water service) shall be CSA approved, SPDT snap-acting, pilot duty rated (125 VA minimum), NEMA 1 enclosure, with scale range and differential suitable for intended application or as shown.

.11 Pressure-Electric (PE) Switches.

.1 Shall be metal or neoprene diaphragm actuated, operating pressure rated 0-175 kPa (0-25 psig), with calibrated scale setpoint range of 14-125 kPa (2-18 psig) minimum, CSA approved.

.2 Provide one- or two-stage switch action SPDT, DPST, or DPDT, as required by application. Electrically rated for pilot duty service (125 VA minimum) and/or for motor control.

.3 Shall be open type (panel-mounted) or enclosed type for remote installation. Enclosed type shall be NEMA 1 unless otherwise specified.

.4 Shall have a permanent indicating gauge on each pneumatic signal line to PE switches.

.12 Local control panels.

.1 All indoor control cabinets shall be fully enclosed NEMA 1 construction with (hinged door) key-lock latch and removable subpanels. A single key shall be common to all field panels and subpanels.

.2 Interconnections between internal and face-mounted devices shall be pre-wired with color-coded stranded conductors neatly installed in plastic troughs and/or tie-wrapped. Terminals for field connections shall be CSA approved for 600 volt service, individually identified per control/interlock drawings, with adequate clearance for field wiring. Control terminations for field connection shall be individually identified per control drawings.

.3 Provide ON/OFF power switch with overcurrent protection for control power sources to each local panel.

## 2.11 WIRING AND RACEWAYS

.1 General: Provide copper wiring, plenum cable, and raceways as specified in the applicable sections of Division 16.

.2 All insulated wire to be copper conductors, UL labelled for 90°C minimum service.

## 2.12 SPACE MOUNTED $CO_2$ SENSORS

.1 Units shall be certified to UL and CSA standards.

.2 The Gas Monitor will be powered by an external power supply rated at 20-28 Vac/dc.

.3 The unit will perform the detection of carbon dioxide. Carbon dioxide will be detected non-dispersive infrared diffusion sampling. The monitor will have resolution levels of 1 ppm with a minimum range of 0-2000 ppm (0-5% accuracy). Temperature and relative humidity variations will have no effect on the unit's accuracy. Infrared monitor life will be no less than 10 years.

.4 The units will require very low levels of maintenance, including only one verification per year where required.

.5 The unit must also be capable of providing a local display of the concentration of CO2 and provide a 4 -20 ma output for connection to a DDC system.

.6 The monitor will be capable of operating within relative humidity ranges of 0-95% and temperature ranges of 0°C to 50°C (32°F to 122°F).

.7 The unit shall have a footprint of 119 mm (4.7") high X 84 mm (3.3 in) wide X 29 mm (1.15") deep. The unit must be designed for in space applications.

.8 The unit must be manufactured within an ISO 9001-2000 production environment and shall be warranted by the manufacturer for a period of five years.

.9 Provide protective cover for installation in gymnasium.

.10 Acceptable product: “Greystone”, in-space application CO2 stand-alone sensor.

**2.13 INSULATED MOTORIZED CONTROL DAMPERS**

.1 Parallel blade, insulated for intakes / exhaust purpose, extruded aluminum, 102 mm depth, 2mm blade thickness, flange mount frame, thermally broken with high density polyurethane injected foam insulation, santoprene blade and jamb seals, linkage concealed in frame, Belimo actuators provided by controls contractor. Size as shown on drawings.

.2 Fail open.

.3 Acceptable Product: “Tamco” series 9000, Alumavent Model 3965 FM

**Part 3 Execution**

**3.1 MANUFACTURER'S INSTRUCTIONS**

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

**3.2 INSTALLATION**

.1 General

.1 The project plans shall be thoroughly examined for control device and equipment locations. Any discrepancies, conflicts, or omissions shall be reported to the Contract Administrator for resolution before rough-in work is started.

.2 The contractor shall inspect the Site to verify that equipment may be installed as shown. Any discrepancies, conflicts, or omissions shall be reported to the Contract Adminstrator for resolution before rough-in work is started.

.3 The contractor shall examine the drawings and specifications for other parts of the Work. If head room or space conditions appear inadequate or if any discrepancies occur between the plans and the contractor’s work and the plans and the work of others the contractor shall report these discrepancies to the Contract Administrator and shall obtain written instructions for any changes necessary to accommodate the contractor’s work with the work of others. Any changes in the Work covered by this specification made necessary by the failure or neglect of the contractor to report such discrepancies shall be made by—and at the expense of—this contractor.

.4 All items shall be installed in accordance with manufacturer’s instructions. All conduit shall be independently supported from the structure in an approved manner.

.5 All control wiring/cabling shall be installed in conduit. J-hooks shall not be permitted.

.6 The control equipment and connecting conduit and wire shall be installed in a neat and workmanlike manner by personnel skilled in this type of installation. All tubing, conduit and plenum rated cable shall be run in an approved manner; conduit shall be run parallel to or at right angles to the building structure. All conduit, tubing, and plenum cable shall be concealed in all finished spaces. Conduit containing wire or

non-metallic tubing may be installed exposed in mechanical rooms or areas where other piping is run exposed.

.7 Non-metallic tubing and plenum cable may be used in concealed accessible spaces provided such installation is allowed by local codes.

.8 All electrical work shall be installed by experienced personnel and conform to CEC and all local codes. Where requirements of Division 16 differ from those contained herein, Division 16 section shall take precedence.

## 3.3 GENERAL WORKMANSHIP

.1 Install equipment, piping, and wiring/raceway parallel to building lines (i.e., horizontal, vertical, and parallel to walls) wherever possible.

.2 Provide sufficient slack and flexible connections to allow for vibration of piping and equipment.

.3 Verify integrity of all wiring to ensure continuity and freedom from shorts and grounds.

.4 All equipment, installation, and wiring shall comply with acceptable industry specifications and standards for performance, reliability, and compatibility and be executed in strict adherence to local codes and standard practices.

## 3.4 WIRING

.1 All control and interlock wiring shall comply with the CEC and local electrical codes and Electrical section of this specification. Where the requirements of this section differ from those in the Electrical section, the requirements of this section shall take precedence.

.2 All CSA Class 1 (line voltage) wiring shall be CSA approved in approved raceway according to CSA and Division 16 requirements.

.3 All low-voltage wiring shall meet CSA Class 2 requirements. (Low-voltage power circuits shall be sub fused when required to meet Class 2 current limit.)

.4 Where CSA Class 2 (current-limited) wires are in concealed and accessible locations, including ceiling return air plenums, approved cables not in raceway may be used provided that cables are CSA approved for the intended application. For example, cables used in ceiling plenums shall be CSA approved specifically for that purpose.

.5 All wiring in mechanical, electrical, or service rooms—or where subject to mechanical damage shall be installed in raceway at levels below 3 m (10 ft).

.6 Do not install Class 2 wiring in raceway containing Class 1 wiring. Boxes and panels containing high voltage wiring and equipment may not be used for low-voltage wiring except for the purpose of interfacing the two (e.g., relays and transformers).

.7 Do not install wiring in raceway containing tubing.

.8 Where Class 2 wiring is run exposed, wiring is to be run parallel along a surface or perpendicular to it and *neatly* tied at 3 m (10 ft) intervals.

.9 Where plenum cables are used without raceway, they shall be supported from or anchored to structural members. Cables shall not be supported by or anchored to ductwork, electrical raceways, piping, or ceiling suspension systems.

.10 All wire-to-device connections shall be made at a terminal block or terminal strip. All wire-to-wire connections shall be at a terminal block.

.11 All wiring within enclosures shall be neatly bundled and anchored to permit access and prevent restriction to devices and terminals.

.12 Maximum allowable voltage for control wiring shall be 120 V. If only higher voltages are available, the contractor shall provide step-down transformers.

.13 All wiring shall be installed as continuous lengths, with no splices permitted between termination points.

.14 Install plenum wiring in sleeves where it passes through walls and floors. Maintain fire rating at all penetrations.

.15 Size of raceway and size and type of wire shall be the responsibility of the contractor, in keeping with the manufacturer's recommendations and CSA requirements, except as noted elsewhere.

.16 Include one pull string in each raceway 2.5 cm (1 in.) or larger.

.17 Use coded conductors throughout with conductors of different colors.

.18 Control and status relays are to be located in designated enclosures only. These enclosures include packaged equipment control panel enclosures unless they also contain Class 1 starters.

.19 Conceal all raceways, except within mechanical, electrical, or service rooms. Install raceway to maintain a minimum clearance of 15 cm (6 in.) from high-temperature equipment (e.g., steam pipes or flues).

.20 Secure raceways with raceway clamps fastened to the structure and spaced according to code requirements. Raceways and pull boxes may not be hung on flexible duct strap or tie rods. Raceways may not be run on or attached to ductwork.

.21 Adhere to this specification's Division 16 requirements where raceway crosses building expansion joints.

.22 Install insulated bushings on all raceway ends and openings to enclosures. Seal top end of all vertical raceways.

.23 The contractor shall terminate all control and/or interlock wiring and shall maintain updated (asbuilt) wiring diagrams with terminations identified at the job Site.

.24 Flexible metal raceways and liquid-tight, flexible metal raceways shall not exceed 1 m (3 ft) in length and shall be supported at each end. Flexible metal raceway less than ½ in. electrical trade size shall not be used. In areas exposed to moisture, including chiller and boiler rooms, liquid-tight, flexible metal raceways shall be used.

.25 Raceway must be rigidly installed, adequately supported, properly reamed at both ends, and left clean and free of obstructions. Raceway sections shall be joined with couplings (according to code). Terminations must be made with fittings at boxes, and ends not terminating in boxes shall have bushings installed.

## 3.5 COMMUNICATION WIRING

.1 The contractor shall adhere to the items listed in the "Wiring" article in Part 3 of the specification.

.2 All cabling shall be installed in a neat and workmanlike manner. Follow manufacturer's installation recommendations for all communication cabling.

.3 Do not install communication wiring in raceway and enclosures containing Class 1 or other Class 2 wiring.

.4 Maximum pulling, tension, and bend radius for cable installation, as specified by the cable manufacturer, shall not be exceeded during installation.

.5 contractor shall verify the integrity of the entire network following the cable installation. Use appropriate test measures for each particular cable.

.6 When a cable enters or exits a building, a lightning arrestor must be installed between the lines and ground. The lighting arrestor shall be installed according to the manufacturer's instructions.

.7 All runs of communication wiring shall be un-spliced length when that length is commercially available.

.8 All communication wiring shall be labelled to indicate origination and destination data.

## 3.6 INSTALLATION OF SENSORS

.1 Install sensors in accordance with the manufacturer's recommendations.

.2 Mount sensors rigidly and adequately for the environment within which the sensor operates.

.3 Room temperature sensors shall be installed on concealed junction boxes properly supported by the wall framing.

.4 All wires attached to sensors shall be air sealed in their raceways or in the wall to stop air transmitted from other areas affecting sensor readings.

.5 Sensors used in mixing plenums shall be of the averaging type. Averaging sensors shall be installed in a serpentine manner vertically across the duct. Each bend shall be supported with a capillary clip.

.6 Low-limit sensors used in mixing plenums shall be installed in a serpentine manner horizontally across duct. Each bend shall be supported with a capillary clip. Provide 3 m of sensing element for each 1 $m^2$ (1 ft of sensing element for each 1 $ft^2$) of coil area.

.7 All pipe-mounted temperature sensors shall be installed in wells. Install all liquid temperature sensors with heat-conducting fluid in thermal wells.

.8 Install outdoor air temperature sensors on north wall, complete with sun shield at designated location.

.9 Differential air static pressure.

.1 Supply Duct Static Pressure: Pipe the high-pressure tap to the duct using a pitot tube. Pipe the low-pressure port to a tee in the high-pressure tap tubing of the corresponding building static pressure sensor (if applicable) or to the location of the duct high-pressure tap and leave open to the plenum.

.2 Return Duct Static Pressure: Pipe the high-pressure tap to the duct using a pitot tube. Pipe the low-pressure port to a tee in the low-pressure tap tubing of the corresponding building static pressure sensor.

.3 Building Static Pressure: Pipe the low-pressure port of the pressure sensor to the static pressure port located on the outside of the building through a high-volume accumulator. Pipe the high-pressure port to a location behind a thermostat cover.

.4 The piping to the pressure ports on all pressure transducers shall contain a capped test port located adjacent to the transducer.

.5 All pressure transducers, shall be located in field device panels, not on the equipment monitored or on ductwork. Mount transducers in a location accessible for service without use of ladders or special equipment.

.6 All air and water differential pressure sensors shall have gauge tees mounted adjacent to the taps. Water gauges shall also have shutoff valves installed before the tee.

## 3.7 FLOW SWITCH INSTALLATION

.1 Use correct paddle for pipe diameter.

.2 Adjust flow switch in accordance with manufacturer's instructions.

## 3.8 ACTUATORS

.1 Mount and link control damper actuators according to manufacturer's instructions.

.1 To compress seals when spring-return actuators are used on normally closed dampers, power actuator to approximately 5° open position, manually close the damper, and then tighten the linkage.

.2 Check operation of damper/actuator combination to confirm that actuator modulates damper smoothly throughout stroke to both open and closed positions.

.3 Provide all mounting hardware and linkages for actuator installation.

.2 Electric/Electronic

.1 Dampers: Actuators shall be direct-mounted on damper shaft or jackshaft unless shown as a linkage installation. For low-leakage dampers with seals, the actuator shall be mounted with a minimum 5° available for tightening the damper seals. Actuators shall be mounted following manufacturer's recommendations.

.2 Valves: Actuators shall be connected to valves with adapters approved by the actuator manufacturer. Actuators and adapters shall be mounted following the actuator manufacturer's recommendations.

## 3.9 WARNING LABELS

.1 Permanent warning labels shall be affixed to all equipment that can be automatically started by the DDC system.

.1 Labels shall use white lettering (12-point type or larger) on a red background.

.2 Warning labels shall read as follows:

C A U T I O N

This equipment is operating under automatic control

and may start or stop at any time without warning.

Switch disconnect to "Off" position before servicing.

.2 Permanent warning labels shall be affixed to all motor starters and all control panels that are connected to multiple power sources utilizing separate disconnects.

.1 Labels shall use white lettering (12-point type or larger) on a red background.

.2 Warning labels shall read as follows:

C A U T I O N

This equipment is fed from more than one

power source with separate disconnects.

Disconnect all power sources before servicing.

## 3.10 IDENTIFICATION OF HARDWARE AND WIRING

.1 All wiring and cabling, including that within factory fabricated panels, shall be labelled at each end within 5 cm (2 in.) of termination with the DDC address or termination number.

.2 All pneumatic tubing shall be labelled at each end within 5 cm (2 in.) of termination with a descriptive identifier.

.3 Permanently label or code each point of field terminal strips to show the instrument or item served.

.4 Identify control panels with minimum 1 cm (½ in.) letters on laminated plastic nameplates.

.5 Identify all other control components with permanent labels. All plug-in components shall be labelled such that removal of the component does not remove the label.

.6 Identify room sensors relating to terminal box or valves with nameplates.

.7 Manufacturers' nameplates and UL or CSA labels are to be visible and legible after equipment is installed.

.8 Identifiers shall match record documents.

## 3.11 CONTROLLERS

.1 Provide a separate controller for each AHU or other HVAC system. A DDC controller may control more than one system provided that all points associated with the system are assigned to the same DDC controller. Points used for control loop reset, such as outside air or space temperature, are exempt from this requirement.

.2 Building Controllers and Custom Application Controllers shall be selected to provide a minimum of 15% spare I/O point capacity for each point type found at each location. If input points are not universal, 15% of each type is required. If outputs are not universal, 15% of each type is required. A minimum of one spare is required for each type of point used.

.3 Future use of spare capacity shall require providing the field device, field wiring, point database definition, and custom software. No additional controller boards or point modules shall be required to implement use of these spare points.

## 3.12 PROGRAMMING

.1 Provide sufficient internal memory for the specified sequences of operation and trend logging. There shall be a minimum of 25% of available memory free for future use.

.2 Point Naming: System point names shall be modular in design, allowing easy operator interface without the use of a written point index.

.3 Software Programming:

.1 Provide programming for the system and adhere to the sequences of operation provided. All other system programming necessary for the operation of the system, but not specified in this document, also shall be provided by the contractor. Imbed into the control program sufficient comment statements to clearly describe each section of the program. The comment statements shall reflect the language used in the sequences of operation.

.4 Operator Interface

.1 Standard graphics—Provide graphics for all mechanical systems identified. Point information on the graphic displays shall dynamically update. Show on each graphic all input and output points for the system. Also show relevant calculated points such as set points.

.2 Show terminal equipment information on a "graphic" summary table. Provide dynamic information for each point shown.

.3 The contractor shall provide all the labour necessary to install, initialize, start up, and troubleshoot all operator interface software and its functions as described in this section. This includes any operating system software, the operator interface database, and any third party software installation and integration required for successful operation of the operator interface.

## 3.13 CONTROL SYSTEM CHECKOUT AND TESTING

.1 Start-up Testing: All testing listed in this article shall be performed by the contractor and shall make up part of the necessary verification of an operating control system. This testing shall be completed before the Contract Administrator is notified of the system demonstration.

.1 The contractor shall furnish all labour and test apparatus required to calibrate and prepare for service of all instruments, controls, and accessory equipment furnished under this specification.

.2 Verify that all control wiring is properly connected and free of all shorts and ground faults. Verify that terminations are tight.

.3 Enable the control systems and verify calibration of all input devices individually. Perform calibration procedures according to manufacturers' recommendations.

.4 Verify that all binary output devices (relays, solenoid valves, two-position actuators and control valves, magnetic starters, etc.) operate properly and that the normal positions are correct.

.5 Verify that all analog output devices (I/Ps, actuators, etc.) are functional, that start and span are correct, and that direction and normal positions are correct. The contractor shall check all control valves and automatic dampers to ensure proper action and closure. The contractor shall make any necessary adjustments to valve stem and damper blade travel.

.6 Verify that the system operation adheres to the sequences of operation. Simulate and observe all modes of operation by overriding and varying inputs and schedules. Tune all DDC loops and optimum start/stop routines.

.7 Alarms and Interlocks:

.1 Check each alarm separately by including an appropriate signal at a value that will trip the alarm.

.2 Interlocks shall be tripped using field contacts to check the logic, as well as to ensure that the fail-safe condition for all actuators is in the proper direction.

.3 Interlock actions shall be tested by simulating alarm conditions to check the initiating value of the variable and interlock action.

.2 Testing and balancing shall also be performed according to the Testing and Balancing section.

## 3.14 CONTROL SYSTEM DEMONSTRATION AND ACCEPTANCE

.1 Refer to Section 21 05 01 – Common Work Results For Mechanical for commissioning details and requirements.

## 3.15 CLEANING

.1 The contractor shall clean up all debris resulting from his/her activities daily. The contractor shall remove all cartons, containers, crates, etc., under his/her control as soon as their contents have been removed. Waste shall be collected and placed in a designated location.

.2 At the completion of Work in any area, the contractor shall clean all Work, equipment, etc., keeping it free from dust, dirt, and debris, etc.

.3 At the completion of Work, all equipment furnished under this section shall be checked for paint damage, and any factory-finished paint that has been damaged shall be repaired to match the adjacent areas. Any cabinet or enclosure that has been deformed shall be replaced with new material and repainted to match the adjacent areas.

## 3.16 TRAINING

.1 Provide training sessions for the City's personnel.

.2 Train the designated staff of the City to enable them to do the following:

.1 Day-to-day Operators:

.1 Proficiently operate the system

.2 Understand system operation, including DDC system control and optimizing routines (algorithms)

.3 Operate the workstation and peripherals

.4 Log on and off the system

.5 Access graphics, point reports, and logs

.6 Adjust and change system set points, time schedules, and holiday schedules

.7 Recognize malfunctions of the system by observation of the printed copy and graphical visual signals

.8 Understand system drawings and Operation and Maintenance manual

.9 Understand the job layout and location of control components

.10 Access data from DDC controllers and ASCs

.3 Provide course outline and materials. The instructor(s) shall provide one copy of training material per student.

.4 The instructor(s) shall be factory-trained instructors experienced in presenting this material.

.5 One 8 hour training session or 2 x 4 hour training sessions are required.

**.6 Provide a follow up training sessions 6 months after the first training session as described above.**

## 3.17 DDC CONTROLS SEQUENCE OF OPERATION (REFER TO MECHANICAL DRAWINGS)

.1 General:

.1 Controls contractor shall enter/confirm the base schedule of the buildings occupied times into the DDC control system and shall train designated building personnel with the new system controls.

.2 Air Handling Units and Heat Recovery Ventilators: (Refer to Sections 23 73 11 - Air Handling Units – Packaged and 23 72 00 Air-to-Air Energy Recovery Equipment).

HRV dampers and actuators by controls contractor.

DDC system shall control air handling systems to achieve occupied/unoccupied modes, discharge air control, space temperature control and setup/setback functions.

.3 Air Handling Unit AHU-1: Splash Pad Dehumidification Unit

.1 Air Handling Unit (AHU-1) shall operate on a programmable occupied / unoccupied schedule.

.2 Provide hard wired freeze stat to close fresh air damper (if open) based on low discharge air temperature (10°C, adjustable) and after time delay (2 minutes, adjustable), shut down unit and alarm in DDC.

.3 AHU-1 heating, cooling and heat pipe sections shall be fully controlled by packaged vendor controls. These controls shall tie into a central AHU controller provided by the manufacturer. A single point connection from this controller to the building's DDC system shall be available.

.4 Occupied / Un-Occupied Modes:

.1 AHU supply and return fans and associated VFDs shall operate continuously. Return fan VFD and associated motorized dampers shall operate to maintain a negative pressure relative to the outdoors. (Un-occupied Mode: Supply and return fan VFDs shall set back to 50% speed (adjustable)).

.2 Outdoor air, return air and relief air dampers shall be modulating for minimum outside air, economizer and dehumidification functions. (Un-occupied Mode: Outdoor air damper shall open/close as necessary to minimize cooling loads in summer).

.3 Outside air shall be controlled by one of the following (whichever is greater)

.1 Amount of outside air required for dehumidification in winter and shoulder seasons.

.2 Amount of outside air required for economizer mode.

.3 Amount of outside air required to limit space $CO_2$ concentrations at or below the set point.

.4 AHU shall maintain space temperature and humidity set points. Provide automatic changeover between heating, cooling/dehumidification, and economizer modes based on outdoor air enthalpy.

.1 Heating Mode:

.1 Gas heating controls to be provided by the air handler supplier.

.2 Supply air temperature shall be controlled by an outdoor air reset schedule in the DDC.

.3 Supply air temperature shall be overridden on call for space heating.

.2 Economizer Mode:

.1 When outdoor enthalpy permits, outside air, return air and relief air dampers shall modulate to maintain space temperature and humidity set points.

.2 Integral relief damper shall modulate open to maintain space pressure.

.3 Lockout economizer when outdoor air enthalpy is greater than indoor air enthalpy.

.3 Dehumidification/Cooling Mode:

.1 Packaged DX cooling controls shall be provided by the air handler supplier.

.2 Enable mechanical dehumidification/cooling when economizer cannot maintain temperature or humidity set point.

.3 Supply air temperature and humidity shall be controlled to maintain space temperature and relative humidity.

.4 Condenser reheat shall be used to reheat sub-cooled air to maintain space temperature set point. Use of packaged air cooled condenser or condenser reheat coil shall be controlled by packaged controls.

.4 Heat Recovery (Heat Pipe):

.1 Heat pipe tilt shall be controlled to maintain 0°C exhaust air discharge temperature.

.2 Integral ΔP sensor shall detect frost build-up and adjust heat pipe tilt for defrost mode.

.3 Heat pipe is sized for 50% of AHU-1 airflow capacity. If additional outside air is required, outside air damper for bypass section shall be

opened and mixed with outside air from heat pipe in AHU mixing box.

.5 Heat Recovery Preheat:

.1 Electric preheat coil upstream of heat pipe shall be controlled by a discharge air temperature sensor.

.2 Preheat coil shall modulate to maintain a discharge ait temperature of -34°C.

.5 Upon detection of high CO2 levels, outdoor air / relief air damper to modulate open. CO2 high limit shall be 1000 ppm.

.5 DDC system shall monitor:

.1 AHU-1 (points shall be pulled from the manufacturer factory controller):

.1 All motorized damper status positions (percent open)

.2 Heating capacity output (percent of total capacity)

.3 Number of compressors operating.

.4 Compressor capacity output (percent of compressor capacity for digital scroll compressors)

.5 Packaged condensing unit status

.2 The following points shall be added to the DDC by the controls contractor through additional sensors and controllers:

.1 Supply and return fan VFDs status (VFD status in percent).

.2 Supply and return airflow rates.

.3 Supply and exhaust airflow rates through heat pipe.

.4 All supply, return and exhaust air temperatures and relative humidity's.

.5 Differential pressure across filter section.

.6 Temperature and humidity within the unit (various sensors, refer to control schematic).

.7 Space temperature and relative humidity.

.8 Space differential pressure relative to outside.

.9 Space $CO_2$ levels.

.10 Outdoor air temperature, humidity and $CO_2$.

.11 Energy savings calculator: show a readout on the DDC graphic for AHU-1 showing the accumulated energy savings per month in dollars.

.6 DDC system shall alarm:

.1 AHU-1

.1 Supply or return fan failure

.2 Damper failure

.3 Heating system failure (freeze stat)

.4 Electric preheat coil failure (discharge air into heat pipe is not maintained)

.5 Dehumidification system failure (high humidity limit)

.6 Pressure clogged filters

.7 Supply duct high pressure (Critical – Shut down AHU fans and generate alarm)

.8 Return duct low pressure (Critical– Shut down AHU fans and generate alarm)

.9 Low supply air temperature from AHU-1 (non-critical)

.2 High $CO_2$ levels (10% above set point)

.3 Low outdoor air flow rates (10% below set point. Set points to be provided during commissioning). Total outdoor air rate is sum of both intakes.

.4 Condensing Unit Failure

.5 Low space temperature (non-critical)

.4 Air Handling Unit AHU-2: MPR and Office Spaces

.1 AHU-2 heating and cooling sections shall be fully controlled by packaged vendor controls. A single point connection for these controllers shall be available for tie-in into the buildings DDC system.

.2 Provide hard wired freeze stat to close fresh air damper (if open) based on low discharge air temperature (10°C, adjustable) and after time delay (2 minutes, adjustable), shut down unit and alarm in DDC.

.3 Air Handling Unit (AHU-2) shall operate on a programmable occupied / unoccupied schedule as follows:

.1 Occupied Mode:

.1 AHU supply and return fans and associated VFDs shall operate continuously. Outside air damper shall modulate to maintain a positive pressure relative to the splash pad.

.2 Outdoor air, return air and relief air dampers shall be modulating.

.3 Supply fan VFD shall operate to maintain a duct pressure set point. Return fan VFD shall track supply fan VFD.

.4 Provide automatic changeover between heating, cooling, and economizer modes based on outdoor air temperature (operator adjustable).

.1 Heating Mode:

.1 Gas heating controls to be provided by the air handler supplier.

.2 Supply air temperature shall be controlled by an outdoor air reset schedule in the DDC.

.1 Cooling Mode:

.1 Packaged DX cooling controls shall be provided by the air handler suppler. Mechanical cooling shall be enabled when economizer is disabled.

.2 Packaged cooling system shall maintain space temperature at set point. (On call for cooling from a given zone thermostat).

.2 Economizer Mode:

.1 Where outdoor enthalpy permits, economizer shall maintain room set point.

.2 Integral relief air damper shall be modulating to maintain positive pressure relative to the splash pad.

.3 Lockout free cooling when outdoor air enthalpy is greater than indoor air enthalpy. (On call for cooling from a given zone thermostat).

.5 Upon detection of high $CO_2$ levels, outdoor air / relief air damper to modulate open. $CO_2$ high limit shall be 1000 ppm.

.2 Un-Occupied Mode:

.1 AHU supply and return fans and associated VFDs shall operate as required. (On call for heating/cooling from any given zone thermostat.)

.2 Outdoor air / relief air dampers closed, return air damper open.

.3 Supply fan VFD shall operate to maintain a duct pressure set point. Return fan VFD shall track supply fan VFD.

.4 Provide automatic changeover between heating, cooling, and economizer modes based on outdoor air temperature (operator adjustable).

.1 Heating Mode:

.1 Gas heating controls to be provided by the air handler supplier.

.2 Supply air set-back temperature shall be controlled by an outdoor air reset schedule in the DDC.

.2 Cooling Mode:

.1 Packaged cooling system shall maintain space set-back temperature.

.3 Economizer Mode:

.1 Where outdoor enthalpy permits, economizer shall maintain room set-back temperature set point.

.2 Integral relief air damper shall be modulating to maintain positive pressure relative to the splash pad.

.3 Lockout free cooling when outdoor air enthalpy is greater than indoor air enthalpy.

.3 DDC system shall monitor:

.1 AHU-2

.1 All motorized damper status positions (percent open)

.2 Heating capacity output (percent of total capacity)

.3 Number of compressors operating.

.4 Compressor capacity output (percent of compressor capacity for digital scroll compressors)

.5 Packaged condensing unit status

.2 The following points shall be added to the DDC by the controls contractor through additional sensors and controllers:

.1 Supply and return fans and VFD status (VFD status in percent)

.2 Damper Status and Positions

.3 Space temperature

.4 Supply and return air temperatures

.5 Outdoor air temperature and humidity.

.6 Differential pressure across filter bank

.7 Space CO2 levels

.2 DDC system shall alarm:

.1 AHU-2

.1 Supply or return fan failure

.2 Damper failure

.3 Heating system failure (freeze stat)

.4 Condensing unit failure

.5 Pressure clogged filters

.6 Supply duct high pressure (Critical – Shut down AHU fans and generate alarm)

.7 Return duct low pressure (Critical– Shut down AHU fans and generate alarm)

.8 Low supply air temperature from AHU-2 (non-critical)

.2 High $CO_2$ levels (10% above set point)

.3 Low outdoor air flow rates (10% below set point. Set points to be provided during commissioning).

.2 Low space temperature – for each zone (non-critical)

.5 Air Handling Unit AHU-3, Return Fan RF-1 and Remote Condensing Unit CU-1: Viewing Lobby and Existing Areas

.1 Provide hard wired freeze stat to close fresh air damper (if open) based on low discharge air temperature (10°C, adjustable) and after time delay (2 minutes, adjustable), shut down unit and alarm in DDC.

.2 Air Handling Unit (AHU-3) and Return Fan (RF-1) shall operate on a programmable occupied / unoccupied schedule as follows:

.1 Occupied Mode:

.1 AHU-3 supply fan, RF-1 and associated VFDs shall operate continuously. Outside air damper shall modulate to maintain a positive pressure relative to the splash pad.

.2 Outdoor air, return air and relief air dampers shall be modulating.

.3 Supply fan VFD shall operate to maintain a duct pressure set point. Return fan VFD shall track supply fan VFD.

.4 Provide automatic changeover between heating, cooling, and economizer modes based on outdoor air temperature (operator adjustable).

.1 Heating Mode:

.1 DDC is to send reset signal to AHU-1 heating coil modulating control valve to maintain discharge air temperature. Control valve to be open 0 to 100% as required to maintain discharge air temperature.

.2 Supply air temperature shall be controlled by an outdoor air reset schedule in the DDC.

.1 Cooling Mode:

.1 Remote condenser CU-1 shall be controlled by packaged controls. Mechanical cooling shall be enabled when economizer is disabled.

.2 Packaged cooling system shall maintain space temperature at set point. (On call for cooling from a given zone thermostat.) and be enabled/disabled by the DDC.

.2 Economizer Mode:

.1 Where outdoor enthalpy permits, economizer shall be staged to maintain room set point.

.2 Integral relief air damper shall be fully open.

.3 Lockout free cooling when outdoor air enthalpy is greater than indoor air enthalpy. (On call for cooling from a given zone thermostat).

.2 Un-Occupied Mode:

.1 AHU-3 supply fan, RF-1 and associated VFDs shall operate as required. (On call for heating/cooling from any given zone thermostat.)

.2 Outdoor air / relief air dampers closed, return air damper open.

.3 Provide automatic changeover between heating, cooling, and economizer modes based on outdoor air temperature (operator adjustable).

.1 Heating Mode:

.1 DDC is to send reset signal to AHU-1 heating coil modulating control valve to maintain set-back discharge air temperature. Control valve to be open 0 to 100% as required to maintain discharge air temperature.

.2 Cooling Mode:

.1 CU-1 cooling system shall maintain space set-back temperature.

.3 Economizer Mode:

.2 Where outdoor enthalpies permit, economizer shall be staged to maintain room set-back set point.

.3 Remote relief damper modulates to fully open.

.4 Lockout free cooling when outdoor air enthalpy is greater than indoor air enthalpy.

.3 DDC system shall monitor:

.1 Supply fan VFD status (VFD status in percent)

.2 RF-1 VFD status (VFD status in percent)

.3 Space temperature

.4 Supply air temperature

.5 Return air temperature

.6 Outdoor air temperature and humidity.

.7 Damper Status and Positions

.8 Pressure drop across the filters

.9 Condensing Unit Status

.3 DDC system shall alarm:

.1 AHU-3

.1 Supply or return fan failure

.2 Damper failure

.3 Heating system failure (freeze stat)

.4 Condensing unit failure

.5 Pressure clogged filters

.6 Supply duct high pressure (Critical – Shut down AHU fans and generate alarm)

.7 Return duct low pressure (Critical– Shut down AHU fans and generate alarm)

.8 Low supply air temperature from AHU-2 (non-critical)

.2 Low space temperature – for each zone (non-critical)

.6 Heat Recovery Ventilators, HRV-1 & HRV-2, PHC-1 & PHC-2, and RHC-10 & RHC-11:

.1 Provide hard wired freeze stat to close outside air and exhaust air dampers (if open) based on low discharge air temperature (10°C, adjustable) and after time delay (2 minutes, adjustable), shut down unit and alarm in DDC.

.2 Heat Recovery Ventilator shall operate on a programmable occupied / unoccupied schedule as follows:

.1 Occupied Mode:

.1 HRV shall operate continuously.

.2 Outdoor air and exhaust air dampers shall be open.

.3 HRV supply and exhaust fans shall operate to maintain a positive pressure within the areas being served.

.4 Provide automatic changeover between heating and non-heating modes based on outdoor air temperature (operator adjustable).

.1 Heating Mode:

.1 Modulating control valve for PHC upstream of HRV shall modulate to maintain a discharge air temperature of 0°C.

.2 Modulating control valve for RHC downstream of HRV shall modulate to maintain discharge air temperature at room temperature set point.

.1 Non-heating Mode:

.3 Modulating heating control valve for PHC upstream of HRV shall be closed.

.4 Modulating heating control valve for RHC downstream of HRV shall be closed.

.5 2-postion HRV bypass dampers shall open/close to bypass HRV.

.2 Un-Occupied Mode:

.1 HRV shall cycle on/off to maintain space temperature at setback temperature

.2 Outdoor air and exhaust air dampers shall be closed. Outside and exhaust air bypass damper shall be open.

.3 HRV shall cycle on to maintain space temperature as follows:

.1 Heating Mode:

.1 HRV shall be on.

.2 Modulating control valve for RHC downstream of HRV shall modulate to maintain space setback temperature.

.3 DDC system shall monitor:

.1 HRV status

.2 Space temperature

.3 Supply air temperature before preheat coil, after preheat coil, after HRV and after RHC

.4 Exhaust air temperature before and after HRV

.5 Outdoor air temperature.

.6 Damper status and positions

.7 Heating valve actuator status and positions.

.4 Energy savings calculator: show a readout on the DDC graphic for each HRV showing the accumulated energy savings per month in dollars.

.4 DDC system shall alarm:

.1 HRV-1 & HRV-2

.8 HRV failure

.9 Damper failure

.10 Heating system failure (freeze stat)

.11 Low supply air temperature from HRV (non-critical)

.7 Variable Air Volume (VAV) Boxes and Hydronic Reheat Coils (RHC)

.1 VAV shall be controlled by a remote wall DDC thermostat. VAV damper shall modulate to provide cooling air to the space and maintain space set point. VAV box flow rates shall modulate between flow rates described in the schedule on the drawing.

.2 Hydronic heating coil valves shall modulate between 0 – 100% open as required to maintain space temperature. Actuator shall be controlled by VAV controller and associated thermostat. VAV box to supply constant volume of air during heating mode.

.3 VAV box shall follow unoccupied modes described in air handler sequence of operations and to maintain space set back or setup temperatures.

.6 Cabinet Unit Heater, CUH-1

.1 Cabinet unit heaters hall be controlled to maintain space temperature set point. A 2-way, 2-position control valve shall be provided to control the heater. Valve shall be controlled by a remote, wall mounted thermostat.

.7 Existing Pool Supply and Return Fans.

.1 Install four new air temperature sensors upstream and downstream of the glycol run-around loop heat reclaim coil in the basement and the mezzanine coil locations.

.2 Install new air flow measuring station at the outside air intake in the basement and at the mezzanine exhaust duct.

.3 Provide an energy savings calculator to show a readout on the DDC graphic for the existing pool ventilation system showing the accumulated energy savings per month in dollars.

.8 Motorized Dampers

.1 Dampers and damper actuators provided for all operating dampers by this Section. Dampers that are located in air handling units are supplied with air handling units with actuators provided by this section. All other remote dampers and actuators provided by this Section.

## 3.18 ALARMS AND MONITORING

.1 Alarms shall be generated on the DDC system for the following events:

.1 Freeze stat on AHU fans (critical)

.2 Fan failure AHU, HRV's, SF, RF's, EF's (critical)

## 3.19 THERMOSTATS AND TEMPERATURE SENSORS

.1 Provide wall-mounted thermostats and/or space temperature sensors suitable for specified operation. **Provide vandal proof protective covers for all units.**

**END OF SECTION**

## Part 1 General

### 1.1 SUMMARY

.1 Section Includes:

.1 Materials and installation for piping, valves and fittings for gas fired equipment.

.2 Sustainable requirements for construction and verification:

### 1.2 REFERENCES

.1 American Society of Mechanical Engineers (ASME)

.1 ASME B16.5, Pipe Flanges and Flanged Fittings.

.2 ASME B16.18, Cast Copper Alloy Solder Joint Pressure Fittings.

.3 ASME B16.22, Wrought Copper and Copper Alloy Solder-Joint Pressure Fittings.

.4 ASME B18.2.1, Square and Hex Bolts and Screws Inch Series.

.2 American Society for Testing and Materials International (ASTM)

.1 ASTM A47/A47M, Standard Specification for Ferritic Malleable Iron Castings.

.2 ASTM A53/A53M, Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc Coated, Welded and Seamless.

.3 ASTM B75M, Standard Specification for Seamless Copper Tube .

.4 ASTM B837, Standard Specification for Seamless Copper Tube for Natural Gas and Liquefied Petroleum (LP) Gas Fuel Distribution Systems.

.3 Canadian Standards Association (CSA International)

.1 CSA W47.1, Certification of Companies for Fusion Welding of Steel.

.4 Canadian Standards Association (CSA)/Canadian Gas Association (CGA)

.1 CAN/CSA B149.1HB, Natural Gas and Propane Installation Code Handbook.

.2 CAN/CSA B149.2, Propane Storage and Handling Code.

.5 Health Canada/Workplace Hazardous Materials Information System (WHMIS)

.1 Material Safety Data Sheets (MSDS).

### 1.3 ACTION AND INFORMATIONAL SUBMITTALS

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

.2 Co-ordinate submittal requirements and provide submittals required by Section 01 47 15 - Sustainable Requirements: Construction.

.3 Product Data:

.1 Submit manufacturer's printed product literature, specifications and datasheet for piping, fittings and equipment.

.2 Indicate on manufacturers catalogue literature following: valves.

.4 Test Reports: submit certified test reports from approved independent testing laboratories indicating compliance with specifications for specified performance characteristics and physical properties.

.5 Certificates: submit certificates signed by manufacturer certifying that materials comply with specified performance characteristics and physical properties.

.6 Instructions: submit manufacturer's installation instructions.

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

**1.4 QUALITY ASSURANCE**

.1 Health and Safety:

.1 Do construction occupational health and safety in accordance with Section 01 35 30 - Health and Safety.

.2 Construction requirements: in accordance with Section 01 47 15 - Sustainable Requirements: Construction.

.3 Verification: contractor's verification in accordance with Section 01 47 15 - Sustainable Requirements.

**1.5 DELIVERY, STORAGE AND HANDLING**

.1 Waste Management: In accordance with 01 74 21 Construction Waste Management.

**Part 2 Products**

**2.1 MATERIALS**

.1 Materials and products in accordance with Section 01 47 15 - Sustainable Requirements: Construction.

**2.2 PIPE**

.1 Steel pipe: to ASTM A53/A53M, Schedule 40, seamless as follows:

.1 NPS 1/2 to 2, screwed.

.2 NPS2 1/2 and over, plain end.

.2 Copper tube: to ASTM B837.

.3 Paint all gas piping yellow.

**2.3 JOINTING MATERIAL**

.1 Screwed fittings: pulverized lead paste.

.2 Welded fittings: to CSA W47.1.

.3 Flange gaskets: nonmetallic flat.

.4 Brazing: to ASTM B837.

**2.4 FITTINGS**

.1 Steel pipe fittings, screwed, flanged or welded:

.1 Malleable iron: screwed, banded, Class 150.

.2 Steel pipe flanges and flanged fittings: to ASME B16.5.

.3 Welding: butt-welding fittings.

.4 Unions: malleable iron, brass to iron, ground seat, to ASTM A47/A47M.

.5 Bolts and nuts: to ASME B18.2.1.

.6 Nipples: schedule 40, to ASTM A53/A53M.

.2 Copper pipe fittings, screwed, flanged or soldered:

.1 Cast copper fittings: to ASME B16.18.

.2 Wrought copper fittings: to ASME B16.22.

**2.5 VALVES**

.1 Provincial Code approved, lubricated plug or ball type.

**Part 3 Execution**

**3.1 MANUFACTURER'S INSTRUCTIONS**

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

**3.2 PIPING**

.1 Install in accordance with Section 23 05 05 - Installation of Pipework and applicable Codes.

.2 Install drip points:

.1 At low points in piping system.

.2 At connections to equipment.

**3.3 VALVES**

.1 Install valves with stems upright or horizontal.

.2 Install valves at branch take-offs to isolate pieces of equipment, and as indicated.

**3.4 FIELD QUALITY CONTROL**

.1 Site Tests/Inspection:

.1 Test system in accordance with CAN/CSA B149.1 and requirements of authorities having jurisdiction.

.2 Manufacturer's Field Services:

.1 Have manufacturer of products supplied under this Section review work involved in handling, installation/application, protection and cleaning of its product[s], and

submit written reports, in acceptable format, to verify compliance of Work with Contract.

.2 Provide manufacturer's field services, consisting of product use recommendations and periodic Site visits for inspection of product installation, in accordance with manufacturer's instructions.

.3 Schedule Site visits to review work at stages listed:

.1 After delivery and storage of products, and when preparatory work on which Work of this Section depends is complete, but before installation begins.

.2 Twice during progress of work at 25% and 60% complete.

.3 Upon completion of work, after cleaning is carried out.

.3 Obtain reports within 3 days of review and submit immediately to Contract Administrator

.4 Verification requirements in accordance with Section 01 47 15 - Sustainable Requirements, include:

.1 Materials and resources.

.2 Storage and collection of recyclables.

.3 Construction waste management.

.4 Resource reuse.

.5 Recycled content.

.6 Local/regional materials.

.7 Certified wood.

.8 Low-emitting materials.

.5 Performance Verification:

.1 Refer to Section 23 08 01 - Performance Verification of Mechanical Piping Systems.

## 3.5 ADJUSTING

.1 Purging: purge after pressure test in accordance with CAN/CSA B149.1.

.2 Pre-Start-Up Inspections:

.1 Check vents from regulators, control valves, terminate outside building in approved location, protected against blockage, damage.

.2 Check gas trains, entire installation is approved by authority having jurisdiction.

## 3.6 CLEANING

.1 Cleaning: in accordance with Section 23 08 02 - Cleaning and Start-Up of Mechanical Piping Systems and CAN/CSA B149.1.

.2 Perform cleaning operations in accordance with manufacturer's recommendations.

.1 Waste Management: In accordance with 01 74 21 Construction Waste Management.

**END OF SECTION**

## Part 1 General

### 1.1 REFERENCES

.1 American National Standards Institute/American Water Works Association (ANSI/AWWA)

.1 ANSI/AWWA C111/A21.11, Standard for Rubber-Gasket Joints for Ductile-Iron Pressure Pipe and Fittings.

.2 American Society of Mechanical Engineers (ASME)

.1 ASME B16.1,Gray Iron Pipe Flanges and Flanged Fittings: Classes 25, 125, and 250.

.2 ASME B16.3, Malleable Iron Threaded Fittings: Classes 150 and 300.

.3 ASME B16.5, Pipe Flanges and Flanged Fittings: NPS through NPS 24 Metric/Inch Standard.

.4 ASME B16.9, Factory-Made Wrought Buttwelding Fittings.

.5 ASME B18.2.1, Square Hex, Heavy Hex and Askew Head Bolts and Hex, Heavy Hex, Hex Flange. Loded Head and Lag Screws (Inch Series).

.6 ASME B18.2.2, Nuts for General Applications: Machine Screw Nuts, Hex, Square, Hex Flange, and Coupling Nuts (Inch Series).

.3 ASTM International

.1 ASTM A47/A47M, Standard Specification for Ferritic Malleable Iron Castings.

.2 ASTM A53/A53M, Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc Coated Welded and Seamless.

.3 ASTM A536, Standard Specification for Ductile Iron Castings.

.4 ASTM B61, Standard Specification for Steam or Valve Bronze Castings.

.5 ASTM B62, Standard Specification for Composition Bronze or Ounce Metal Castings.

.6 ASTM E202, Standard Test Method for Analysis of Ethylene Glycols and Propylene Glycols.

.4 Canada Green Building Council (CaGBC)

.1 LEED Canada 2009 for Design and Construction, LEED Canada 2009 for Design and Construction Leadership in Energy and Environmental Design Green Building Rating System Reference Guide.

.5 CSA International

.1 CSA B242, Groove and Shoulder Type Mechanical Pipe Couplings.

.2 CSA W48, Filler Metals and Allied Materials for Metal Arc Welding.

.6 Manufacturer's Standardization of the Valve and Fittings Industry (MSS)

.1 MSS-SP-67, Butterfly Valves.

.2 MSS-SP-80, Bronze Gate, Globe, Angle and Check Valves.

### 1.2 ACTION AND INFORMATIONAL SUBMITTALS

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

.2 Product Data:

.1 Submit manufacturer's instructions, printed product literature and data sheets for hydronic systems and include product characteristics, performance criteria, physical size, finish and limitations.

.3 Shop Drawings:

.1 Indicate on drawings:

.1 Components and accessories.

.4 Sustainable Design Submittals:

.1 Submittals: in accordance with Section 01 47 15 - LEED Sustainable Requirements.

**1.3 CLOSEOUT SUBMITTALS**

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

.2 Operation and Maintenance Data: submit operation and maintenance data for hydronic systems for incorporation into manual.

.1 Include special servicing requirements.

**1.4 DELIVERY, STORAGE AND HANDLING**

.1 Deliver, store and handle materials in accordance with Section 01 60 00 - Common Product Requirements] [with manufacturer's written instructions.

.2 Delivery and Acceptance Requirements: deliver materials to Site in original factory packaging, labelled with manufacturer's name and address.

.3 Storage and Handling Requirements:

.1 Store materials in accordance with manufacturer's recommendations in clean, dry, well-ventilated area.

.2 Store and protect hydronic systems from damage.

.3 Replace defective or damaged materials with new.

.4 Waste Management: In accordance with 01 74 21 Construction Waste Management.

**Part 2 Products**

**2.1 PIPE**

.1 Steel pipe: to ASTM A53/A53M, Grade B, as follows:

.1 To NPS 6: Schedule 40.

**2.2 PIPE JOINTS**

.1 NPS 2 and under: screwed fittings with PTFE tape.

.2 NPS 2-1/2 and over: welding fittings and flanges to CSA W48.

.3 Roll grooved: standard or rigid coupling to CSA B242.

.4 Flanges: plain or raised face, slip-on or weld neck.

.5 Orifice flanges: slip-on raised face, 2100 kPa.

.6 Flange gaskets: to ANSI/AWWA C111/ A21.11.

.7 Pipe thread: taper.

.8 Bolts and nuts: to ANSI B18.2.1 and ANSI/ASME B18.2.2.

.9 Roll grooved coupling gaskets: type EPDM.

## 2.3 FITTINGS

.1 Screwed fittings: malleable iron, to ASME B16.3, Class 150.

.2 Pipe flanges and flanged fittings:

.1 Cast iron: to ASME B16.1, Class 125.

.2 Steel: to ASME B16.5.

.3 Butt-welding fittings: steel, to ASME B16.9.

.4 Unions: malleable iron

.5 Fittings for roll grooved piping: malleable iron to ASTM A47/A47M or ductile iron to ASTM A536.

## 2.4 VALVES

.1 Connections:

.1 NPS 2 and smaller: screwed ends.

.2 NPS 2-1/2 and larger: flanged or grooved ends.

.2 Butterfly valves: to MSS-SP-67:

.1 Lug type, ductile iron disc, 410 SS stem, NBR (Buna-n) liner, 200 psi, ductile iron body.

.2 Provide lever handle up to and including 8” diameter valves

.3 Proved gear operator for valves 10” diameter and larger.

.4 Acceptable material: “Kitz” 6112BL or approved alternate.

.3 Flow Balance Valves:

.1 Size: 13 mm – 63 mm

.1 Forged brass body, nickel-plated brass ball, Teflon seals, combination P/T test valves and air vents, memory stop with graduated markings. Valve comes fully assembled.

.2 Valve pressure drop shall not exceed 9 kPa (3 ft water column).

.3 Acceptable Product: “Speedset”, Bell & Gossett, Armstrong.

.4 Swing check valves:

.1 NPS 2-1/2 and over:

.1 Manufactured using ASTM A126 Class B Cast Iron with Buna-N resilient disc seat and comply with MSS-SP-71.

.2 Valve to be pressure rated to 175psi CWP with flanged ends that comply with ANSI B16.10 and ANSI B16.1 Class 125 standards.

.3 Valve shall have a full port design, and be in-line repairable.

.5 Ball valves:

.1 NPS 2 and under: as specified Section 23 05 23.01 - Valves - Bronze.

## Part 3 Execution

### 3.1 EXAMINATION

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

.1 Visually inspect substrate in presence of Contract Administrator.

.2 Inform Contract Administrator of unacceptable conditions immediately upon discovery.

.3 Proceed with installation only after unacceptable conditions have been remedied.

### 3.2 PIPING INSTALLATION

.1 Install pipework in accordance with Section 23 05 05 - Installation of Pipe Work.

### 3.3 CIRCUIT BALANCING VALVES

.1 Install flow measuring stations and flow balancing valves as indicated.

.2 Remove handwheel after installation and when TAB is complete.

.3 Tape joints in prefabricated insulation on valves installed in chilled water mains.

### 3.4 CLEANING, FLUSHING AND START-UP

.1 In accordance with Section 23 08 02 - Cleaning and Start-Up of Mechanical Piping Systems.

### 3.5 TESTING

.1 Test system in accordance with Section 21 05 01 - Common Work Results for Mechanical.

.2 For glycol systems, retest with propylene glycol to ASTM E202, inhibited, for use in building system after cleaning. Repair leaking joints, fittings or valves.

### 3.6 BALANCING

.1 In accordance with Section 23 05 93 - Testing, Adjusting and Balancing for HVAC for applicable procedures and tolerances.

### 3.7 GLYCOL CHARGING

.1 Retest for concentration to ASTM E202 after cleaning.

## 3.8 PERFORMANCE VERIFICATION

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

## 3.9 CLEANING

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

.1 Leave Work area clean at end of each day.

.2 Final Cleaning: upon completion remove surplus materials, rubbish, tools and equipment in accordance with Section 01 74 00 - Cleaning.

.3 Waste Management: In accordance with 01 74 21 Construction Waste Management.

## 3.10 PROTECTION

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

.2 Repair damage to adjacent materials caused by hydronic systems installation.

**END OF SECTION**

## Part 1 General

### 1.1 REFERENCES

.1 ASME

.1 ASME Boiler and Pressure Vessel Code (BPVC), Section VII.

.2 ASTM International

.1 ASTM A47/A47M, Standard Specification for Ferritic Malleable Iron Castings.

.2 ASTM A278/A278M, Standard Specification for Gray Iron Castings for Pressure-Containing Parts for Temperatures up to 650 degrees F (350 degrees C).

.3 ASTM A516/A516M, Standard Specification for Pressure Vessel Plates, Carbon Steel, for Moderate - and Lower - Temperature Service.

.4 ASTM A536, Standard Specification for Ductile Iron Castings.

.5 ASTM B62, Standard Specification for Composition Bronze or Ounce Metal Castings.

.3 Canada Green Building Council (CaGBC)

.1 LEED Canada 2009 for Design and Construction, LEED Canada 2009 for Design and Construction Leadership in Energy and Environmental Design Green Building Rating System Reference Guide.

.4 CSA Group

.1 CSA B51, Boiler, Pressure Vessel, and Pressure Piping Code.

### 1.2 ACTION AND INFORMATIONAL SUBMITTALS

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

.2 Product Data:

.1 Submit manufacturer's instructions, printed product literature and data sheets for expansion tanks, air vents, separators, valves, and strainers and include product characteristics, performance criteria, physical size, finish and limitations.

.3 Sustainable Design Submittals:

.1 Submittals: in accordance with Section 01 47 15 - LEED Sustainable Requirements.

### 1.3 CLOSEOUT SUBMITTALS

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

.2 Operation and Maintenance Data: submit operation and maintenance data for hydronic specialties for incorporation into manual.

.3 Submit 4 copies of operation and maintenance manual.

### 1.4 DELIVERY, STORAGE AND HANDLING

.1 Deliver, store and handle materials in accordance with Section 01 60 00 - Common Product Requirements and with manufacturer's written instructions.

.2 Delivery and Acceptance Requirements: deliver materials to Site in original factory packaging, labelled with manufacturer's name and address.

.3 Storage and Handling Requirements:

.1 Store materials in accordance with manufacturer's recommendations in clean, dry, well-ventilated area.

.2 Store and protect hydronic specialties from damage.

.3 Replace defective or damaged materials with new.

.4 Waste Management: In accordance with 01 74 21 Construction Waste Management.

## Part 2 Products

### 2.1 DIAPHRAGM TYPE EXPANSION TANK, EXP-1

.1 ASME rated, diaphragm expansion tank with pre-charged air connection and 13 mm system connection.

.1 Volume: 8 gallons

.2 Acceptance Volume: 2.4 gallons

.3 Fluid: Water

.4 Height: 19.5”

.5 Diameter: 12”.

.6 Maximum Working Pressure: 125 psig

.7 Maximum Working Temperature: 240°F

.8 Shell: Steel

.9 Diaphragm: Heavy duty Butyl

.2 Acceptable Product: “Amtrol” model Extrol AX-15V.

### 2.2 DIAPHRAGM TYPE EXPANSION TANK, EXP-2

.1 ASME rated, diaphragm expansion tank with pre-charged air connection and 13 mm system connection.

.1 Volume: 21.7 gallons

.2 Acceptance Volume: 11.3 gallons

.3 Fluid: Water

.4 Height: 29.5”

.5 Diameter: 16.25”.

.6 Maximum Working Pressure: 125 psig

.7 Maximum Working Temperature: 240°F

.8 Shell: Steel

.9 Diaphragm: Heavy duty Butyl

.2 Acceptable Product: “Amtrol” model Extrol AX-40V.

**2.3 GLYCOL MAKEUP UNIT, GMU-1:**

.1 System shall include 208 litre (55 US gallon) storage/mixing tank with cover and include the following:

.1 Pump suction hose with inlet strainer.
.2 Pressure pump with thermal cut-out.
.3 Integral pressure switch.
.4 Integral check valve.
.5 Cord and plug.
.6 Pre-charged accumulator tank with EPDM diaphragm.
.7 Manual diverter valve for purging air and agitating contents of storage tank.
.8 Pressure regulating valve adjustable (5 – 55 psig) complete with pressure gauge.
.9 Built in check valve.
.10 Union connection.
.11 13 mm x 900 long flexible connection hose with check valve.
.12 Low level pump cut-out.

.2 Pressure pump shall be capable of running dry without damage.

.3 Power supply of 115V/1ph/60Hz.

.4 Unit shall be complete preassembled and certified by a recognized testing agency to CSA standard C22.2 No 68.

.5 Acceptable Product: "Axiom" model SF100.

**2.4 WATER MAKEUP UNIT, WMU-1:**

.1 System shall include 65 litre (17 US gallon) storage/mixing tank with moulded in level gauge shall include the following:

.1 5" (125 mm) fill/access opening and cover
.2 Pump suction hose with inlet strainer and check valve.
.3 Pressure pump with fuse protection.
.4 Low fluid level pump cut-out float switch.
.5 Manual diverter valve for purging air and agitating contents of storage tank.
.6 Pressure switch with snubber and two sets of SPST dry contacts, each individually adjustable from 10 – 25 psi cut-out pressure
.7 Factory cut-out pressure set to 12 psig with liquid filled pressure gauge.
.8 Unit to be complete with fused power supply adapter with LED power indicator light

.2 115V/1ph/60Hz to 24 VDC 50 Watts AC supplied loose for field installation.

.3 Pressure pump shall be capable of running dry without damage.

.4 Unit shall be complete preassembled at the factory.

.5 Acceptable Product: "Axiom" model MF300.

**2.5 AUTOMATIC AIR VENT**

.1 Brass body and vent head, non-ferrous float. 1034 kPa maximum working pressure, maximum operating temperature of 132 degrees C.

.2 Acceptable Product: "Spirotherm", "Spirotop" VTP-1.

**2.6 STRAINER (FOR USE WITH ECM PUMPS)**

.1 Dirt separator with magnet in steel.

.2 ANSI B16.5 CLASS 150 RF flanged connections from 2" to 6". Top connection 3/4" MNPT (with cap).

.3 Supplied with drain ball valve brass body with 1" NPT for drain.

.4 Internal mesh element of stainless steel and HDPE.

.5 Steel body with a stack of neodymium rare-earth magnets inside a brass dry-well, removable for purging.

.6 Non-asbestos fiber hydraulic seals.

.7 Suitable fluids: water or 50% maximum glycol solution.

.8 Maximum working pressure 150 psi (10 bar). Temperature range 32 to 270°F (0 to 132°C).

.9 Particle separation capacity: to 0.2 mil. Ferrous impurities separation efficiency: up to 100% removal.

.10 The separator is designed and built in accordance with Section VIII, Division 1 of the ASME Boiler and Pressure Vessel Code and tagged and registered with the National Board of Boiler and Pressure Vessel Inspectors and stamped for 150 psi (10 bar) working pressure, with ASME U stamp.

.11 Blowdown connection: NPS 1".

.12 Screen: stainless steel, 1.19 mm perforations.

.13 Working pressure: 860 kPa.

.14 Acceptable Product: "Caleffi" model NA5464M.

**2.7 CHEMICAL TREATMENT SYSTEM**

.1 Chemical Pot Feeder:

.1 7.6 L bypass feeder, 1380 kPa (200 psig) working pressure, 11 gauge steel tank shell and heads, cast iron with Buna N seal tank cap.

.2 Acceptable Product: "BetzDearborn – Neptune Bypass Feeder" Model: BDF-2.

.3 Accessories: Provide initial chemical treatment, test kit, and Site inspections as supplied by BetzDearborn.

.2 Sidestream Filter:

.1 Filter housing and cartridge, cast iron head, carbon steel shell, 19 mm (3/4") inlet and outlet, carbon steel capscrew drain.

.2 Acceptable Product: "BetzDearborn – Filterite" Model: LMO10 and 30 micron filter cartridge.

.3 Flow Indicator:

.1 20 mm flow indicator, 304 stainless steel body and internals, fused glass window, metric and U.S. scales (15-30 LPM and 4-9 GPM), stainless steel return spring, 1082 kPa maximum pressure.

.2 Acceptable Product: "BetzDearborn" Model: Filter-Mate ¾

## Part 3 Execution

### 3.1 EXAMINATION

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

.1 Visually inspect substrate in presence of Contract Administrator.

.2 Inform Contract Administrator of unacceptable conditions immediately upon discovery.

.3 Proceed with installation only after unacceptable conditions have been remedied.

### 3.2 APPLICATION

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

### 3.3 GENERAL

.1 Run drain lines and blow off connections to terminate above nearest drain (water systems) or makeup tanks (glycol systems).

.2 Maintain adequate clearance to permit service and maintenance.

.3 Check shop drawings for conformance of tappings for ancillaries and for equipment operating weights.

### 3.4 STRAINERS

.1 Install in horizontal or down flow lines.

.2 Ensure clearance for removal of basket.

.3 Install ahead of each pump.

### 3.5 AUTOMATIC AIR VENTS

.1 Install at high points of systems.

### 3.6 EXPANSION TANKS

.1 Adjust expansion tank pressure.

## 3.7 PRESSURE SAFETY RELIEF VALVES

.1 Run discharge pipe to terminate above nearest drain (water systems) or makeup tank (glycol systems).

## 3.8 CLEANING

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

.1 Leave Work area clean at end of each day.

.2 Final Cleaning: upon completion remove surplus materials, rubbish, tools and equipment in accordance with Section 01 74 00 - Cleaning.

.3 Waste Management: In accordance with 01 74 21 Construction Waste Management.

**END OF SECTION**

## Part 1 General

### 1.1 REFERENCES

.1 American Society of Heating Refrigeration and Air-Conditioning Engineers (ASHRAE)

.1 ANSI/ASHRAE/IES Standard 90.1, Energy Standard for Buildings Except Low-Rise Residential Buildings.

.2 Canada Green Building Council (CaGBC)

.1 LEED Canada 2009 for Design and Construction, LEED Canada 2009 for Design and Construction Leadership in Energy and Environmental Design Green Building Rating System Reference Guide.

.3 CSA Group

.1 CAN/CSA-B214, Installation Code for Hydronic Heating Systems.

.4 Electrical Equipment Manufacturers Association of Canada (EEMAC)

.5 National Electrical Manufacturers' Association (NEMA)

.1 NEMA MG 1, Motors and Generators.

### 1.2 ACTION AND INFORMATIONAL SUBMITTALS

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

.2 Product Data:

.1 Submit manufacturer's instructions, printed product literature and data sheets for pump, circulator, and equipment and include product characteristics, performance criteria, physical size, finish and limitations indicate point of operation, and final location in field assembly.

.3 Shop Drawings:

.1 Submit manufacturer's detailed composite wiring diagrams for control systems showing factory installed wiring and equipment on packaged equipment or required for controlling devices or ancillaries, accessories and controllers.

.4 Sustainable Design Submittals:

.1 Submittals: in accordance with Section 01 47 15 - LEED Sustainable Requirements.

### 1.3 CLOSEOUT SUBMITTALS

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

.2 Operation and Maintenance Data: submit operation and maintenance data for hydronic pumps for incorporation into manual.

### 1.4 DELIVERY, STORAGE AND HANDLING

.1 Deliver, store and handle materials in accordance with Section 01 60 00 - Common Product Requirements] [with manufacturer's written instructions.

.2 Delivery and Acceptance Requirements: deliver materials to Site in original factory packaging, labelled with manufacturer's name and address.

.3 Storage and Handling Requirements:

.1 Store materials in accordance with manufacturer's recommendations in clean, dry, well-ventilated area.

.2 Store and protect hydronic pumps from damage.

.3 Replace defective or damaged materials with new.

.4 Waste Management: In accordance with 01 74 21 Construction Waste Management.

## Part 2 Products

### 2.1 EQUIPMENT

.1 Size and select components to: CAN/CSA-B214.

### 2.2 POOL WATER BOILER CIRCULATION PUMP, PU-1 & PU-2:

.1 Performance: 20 gpm at 22 ft of head, 1/6 motor HP, 3300 motor RPM, 115V/1ph, 2.1 Amps and ODP motor enclosure.

.2 The pumps shall be of the horizontal, permanently lubricated type, specifically designed and guaranteed for quiet operation. Pump shall have a cast iron body.

.3 The pumps shall have a steel shaft supported by permanently lubricated, sealed precision ball bearings. The pumps are to be equipped with a water-tight seal to prevent leakage. Mechanical seal faces to be carbon on silicon carbide. The motor shall be non-overloading at any point on the pump performance curve.

.4 The motor shall be of the drip-proof, sealed precision ball bearing, quiet-operating construction. The permanent split capacitor motor shall be equipped with thermal overload protection.

.5 Pumps to be suitable for 225°F (107°C) operating temperature at 150 psig (10 bar) working pressure.

.6 Acceptable Product: “Bell & Gossett” model PL-36.

### 2.3 POOL WATER HEATING SYSTEM CIRCULATION PUMP, PU-3 & PU-4:

.1 Performance: 17 gpm at 38 ft of head, 30-500 Watts, 1/2 motor HP, 1500-4500 motor RPM, , 208V/1ph, 0.2 – 2.0 Amps.

.2 The pumps shall be a wet rotor inline pump, in cast iron body construction specifically designed for quiet operation. Suitable standard operations at 230° F and 175 PSIG working pressure.

.3 The pump internals shall be capable of being serviced without disturbing piping connections.

.4 Pump shall be equipped with a water-tight seal to prevent leakage.

.5 Pump volute shall be of a cast iron design for heating systems. The connection style on the cast iron and bronze pumps shall be flanged.

.6 Flange to Flange dimension shall be standard sizes. Flange dimensions shall be HVAC industry standard 2 or 4 bolts sizes.

.7 Motor shall be a synchronous, permanent-magnet (PM) motor and tested with the pump as one unit. Conventional induction motors will not be acceptable.

.8 Each motor shall have an Integrated Variable Frequency Drive tested as one unit by the manufacturer.

.9 Integrated motor protection shall be verified by UL to protect the pump against over/under voltage, over temperature of motor and/or electronics, over current, locked rotor and dry run (no load condition).

.10 Pump shall have BACnet connections built into the VFD as standard.

.11 Analog inputs, such as 0-10V and 4-20mA, are standard inputs built into the VFD.

.12 Pumps shall be UL 778 listed and bear the UL Listed Mark for USA and Canada with on-board thermal overload protection.

.13 Each pump shall be factory performance tested before shipment.

.14 Operating Mode:

.1 Proportional Pressure – The differential pressure will continuously increase or decrease along a linear curve based on the flow demand.

.15 Acceptable Product: "Bell & Gossett" ecocirc XL model 55-45.

**2.4 SPACE HEATING BOILER CIRCULATION PUMP, PU-5 & PU-6:**

.1 Performance: 58 gpm at 65 ft of head, 1.82 BHP, 3HP motor, 1800 motor RPM, 52.49% efficiency, 575V/3ph and ODP motor enclosure.

.2 The pumps shall be close-coupled, inline for vertical installation, in cast iron stainless steel fitted construction specifically designed for quiet operation. Suitable standard operations at 225°F and 175 PSIG working pressure. The pump internals shall be capable of being serviced without disturbing piping connections.

.3 The pumps shall have a solid alloy steel shaft that is integral to the motor. A non-ferrous shaft sleeve shall be employed to completely cover the wetted area under the seal.

.4 The motor bearings shall support the shaft via heavy-duty grease lubricated ball bearings.

.5 Pump shall be equipped with an internally flushed mechanical seal assembly installed in an enlarged tapered seal chamber. Seal assembly shall have a stainless steel housing, Buna bellows and seat gasket, stainless steel spring, and be of a carbon ceramic design with the carbon face rotating against a stationary ceramic face.

.6 Pump shaft shall connect to a stainless steel impeller. Impeller shall be hydraulically and dynamically balanced. The allowable residual imbalance conforms to ANSI grade 6.3, keyed to the shaft and secured by a stainless steel locking capscrew or nut.

.7 Pump should be designed to allow for true back pull-out access to the pump's working components for ease of maintenance.

.8 Pump volute shall be of a Class 30 cast iron design for heating systems rated for 175 PSIG with integral cast iron flanges drilled for 125# ANSI companion flanges. Volute shall include gauge ports at nozzles, and vent and drain ports. The volute shall be

designed with a base ring matching an ANSI 125# flange that can be used for pump support

.9 Motors shall meet scheduled horsepower, speed, voltage, and enclosure design. Motors shall have heavy-duty grease lubricated ball bearings to offset the additional bearing loads associated with the closed-coupled pump design. Motors shall be non-overloading at any point on the pump curve and shall meet NEMA specifications.

.10 Pumps shall conform to ANSI/HI 9.6.3.1 standard for Preferred Operating Region (POR).

.11 Pump shall be of a maintainable design and for ease of maintenance should use machine fit parts and not press fit components.

.12 Each pump shall be factory tested and name-plated before shipment.

.13 Acceptable Product: "Bell & Gossett" Series e-80 model 1.5x1.5x9.5B.

**2.5 SPACE HEATING SYSTEM CIRCULATION PUMP, PU-7 & PU-8:**

.1 Performance: 60 gpm at 45 ft of head, 55 – 1400 Watts, 2 HP motor, 900 – 3300 motor RPM, , 208V/1ph, 0.6 – 6.0 Amps.

.2 The pumps shall be a wet rotor inline pump, in cast iron body construction specifically designed for quiet operation. Suitable standard operations at 230° F and 175 PSIG working pressure.

.3 The pump internals shall be capable of being serviced without disturbing piping connections.

.4 Pump shall be equipped with a water-tight seal to prevent leakage.

.5 Pump volute shall be of a cast iron design for heating systems. The connection style on the cast iron and bronze pumps shall be flanged.

.6 Flange to Flange dimension shall be standard sizes. Flange dimensions shall be HVAC industry standard 2 or 4 bolts sizes.

.7 Motor shall be a synchronous, permanent-magnet (PM) motor and tested with the pump as one unit. Conventional induction motors will not be acceptable.

.8 Each motor shall have an Integrated Variable Frequency Drive tested as one unit by the manufacturer.

.9 Integrated motor protection shall be verified by UL to protect the pump against over/under voltage, over temperature of motor and/or electronics, over current, locked rotor and dry run (no load condition).

.10 Pump shall have BACnet connections built into the VFD as standard.

.11 Analog inputs, such as 0-10V and 4-20mA, are standard inputs built into the VFD.

.12 Pumps shall be UL 778 listed and bear the UL Listed Mark for USA and Canada with on-board thermal overload protection.

.13 Each pump shall be factory performance tested before shipment.

.14 Operating Mode:

.1 Proportional Pressure – The differential pressure will continuously increase or decrease along a linear curve based on the flow demand.

.15 Acceptable Product: “Bell & Gossett” ecocirc XL model 70-145.

## Part 3 Execution

### 3.1 EXAMINATION

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

.1 Visually inspect substrate in presence of Contract Administrator.

.2 Inform Contract Administrator of unacceptable conditions immediately upon discovery.

.3 Proceed with installation only after unacceptable conditions have been remedied.

### 3.2 APPLICATION

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

### 3.3 INSTALLATION

.1 Install hydronic pumps to: CAN/CSA-B214.

.2 In line circulators: install as indicated by flow arrows.

.1 Support at inlet and outlet flanges or unions.

.2 Install with bearing lubrication points accessible.

.3 Ensure that pump body does not support piping or equipment.

.1 Provide stanchions or hangers for this purpose.

.2 Refer to manufacturer's installation instructions for details.

.4 Pipe drain tapping to floor.

.5 Install volute venting pet cock in accessible location.

.6 Check rotation prior to start-up.

.7 Install pressure gauge test cocks.

### 3.4 START-UP

.1 General:

.1 In accordance with Section 01 91 13 - General Commissioning (Cx) Requirements: General Requirements; supplemented as specified herein.

.2 In accordance with manufacturer's recommendations.

.2 Procedures:

.1 Before starting pump, check that cooling water system over-temperature and other protective devices are installed and operative.

.2 After starting pump, check for proper, safe operation.

.3 Check installation, operation of mechanical seals, packing gland type seals. Adjust as necessary.

.4 Check base for free-floating, no obstructions under base.

.5 Run-in pumps for 12 continuous hours minimum.

.6 Verify operation of over-temperature and other protective devices under low- and no-flow condition.

.7 Eliminate air from scroll casing.

.8 Adjust water flow rate through water-cooled bearings.

.9 Adjust flow rate from pump shaft stuffing boxes to manufacturer's recommendation.

.10 Adjust alignment of piping and conduit to ensure true flexibility.

.11 Eliminate cavitation, flashing and air entrainment.

.12 Adjust pump shaft seals, stuffing boxes, glands.

.13 Measure pressure drop across strainer when clean and with flow rates as finally set.

.14 Replace seals if pump used to degrease system or if pump used for temporary heat.

.15 Verify lubricating oil levels.

## 3.5 PERFORMANCE VERIFICATION (PV)

.1 General:

.1 Verify performance in accordance with Section 01 91 13 - General Commissioning (Cx) Requirements: General Requirements, supplemented as specified herein.

.2 Verify that manufacturer's performance curves are accurate.

.3 Ensure valves on pump suction and discharge provide tight shut-off.

.4 Mark points of design and actual performance at design conditions as finally set upon completion of TAB.

.5 Commissioning Reports: in accordance with Section 01 91 13 - General Commissioning (Cx) Requirements reports supplemented as specified herein. Reports to include:

.1 Record of points of actual performance at maximum and minimum conditions and for single and parallel operation as finally set at completion of commissioning on pump curves.

.2 Use Report Forms specified in Section 01 91 13 - General Commissioning (Cx) Requirements: Report Forms and Schematics.

.3 Pump performance curves (family of curves).

**3.6 CLEANING**

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

.1 Leave Work area clean at end of each day.

.2 Final Cleaning: upon completion remove surplus materials, rubbish, tools and equipment in accordance with Section 01 74 00 - Cleaning.

.3 Waste Management: In accordance with 01 74 21 Construction Waste Management.

**END OF SECTION**

## Part 1 General

### 1.1 REFERENCES

.1 ASME

.1 ASME B16.22, Wrought Copper and Copper Alloy Solder - Joint Pressure Fittings.

.2 ASME B16.24, Cast Copper Pipe Flanges and Flanged Fittings: Class 150, 300, 600, 900, 1500 and 2500.

.3 ASME B16.26, Cast Copper Alloy Fittings for Flared Copper Tubes.

.4 ASME B31.5, Refrigeration Piping and Heat Transfer Components.

.2 ASTM International

.1 ASTM A307, Standard Specification for Carbon Steel Bolts and Studs, and Threaded Rod 60,000 PSI Tensile Strength.

.2 ASTM B280, Standard Specification for Seamless Copper Tube for Air Conditioning and Refrigeration Field Service.

.3 Canada Green Building Council (CaGBC)

.1 LEED Canada 2009 for Design and Construction, LEED Canada 2009 for Design and Construction Leadership in Energy and Environmental Design Green Building Rating System Reference Guide.

.4 CSA Group

.1 CSA B52, B52 Package, Mechanical Refrigeration Code.

.5 Environment Canada (EC)

.1 EPS 1/RA/1, Environmental Code of Practice for the Elimination of Fluorocarbon Emissions from Refrigeration and Air Conditioning Systems.

### 1.2 ACTION AND INFORMATIONAL SUBMITTALS

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

.2 Product Data:

.1 Submit manufacturer's instructions, printed product literature and data sheets for refrigerant piping, fittings and equipment and include product characteristics, performance criteria, physical size, finish and limitations.

.2 Submit 2 copies of WHMIS MSDS in accordance with Section 01 35 30 - Health and Safety and Section 01 35 43 - Environmental Procedures. 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 Sustainable Design Submittals:

.1 Submittals: in accordance with Section 01 47 15 - LEED Sustainable Requirements.

**1.3 CLOSEOUT SUBMITTALS**

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

.2 Operation and Maintenance Data: submit operation and maintenance data for refrigerant piping for incorporation into manual.

**1.4 DELIVERY, STORAGE AND HANDLING**

.1 Deliver, store and handle materials in accordance with Section 01 60 00 - Common Product Requirements and with manufacturer's written instructions.

.2 Delivery and Acceptance Requirements: deliver materials to Site in original factory packaging, labelled with manufacturer's name and address.

.3 Storage and Handling Requirements:

.1 Store materials in accordance with manufacturer's recommendations in clean, dry, well-ventilated area.

.2 Store and protect refrigerant piping, fittings and equipment from damage.

.3 Replace defective or damaged materials with new.

.4 Waste Management: In accordance with 01 74 21 Construction Waste Management.

**Part 2 Products**

**2.1 TUBING**

.1 Processed for refrigeration installations, deoxidized, dehydrated and sealed.

.1 Hard copper: to ASTM B280, type ACR.

.2 Annealed copper: to ASTM B280, with minimum wall thickness as per CSA B52 and ASME B31.5.

**2.2 FITTINGS**

.1 Service: design pressure 2070 kPa and temperature 121 degrees C.

.2 Brazed:

.1 Fittings: wrought copper to ASME B16.22.

.2 Joints: silver solder, 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.

**2.3 PIPE SLEEVES**

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

**2.4 VALVES**

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

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

## Part 3 Execution

**3.1 EXAMINATION**

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

.1 Visually inspect substrate in presence of Contract Administrator.

.2 Inform Contract Administrator of unacceptable conditions immediately upon discovery.

.3 Proceed with installation only after unacceptable conditions have been remedied.

**3.2 MANUFACTURER'S INSTRUCTIONS**

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

**3.3 GENERAL**

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

**3.4 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.

**3.5 PIPING INSTALLATION**

.1 General:

.1 Soft annealed copper tubing: bend without crimping or constriction. Hard drawn copper tubing: do not bend. Minimize use of fittings.

.2 Hot gas lines:

.1 Pitch at least 1:240 down in direction of flow to prevent oil return to compressor during operation.

.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 $m^3/s$ at minimum load. Connect upstream of traps on large riser.

## 3.6 PRESSURE AND LEAK TESTING

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

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

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

## 3.7 FIELD QUALITY CONTROL

.1 Site Tests/Inspection:

.1 Close service valves on factory charged equipment.

.2 Ambient temperatures to be at least 1] degrees C for at least 1] 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 5 Pa 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 hours.

.2 Break vacuum with refrigerant to 14 kPa.

.3 Final to 5 Pa absolute and hold for at least 12 hours.

.4 Isolate pump from system, record vacuum and time readings until stabilization of vacuum.

.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.

## 3.8 DEMONSTRATION

.1 Instructions:

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

## 3.9 CLEANING

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

.1 Leave Work area clean at end of each day.

.2 Final Cleaning: upon completion remove surplus materials, rubbish, tools and equipment in accordance with Section 01 74 00 - Cleaning.

.3 Waste Management: In accordance with 01 74 21 Construction Waste Management.

**END OF SECTION**

## Part 1 General

### 1.1 REFERENCES

.1 American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE)

.2 ASTM International

.1 ASTM A653/A653M, Standard Specification for Steel Sheet, Zinc Coated (Galvanized) or Zinc-Iron Alloy Coated (Galvannealed) by the Hot-Dip Process.

.3 Canada Green Building Council (CaGBC)

.1 LEED Canada 2009 for Design and Construction, LEED Canada 2009 for Design and Construction Leadership in Energy and Environmental Design Green Building Rating System Reference Guide.

.4 Green Seal Environmental Standards (GS)

.1 GS-36, Standard for Adhesives for Commercial Use.

.5 National Fire Protection Association (NFPA)

.1 NFPA 90A, Standard for the Installation of Air-Conditioning and Ventilating Systems.

.2 NFPA 90B, Standard for the Installation of Warm Air Heating and Air-Conditioning Systems.

.6 Sheet Metal and Air Conditioning Contractors' National Association (SMACNA)

.1 SMACNA HVAC Duct Construction Standards - Metal and Flexible.

.2 SMACNA HVAC Air Duct Leakage Test Manual.

.3 IAQ Guideline for Occupied Buildings Under Construction.

### 1.2 ACTION AND INFORMATIONAL SUBMITTALS

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

.2 Sustainable Design Submittals:

.1 Submittals: in accordance with Section 01 47 15 - LEED Sustainable Requirements.

### 1.3 DELIVERY, STORAGE AND HANDLING

.1 Deliver, store and handle materials in accordance with Section 01 60 00 - Common Product Requirements and with manufacturer's written instructions.

.2 Delivery and Acceptance Requirements: deliver materials to Site in original factory packaging, labelled with manufacturer's name and address.

.3 Storage and Handling Requirements:

.1 Store materials in accordance with manufacturer's recommendations in clean, dry, well-ventilated area.

.2 Store and protect metal ducts from damage.

.3 Replace defective or damaged materials with new.

.4 Waste Management: In accordance with 01 74 21 Construction Waste Management.

## Part 2 Products

### 2.1 SEAL CLASSIFICATION

.1 Classification as follows:

| Maximum Pressure Pa | SMACNA Seal Class |
|---|---|
| 500 | B |
| 250 | B |
| 125 | B |
| 125 | B |

.2 Seal classification:

.1 Class B: longitudinal seams, transverse joints and connections made airtight with sealant.

### 2.2 SEALANT

.1 Sustainability Characteristics:

.1 Adhesives and sealants: in accordance with Section 07 92 00 - Joint Sealants.

.2 Adhesives and sealants: Maximum VOC limit in accordance with Section 01 47 15 - LEED Sustainable Requirements

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

### 2.3 DUCT LEAKAGE

.1 In accordance with SMACNA HVAC Air Duct Leakage Test Manual and National Energy Code for Buildings.

### 2.4 FITTINGS

.1 Fabrication: to SMACNA.

.2 Radiused elbows:

.1 Rectangular: standard radius or short radius without turning vanes. Centreline radius: 1.5 times width of duct.

.2 Round: smooth radius. 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, 45 degrees entry on branch.

.2 Round main and branch: enter main duct at 45 degrees with conical connection.

.3 Provide volume control damper in branch duct near connection to main duct.

.4 Main duct branches: with splitter damper.

.5 Transitions:

.1 Diverging: 20 degrees maximum included angle.

.2 Converging: 30 degrees maximum included angle.

.6 Offsets:

.1 Full radiused elbows.

.7 Obstruction deflectors: maintain full cross-sectional area.

.1 Maximum included angles: as for transitions.

## 2.5 FIRE STOPPING

.1 Retaining angles around duct, on both sides of fire separation in accordance with Section 07 84 00 - Fire Stopping.

.2 Fire stopping material and installation must not distort duct.

## 2.6 GALVANIZED STEEL

.1 Lock forming quality: to ASTM A653/A653M, Z90 zinc coating.

.2 Thickness, fabrication and reinforcement: to SMACNA.

.3 Joints: SMACNA.

## 2.7 HANGERS AND SUPPORTS

.1 Hangers and Supports: in accordance with Section 23 05 29 - Hangers and Supports for HVAC Piping and Equipment.

.1 Strap hangers: of same material as duct but next sheet metal thickness heavier than duct.

.1 Maximum size duct supported by strap hanger: 500 mm. Larger ducts to use trapeze hangers.

.2 Hanger configuration: to SMACNA.

.3 Hangers: galvanized steel angle with galvanized steel rods to SMACNA following table:

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

.4 Upper hanger attachments:

.1 For concrete: manufactured concrete inserts.

.2 For steel joist: manufactured joist clamp or steel plate washer.

.3 For steel beams: manufactured beam clamps

## Part 3 Execution

### 3.1 EXAMINATION

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

.1 Visually inspect substrate in presence of Contract Administrator.

.2 Inform Contract Administrator of unacceptable conditions immediately upon discovery.

.3 Proceed with installation only after unacceptable conditions have been remedied.

### 3.2 GENERAL

.1 Do Work in accordance SMACNA.

.2 Do not break continuity of insulation vapour barrier with hangers or rods.

.1 Insulate strap hangers 100 mm beyond insulated duct.

.3 Support risers in accordance with SMACNA.

.4 Install breakaway joints in ductwork on sides of fire separation.

.5 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.

### 3.3 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 as follows:

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

### 3.4 WATERTIGHT DUCT

.1 Provide watertight duct for:

.1 Fresh air intake.

.2 Exhaust discharges

.2 Form bottom of horizontal duct without longitudinal seams.

.1 Solder or weld joints of bottom and side sheets.

.2 Seal all other joints with duct sealer.

.3 Slope horizontal branch ductwork down towards louvers served.

.1 Slope header ducts down toward risers.

.2 Provide drain piping to floor.

## 3.5 SEALING AND TAPING

.1 Apply sealant in accordance with SMACNA.

## 3.6 CLEANING

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

.1 Leave Work area clean at end of each day.

.2 Final Cleaning: upon completion remove surplus materials, rubbish, tools and equipment in accordance with Section 01 74 00 - Cleaning.

.3 Waste Management: In accordance with 01 74 21 Construction Waste Management.

**END OF SECTION**

## Part 1 General

### 1.1 REFERENCES

.1 Canada Green Building Council (CaGBC)

.1 LEED Canada 2009 for Design and Construction, LEED Canada 2009 for Design and Construction Leadership in Energy and Environmental Design Green Building Rating System Reference Guide.

.2 Sheet Metal and Air Conditioning Contractors' National Association (SMACNA)

.1 SMACNA - HVAC Duct Construction Standards - Metal and Flexible.

### 1.2 ACTION AND INFORMATIONAL SUBMITTALS

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

.2 Product Data:

.1 Submit manufacturer's instructions, printed product literature and data sheets for [air duct accessories] and include product characteristics, performance criteria, physical size, finish and limitations.

.2 Indicate:

.1 Flexible connections.

.2 Duct access doors.

.3 Turning vanes.

.4 Instrument test ports.

.3 Sustainable Design Submittals:

.1 Submittals: in accordance with Section 01 47 15 - LEED Sustainable Requirements.

### 1.3 DELIVERY, STORAGE AND HANDLING

.1 Deliver, store and handle materials in accordance with Section 01 60 00 - Common Product Requirements and with manufacturer's written instructions.

.2 Delivery and Acceptance Requirements: deliver materials to Site in original factory packaging, labelled with manufacturer's name and address.

.3 Storage and Handling Requirements:

.1 Store materials in accordance with manufacturer's recommendations in clean, dry, well-ventilated area.

.2 Store and protect air duct accessories from damage.

.3 Replace defective or damaged materials with new.

.4 Waste Management: In accordance with 01 74 21 Construction Waste Management.

## Part 2 Products

### 2.1 GENERAL

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

### 2.2 FLEXIBLE CONNECTIONS

.1 Frame: galvanized sheet metal frame with fabric clenched by means of double locked seams.

.2 Material:

.1 Fire resistant, self-extinguishing, neoprene coated glass fabric, temperature rated at minus 40 degrees C to plus 90 degrees C, density of 1.3 kg/$m^2$.

### 2.3 ACCESS DOORS IN DUCTS

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

.2 Insulated Ducts: sandwich construction of same material as duct, one sheet metal thickness heavier, minimum 0.6 mm thick complete with sheet metal angle frame and 25 mm thick rigid glass fibre insulation.

.3 Gaskets: [neoprene] [foam rubber].

.4 Hardware:

.1 Up to 300 x 300 mm: two sash locks.

.2 301 to 450 mm: four sash locks.

.3 451 to 1000 mm: piano hinge and minimum two sash locks.

.4 Hold open devices.

### 2.4 TURNING VANES

.1 Factory or shop fabricated double thickness, to recommendations of SMACNA.

## Part 3 Execution

### 3.1 EXAMINATION

.1 Verification of Conditions: verify that conditions of substrate previously installed under other Sections or Contracts are acceptable for air duct accessories installation in accordance with manufacturer's written instructions.

.1 Visually inspect substrate in presence of Contract Administrator.

.2 Inform Contract Administrator of unacceptable conditions immediately upon discovery.

.3 Proceed with installation only after unacceptable conditions have been remedied.

## 3.2 INSTALLATION

.1 Flexible Connections:

.1 Install in following locations:

.1 Inlets and outlets to supply air units and fans.

.2 Inlets and outlets of exhaust and return air fans.

.3 As indicated.

.2 Length of connection: 100 mm.

.3 Minimum distance between metal parts when system in operation: 75 mm.

.4 Install in accordance with recommendations of SMACNA.

.5 When fan is running:

.1 Ducting on sides of flexible connection to be in alignment.

.2 Ensure slack material in flexible connection.

.2 Access Doors and Viewing Panels:

.1 Size:

.1 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 Turning Vanes:

.1 Install in accordance with recommendations of SMACNA and as indicated.

## 3.3 CLEANING

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

.1 Leave Work area clean at end of each day.

.2 Final Cleaning: upon completion remove surplus materials, rubbish, tools and equipment in accordance with Section 01 74 00 - Cleaning.

.3 Waste Management: In accordance with 01 74 21 Construction Waste Management.

**END OF SECTION**

## Part 1 General

### 1.1 REFERENCES

.1 Canada Green Building Council (CaGBC)

.1 LEED Canada 2009 for Design and Construction, LEED Canada 2009 for Design and Construction Leadership in Energy and Environmental Design Green Building Rating System Reference Guide.

.2 Sheet Metal and Air Conditioning National Association (SMACNA)

.1 SMACNA HVAC Duct Construction Standards, Metal and Flexible.

### 1.2 ACTION AND INFORMATIONAL SUBMITTALS

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

.2 Product Data:

.1 Submit manufacturer's instructions, printed product literature and data sheets for [dampers] and include product characteristics, performance criteria, physical size, finish and limitations.

.3 Sustainable Design Submittals:

.1 Submittals: in accordance with Section 01 47 15 - LEED Sustainable Requirements.

### 1.3 CLOSEOUT SUBMITTALS

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

.2 Operation and Maintenance Data: submit operation and maintenance data for dampers for incorporation into manual.

### 1.4 DELIVERY, STORAGE AND HANDLING

.1 Deliver, store and handle materials in accordance with Section 01 60 00 - Common Product Requirements and with manufacturer's written instructions.

.2 Delivery and Acceptance Requirements: deliver materials to Site in original factory packaging, labelled with manufacturer's name and address.

.3 Storage and Handling Requirements:

.1 Store materials in accordance with manufacturer's recommendations in clean, dry, well-ventilated area.

.2 Store and protect dampers from damages.

.3 Replace defective or damaged materials with new.

.4 Waste Management: In accordance with 01 74 21 Construction Waste Management.

## Part 2 Products

### 2.1 GENERAL

.1 Manufacture to SMACNA standards.

### 2.2 SINGLE BLADE DAMPERS

.1 Fabricate from same material as duct, but one sheet metal thickness heavier. V-groove stiffened.

.2 Size and configuration to recommendations of SMACNA.

.3 Locking quadrant with shaft extension to accommodate insulation thickness.

.4 Inside and outside nylon end bearings.

.5 Channel frame of same material as adjacent duct, complete with angle stop.

### 2.3 MULTI-BLADED DAMPERS

.1 Factory manufactured of material compatible with duct.

.2 Opposed blade: configuration, metal thickness and construction to recommendations of SMACNA.

.3 Maximum blade height: 100] mm.

.4 Bearings: pin in bronze bushings.

.5 Linkage: shaft extension with locking quadrant.

.6 Channel frame of same material as adjacent duct, complete with angle stop.

## Part 3 Execution

### 3.1 EXAMINATION

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

.1 Visually inspect substrate in presence of Contract Administrator.

.2 Inform Contract Administrator of unacceptable conditions immediately upon discovery.

.3 Proceed with installation only after unacceptable conditions have been remedied.

### 3.2 INSTALLATION

.1 Install where indicated.

.2 Install in accordance with recommendations of SMACNA and in accordance with manufacturer's instructions.

.3 Locate balancing dampers in each branch duct, for supply, return and exhaust systems.

.4 Runouts to registers and diffusers: install single blade damper located as close as possible to main ducts.

.5 Dampers: vibration free.

.6 Ensure damper operators are observable and accessible.

## 3.3 CLEANING

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

.1 Leave Work area clean at end of each day.

.2 Final Cleaning: upon completion remove surplus materials, rubbish, tools and equipment in accordance with Section 01 74 00 - Cleaning.

.3 Waste Management: In accordance with 01 74 21 Construction Waste Management.

**END OF SECTION**

## Part 1 General

### 1.1 REFERENCES

.1 Canada Green Building Council (CaGBC)

.1 LEED Canada 2009 for Design and Construction, LEED Canada 2009 for Design and Construction Leadership in Energy and Environmental Design Green Building Rating System Reference Guide.

.2 National Fire Protection Association (NFPA)

.1 NFPA 90A, Standard for the Installation of Air Conditioning and Ventilating Systems.

.3 Underwriters Laboratories of Canada (ULC)

.1 CAN/ULC-S112, Standard Test Method of Fire Test of Fire Damper Assemblies.

.2 CAN/ULC-S112.2, Standard Method of Fire Test of Ceiling Fire Stop Flap Assemblies.

.3 ULC-S505, Standard for Fusible Links for Fire Protection Service.

### 1.2 ACTION AND INFORMATIONAL SUBMITTALS

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

.2 Product Data:

.1 Submit manufacturer's instructions, printed product literature and data sheets for fire dampers and include product characteristics, performance criteria, physical size, finish and limitations.

.2 Indicate the following:

.1 Fire dampers.

.2 Fusible links.

.3 Design details of break-away joints.

.3 Certificates: submit certificates signed by manufacturer certifying that materials comply with specified performance characteristics and physical properties.

.4 Sustainable Design Submittals:

.1 Submittals: in accordance with Section 01 47 15 - LEED Sustainable Requirements.

### 1.3 CLOSEOUT SUBMITTALS

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

.2 Operation and Maintenance Data: submit operation and maintenance data for fire dampers for incorporation into manual.

### 1.4 MAINTENANCE MATERIAL SUBMITTALS

.1 Extra Materials:

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

### 1.5 DELIVERY, STORAGE AND HANDLING

.1 Deliver, store and handle materials in accordance with Section 01 60 00 - Common Product Requirements.

.2 Delivery and Acceptance Requirements: deliver materials to Site in original factory packaging, labelled with manufacturer's name and address.

.3 Storage and Handling Requirements:

.1 Store materials in accordance with manufacturer's recommendations in clean, dry, well-ventilated area.

.2 Store and protect fire dampers from damage.

.3 Replace defective or damaged materials with new.

.4 Waste Management: In accordance with 01 74 21 Construction Waste Management.

## Part 2 Products

### 2.1 FIRE DAMPERS

.1 Fire dampers: arrangement Type B, dynamic type, ULC listed, and meet requirements of authorities having jurisdiction. Fire damper assemblies shall be fire tested in accordance with CAN/ULC-S112.

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

.1 Fire dampers: 1-1/2 hour fire rated unless otherwise indicated.

.2 Fire dampers: automatic operating type and have dynamic rating suitable for maximum air velocity and pressure differential to which it will be subjected.

.3 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.

.4 Equip fire dampers with steel sleeve or frame installed disruption ductwork or impair damper operation.

.5 Design and construct dampers to not reduce duct or air transfer opening cross-sectional area.

.6 Dampers shall be installed so that the centerline of the damper depth or thickness is located in the centerline of the wall, partition of floor slab depth or thickness.

.7 Acceptable Manufacturers: “Nailor”, “Greenheck”.

## Part 3 Execution

### 3.1 EXAMINATION

.1 Verification of Conditions: verify that conditions of substrate previously installed under other Sections or Contracts are acceptable for fire and smoke damper installation in accordance with manufacturer's written instructions.

.1 Visually inspect substrate in presence of Contract Administrator.

.2 Inform Contract Administrator of unacceptable conditions immediately upon discovery.

.3 Proceed with installation only after unacceptable conditions have been remedied.

## 3.2 INSTALLATION

.1 Install in accordance with 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 - Air Duct Accessories.

.5 Co-ordinate with installer of fire stopping.

.6 Ensure 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.

## 3.3 CLEANING

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

.1 Leave Work area clean at end of each day.

.2 Final Cleaning: upon completion remove surplus materials, rubbish, tools and equipment in accordance with Section 01 74 00 - Cleaning.

.3 Waste Management: In accordance with 01 74 21 Construction Waste Management.

**END OF SECTION**

## Part 1 General

### 1.1 REFERENCES

.1 American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc. (ASHRAE)

.2 Canada Green Building Council (CaGBC)

.1 LEED Canada 2009 for Design and Construction, LEED Canada 2009 for Design and Construction Leadership in Energy and Environmental Design Green Building Rating System Reference Guide.

.3 National Fire Protection Association (NFPA)

.1 NFPA 90A, Standard for the Installation of Air-Conditioning and Ventilating Systems.

.2 NFPA 90B, Standard for Installation of Warm Air Heating and Air-Conditioning Systems.

.4 Sheet Metal and Air-Conditioning Contractors' National Association (SMACNA)

.1 SMACNA HVAC Duct Construction Standards - Metal and Flexible.

.2 SMACNA IAQ Guideline for Occupied Buildings under Construction.

.5 Underwriters' Laboratories (UL)

.1 UL 181, Standard for Factory-Made Air Ducts and Air Connectors.

.6 Underwriters' Laboratories of Canada (ULC)

.1 CAN/ULC-S110, Standard Methods of Tests for Air Ducts.

### 1.2 ACTION AND INFORMATIONAL SUBMITTALS

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

.2 Product Data:

.1 Submit manufacturer's instructions, printed product literature and data sheets for flexible ducts and include product characteristics, performance criteria, physical size, finish and limitations.

.2 Indicate:

.1 Thermal properties.

.2 Friction loss.

.3 Acoustical loss.

.4 Leakage.

.5 Fire rating.

.3 Test and Evaluation Reports:

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

.4 Sustainable Design Submittals:

.1 Submittals: in accordance with Section 01 47 15 - LEED Sustainable Requirements.

**1.3 DELIVERY, STORAGE AND HANDLING**

.1 Deliver, store and handle materials in accordance with Section 01 60 00 - Common Product Requirements and with manufacturer's written instructions.

.2 Delivery and Acceptance Requirements: deliver materials to Site in original factory packaging, labelled with manufacturer's name and address.

.3 Storage and Handling Requirements:

.1 Store materials in accordance with manufacturer's recommendations in clean, dry, well-ventilated area.

.2 Store and protect flexible ducts from damage.

.3 Replace defective or damaged materials with new.

.4 Waste Management: In accordance with 01 74 21 Construction Waste Management.

**Part 2 Products**

**2.1 GENERAL**

.1 Factory fabricated to CAN/ULC-S110.

.2 Pressure drop coefficients listed below are based on relative sheet metal duct pressure drop coefficient of 1.00.

.3 Flame spread rating not to exceed 25. Smoke developed rating not to exceed 50.

**2.2 NON-METALLIC - UNINSULATED**

.1 Non-collapsible, coated mineral base fabric type, mechanically bonded to, and helically supported by, external wire, as indicated.

.2 Performance:

.1 Factory tested to 2.5 kPa without leakage.

.2 Maximum relative pressure drop coefficient: 3.

**2.3 NON-METALLIC - INSULATED**

.1 Non-collapsible, coated mineral base fabric type mechanically bonded to, and helically supported by, external steel wire with factory applied, 37 mm thick flexible mineral fibre thermal insulation with vapour barrier and vinyl jacket.

.2 Performance:

.1 Factory tested to 2.5 kPa without leakage.

.2 Maximum relative pressure drop coefficient: 3.

## Part 3 Execution

### 3.1 EXAMINATION

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

.1 Visually inspect substrate in presence of Contract Administrator.

.2 Inform Contract Administrator of unacceptable conditions immediately upon discovery.

.3 Proceed with installation only after unacceptable conditions have been remedied.

### 3.2 DUCT INSTALLATION

.1 Install in accordance with: relevant standard.

### 3.3 CLEANING

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

.1 Leave Work area clean at end of each day.

.2 Final Cleaning: upon completion remove surplus materials, rubbish, tools and equipment in accordance with Section 01 74 00 - Cleaning.

.3 Waste Management: In accordance with 01 74 21 Construction Waste Management.

**END OF SECTION**

## Part 1 General

### 1.1 REFERENCES

.1 American National Standards Institute/Air Movement and Control Association (ANSI/AMCA)

.1 ANSI/AMCA Standard 99, Standards Handbook.

.2 ANSI/AMCA Standard 210/(ANSI/ASHRAE 51-07), Laboratory Methods of Testing Fans for Aerodynamic Performance Rating.

.3 ANSI/AMCA Standard 300, Reverberant Room Method for Sound Testing of Fans.

.4 ANSI/AMCA Standard 301, Methods for Calculating Fan Sound Ratings from Laboratory Test Data.

.2 Canada Green Building Council (CaGBC)

.1 LEED Canada 2009 for Design and Construction, LEED Canada 2009 for Design and Construction Leadership in Energy and Environmental Design Green Building Rating System Reference Guide.

.3 The Master Painters Institute (MPI)

.1 Architectural Painting Specification Manual.

.1 MPI #18, Primer, Zinc Rich, Organic.

### 1.2 ACTION AND INFORMATIONAL SUBMITTALS

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

.2 Product Data:

.1 Submit manufacturer's instructions, printed product literature and data sheets for HVAC fans and include product characteristics, performance criteria, physical size, finish and limitations.

.3 Shop Drawings:

.1 Provide:

.1 Fan performance curves showing point of operation, kW and efficiency.

.2 Sound rating data at point of operation.

.2 Indicate:

.1 Motors, sheaves, bearings, shaft details.

.4 Sustainable Design Submittals:

.1 Submittals: in accordance with Section 01 47 15 - LEED Sustainable Requirements.

### 1.3 MAINTENANCE MATERIAL SUBMITTALS

.1 Extra Materials:

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

.1 Provide:

.1 Matched sets of belts.

**1.4 DELIVERY, STORAGE AND HANDLING**

.1 Deliver, store and handle materials in accordance with Section 01 60 00 - Common Product Requirements and with manufacturer's written instructions.

.2 Delivery and Acceptance Requirements: deliver materials to Site in original factory packaging, labelled with manufacturer's name and address.

.3 Storage and Handling Requirements:

.1 Store materials in accordance with manufacturer's recommendations in clean, dry, well-ventilated area.

.2 Store and protect HVAC fans from damage.

.3 Replace defective or damaged materials with new.

.4 Waste Management: In accordance with 01 74 21 Construction Waste Management.

**Part 2 Products**

**2.1 RETURN FAN, RF-1:**

.1 Performance: 2,000 cfm at 0.75" w.c. ESP, 1070 fan RPM, 0.44 BHP, ¾ HP motor, 208V/1ph, 1140 motor RPM, ODP motor enclosure, 6.1 FLA. Sound ratings shall be 9.7 Sones (inlet) and 6.4 Sones (radiated).

.2 Wheel:

.1 Non-overloading, backward inclined centrifugal wheel.

.2 Constructed of aluminum .

.3 Statically and dynamically balanced in accordance to AMCA Standard 204-05.

.4 The wheel cone and fan inlet will be matched and shall have precise running tolerances for maximum performance and operating efficiency.

.5 Single thickness blades are securely riveted or welded to a heavy gauge back plate and wheel cone.

.3 Electronically Commutated Motor:

.1 Motor enclosures: Open type

.2 Motor to be a DC electronic commutation type motor (ECM) specifically designed for fan applications. AC induction type motors are not acceptable. Examples of unacceptable motors are: Shaded Pole, Permanent Split Capacitor (PSC), Split Phase, Capacitor Start and 3 phase induction type motors.

.3 Motors are permanently lubricated, heavy duty ball bearing type to match with the fan load and pre-wired to the specific voltage and phase.

.4 Internal motor circuitry to convert AC power supplied to the fan to DC power to operate the motor.

.5 Motor shall be speed controllable down to 20% of full speed (80% turndown). Speed shall be controlled by either a potentiometer dial mounted at the motor or by a 0-10 VDC signal.

.6 Motor shall be a minimum of 85% efficient at all speeds.

.4 Housing/Cabinet Construction:

.1 Construction material: Galvanized.

.2 Square design constructed of heavy gauge galvanized steel and shall include square duct mounting collars.

.3 Housing and bearing supports shall be constructed of heavy gauge bolted and welded steel construction to prevent vibration and to rigidly support the shaft and bearing assembly.

.5 Housing Supports and Drive Frame:

.1 Housing supports are constructed of structural steel with formed flanges.

.2 Drive frame is welded steel which supports the motor.

.6 Access Panels:

.1 Two sided access panels, permit easy access to all internal components.

.2 Located perpendicular to the motor mounting panel.

.7 Acceptable Product: “Greenheck” model SQ-160-VG.

## Part 3 Execution

### 3.1 EXAMINATION

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

.1 Visually inspect substrate in presence of Contract Administrator.

.2 Inform Contract Administrator of unacceptable conditions immediately upon discovery.

.3 Proceed with installation only after unacceptable conditions have been remedied.

### 3.2 FAN INSTALLATION

.1 Install fans as indicated, complete with flexible connections in accordance with Section 23 33 00 - Air Duct Accessories.

.2 Provide sheaves and belts required for final air balance.

.3 Bearings and extension tubes to be easily accessible.

.4 Access doors and access panels to be easily accessible.

### 3.3 CLEANING

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

.1 Leave Work area clean at end of each day.

.2 Final Cleaning: upon completion remove surplus materials, rubbish, tools and equipment in accordance with Section 01 74 00 - Cleaning.

.3 Waste Management: In accordance with 01 74 21 Construction Waste Management.

**END OF SECTION**

## Part 1 General

### 1.1 REFERENCES

.1 American National Standards Institute/Air Movement and Control Association (ANSI/AMCA)

.1 ANSI/AMCA Standard 210/(ANSI/ASHRAE 51-07), Laboratory Methods of Testing Fans for Aerodynamic Performance Rating.

.2 Canada Green Building Council (CaGBC)

.1 LEED Canada 2009 for Design and Construction, LEED Canada 2009 for Design and Construction Leadership in Energy and Environmental Design Green Building Rating System Reference Guide.

.3 International Organization of Standardization (ISO)

.1 ISO 3741, Acoustics-Determination of Sound Power Levels of Noise Sources Using Sound Pressure - Precision Methods for Reverberation Rooms.

.4 National Fire Protection Association (NFPA)

.1 NFPA 90A, Standard for the Installation of Air Conditioning and Ventilating Systems.

.5 Underwriter's Laboratories (UL)

.1 UL 181, Factory-Made Air Ducts and Air Connectors.

### 1.2 ACTION AND INFORMATIONAL SUBMITTALS

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

.2 Product Data:

.1 Submit manufacturer's instructions, printed product literature and data sheets for air terminal units and include product characteristics, performance criteria, physical size, finish and limitations.

.3 Shop Drawings:

.1 Indicate the following:

.1 Capacity.

.2 Pressure drop.

.3 Noise rating.

.4 Leakage.

.4 Sustainable Design Submittals:

.1 Submittals: in accordance with Section 01 47 15 - LEED Sustainable Requirements.

### 1.3 CLOSEOUT SUBMITTALS

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

.2 Operation and Maintenance Data: submit operation and maintenance data for air terminal units for incorporation into manual.

**1.4 DELIVERY, STORAGE AND HANDLING**

.1 Deliver, store and handle materials in accordance with Section 01 60 00 - Common Product Requirements and with manufacturer's written instructions.

.2 Delivery and Acceptance Requirements: deliver materials to Site in original factory packaging, labelled with manufacturer's name and address.

.3 Storage and Handling Requirements:

.1 Store materials in accordance with manufacturer's recommendations in clean, dry, well-ventilated area.

.2 Store and protect air terminal units from damage.

.3 Replace defective or damaged materials with new.

.4 Waste Management: In accordance with 01 74 21 Construction Waste Management.

**Part 2 Products**

**2.1 MANUFACTURED UNITS**

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

**2.2 VARIABLE AIR VOLUME BOXES, VAV-1 to VAV-9:**

.1 Performance: Refer to schedule on drawings.

.2 Single duct, variable volume assemblies shall be pressure independent and shall reset to any air flow between zero and the maximum cataloged air volume. Sound ratings of air distribution assemblies shall not exceed 20 NC at 0.5” w.g. static pressure drop across the unit. Performance shall be AHRI certified.

.3 The air flow sensor shall be of a cross configuration located at the inlet of the assembly. The sensor shall have twelve total pressure sensing ports and a center averaging chamber designed to accurately average the flow across the inlet of the assembly. Sensor shall provide accuracy within 5% with a 90° sheet metal elbow directly at the inlet of the assembly. The air flow sensor shall amplify the sensed air flow signal.

.4 The assembly casing shall be constructed of 22 gauge zinc-coated steel, internally lined with 1/2 in. thick, fiberglass insulation. Any cut edges of fiberglass exposed to the air stream shall be coated with NFPA-90A approved sealant. The casing shall be constructed to maintain a maximum leakage rate of 3 cfm at 1” w.g.

.5 The primary air valve damper shall be heavy gauge metal, with peripheral gasket and solid steel shaft, pivoted in self-lubricating bearings. In the full closed position, air leakage past the closed damper shall not exceed 2% of the nominal catalog rating at 3 in. w.g. inlet static pressure, when tested in accordance with ASHRAE 130. The entire valve/damper assembly shall be tested to 1.25 million cycles without failure.

.6 Provide manufacturer digital controller complete with thermostat to control the VAV box. Controller shall be BACnet ready.

.7 Acceptable Product: “Price” series SDV. Refer to performance schedule for sizes.

## Part 3 Execution

### 3.1 EXAMINATION

.1 Verification of Conditions: verify that conditions of substrate previously installed under other Sections or Contracts are acceptable for air terminal units installation in accordance with manufacturer's written instructions.

.1 Visually inspect substrate in presence of Contract Administrator.

.2 Inform Contract Administrator of unacceptable conditions immediately upon discovery.

.3 Proceed with installation only after unacceptable conditions have been remedied.

### 3.2 INSTALLATION

.1 Install in accordance with manufacturers recommendations.

.2 Support independently of ductwork.

.3 Install with a minimum of four duct diameters of straight inlet duct, same size as inlet.

.4 Locate controls, dampers and access panels for easy access.

### 3.3 CLEANING

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

.1 Leave Work area clean at end of each day.

.2 Final Cleaning: upon completion remove surplus materials, rubbish, tools and equipment in accordance with Section 01 74 00 - Cleaning.

.3 Waste Management: In accordance with 01 74 21 Construction Waste Management.

**END OF SECTION**

## Part 1 General

### 1.1 REFERENCES

.1 Canada Green Building Council (CaGBC)

.1 LEED Canada 2009 for Design and Construction, LEED Canada 2009 for Design and Construction Leadership in Energy and Environmental Design Green Building Rating System Reference Guide.

### 1.2 ACTION AND INFORMATIONAL SUBMITTALS

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

.2 Product Data:

.1 Submit manufacturer's instructions, printed product literature and data sheets for diffusers, registers and grilles and include product characteristics, performance criteria, physical size, finish and limitations.

.2 Indicate following:

.1 Capacity.

.2 Throw and terminal velocity.

.3 Noise criteria.

.4 Pressure drop.

.5 Neck velocity.

.3 Sustainable Design Submittals:

.1 Submittals: in accordance with Section 01 47 15 - LEED Sustainable Requirements.

### 1.3 MAINTENANCE MATERIAL SUBMITTALS

.1 Extra Materials:

.1 Provide maintenance materials in accordance with Section 01 78 00 - Closeout Submittals.

.2 Include:

.1 Keys for volume control adjustment.

.2 Keys for air flow pattern adjustment.

### 1.4 DELIVERY, STORAGE AND HANDLING

.1 Deliver, store and handle materials in accordance with Section 01 60 00 - Common Product Requirements and with manufacturer's written instructions.

.2 Delivery and Acceptance Requirements: deliver materials to Site in original factory packaging, labelled with manufacturer's name and address.

.3 Storage and Handling Requirements:

.1 Store materials in accordance with manufacturer's recommendations in clean, dry, well-ventilated area.

.2 Store and protect diffuser, registers and grilles from damages.

.3 Replace defective or damaged materials with new.

.4 Waste Management: In accordance with 01 74 21 Construction Waste Management.

## Part 2 Products

### 2.1 GENERAL

.1 To meet capacity, pressure drop, terminal velocity, throw, noise level, neck velocity.

.2 Frames:

.1 Full perimeter gaskets.

.2 Plaster frames where set into plaster or gypsum board.

.3 Concealed fasteners.

.3 Concealed manual volume control damper operators.

.4 Colour: as indicated on grille schedule. Confirm all colours with Contract Administrator.

.5 Acceptable Manufacturer: "E.H. Price Ltd", as per grille schedule.

### 2.2 MANUFACTURED UNITS

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

### 2.3 GRILLE SCHEDULE

.1 As indicated on drawings.

## Part 3 Execution

### 3.1 EXAMINATION

.1 Verification of Conditions: verify that conditions of substrate previously installed under other Sections or Contracts are acceptable for diffuser, register and grille installation in accordance with manufacturer's written instructions.

.1 Visually inspect substrate in presence of Contract Administrator.

.2 Inform Contract Administrator of unacceptable conditions immediately upon discovery.

.3 Proceed with installation only after unacceptable conditions have been remedied.

### 3.2 INSTALLATION

.1 Install in accordance with manufacturer's instructions.

.2 Bolt grilles, registers and diffusers, in place, in gymnasium and similar game rooms.

.3 Provide concealed safety chain on each grille, register and diffuser in gymnasium and similar game rooms and elsewhere as indicated.

## 3.3 CLEANING

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

.1 Leave Work area clean at end of each day.

.2 Final Cleaning: upon completion remove surplus materials, rubbish, tools and equipment in accordance with Section 01 74 00 - Cleaning.

.3 Waste Management: In accordance with 01 74 21 Construction Waste Management.

**END OF SECTION**

## Part 1 General

### 1.1 REFERENCES

.1 American Boiler Manufacturers Association (ABMA)

.2 ASME

.1 ASME Boiler and Pressure Vessel Code (BPVC), Section VII.

.3 Canada Green Building Council (CaGBC)

.1 LEED Canada 2009 for Design and Construction, LEED Canada 2009 for Design and Construction Leadership in Energy and Environmental Design Green Building Rating System Reference Guide.

.4 CSA Group

.1 CAN1-3.1, Industrial and Commercial Gas-Fired Package Boilers.

.2 CSA B51, Boiler, Pressure Vessel, and Pressure Piping Code.

.3 CSA B149.1, Natural Gas and Propane Installation Code.

.4 ANSI Z21.13/CSA 4.9, Gas-Fired Low-Pressure Steam and Hot Water Boilers.

.5 Electrical and Electronic Manufacturers Association of Canada (EEMAC)

### 1.2 ACTION AND INFORMATIONAL SUBMITTALS

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

.2 Product Data:

.1 Submit manufacturer's instructions, printed product literature and data sheets for heating boilers and include product characteristics, performance criteria, physical size, finish and limitations.

.3 Shop Drawings:

.1 Indicate on drawings:

.1 General arrangement showing terminal points, instrumentation test connections.

.2 Clearances for operation, maintenance, servicing, tube cleaning, tube replacement.

.3 Foundations with loadings, anchor bolt arrangements.

.4 Piping hook-ups.

.5 Equipment electrical drawings.

.6 Burners and controls.

.7 All miscellaneous equipment.

.8 Flame safety control system.

.9 Breeching and stack configuration.

.2 Engineering data to include:

.1 Boiler efficiency at 25%, 50%, 75%, and 100% of design capacity.

.2 Radiant heat loss at 100% design capacity.

.4 Certificates: submit certificates signed by manufacturer certifying that materials comply with specified performance characteristics and physical properties.

.5 Sustainable Design Submittals:

.1 Submittals: in accordance with Section 01 47 15 - LEED Sustainable Requirements.

## 1.3 CLOSEOUT SUBMITTALS

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

.2 Operation and Maintenance Data: submit operation and maintenance data for heating boilers for incorporation into manual.

## 1.4 QUALITY ASSURANCE

.1 Regulatory Requirements: Work to be performed in compliance with provincial regulations.

## 1.5 MAINTENANCE MATERIAL SUBMITTALS

.1 Extra materials:

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

.1 Special tools for burners, access opening, handholes and Operation and Maintenance.

.2 Spare parts for 1 year of operation.

.3 Spare gaskets.

.4 Spare gauge glass inserts.

.5 Probes and sealants for electronic indication.

.6 Spare burner tips.

.7 Spare burner gun.

.8 Safety valve test gauge.

## 1.6 DELIVERY, STORAGE AND HANDLING

.1 Deliver, store and handle materials in accordance with Section 01 60 00 - Common Product Requirements and with manufacturer's written instructions.

.2 Delivery and Acceptance Requirements: deliver materials to Site in original factory packaging, labelled with manufacturer's name and address.

.3 Storage and Handling Requirements:

.1 Store materials in accordance with manufacturer's recommendations in clean, dry, well-ventilated area.

.2 Store and protect boiler and equipment from damages.

.3 Replace defective or damaged materials with new.

.4 Waste Management: In accordance with 01 74 21 Construction Waste Management.

## Part 2 Products

### 2.1 GENERAL

.1 Packaged boiler:

.1 Complete with burner and necessary accessories and controls.

.2 Factory tested at rated capacity to, and bearing seal or nameplate certifying compliance with local regulations

.3 Ready for attachment to piping, electrical power, controls, flue gases exhaust.

.4 Designed and constructed to ASME Boiler and Pressure vessel Code.

.5 CRN (Canadian Registration Number), to CSA B51.

### 2.2 POOL WATER HEATING BOILERS, B-1 & B-2:

.1 Performance: 299,000 Btu/hr input, 278,000 Btu/hr output, 95 thermal efficiency.

.2 Boiler shall be provided with the following standard equipment and features:

.1 439 Stainless steel fire tube heat exchanger

.2 ASME stamped heat exchanger

.3 Turndown ratios od 4.1:1

.4 100mm diameter vent connection

.5 Low NOx

.6 Controller shall include:

.1 Integrated cascade function

.2 Communication modules to communicate to DDC

.3 Two outdoor reset curves / set points

.4 Multiple zone control

.5 Multiple circulator control

.3 Acceptable Product: “Triangle Tube” Prestige Solo model Solo 299.

### 2.3 SPACE HEATING BOILER, B-3 & B-4:

.1 Performance: 600,000 Btu/hr input, 572,000 Btu/hr output, 95.3% thermal efficiency.

.2 Boiler shall be provided with the following standard equipment and features:

.1 Modulation down to 20% of full fire (5:1 turndown)

.2 Sealed combustion chamber

.3 Pre-mix stainless steel burner

.4 Burner site glass

.5 Low NOx system exceeds the most stringent regulations for air quality - 10 ppm NOx

.6 Horizontal or vertical direct vent

.7 Vent and air pipe lengths of up to 100 equivalent feet (each)

.8 Built-in condensate trap

.9 Vent temperature cutoff

.10 Direct spark ignition system
.11 Stainless steel heat exchanger with welded construction
.12 ASME “H” stamp
.13 75 psi (517 kPa) ASME rated pressure relief valve
.14 Temperature & pressure gauge
.15 Drain valve
.16 Pump control for boiler pump
.17 Electronic PID modulating control stages up to eight boilers
.18 Large user-interface and display
.19 Alarm output
.20 Accepts (4-20mA or 0-10V) modulation control
.21 Manual reset high limit
.22 Zero clearance to combustibles
.23 10 year limited warranty
.24 Floor-standing appliance
.25 All connections are on top of the unit
.26 Works with BAS. Provide N2 protocol communication card
.27 CSD-1 Compliant
.28 Outdoor reset

.3 Acceptable Product: “Triangle Tube” Keystone model KS 600.

## Part 3 Execution

### 3.1 EXAMINATION

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

.1 Visually inspect substrate in presence of Contract Administrator.
.2 Inform Contract Administrator of unacceptable conditions immediately upon discovery.
.3 Proceed with installation only after unacceptable conditions have been remedied.

### 3.2 MANUFACTURER'S INSTRUCTIONS

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

### 3.3 INSTALLATION

.1 Install in accordance with ASME Boiler and Pressure Vessels Code, regulations of Province having jurisdiction, and manufacturers recommendations.

.2 Make required piping connections to inlets and outlets recommended by boiler manufacturer.

.3 Maintain clearances as indicated or if not indicated, as recommended by manufacturer for operation, servicing and maintenance without disruption of operation of any other equipment/system.

.4 Mount unit level.

.5 Pipe hot water relief valves full size to nearest drain (or to makeup tank for glycol systems).

.6 Natural gas fired installations: in accordance with CSA B149.1.

## 3.4 MOUNTINGS AND ACCESSORIES

.1 Safety valves and relief valves:

.1 Run separate discharge from each valve.

.2 Terminate discharge pipe as indicated.

.3 Run drain pipe from each valve outlet and drip pan elbow to above nearest drain (or to makeup tank for glycol systems).

## 3.5 FIELD QUALITY CONTROL

.1 Commissioning:

.1 Manufacturer to:

.1 Certify installation.

.2 Start up and commission installation.

.3 Carry out on-site performance verification tests.

.4 Demonstrate operation and maintenance.

.2 Provide Contract Administrator at least 24 hours notice prior to inspections, tests, and demonstrations. Submit written report of inspections and test results.

## 3.6 CLEANING

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

.1 Leave Work area clean at end of each day.

.2 Final Cleaning: upon completion remove surplus materials, rubbish, tools and equipment in accordance with Section 01 74 00 - Cleaning.

.3 Waste Management: In accordance with 01 74 21 Construction Waste Management.

**END OF SECTION**

## Part 1 General

### 1.1 REFERENCES

.1 Canada Green Building Council (CaGBC)

.1 LEED Canada 2009 for Design and Construction, LEED Canada 2009 for Design and Construction Leadership in Energy and Environmental Design Green Building Rating System Reference Guide.

### 1.2 ACTION AND INFORMATIONAL SUBMITTALS

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

.2 Product Data:

.1 Submit manufacturer's instructions, printed product literature and data sheets for duct heaters and include product characteristics, performance criteria, physical size, finish and limitations.

.2 Submit product data and include:

.1 Heater: total Btu/hr rating.

.2 Maximum discharge temperature.

.3 Unit support.

.4 Clearance from combustible materials.

.5 Pressure drop operating airflow.

.3 Sustainable Design Submittals:

.1 Submittals: in accordance with Section 01 47 15 - LEED Sustainable Requirements.

### 1.3 DELIVERY, STORAGE AND HANDLING

.1 Deliver, store and handle materials in accordance with Section 01 60 00 - Common Product Requirements and with manufacturer's written instructions.

.2 Delivery and Acceptance Requirements: deliver materials to Site in original factory packaging, labelled with manufacturer's name and address.

.3 Storage and Handling Requirements:

.1 Store materials in accordance with manufacturer's recommendations in clean, dry, well-ventilated area.

.2 Store and protect duct heaters from damage.

.3 Replace defective or damaged materials with new.

.4 Waste Management: In accordance with 01 74 21 Construction Waste Management.

## Part 2 Products

### 2.1 HYDRONIC REHEAT COILS, RHC-1 TO RHC-12, PHC-1 TO PHC-3:

.1 Performance: Refer to schedule on drawings.

.2 Coils shall be 5/8" O.D, constructed of copper tube, aluminum fin, and copper headers with schedule 40 steel pipe connectors. Fins constructed of aluminum shall be rippled for maximum heat transfer and shall be mechanically bonded to the tubes by mechanical expansion of the tubes. The coils shall have a galvanized steel casing. All coils shall be factory tested with air at 300 psig (2070 kPa) while immersed in an illuminated water tank. Headers with schedule 40 steel pipe connections utilize male N.P.T. Headers shall be outside the ductwork for maximum serviceability. The non-headered end of the coil shall be fully concealed. Water and glycol coils shall be circuited to provide adequate tube velocities to meet design requirements. Internal turbulators are not acceptable. 5/8" O.D. tube diameter water coils shall be ARI Certified.

.3 Acceptable Manufacturer: "Daikin", "Engineered Air".

## Part 3 Execution

### 3.1 EXAMINATION

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

.1 Visually inspect substrate in presence of Contract Administrator.

.2 Inform Contract Administrator of unacceptable conditions immediately upon discovery.

.3 Proceed with installation only after unacceptable conditions have been remedied.

### 3.2 FIELD QUALITY CONTROL

.1 Perform tests in accordance with Section 01 91 13 - General Commissioning (Cx) Requirements.

.2 Perform tests in presence of Contract Administrator.

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

### 3.3 CLEANING

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

.1 Leave Work area clean at end of each day.

.2 Final Cleaning: upon completion remove surplus materials, rubbish, tools and equipment in accordance with Section 01 74 00 - Cleaning.

.3 Waste Management: In accordance with 01 74 21 Construction Waste Management.

**END OF SECTION**

## Part 1 General

### 1.1 REFERENCES

.1 American Society of Mechanical Engineers (ASME)

.1 ASME Boiler and Pressure Vessel Code.

.2 Canada Green Building Council (CaGBC)

.1 LEED Canada 2009 for Design and Construction, LEED Canada 2009 for Design and Construction Leadership in Energy and Environmental Design Green Building Rating System Reference Guide.

.3 CSA International

.1 CSA B51, Boiler, Pressure Vessel, and Pressure Piping Code.

### 1.2 ACTION AND INFORMATIONAL SUBMITTALS

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

.2 Product Data:

.1 Submit manufacturer's instructions, printed product literature and data sheets for heat exchangers and include product characteristics, performance criteria, physical size, finish and limitations.

.3 Shop Drawings:

.1 Shop drawings to indicate project layout, including layout and dimensions of heat exchangers and system.

.1 Indicate manufacturer's recommended clearances for tube withdrawal and manipulation of tube cleaning tools.

.4 Manufacturer's Instructions: submit manufacturer's installation instructions.

.5 Sustainable Design Submittals:

.1 Submittals: in accordance with Section 01 47 15 - LEED Sustainable Requirements.

### 1.3 CLOSEOUT SUBMITTALS

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

.2 Operation and Maintenance Data: submit operation and maintenance data for heat exchangers for incorporation into manual.

### 1.4 DELIVERY, STORAGE AND HANDLING

.1 Deliver, store and handle materials in accordance with Section 01 60 00 - Common Product Requirements and with manufacturer's written instructions.

.2 Delivery and Acceptance Requirements: deliver materials to Site in original factory packaging, labelled with manufacturer's name and address.

.3 Storage and Handling Requirements:

.1 Store materials in accordance with manufacturer's recommendations in clean, dry, well-ventilated area.

.2 Store and protect heat exchangers from damage.

.3 Replace defective or damaged materials with new.

.4 Waste Management: In accordance with 01 74 21 Construction Waste Management.

## Part 2 Products

### 2.1 BRAZED PLATE HEAT EXCHANGERS, HX-1 & HX-2

.1 HX-1 performance and construction:

| | Pool Side | Boiler Side | |
|---|---|---|---|
| Fluid Circulated : | Water | Water | |
| Total Flow : | 26.06 | 13.10 | gpm |
| Inlet Temperature : | 84 | 130 | deg. F |
| Outlet Temperature : | 99 | 100 | deg. F |
| Pressure Drop : | 4.92 | 1.42 | psig |
| Number of Passes * Channels: | 1*21 | 1*20 | |
| Pressure, Design/Test | 435/480 | 435/480 | psig |
| Design Temp Min/Max: | -310/450 | -310/450 | Deg. |
| Inlet Connection: | 1 | 1 | Inch |
| Outlet Connection: | 1 | 1 | Inch |
| Total Number of Plates: | 42 | | |
| Total Heat Exchanged: | 194,808.79 | | Btu/hr |
| Estimated Weight, Empty/Operating: | 18.98 / 24.42 | | lb |
| Overall Dimensions: | 12.20 x 4.40 x 5.67 | | Inch |
| Plate Material: | 316L SS | | |
| Brazing Material: | Nickel | | |
| Approvals: | ASME | | |

.2 HX-2 Performance:

| | Pool Side | Boiler Side | |
|---|---|---|---|
| Fluid Circulated : | Water | Water | |
| Total Flow : | 8.16 | 4.10 | gpm |
| Inlet Temperature : | 84 | 130 | deg. F |
| Outlet Temperature : | 99 | 100 | deg. F |
| Pressure Drop : | 2.62 | 0.88 | psig |
| Number of Passes * Channels: | 1*11 | 1*10 | |
| Pressure, Design/Test | 435/480 | 435/480 | psig |
| Design Temp Min/Max: | -310/450 | -310/450 | Deg. |
| Inlet Connection: | 3/4 | 3/4 | Inch |
| Outlet Connection: | 3/4 | 3/4 | Inch |
| Total Number of Plates: | 22 | | |
| Total Heat Exchanged: | 60,970.69 | | Btu/hr |
| Estimated Weight, | 7.06 / 8.39 | | lb |

| | Pool Side | Boiler Side | |
|---|---|---|---|
| Empty/Operating: | | | |
| Overall Dimensions: | 8.45 x 3.18 x 3.31 | | Inch |
| Plate Material: | 316L SS | | |
| Brazing Material: | Nickel | | |
| Approvals: | ASME | | |

.3 A brazed plate, water to water, type heat exchanger of the sizes and capacities noted on the schedule. The heat exchanger shall consist of stainless steel heat transfer plates, Nickel brazing material, and stainless steel NPT connections. Unit's shall be specifically designed for 435 PSIG working pressure at 435°F. Heat exchanger selection shall be optimized by the manufacturer to provide minimum heat transfer surface area requirements under specified capacity and pressure drops.

.4 The brazed plate heat exchanger shall be shipped to the Site as completely assembled units. The channel plates shall be nickel brazed to create a sealed system. Edges, ports, and all channel plate contact points are also brazed for strength.

.5 Stainless steel plates shall be configured to create flow channels between the plates in a counterflow direction.

.6 Nozzle connection shall be constructed of stainless steel and shall be of an NPT design. All nozzle connections shall be factory sealed prior to shipment to prevent the entrance of foreign matter into the heat exchanger during shipment, storage, and installation.

.7 Heat exchanger manufacturer shall be ISO-9001 certified.

.8 Acceptable Product: "Bell & Gossett" model BP.

## Part 3 Execution

### 3.1 EXAMINATION

.1 Verification of Conditions: verify conditions of substrates previously installed under other Sections or Contracts are acceptable for heat exchanger installation in accordance with manufacturer's written instructions.

.1 Visually inspect substrate in presence of Contract Administrator.

.2 Inform Contract Administrator of unacceptable conditions immediately upon discovery.

.3 Proceed with installation only after unacceptable conditions have been remedied.

### 3.2 INSTALLATION

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

.2 General: install level and firmly anchored to supports in accordance with manufacturer's recommendations.

.3 Tube in shell heat exchangers: arrange piping so that tube bundle can be removed after disconnecting two unions or flanges adjacent to head and without disturbing other equipment and systems.

.4 Plate exchangers: install in accordance with manufacturer's recommendations.

## 3.3 APPURTENANCES

.1 Install thermometer wells with thermometers on inlet and outlet of primary and secondary side.

## 3.4 FIELD QUALITY CONTROL

.1 Site Tests and Inspections:

.1 Perform tests to ensure heat exchangers are functional.

.2 Obtain written report from manufacturer verifying compliance of Work, in handling, installing, applying, protecting and cleaning of product.

## 3.5 SYSTEM START-UP

.1 General: perform start-up operations in accordance with Section 01 91 13 - General Commissioning (Cx) Requirements: General Requirements, supplemented as specified herein.

.2 Check heater for cleanliness on primary and secondary sides.

.3 Check water treatment system is complete, operational and correct treatment is being applied.

.4 Check installation, settings, operation of relief valves and safety valves.

.5 Check installation, location, settings and operation of operating, limit and safety controls.

.6 General: perform performance verification in accordance with Section 01 91 13 - General Commissioning (Cx) Requirements: General Requirements, supplemented as specified.

.7 Timing: only after TAB of hydronic systems have been successfully completed.

.8 Primary/Secondary sides:

.1 Measure flow rate, pressure drop and water temperature at heater inlet and outlet.

.2 Verify installation and operation of air elimination devices.

.9 Calculate heat transfer from primary and secondary sides.

.10 Simulate heating water temperature schedule and repeat above procedures.

.11 Verify settings, operation, safe discharge from safety valves and relief valves.

.12 Verify settings, operation of operating, limit and safety controls and alarms.

.13 Reports:

.1 In accordance with Section 01 91 13 - General Commissioning (Cx) Requirements: Reports, supplemented as specified herein.

## 3.6 CLEANING

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

.1 Leave Work area clean at end of each day.

.2 Final Cleaning: upon completion remove surplus materials, rubbish, tools and equipment in accordance with Section 01 74 00 - Cleaning.

.2 Waste Management: In accordance with 01 74 21 Construction Waste Management.

**3.7 DEMONSTRATION**

.1 Training: provide training in accordance with Section 01 91 13 - General Commissioning (Cx) Requirements: Training of O M Personnel.

**3.8 PROTECTION**

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

.2 Repair damage to adjacent materials caused by heat exchanger installation.

**END OF SECTION**

## Part 1 General

### 1.1 REFERENCES

.1 American Society of Heating, Refrigeration and Air-Conditioning Engineers (ASHRAE)

.1 ASHRAE 84, Method of Testing Air-to-Air Heat/Energy Exchangers (ANSI approved).

.2 Canada Green Building Council (CaGBC)

.1 LEED Canada 2009 for Design and Construction, LEED Canada 2009 for Design and Construction Leadership in Energy and Environmental Design Green Building Rating System Reference Guide.

### 1.2 ACTION AND INFORMATIONAL SUBMITTALS

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

.2 Product Data:

.1 Submit manufacturer's instructions, printed product literature and data sheets for energy recovery equipment and include product characteristics, performance criteria, physical size, finish and limitations.

.3 Shop Drawings:

.1 Submit drawings indicating physical dimensions, performance characteristics and energy savings.

.4 Sustainable Design Submittals:

.1 Submittals: in accordance with Section 01 47 15 - LEED Sustainable Requirements.

### 1.3 MAINTENANCE MATERIAL SUBMITTALS

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

.2 Extra Materials:

.1 Furnish list of individual manufacturer's recommended spare parts for equipment include:

.1 Bearings and seals.

.2 List of specialized tools necessary for adjusting, repairing or replacing.

### 1.4 DELIVERY, STORAGE AND HANDLING

.1 Deliver, store and handle materials in accordance with Section 01 60 00 - Common Product Requirements and with manufacturer's written instructions.

.2 Delivery and Acceptance Requirements: deliver materials to Site in original factory packaging, labelled with manufacturer's name and address.

.3 Storage and Handling Requirements:

.1 Store materials in accordance with manufacturer's recommendations in clean, dry, well-ventilated area.

.2 Store and protect energy recovery equipment from damage.

.3 Replace defective or damaged materials with new.

.4 Waste Management: In accordance with 01 74 21 Construction Waste Management.

## Part 2 Products

### 2.1 GENERAL

.1 Comply with ASHRAE 84.

### 2.2 HEAT RECOVERY VENTILATOR, HRV-1:

.1 Performance:

.1 Airflow: 2,100 cfm

.2 E.S.P.: 1" w.c.

.3 Exhaust air temperature: 72°F

.4 Outside air temperature: 32°F

.5 Supply air temperature: 45.2°F

.6 Efficiency: 49.9%

.2 Cabinet:

.1 Cabinet shall be double wall constructed from 22 gauge galvanized steel inner wall, 22 gauge galvanized steel outer wall and shall be fully insulated with 25 mm foil-faced insulation

.2 The unit shall be equipped with a hinged front access panel to access serviceable parts.

.3 Heat Recovery Core and Filters:

.1 The heat exchanger shall be a polypropylene core constructed of flame retardant material and certified and currently listed with AHRI to Standard 1060.

.2 Unit shall come complete with 50 mm MERV 8 filters.

.4 Motors/Blowers:

.1 Blowers shall be forward curved DWDI, dynamically balanced and operate at not more than 1500 rpm. Internal vibration isolation is not required.

.2 Blower housing shall be galvanized steel.

.3 Motors shall be continuous duty, permanently lubricated with a service factor of 1.15, matched to the fan load and required voltage and phase.

.4 Motors enclosure shall be Totally Enclosed.

.5 Electrical:

.1 Unit shall have a single point power connection within a NEMA4 enclosure with integral non-fused disconnect switch.

.2 The unit shall come c/w 24 VAC control transformer with 200 VA for internal and remote controls.

.6 Defrost:

.1 No defrost controls required.

.7 Unit to be set on support brackets hung by vibration isolation hangers to minimise noise.

.8 Acceptable Product: “Nu-Air” model NU2035.

**2.3 HEAT RECOVERY VENTILATOR, HRV-2:**

.1 Performance:

.1 Airflow: 220 cfm

.2 E.S.P.: 0.5” w.c.

.3 Exhaust air temperature: 72°F

.4 Outside air temperature: 32°F

.5 Supply air temperature: 54.8°F

.6 Efficiency: 61.8%

.2 Cabinet:

.1 Cabinet shall be constructed of 0.050 aluminum with a painted white enamel finish and shall be fully insulated with 25 mm foil-faced insulation

.2 The unit shall be equipped with a top-hinged access door that can be completely removed for machine service. Access door shall be equipped with a disconnect switch to disengage the motors when the door is opened.

.3 The unit shall be equipped with a built-in, positive slope, aluminum drain pan and shall have a minimum of two (2) condensate drains. Drain plugs shall be 15 mm.

.4 914 mm length, 584 mm height, and 432 mm width.

.3 Heat Recovery Core and Filters:

.1 The heat exchanger shall be a plate type polypropylene cross-flow core and shall have cross leakage of less than 2%.

.2 13 mm polyester filters shall be located in each air stream before the heat exchanger core and must be completely accessible for cleaning or replacement. They shall have a 30%-40% ASHRAE dust spot efficiency.

.4 Motors/Blowers:

.1 Unit shall be equipped with two forward curved, dual inlet impellers using permanently sealed bearings.

.2 Motors of HRV shall operate at a maximum of 1275 RPM and be capable of operating at two speeds. Low speed shall be field-adjustable using the on-board microprocessor to between 40% and 70% of high speed.

.5 Electrical:

.1 Unit shall have a single point power connection operating on 115V / 1ph / 60 Hz, 4.5 full load Amps.

.2 The unit shall be equipped with contacts powered with 24 VAC input for external control by building management system.

.3 Unit shall be provided with a microprocessor having 24V circuit protection and a self-resetting fuse.

.6 Defrost:

.1 No defrost controls required.

.7 Unit to be set on support brackets hung by vibration isolation hangers to minimise noise.

.8 Acceptable Product: “Nu-Air” model NU0305.

**2.4 HEAT RECOVERY VENTILATOR, HRV-3:**

.1 Performance:

.1 Airflow: 425 L/s (900 cfm)

.2 E.S.P.: 249 Pa (1” w.c).

.3 Exhaust air temperature: 72°F

.4 Outside air temperature: 32°F

.5 Supply air temperature: 48.9°F

.2 Cabinet:

.1 Cabinet shall be constructed of 22 gauge galvanized steel with a 0.050 pre-painted aluminum finish and shall be fully insulated with 25 mm foil-faced insulation

.2 The unit shall be equipped with a top-hinged access door that can be completely removed for machine service. Access door shall be equipped with a disconnect switch to disengage the motors when the door is opened.

.3 The unit shall be equipped with a built-in, positive slope, aluminum drain pan and shall have a minimum of two (2) condensate drains. Drain plugs shall be 15 mm.

.4 1372 mm length, 762 mm height, and 659 mm depth.

.3 Heat Recovery Core and Filters:

.1 The heat exchanger shall be a plate type polypropylene cross-flow core and shall have cross leakage of less than 2%.

.2 25 mm pleated filters shall be located in each air stream before the heat exchanger core and must be completely accessible for cleaning or replacement. They shall have a 30%-40% ASHRAE dust spot efficiency.

.4 Motors/Blowers:

.1 Unit shall be equipped with two direct drive double width double inlet (DWDI) impellers using permanently sealed bearings.

.2 Motors of HRV shall operate at a maximum of 1625 RPM and be capable of operating at two speeds.

.5 Electrical:

.1 Unit shall have a single point power connection operating on 115V / 1ph / 60 Hz, 20 full load Amps.

.2 The unit shall be equipped with contacts powered with 24 VAC input for external control by building management system.

.6 Defrost:

.1 No defrost controls required.

.7 Unit shall be supported from floor with vibration isolation pads.

.8 Acceptable Product: “Nu-Air” model NU1200.

## Part 3 Execution

### 3.1 EXAMINATION

.1 Verification of Conditions: verify that conditions of substrate previously installed under other Sections or Contracts are acceptable for energy recovery equipment installation in accordance with manufacturer's written instructions.

.1 Visually inspect substrate in presence of Contract Administrator.

.2 Inform Contract Administrator of unacceptable conditions immediately upon discovery.

.3 Proceed with installation only after unacceptable conditions have been remedied.

### 3.2 INSTALLATION

.1 Install in accordance with manufacturers recommendations.

.2 Support independently of adjacent ductwork [with flexible connections].

.3 Install access doors in accordance with Section 23 33 00 - Air Duct Accessories for access to coils, dampers, etc.

### 3.3 FIELD QUALITY CONTROL

.1 Tests:

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

### 3.4 CLEANING

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

.1 Leave Work area clean at end of each day.

.2 Final Cleaning: upon completion remove surplus materials, rubbish, tools and equipment in accordance with Section 01 74 00 - Cleaning.

.3 Waste Management: In accordance with 01 74 21 Construction Waste Management.

**END OF SECTION**

## Part 1 General

### 1.1 REFERENCES

.1 American National Standards Institute/Air-Conditioning, Heating and Refrigeration Institute (ANSI/AHRI)

.1 ANSI/AHRI 430], Performance Rating of Central Station Air-Handling Units.

.2 American National Standards Institute/American Society of Heating, Refrigeration and Air Condition Engineers/Illuminating Engineering Society (ANSI/ASHRAE/IES)

.1 ANSI/ASHRAE 52.2, Method of Testing General Ventilation Air-Cleaning Devices for Removal Efficiency by Particle Size.

.2 ANSI/ASHRAE/IES 90.1, Energy Standard for Buildings Except Low-Rise Residential Buildings.

.3 Canada Green Building Council (CaGBC)

.1 LEED Canada 2009 for Design and Construction, LEED Canada 2009 for Design and Construction Leadership in Energy and Environmental Design Green Building Rating System Reference Guide.

.4 Green Seal (GS)

.1 GS-11, Standard for Paints and Coatings.

.2 GS-36, Standard for Adhesives for Commercial Use.

.5 Master Painters Institute (MPI)

.1 Architectural Painting Specification Manual - [current edition].

.1 MPI #18.

.6 South Coast Air Quality Management District (SCAQMD)

.1 SCAQMD Rule 1113, Architectural Coatings.

.2 SCAQMD Rule 1168, Adhesives and Sealants.

### 1.2 ACTION AND INFORMATIONAL SUBMITTALS

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

.2 Product Data:

.1 Submit manufacturer's instructions, printed product literature and data sheets for packaged air handlers and include product characteristics, performance criteria, physical size, finish and limitations.

.3 Shop Drawings:

.1 Indicate on drawings: fans, fan curves showing point of operation, motors, filters, mixing box, dampers, VFDs. include performance data.

.4 Sustainable Design Submittals:

.1 Submittals: in accordance with Section 01 47 15 - LEED Sustainable Requirements.

**1.3 CLOSEOUT SUBMITTALS**

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

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

**1.4 MAINTENANCE MATERIAL SUBMITTALS**

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

.2 Provide 1 spare set of filters.

.3 Provide list of individual manufacturer's recommended spare parts for equipment such as bearings and seals, and addresses of suppliers, together with list of specialized tools necessary for adjusting, repairing or replacing, for placement into operating manual.

**1.5 DELIVERY, STORAGE AND HANDLING**

.1 Deliver, store and handle materials in accordance with Section 01 60 00 - Common Product Requirements and with manufacturer's written instructions.

.2 Delivery and Acceptance Requirements: deliver materials to Site in original factory packaging, labelled with manufacturer's name and address.

.3 Storage and Handling Requirements:

.1 Store materials in accordance with manufacturer's recommendations in clean, dry, well-ventilated area.

.2 Store and protect air handling equipment from damage.

.3 Replace defective or damaged materials with new.

.4 Waste Management: In accordance with 01 74 21 Construction Waste Management.

**Part 2 Products**

**2.1 GENERAL**

.1 Factory assembled components to form unit[s] supplying air at designed conditions, as indicated.

.2 Certify ratings: to ANSI/AHRI 430 with AHRI seal.

**2.2 INDOOR AIR HANDLING UNIT, AHU-3:**

.1 Performance: Refer to performance schedule at end of section.

.2 General:

.1 Air Handling Units shall be built to the level of quality as herein specified and to the description of the Air Handling Unit Schedule.

.2 Substitution of any product other than that specified, must ensure no deviation below the stated capacities, air flow rate, heat transfer rate, filtration efficiency and air mixing quality. Power requirements must not be exceeded, and where specifically defined, sound power levels must not be exceeded.

.3 Unless stated otherwise, air-handling units are to be shipped to the job in one piece, factory assembled. Modular units assembled to achieve a close proximation to the intent of this specification will not be considered equal. All equipment shall where specified and applicable, be pre-wired, and factory certified by an approved testing agency such as CETL, ETLUS, UL, CSA prior to shipment.

.4 Pre-wired air handling units shall bear an approved label with all the necessary identification marks, electrical data.

.5 All electrical circuits shall undergo a dielectric strength test, and shall be factory tested and checked as to proper function.

.6 The air handling units and major components shall be products of manufacturers regularly engaged in the production of such equipment and with a minimum of fifteen continuous years of proven production experience.

.7 Air Handling Units shall be as manufactured by Engineered Air and be base bid. Alternate products must show savings and clearly indicate all areas where they do not meet specified product.

.3 Unit Construction:

.1 Air handling cabinetry shall conform to the following:

.1 Inner and outer face panels shall be galvaneal to provide extended casing life. (Indoor unit construction – wall and roof panels.

.2 Outer and / or Inner face panels shall consist of galvaneal material.

.3 Outer and / or Inner face panels shall be cleaned with degreasing solvent to remove oil and metal oxides and primed with two-part acid based etching prime.

.4 Metal foam panel shall be structurally equal to 16 gauge galvanized steel outer face panel with 22 gauge galvanized steel inner face panel.

.5 Foam core shall be continuous foamed in place , Non-CFC polyurethane with the nominal properties:

.1 92% closed cell structure.

.2 Density: minimum 2.0 lbs./cu.ft (32.0Kg/al.m) minimum.

.3 Compressive Strength: 22 psi (152 Kpa)

.6 Flashing and trim shall be formed sheet metal to match the panels.

.7 Thermal transmission tested in accordance with ASTM C518.

.8 Panels shall provide minimum R-Value=16, minimum U-Value 0.0625.

.2 Units shall be provided with access doors to the following components: fans and motors, filters, dampers and operators, access plenums, electrical control panels, burner compressor compartments. Access doors shall be large enough for easy access. Removal of screwed wall panels will not be acceptable.

.3 Units shall be provided with hinged access doors, with e-profile gasket, fully lined, and a minimum of two Leverlok fasteners for all units.

.4 Cooling coil drain pans shall be fabricated of stainless steel and are an integral part of the floor paneling, a minimum of 2" (51mm) deep, with welded corners. Drain pans shall extend a minimum of 6" (152mm) downstream of coil face and be provided with a 1 ½" (38mm) S.S. M.P.T. drain connection. Drain pans must

have a fast pan and be sloped and pitched such that there is no standing water. Intermediate fast pans shall be provided between cooling coils where required for effective moisture removal.

.5 For swimming pool applications the following specialized construction and features for air handling units shall be provided:

.1 Locate damper motors and series 90 style controllers out of air stream. Heresite coat control bulbs located in air stream.

.2 4" (120mm) Drain pan in mixing section.

.3 Solid-state humidistat (Honeywell H46).

.4 Motors to be TEFC Super-E with 1.15 service factor.

.5 Blower and motor drive belts shall have a 1.5 service factor.

.6 Heresite coat coils.

.7 Coat fan shafts with chlorine resistant coating.

.8 Gasket and/or caulk seal all opening between control panel and the air stream.

.4 Fans:

.1 Centrifugal fans shall be rated in accordance with AMCA Standard Test Code, Bulletin 210. Fan manufacturer shall be a member of AMCA. All fans and fan assemblies shall be dynamically balanced during factory test run. Fan shafts shall be selected for stable operation at least 20% below the first critical RPM. Fan shafts shall be provided with a rust inhibiting coating.

.2 Forward curved and Airfoil fans shall be equipped with greaseable pillow block bearings, supported on a rigid structural steel frame.

.3 Drives shall be adjustable on fans with motors 7 1/2 HP (5.6 kW) or smaller. On fans with larger motors, fixed drives shall be provided. All drives shall be provided with a rust inhibiting coating. The air balancer shall provide for drive changes (if required) during the air balance procedure.

.4 Fan and associated motor shall be suited for variable volume operation. **Variable frequency drive provided by others.**

.5 Motor and fan bearings and drive assembly shall be located inside the fan plenum to minimize bearing wear and to allow for internal vibration isolation of the fan-motor assembly, where required. Motor mounting shall be adjustable to allow for variations in belt tension.

.6 Fan-motor assemblies shall be provided with vibration isolators. Isolators shall be bolted to steel channel welded to unit floor, which is welded to the structural frame of the unit. The isolators shall be neoprene-in-shear type for single 9" (230mm) to 15" (380mm) diameters forward curve fans. All other fans shall incorporate vertical spring type isolators with leveling bolts, bridge bearing waffled pads with minimum 1" (25mm) static deflection designed to achieve high isolation efficiency. Use of separate bumper or snubber is not acceptable. Fans shall be attached to the discharge panel by a polyvinyl chloride coated polyester woven fabric, with a sealed double locking fabric to metal connection.

.7 Provide single extended grease line from far side to access side bearing.

.8 Fan motors shall TEFC (totally enclosed fan cooled) Super E high efficiency type.

.5 Coils

.1 Coils shall be 1/2" O.D. as manufactured by Engineered Air, constructed of copper tube, aluminum fin, and copper headers with schedule 40 steel pipe connectors.

.2 Fins constructed of aluminum or copper shall be rippled for maximum heat transfer and shall be mechanically bonded to the tubes by mechanical expansion of the tubes. The coils shall have a galvanized steel casing. All coils shall be factory tested with air at 300 psig (2070 kPa) while immersed in an illuminated water tank.

.3 Headers shall be outside the air-handling unit for maximum serviceability except for blow through applications where headers are internal. The non-headered end of the coil shall be fully concealed. Provide auxiliary drain pan complete with ½" (13mm) MPT drain connection at headered end of cooling coils.

.4 Coils shall be removable from the unit at the header end, unless shown otherwise on the drawings.

.5 Multiple row coils shall be of staggered tube design circuited to optimize capacity with minimum pressure drop.

.6 Filters:

.1 Filter sections shall be provided with adequately sized access doors to allow easy removal of filters. Filter removal shall be from one side as noted on the drawings.

.2 2"(50mm) Pleated Panel Disposable Filters: An optimum blend of natural and synthetic fiber media with a rust resistant support grid and high-wet strength beverage board enclosing frame with diagonal support members bonded to the air entering and air exiting side of each pleat. Permanent re-usable metal enclosing frame. The filter media shall have a minimum efficiency of 30-35% on ASHRAE Standard 52.1-92, and a minimum of MERV 8 per ASHRAE 52.2. Rated U.L. Class 2.

.3 Filter media shall meet UL Class 2 standards.

.7 Dampers:

.1 Damper frames shall be U-shaped galvanized metal sections securely screwed or welded to the air handling unit chassis. Pivot rods of 1/2" (13mm) aluminum shall turn in nylon or bronze bushings. Rods shall be secured to the blade by means of straps and set screws.

.2 Blades shall be 18 gauge (1.3mm) galvanized metal with two breaks on each edge and three breaks on centerline for rigidity. The pivot rod shall "nest" in the centerline break. Damper edges shall interlock. Maximum length of damper between supports shall be 48”(1219 mm). Damper linkage brackets shall be constructed of galvanized metal.

.3 Dampers shall be extruded aluminum, low leak, thermally broken, insulated blade Tamco Series 9000.

.4 Mixing dampers shall be parallel blade type.

.8 Factory Supplied Controls / Wiring

.1 Provide a system of motor control, including all necessary terminal blocks, motor contactors, motor overload protection, grounding lugs, control transformers, auxiliary contactors and terminals for the connection of external control devices or relays.

.2 Fire alarm circuits (where required) shall be powered from a relay in unit circuitry.

.3 Heating control and valve, cooling control and motor start/stop are By Others.

## Part 3 Execution

### 3.1 EXAMINATION

.1 Verification of Conditions: verify that conditions of substrate previously installed under other Sections or Contracts are acceptable for air handling equipment installation in accordance with manufacturer's written instructions.

.1 Visually inspect substrate in presence of Contract Administrator.

.2 Inform Contract Administrator of unacceptable conditions immediately upon discovery.

.3 Proceed with installation only after unacceptable conditions have been remedied.

### 3.2 INSTALLATION

.1 Provide appropriate protection apparatus.

.2 Install units in accordance with manufacturer's instructions and as indicated.

.3 Ensure adequate clearance for servicing and maintenance.

### 3.3 FANS

.1 Install fan sheaves required for final air balance.

.2 Install flexible connections at fan inlet and fan outlets.

.3 Install vibration isolators.

### 3.4 DRIP PANS

.1 Install deep seal P-traps on drip lines.

.1 Depth of water seal to be 1.5 times static pressure at this point.

### 3.5 CLEANING

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

.1 Leave Work area clean at end of each day.

.2 Final Cleaning: upon completion remove surplus materials, rubbish, tools and equipment in accordance with Section 01 74 00 - Cleaning.

.3 Waste Management: In accordance with 01 74 21 Construction Waste Management.

AHU Performance Schedule:

| | |
|---|---|
| Equipment Tag: | AHU-3 |
| Manufacturer: | Engineered Air |
| Model number: | LM3/C |
| Supply Air Fan: | |
| Airflow (cfm): | 2,000 |
| E.S.P. (in. w.c.): | 1.00 |
| Motor (HP): | 2.0 |
| Operating Power (BHP): | 1.32 |
| Operating fan RPM: | 1,538 |
| Heating Performance: | |
| Heating Type: | Hydronic |
| Fluid: | 50% Propylene Glycol |
| Capacity (Btu/hr): | 123,120 |
| Actuator: | 3-way, modulating |
| *Water Side:* | |
| EWT / LWT (°F): | 120 / 103 |
| Flow Rate (gpm): | 16.0 |
| Pressure drop (ft): | 7.5 |
| *Air Side:* | |
| EAT / LAT (°F): | 42 / 99 |
| Pressure drop (in. w.c.): | 0.28 |
| Cooling Performance: | |
| Refrigerant: | R-22 |
| Total Capacity (Btu/hr): | 91,000 |
| Air EDBT / EWBT (°F): | 80.0 / 67.0 |
| Air LDBT / LWBT (°F): | 531. / 52.2 |
| Electrical (Summer Condition): | |
| Voltage: | 575/3/60 |
| Unit MCA (A): | 3.7 |
| Maximum Breaker (A): | 15.0 |
| Weight (lbs): | 1,659 |
| Overall Dimensions (mm): | 2692 L x 1067 W x 889 H |

**END OF SECTION**

## Part 1 General

### 1.1 REFERENCES

.1 American Gas Association (AGA)

.2 American National Standards Institute/Air-Conditioning, Heating and Refrigeration Institute (ANSI/AHRI)

.1 ANSI/AHRI 210/240, Performance Rating of Unitary Air-Conditioning and Air-Source Heat Pump Equipment.

.2 ANSI/AHRI 270, Sound Rating of Outdoor Unitary Equipment.

.3 Canada Green Building Council (CaGBC)

.1 LEED Canada 2009 for Design and Construction, LEED Canada 2009 for Design and Construction Leadership in Energy and Environmental Design Green Building Rating System Reference Guide.

.4 CSA Group

.1 CSA B52, Mechanical Refrigeration Code.

.2 CSA C22.1, Canadian Electrical Code, Part 1 (22nd Edition), Safety Standard for Electrical Installations.

.5 National Fire Protection Association (NFPA)

.1 NFPA 90A, Standard for the Installation of Air Conditioning and Ventilating Systems.

.6 Underwriters Laboratories (UL)

.1 UL 1995, Standard for Heating and Cooling Equipment.

### 1.2 ACTION AND INFORMATIONAL SUBMITTALS

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

.2 Product Data:

.1 Submit manufacturer's instructions, printed product literature and data sheets for outdoor HVAC equipment and include product characteristics, performance criteria, physical size, finish and limitations.

.3 Shop Drawings:

.1 Drawings to indicate project layout and dimensions; indicate:

.1 Equipment, piping, and connections, together with valves, strainers, control assemblies, thermostatic controls, auxiliaries and hardware, and recommended ancillaries which are mounted, wired and piped ready for final connection to building system, its size and recommended bypass connections.

.2 Piping, valves, fitting shipped loose showing final location in assembly.

.3 Control equipment.

.4 Dimensions, internal and external construction details, recommended method of installation with proposed structural steel support, mounting curb details, sizes and location of mounting bolt holes; include mass distribution drawings showing point loads.

.5 Detailed composite wiring diagrams for control systems showing factory installed wiring and equipment on packaged equipment or required for controlling devices of ancillaries, accessories, controllers.

.6 fan performance curves.

.7 Details of vibration isolation.

.8 Estimate of sound levels to be expected across individual octave bands in dB referred to A rating.

.9 Type of refrigerant used.

.4 Sustainable Design Submittals:

.1 Submittals: in accordance with Section 01 47 15 - LEED Sustainable Requirements.

**1.3 CLOSEOUT SUBMITTALS**

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

.2 Operation and Maintenance Data: submit operation and maintenance data for outdoor HVAC equipment for incorporation into manual.

.1 Indicate: brief description of unit, indexed, with details of function, operation, control, and service for components.

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

**1.4 DELIVERY, STORAGE AND HANDLING**

.1 Deliver, store and handle materials in accordance with Section 01 60 00 - Common Product Requirements and with manufacturer's written instructions.

.2 Delivery and Acceptance Requirements: deliver materials to Site in original factory packaging, labelled with manufacturer's name and address.

.3 Storage and Handling Requirements:

.1 Store materials in accordance with manufacturer's recommendations in clean, dry, well-ventilated area.

.2 Store and protect outdoor HVAC equipment from damages.

.3 Replace defective or damaged materials with new.

.4 Waste Management: In accordance with 01 74 21 Construction Waste Management.

**Part 2 Products**

**2.1 PACKAGED OUTDOOR AIR HANDLING UNIT, AHU-1:**

.1 Performance: Refer to performance schedule at end of section.

.2 General:

.1 Air handling unit shall be built to the level of quality as herein specified and to the description of the Air Handling Unit Schedule.

.2 Unless stated otherwise, air-handling units are to be shipped to the job in one piece, factory assembled. Modular units assembled to achieve a close approximation to the intent of this specification will not be considered equal. All

equipment shall where specified and applicable, be pre-wired, and factory certified by an approved testing agency such as CETL, ETLUS, UL, CSA prior to shipment.

.3 Pre-wired air handling units shall bear an approved label with all the necessary identification marks, electrical data.

.1 Unit must conform to regulations set out in the Canadian Energy Efficiency Act for large air conditioners (condensing units). Packaged units shall be tested to CSA Standard C746-98 and must bear an EEV (energy efficiency verification) label provided by CSA. Where specified as factory packaged air conditioning unit, factory assembled split systems do not conform to the Canadian Energy Efficiency Act and will not be considered.

.4 All electrical circuits shall undergo a dielectric strength test, and shall be factory tested and checked as to proper function.

.5 The air handling units and major components shall be products of manufacturers regularly engaged in the production of such equipment and with a minimum of fifteen continuous years of proven production experience.

.3 Unit Construction:

.1 Air handling cabinetry shall conform to the following:

.1 Inner and outer face panels shall be galvaneal to provide extended casing life. Outdoor unit construction shall include Membrane roof material. Roofing material is minimum 48 mil (1.2mm) thermoplastic membrane with fiberglass reinforcement. Membrane is adhered to roof surface with clear solvent base contact adhesive. All roof surfaces rolled over edges to ensure proper water runoff. Membrane color Energy Smart White.

.2 Outer and / or Inner face panels shall consist of galvaneal material.

.3 Outer and / or Inner face panels shall be cleaned with degreasing solvent to remove oil and metal oxides and primed with two-part acid based etching prime.

.4 Metal foam panel shall be structurally equal to 16 gauge galvanized steel outer face panel with 22 gauge galvanized steel inner face panel.

.5 Foam core shall be continuous foamed in place, Non-CFC polyurethane with the nominal properties:

.1 92% closed cell structure.

.2 Density: minimum 2.0 lbs./cu.ft (32.0Kg/al.m) minimum.

.3 Compressive Strength: 22 psi (152 Kpa).

.6 Flashing and trim shall be formed sheet metal to match the panels.

.7 Thermal transmission tested in accordance with ASTM C518.

.8 Panels shall provide minimum R-Value=16, minimum U-Value 0.0625.

.2 Units shall be provided with access doors to the following components: fans and motors, filters, dampers and operators, access plenums, electrical control panels, burner compressor compartments. Access doors shall be large enough for easy access. Removal of screwed wall panels will not be acceptable.

.3 Units shall be provided with hinged access doors, with e-profile gasket, fully lined, and a minimum of two Leverlok fasteners for all units.

.4 Cooling coil drain pans shall be fabricated of stainless steel and are an integral part of the floor paneling, a minimum of 2" (51mm) deep, with welded corners. Drain pans shall extend a minimum of 6" (152mm) downstream of coil face and be provided with a 1 ½" (38mm) S.S. M.P.T. drain connection. Drain pans must have a fast pan and be sloped and pitched such that there is no standing water. Intermediate fast pans shall be provided between cooling coils where required for effective moisture removal.

.5 The floor is to act as drain pan on all sections downstream of the mixing dampers and shall be complete with 2" (51mm) upturn standing seams around perimeter (or 2" (51mm) perimeter collar continuously welded to the unit base) and welded corners to ensure the floor is watertight. Alternately screwing down, tack welding and caulking of this collar is not acceptable. Provide 1 ½" (38mm) drain connections for complete drainability of the base pan.

.6 All drain connections (except cooling coil and heat pipe supply) shall be piped directly under the unit and through the roof curb

.7 For swimming pool applications the following specialized construction and features for air handling units shall be provided:

.1 Locate damper motors and series 90 style controllers out of pool air stream. Heresite coat control bulbs located in air stream.

.2 4" (120mm) Drain pan in mixing section.

.3 Solid-state controls (e.g. DJM & Carel) with minimum discharge set at 74°F (23°C).

.4 Solid-state humidistat (Honeywell H46).

.5 Motors to be TEFC Super-E with 1.15 service factor.

.6 Blower and motor drive belts shall have a 1.5 service factor.

.7 Heresite coat coils.

.8 Coat fan shafts with chlorine resistant coating.

.9 Gasket and/or caulk seal all opening between control panel and the air stream.

.10 Insulated box over high limit on outdoor units where design temperature is 0°F (-18°C) or less.

.8 Air handling units shall be weatherproofed and equipped for installation outdoors. This shall include generally for the prevention of infiltration of rain and snow into the unit, louvers or hoods on air intakes and exhaust openings with 1"(25mm) galvanized inlet screens; rain gutters or diverters over all access doors; all joints caulked with a water resistant sealant; drain trap(s) connections for field supply and installation of drain traps.

.9 Provide full perimeter mounting curb of heavy gauge sheet metal, minimum of 24" (610mm) high, and complete with wood nailer, neoprene sealing strip, and fully welded "Z" bar with 1" (25mm) upturn on inner perimeter, to provide a complete seal against the elements. External insulation and flashing of the curb shall be provided by the Contractor.

.4 Fans:

.1 Centrifugal fans shall be rated in accordance with AMCA Standard Test Code, Bulletin 210. Fan manufacturer shall be a member of AMCA. All fans and fan assemblies shall be dynamically balanced during factory test run. Fan shafts

shall be selected for stable operation at least 20% below the first critical RPM. Fan shafts shall be provided with a rust inhibiting coating.

.2 Forward curved and Airfoil fans shall be equipped with greaseable pillow block bearings, supported on a rigid structural steel frame.

.3 Drives shall be adjustable on fans with motors 7 1/2 HP (5.6 kW) or smaller. On fans with larger motors, fixed drives shall be provided. All drives shall be provided with a rust inhibiting coating. The air balancer shall provide for drive changes (if required) during the air balance procedure.

.4 Provide full dedicated outside air fan as scheduled. The use of power exhaust propeller or centrifugal fan arrangements will not be considered.

.5 Provide variable air volume fan control via adjustable frequency drive which shall be mounted in a NEMA 1 enclosure and shall be labeled by an approved testing agency such as UL.

.1 Sine wave carrier input, PWM output. IGBT transistors. Adjustable acceleration and deceleration timing.

.2 Keypad to be removable, with alphanumeric display able to provide output status monitoring, output frequency, output voltage, output RPM, and output current. Include fault log display with capacity for the recent 30 faults with a time stamp. Diagnostic display menus to include reference speed command, heat sink temp, bus voltage, active I/O command status, time from power up, and current setting.

.3 Line and load reactors required for all 575 volt applications.

.4 Drive shall be factory supplied and installed in a vented enclosure.

.5 Minimum CFM of 50% on DX systems and gas fired heat exchangers.

.6 Acceptable Manufacturer: “ABB”, “Eaton”. Drives shall be complete with all modules required to communicate with an N2 protocol.

.6 Motor, fan bearings and drive assembly shall be located inside the fan plenum to minimize bearing wear and to allow for internal vibration isolation of the fan-motor assembly, where required. Motor mounting shall be adjustable to allow for variations in belt tension.

.7 Fan-motor assemblies shall be provided with vibration isolators. Isolators shall be bolted to steel channel welded to unit floor, which is welded to the structural frame of the unit. The isolators shall be neoprene-in-shear type for single 9" (230mm) to 15" (380mm) diameters forward curve fans. All other fans shall incorporate vertical spring type isolators with leveling bolts, bridge bearing waffled pads with minimum 1" (25mm) static deflection designed to achieve high isolation efficiency. Use of separate bumper or snubber is not acceptable. Fans shall be attached to the discharge panel by a polyvinyl chloride coated polyester woven fabric, with a sealed double locking fabric to metal connection.

.8 Provide single extended grease line from far side to access side bearing.

.9 Fan motors shall TEFC (totally enclosed fan cooled) Super E high efficiency type.

.5 Coils:

.1 Coils shall be 1/2" O.D., constructed of copper tube, aluminum fin, and copper headers with schedule 40 steel pipe connectors.

.2 Fins constructed of aluminum or copper shall be rippled for maximum heat transfer and shall be mechanically bonded to the tubes by mechanical expansion of the tubes. The coils shall have a galvanized steel casing. All coils shall be factory tested with air at 300 psig (2070 kPa) while immersed in an illuminated water tank.

.3 Headers shall be outside the air-handling unit for maximum serviceability except for blow through applications where headers are internal. The non-headered end of the coil shall be fully concealed. Provide auxiliary drain pan complete with ½" (13mm) MPT drain connection at headered end of cooling coils.

.4 Coils shall be removable from the unit at the header end, unless shown otherwise on the drawings.

.5 Multiple row coils shall be of staggered tube design circuited to optimize capacity with minimum pressure drop.

.6 Refrigerant evaporator type coils shall be equipped with distributors connected to the coil by copper tubes. Where a hot gas bypass is required, the inlet shall be at the refrigerant distributor. Solenoid valves, expansion valves, and related accessories are to be provided and installed by the refrigeration contractor.

.7 Refrigerant coils with multiple compressors shall be alternate tube circuited in order to distribute the cooling effect over the entire coil face at reduced load conditions. Provision for use of thermal expansion valves must be included for variable air volume and/or make-up air applications.

.6 Electric Heat:

.1 Electric resistance heaters shall be provided in the capacities, voltage, and steps of control as noted in the Schedules and shall bear a listing or certification mark from an authorized agency.

.2 Heater elements shall be installed a minimum of 12" (305mm) downstream from air filters. Insulation in heating sections shall be fibre-reinforced foil faced. Should discharge air exceed 105°F (40°C), employ motors in air stream with Class F insulation. Over 150°F (65°C) discharge air temperature, mount motors out of the heated air stream.

.3 Heater element wiring shall terminate in a full height enclosure at one end of the heater. All internal wiring shall terminate on clearly identified terminal blocks. A wiring diagram shall be provided on the enclosure cover.

.4 Heaters shall be equipped with an automatic reset disc type thermal cut-out. Heaters rated at 30 kW and less shall be equipped with an additional manual reset disc type thermal cut-out.

.5 Heater elements shall be open type nickel-chromium construction, (2/3 Ni, 1/3 Cr) with a maximum of 22.5 kw/ft2. Coil terminal pins shall be mechanically secured and insulated from the frame by means of non-rotating ceramic bushings.

.6 Heating coil casings shall be corrosion resistant and made of galvanized steel of suitable gauge as required by approval agency.

.7 Electric Heat shall be controlled via ambient temperature controller.

.7 Indirect Fired High Efficiency Gas Heating Section:

.1 General:

.1 Heating units shall be indirect natural, fired approved for both sea level and high altitude areas. The entire package, including damper controls,

fan controls, and all other miscellaneous controls and accessories shall be approved by an independent testing authority and carry the approval label of that authority as a complete operating package.

.2 All units must exceed the ASHRAE 90.1 requirement of steady state efficiency at low fire operation.

.3 Operating natural gas pressure at unit(s) manifold shall be 7"w.c. (1750 Pa).

.4 Gas fired units shall be approved for operation in 40°F (-40°C) locations.

.2 Heat Exchanger/Burner Assembly:

.1 Heat exchanger shall be a primary drum and multi-tube secondary assembly constructed of titanium stainless steel with multi-plane metal turbulators and shall be of a floating stress relieved design. Heat exchanger shall be provided with condensate drain connection. The heat exchanger casing shall have 1"(25mm) of insulation between the outer cabinet and inner heat reflective galvanized steel liner. Blower location shall be engineered to improve the required air flow pattern around the heat exchanger. Using duct type furnaces and closed coupled blowers are not acceptable.

.2 Units with high efficiency heat exchangers (DJX) shall be tested and certified to ANSI/CSA standards to provide a minimum of 90% efficiency throughout the entire operating range as required by ASHRAE 90.1. The manufacturer shall be routinely engaged in the manufacture of this type of high efficiency equipment.

.3 The heat exchanger/burner assembly shall be a blow through positive pressure type. Units incorporating the DJM module shall have an interrupted pilot ignition system to provide increased safety. Units using continuous or intermittent pilots are not acceptable.

.4 Flame surveillance shall be from the main flame after ignition not the pilot flame. The burner and gas train shall be in a cabinet enclosure. Atmospheric burners or burners requiring power assisted venting are not acceptable.

.5 The heat exchanger/burner assembly shall include 15:1 turndown for all input ranges from 100MBH to 1400MBH (29.3 kW to 410 kW). The high turn down heat exchanger/burner assembly minimum input shall be capable of controlling 6.7% of its rated input, excluding the pilot assembly, without on/off cycling and include built in electronic linearization of fuel and combustion air. Efficiency shall increase from high to low fire.

.3 Venting:

.1 Installation and venting provisions must be in accordance with CAN/CSA Standard B149.1, ANSI Z223.1-NFPA 54, and local authorities having jurisdiction. Standard outdoor DJX provided with stainless steel flue.

.4 Controls:

.1 Electronic DJM module (Modulating Fuel w/ Modulating Combustion Air) complete with proportional and integral control with discharge air sensor to maintain set point temperature and provide rapid response to incremental changes in discharge air temperature. Combustion air motor

speed varies proportionally in response to the modulation of gas flow to provide optimum fuel/air mixture and efficiency at all conditions. Combustion blower RPM shall be proved using a hall effect speed sensor. Two speed or step speed combustion blowers are not acceptable.

.2 Combustion efficiency of high efficiency heat exchangers shall increase by up to 1-3% from high fire to low fire while turning down on units incorporating 15:1 turndown (HT Burner). Heat exchangers shall provide a minimum of 90% efficiency throughout the entire operating range.

.3 Alternate manufacturers units that do not incorporate a variable speed combustion air blower shall have a modulating gas valve and a combustion air damper with a linear linkage connected to an actuator which has a minimum of 100 steps of control.

.4 Installing contractor to check with local codes and jurisdictions regarding field connecting condensate drain connection to sanitary sewer. A condensate neutralizer may be required. Contractor to provide piping to condensate drain connection with all DJX heat exchangers.

.5 Installing contractor is to locate condensate neutralizing tank in a heated space away from the appliance at a point lower than the unit heat exchanger to promote gravity flow to sanitary sewer. Where this is not possible, a condensate pump may be required.

.8 Filters:

.1 Filter sections shall be provided with adequately sized access doors to allow easy removal of filters. Filter removal shall be from one side as noted on the drawings.

.2 2"(50mm) Pleated Panel Disposable Filters: An optimum blend of natural and synthetic fiber media with a rust resistant support grid and high-wet strength beverage board enclosing frame with diagonal support members bonded to the air entering and air exiting side of each pleat. Permanent re-usable metal enclosing frame. The filter media shall have a minimum efficiency of 30-35% on ASHRAE Standard 52.1-92, and a minimum of MERV 8 per ASHRAE 52.2. Rated U.L. Class 2.

.3 Where filters are provided in air handling units for make-up air applications and where hoar frost may occur, only steel frame filters are acceptable. Where indicated, units shall have both summer (upstream of heating coil or gas heat exchanger) and winter (downstream of heating coil or gas heat exchanger) filter sections. Only one set of filters is installed depending on ambient conditions.

.4 Filter media shall meet UL Class 2 standards.

.9 Dampers:

.1 Damper frames shall be U-shaped galvanized metal sections securely screwed or welded to the air handling unit chassis. Pivot rods of 1/2" (13mm) aluminum shall turn in nylon or bronze bushings. Rods shall be secured to the blade by means of straps and set screws.

.2 Blades shall be 18 gauge (1.3mm) galvanized metal with two breaks on each edge and three breaks on centerline for rigidity. The pivot rod shall "nest" in the centerline break. Damper edges shall interlock. Maximum length of damper between supports shall be 48”(1219 mm). Damper linkage brackets shall be constructed of galvanized metal.

.3 Dampers shall be extruded aluminum, low leak, thermally broken, insulated blade Tamco Series 9000.

.4 Mixing dampers shall be parallel blade type.

.5 Two position inlet dampers shall be parallel blade type.

.6 Gravity relief dampers shall be single blade gasketted design.

.10 Mechanical Cooling:

.1 Compressors shall be hermetic type. Compressors are set on resilient neoprene mounts and complete with live voltage break internal overload protection and internal pressure relief valve.

.2 Air Cooled Condenser:

.1 Condenser coils shall be copper tube type, mechanically expanded into aluminum fins. Coils shall be factory tested with air at 300 psig (2070 kPa) while immersed in an illuminated water tank.

.2 Condenser fans shall be direct driven propeller type arranged for vertical draw through airflow. Motors shall be weather resistant type, with integral overload protection and designed for vertical shaft condenser fan applications. Fan and motor assemblies shall be mounted on a formed orifice plate for optimum efficiency with minimum noise level.

.3 Condenser fan shall be fully housed fan with protective screen and fluted blades for optimum efficiency with minimum noise level.

.4 Condenser to form an integral part of the unit.

.3 Packaged Air Conditioning Units:

.1 Packaged units shall be CETL, ETLUS approved and operate down to 50°F(10°C) as standard. Where applicable, multiple refrigeration circuits shall be separate from each other. Refrigeration circuits shall be complete with liquid line filter-driers, and service ports fitted with Schraeder fittings. Units with over 6 Ton hermetic compressors and all units with semi-hermetic compressors shall also incorporate load compensated thermal expansion valves with external equalizers and combination sight glass moisture indicators. Semi-hermetic compressor units shall have condensers designed for 15°F (8°C) liquid subcooling and be equipped with suction line filters and liquid line manual shutoff valves. The complete piping system shall be purged and pressure tested with dry nitrogen, then tested again under vacuum. Each system shall be factory run and adjusted prior to shipment.

.2 Packaged units shall be supplied with R-410 refrigerant.

.3 Controls for hermetic compressor units shall include compressor and condenser fan motor contactors, supply fan contactors and overload protection, control circuit transformer, cooling relays, ambient compressor lockout, automatic reset low pressure controls, and manual reset high pressure controls on compressors over 6 tons. Head pressure actuated fan cycling control shall be provided on all multiple condenser fan units.

.4 Four stages of switched condenser reheat with two way valve control to either independent condenser reheat coil or remote condenser no modulating. System must include receivers, subcooling condenser circuits and check valves.

.5 Provide five minute anti-cycle timers.

.6 Provide interstage time delay timers.

.7 Compressors shall be located on the side of the unit in a service enclosure complete with hinged access doors for ease of service.

.8 C-TRAC3 Controller

.1 The controller shall automatically start in heating, economizer, or cooling mode based on continuously monitored ambient temperature and load requirements.

.2 The controller shall include an adjustable low limit set point for freeze protection to cease equipment operation in the event of low discharge temperature. If the discharge air temperature falls below the adjusted set point, the blowers will shut down and the outside air dampers shall close.

.3 Dual sensors shall be used in the discharge air for precise temperature control.

.1 In Occupied/Unoccupied mode the controller shall be capable of unoccupied heating with adjustable temperature setback with intermittent blower operation.

.2 The C-TRAC3 electronic temperature control system shall provide up to 5 stages of mechanical cooling control to maintain discharge (room) temperature. The minimum run and off time for the compressors shall be variable based on load requirements.

.3 When in heating mode, the C-TRAC3 shall provide a signal to the DJM2 programmed logic heating controller for series DJ gas fired heater.

.4 Communication:

.1 The C-TRAC3 shall have indication and troubleshooting LED lights, multi-meter set point and sensor temperature test points, and a common alarm contact in the event of equipment failure. Information can be accessed from a PDA (personal digital assistant) or laptop computer for improved access to control settings using Engineered Air SMC software.

.5 C-TRAC with Carel Controller

.1 The Carel Controller will provide the following functions: status, monitoring, command and reset signals. Based on EMS Communication of BACnet MSTP.

.6 Normal operation of the unit shall allow the BACnet controller to reset the discharge air temperature, start/stop the unit

.11 Factory Supplied Controls / Wiring:

.1 Provide a system of motor control, including all necessary terminal blocks, motor contactors, motor overload protection, grounding lugs, control transformers, auxiliary contactors and terminals for the connection of external control devices or relays.

.2 Gas fired units shall also include high limit and combustion airflow switch.

.3 Fire alarm circuits (where required) shall be powered from a relay in unit circuitry.

.12 HRP (QDT) Heat Pipes:

.1 General:

.1 The heat pipe shall be the sole responsibility of the unit manufacturer. The manufacturer shall guarantee the performance of the pipe as to its total heat transfer capacity, and its operation. Alternate reclaim devices shall meet or exceed the performance noted in the schedules, without exceeding the fan power requirements specified.

.2 Heat Exchanger Design:

.1 The heat recovery device shall be an air-to-air heat pipe heat exchanger. The basis of design shall be the HRP (QDT) heat pipe.

.2 The heat exchanger core shall be of 5/8" seamless aluminum tubing permanently expanded into aluminum fins. Each tube shall be an individually sealed heat pipe filled with a working fluid conforming to Group 1 in the American National Standard Safety Code for Mechanical Refrigeration. Serpentine coils or headered tubes will not be considered.

.3 The secondary surface shall be continuous plate aluminum fins of corrugated design to produce maximum heat transfer efficiency, and reduce the frost threshold of the unit.

.3 Tube Construction:

.1 Heat pipe tubes must be wicked. The capillary wick of each heat pipe shall be an integral part of the inner wall of the tube to provide a completely wetted surface for maximum heat pipe capacity with minimum heat transfer resistance. Non wicked heat pipes will not be considered.

.4 Air Stream Partition:

.1 A partition shall be provided to isolate the exhaust and supply air streams from each other to prevent cross-contamination. The partition shall be a standard single piece sheet metal divider. Tubes are expanded into this divider to form a positive seal against air leakage.

.5 Temperature and Frost Control:

.1 Standard control for a QDT coil is the combination of face and bypass dampers and an Engineered Air Q-TRAC controller.

.6 Q-TRAC Controller:

.1 The controller shall be a solid-state dedicated device manufactured by Engineered Air. Operation shall be to effectively tilt the heat pipe to achieve accurate supply air temperature control.

**.13 All drain lines shall be installed, insulated and heat traced to the basement by the contractor. The contractor and supplier shall coordinate to ensure the base rail is high enough to permit drain piping to have sufficient slope**

**.14 Access doors (hatches) shall be provided in the unit floor at each drain connection to permit access to the connection after installation. An access door shall also be installed in the AHU floor right before the basement wall.**

.15 Acceptable Manufacturer: "Engineered Air". Refer to performance schedule for model number.

**2.2 PACKAGED OUTDOOR AIR HANDLING UNIT, AHU-2:**

.1 Performance: Refer to performance schedule at end of section.

.2 General:

.1 Air Handling Units shall be built to the level of quality as herein specified and to the description of the Air Handling Unit Schedule.

.2 Unless stated otherwise, air-handling units are to be shipped to the job in one piece, factory assembled. Modular units assembled to achieve a close proximation to the intent of this specification will not be considered equal. All equipment shall where specified and applicable, be pre-wired, and factory certified by an approved testing agency such as CETL, ETLUS, UL, CSA prior to shipment.

.3 Pre-wired air handling units shall bear an approved label with all the necessary identification marks, electrical data.

.4 Unit must conform to regulations set out in the Canadian Energy Efficiency Act for large air conditioners (condensing units). Packaged units shall be tested to CSA Standard C746-98 and must bear an EEV (energy efficiency verification) label provided by CSA. Where specified as factory packaged air conditioning unit, factory assembled split systems do not conform to the Canadian Energy Efficiency Act and will not be considered.

.5 All electrical circuits shall undergo a dielectric strength test, and shall be factory tested and checked as to proper function.

.6 The air handling units and major components shall be products of manufacturers regularly engaged in the production of such equipment and with a minimum of fifteen continuous years of proven production experience.

.3 Unit Construction:

.1 Air handling cabinetry shall conform to the following:

.1 Inner and outer face panels shall be galvaneal to provide extended casing life. (Indoor unit construction – wall and roof panels. Outdoor unit construction shall include Membrane roof material. Roofing material is minimum 48 mil (1.2mm) thermoplastic membrane with fiberglass reinforcement. Membrane is adhered to roof surface with clear solvent base contact adhesive. All roof surfaces rolled over edges to ensure proper water runoff. Membrane color Energy Smart White.

.2 Outer and / or Inner face panels shall consist of galvaneal material.

.3 Outer and / or Inner face panels shall be cleaned with degreasing solvent to remove oil and metal oxides and primed with two-part acid based etching prime.

.4 Metal foam panel shall be structurally equal to 16 gauge galvanized steel outer face panel with 22 gauge galvanized steel inner face panel.

.5 Foam core shall be continuous foamed in place , Non-CFC polyurethane with the nominal properties:

.1 92% closed cell structure.

.2 Density: minimum 2.0 lbs./cu.ft (32.0Kg/al.m) minimum.

.3 Compressive Strength: 22 psi (152 Kpa)

.6 Flashing and trim shall be formed sheet metal to match the panels.

.7 Thermal transmission tested in accordance with ASTM C518.

.8 Panels shall provide minimum R-Value=16, minimum U-Value 0.0625.

.2 Units shall be provided with access doors to the following components: fans and motors, filters, dampers and operators, access plenums, electrical control panels, burner compressor compartments. Access doors shall be large enough for easy access. Removal of screwed wall panels will not be acceptable.

.3 Units shall be provided with hinged access doors, with e-profile gasket, fully lined, and a minimum of two Leverlok fasteners for all units.

.4 Cooling coil drain pans shall be fabricated of stainless steel and are an integral part of the floor paneling, a minimum of 2" (51mm) deep, with welded corners. Drain pans shall extend a minimum of 6" (152mm) downstream of coil face and be provided with a 1 ½" (38mm) S.S. M.P.T. drain connection. Drain pans must have a fast pan and be sloped and pitched such that there is no standing water. Intermediate fast pans shall be provided between cooling coils where required for effective moisture removal.

.5 For swimming pool applications the following specialized construction and features for air handling units shall be provided:

.1 Locate damper motors and series 90 style controllers out of air stream. Heresite coat control bulbs located in air stream.

.2 4” (120mm) Drain pan in mixing section.

.3 Solid-state humidistat (Honeywell H46).

.4 Motors to be TEFC Super-E with 1.15 service factor.

.5 Blower and motor drive belts shall have a 1.5 service factor.

.6 Heresite coat coils.

.7 Coat fan shafts with chlorine resistant coating.

.8 Gasket and/or caulk seal all opening between control panel and the air stream.

.9 Insulated box over high limit on outdoor units where design temperature is 0°F (-18°C) or less.

.6 Air handling units shall be weatherproofed and equipped for installation outdoors. This shall include generally for the prevention of infiltration of rain and snow into the unit, louvers or hoods on air intakes and exhaust openings with 1"(25mm) galvanized inlet screens; rain gutters or diverters over all access doors; all joints caulked with a water resistant sealant; drain trap(s) connections for field supply and installation of drain traps.

.7 Provide full perimeter roof mounting curb of heavy gauge sheet metal, minimum of 12” (305mm) high, and complete with wood nailer, neoprene sealing strip, and fully welded "Z" bar with 1" (25mm) upturn on inner perimeter, to provide a complete seal against the elements. External insulation and flashing of the roof-mounting curb shall be provided by the Roofing Subcontractor.

.4 Fans:

.1 Centrifugal fans shall be rated in accordance with AMCA Standard Test Code, Bulletin 210. Fan manufacturer shall be a member of AMCA. All fans and fan assemblies shall be dynamically balanced during factory test run. Fan shafts

shall be selected for stable operation at least 20% below the first critical RPM. Fan shafts shall be provided with a rust inhibiting coating.

.2 Forward curved and Airfoil fans shall be equipped with greaseable pillow block bearings, supported on a rigid structural steel frame.

.3

.4 Drives shall be adjustable on fans with motors 7 1/2 HP (5.6 kW) or smaller. On fans with larger motors, fixed drives shall be provided. All drives shall be provided with a rust inhibiting coating. The air balancer shall provide for drive changes (if required) during the air balance procedure.

.5 Provide full dedicated outside air fan as scheduled. The use of power exhaust propeller or centrifugal fan arrangements will not be considered.

.6 Provide variable air volume fan control via adjustable frequency drive which shall be mounted in a NEMA 1 enclosure and shall be labeled by an approved testing agency such as UL.

.1 Sine wave carrier input, PWM output. IGBT transistors. Adjustable acceleration and deceleration timing.

.2 Keypad to be removable, with alphanumeric display able to provide output status monitoring, output frequency, output voltage, output RPM, and output current. Include fault log display with capacity for the recent 30 faults with a time stamp. Diagnostic display menus to include reference speed command, heat sink temp, bus voltage, active I/O command status, time from power up, and current setting.

.3 Line and load reactors required for all 460 and 575 volt applications.

.4 Drive shall be factory supplied and installed in a vented enclosure.

.5 Minimum CFM of 50% on DX systems and gas fired heat exchangers.

.6 Acceptable Manufacturer: “ABB”, “Eaton”. Drives shall be complete with all modules required to communicate with an N2 protocol.

.7 Motor, fan bearings and drive assembly shall be located inside the fan plenum to minimize bearing wear and to allow for internal vibration isolation of the fan-motor assembly, where required. Motor mounting shall be adjustable to allow for variations in belt tension.

.8 Fan-motor assemblies shall be provided with vibration isolators. Isolators shall be bolted to steel channel welded to unit floor, which is welded to the structural frame of the unit. The isolators shall be neoprene-in-shear type for single 9" (230mm) to 15" (380mm) diameters forward curve fans. All other fans shall incorporate vertical spring type isolators with leveling bolts, bridge bearing waffled pads with minimum 1" (25mm) static deflection designed to achieve high isolation efficiency. Use of separate bumper or snubber is not acceptable. Fans shall be attached to the discharge panel by a polyvinyl chloride coated polyester woven fabric, with a sealed double locking fabric to metal connection.

.9 Provide single extended grease line from far side to access side bearing.

.10 Fan motors shall TEFC (totally enclosed fan cooled) Super E high efficiency type.

.5 Coils:

.1 Coils shall be 1/2" O.D. as manufactured by Engineered Air, constructed of copper tube, aluminum fin, and copper headers with schedule 40 steel pipe connectors.

.2 Fins constructed of aluminum or copper shall be rippled for maximum heat transfer and shall be mechanically bonded to the tubes by mechanical expansion of the tubes. The coils shall have a galvanized steel casing. All coils shall be factory tested with air at 300 psig (2070 kPa) while immersed in an illuminated water tank.

.3 Headers shall be outside the air-handling unit for maximum serviceability except for blow through applications where headers are internal. The non-headered end of the coil shall be fully concealed. Provide auxiliary drain pan complete with ½" (13mm) MPT drain connection at headered end of cooling coils.

.4 Coils shall be removable from the unit at the header end, unless shown otherwise on the drawings.

.5 Multiple row coils shall be of staggered tube design circuited to optimize capacity with minimum pressure drop.

.6 Refrigerant evaporator type coils shall be equipped with distributors connected to the coil by copper tubes. Where a hot gas bypass is required, the inlet shall be at the refrigerant distributor. Solenoid valves, expansion valves, and related accessories are to be provided and installed by the refrigeration contractor.

.7 Refrigerant coils with multiple compressors shall be alternate tube circuited in order to distribute the cooling effect over the entire coil face at reduced load conditions. Provision for use of thermal expansion valves must be included for variable air volume and/or make-up air applications.

.6 Gas Heat Section:

.1 General

.1 Heating units shall be indirect natural, fired approved for both sea level and high altitude areas. The entire package, including damper controls, fan controls, and all other miscellaneous controls and accessories shall be approved by an independent testing authority and carry the approval label of that authority as a complete operating package.

.2 All units must exceed the ASHRAE 90.1 requirement of steady state efficiency at low fire operation.

.3 Operating natural gas pressure at unit(s) manifold shall be 7"w.c.(1750 Pa).

.4 Gas fired units shall be approved for operation in 40°F(-40°C) locations.

.2 Heat Exchanger/Burner Assembly

.1 Heat exchanger shall be a primary drum and multi-tube secondary assembly constructed of titanium stainless steel with multi-plane metal turbulators and shall be of a floating stress relieved design. Heat exchanger shall be provided with condensate drain connection. The heat exchanger casing shall have 1"(25mm) of insulation between the outer cabinet and inner heat reflective galvanized steel liner. Blower location shall be engineered to improve the required air flow pattern around the heat exchanger. Using duct type furnaces and closed coupled blowers are not acceptable.

.2 Units with optional high efficiency heat exchangers (DJX) shall be tested and certified to ANSI/CSA standards to provide a minimum of 90% efficiency throughout the entire operating range as required by ASHRAE 90.1. The manufacturer shall be routinely engaged in the manufacture of this type of high efficiency equipment.

.3 The heat exchanger/burner assembly shall be a blow through positive pressure type. Units incorporating the DJM module shall have an interrupted pilot ignition system to provide increased safety. Units using continuous or intermittent pilots are not acceptable.

.4 Flame surveillance shall be from the main flame after ignition not the pilot flame. The burner and gas train shall be in a cabinet enclosure. Atmospheric burners or burners requiring power assisted venting are not acceptable.

.5 The heat exchanger/burner assembly shall include 15:1 turndown for all input ranges from 100MBH to 1400MBH (29.3 kW to 410 kW). The high turn down heat exchanger/burner assembly minimum input shall be capable of controlling 6.7% of its rated input, excluding the pilot assembly, without on/off cycling and include built in electronic linearization of fuel and combustion air. Efficiency shall increase from high to low fire.

.3 Venting

.1 Installation and venting provisions must be in accordance with CAN/CSA Standard B149.1, ANSI Z223.1-NFPA 54, and local authorities having jurisdiction. Standard outdoor DJX provided with stainless steel flue.

.4 Controls

.1 Electronic DJM module (Modulating Fuel w/ Modulating Combustion Air) complete with proportional and integral control with discharge air sensor to maintain set point temperature and provide rapid response to incremental changes in discharge air temperature. Combustion air motor speed varies proportionally in response to the modulation of gas flow to provide optimum fuel/air mixture and efficiency at all conditions. Combustion blower RPM shall be proved using a hall effect speed sensor. Two speed or step speed combustion blowers are not acceptable.

.2 Combustion efficiency of high efficiency heat exchangers shall increase by up to 1-3% from high fire to low fire while turning down on units incorporating 15:1 turndown (HT Burner). Heat exchangers shall provide a minimum of 90% efficiency throughout the entire operating range.

.3 Alternate manufacturers units that do not incorporate a variable speed combustion air blower shall have a modulating gas valve and a combustion air damper with a linear linkage connected to an actuator which has a minimum of 100 steps of control.

.4 Installing contractor to check with local codes and jurisdictions regarding field connecting condensate drain connection to sanitary sewer. A condensate neutralizer may be required. Contractor to provide piping to condensate drain connection with all DJX heat exchangers.

.5 Installing contractor is to locate condensate neutralizing tank in a heated space away from the appliance at a point lower than the unit heat

exchanger to promote gravity flow to sanitary sewer. Where this is not possible, a condensate pump may be required.

.7 Filters:

.1 Filter sections shall be provided with adequately sized access doors to allow easy removal of filters. Filter removal shall be from one side as noted on the drawings.

.2 2"(50mm) Pleated Panel Disposable Filters: An optimum blend of natural and synthetic fiber media with a rust resistant support grid and high-wet strength beverage board enclosing frame with diagonal support members bonded to the air entering and air exiting side of each pleat. Permanent re-usable metal enclosing frame. The filter media shall have a minimum efficiency of 30-35% on ASHRAE Standard 52.1-92, and a minimum of MERV 8 per ASHRAE 52.2. Rated U.L. Class 2.

.3 Filter media shall meet UL Class 2 standards.

.8 Dampers:

.1 Damper frames shall be U-shaped galvanized metal sections securely screwed or welded to the air handling unit chassis. Pivot rods of 1/2" (13mm) aluminum shall turn in nylon or bronze bushings. Rods shall be secured to the blade by means of straps and set screws.

.2 Blades shall be 18 gauge (1.3mm) galvanized metal with two breaks on each edge and three breaks on centerline for rigidity. The pivot rod shall "nest" in the centerline break. Damper edges shall interlock. Maximum length of damper between supports shall be 48”(1219 mm). Damper linkage brackets shall be constructed of galvanized metal.

.3 Dampers shall be extruded aluminum, low leak, thermally broken, insulated blade Tamco Series 9000.

.4 Mixing dampers shall be parallel blade type.

.5 Two position inlet dampers shall be parallel blade type.

.6 Gravity relief dampers shall be single blade gasketted design.

.9 Mechanical Cooling:

.1 Compressors shall be hermetic type. Compressors are set on resilient neoprene mounts and complete with live voltage break internal overload protection and internal pressure relief valve.

.2 Air Cooled Condenser

.1 Condenser coils shall be copper tube type, mechanically expanded into aluminum fins. Coils shall be factory tested with air at 300 psig (2070 kPa) while immersed in an illuminated water tank.

.2 Condenser fans shall be direct driven propeller type arranged for vertical draw through airflow. Motors shall be weather resistant type, with integral overload protection and designed for vertical shaft condenser fan applications. Fan and motor assemblies shall be mounted on a formed orifice plate for optimum efficiency with minimum noise level.

.3 Condenser fan shall be fully housed fan with protective screen and fluted blades for optimum efficiency with minimum noise level.

.4 Condenser to form an integral part of the unit.

.3 Packaged Air Conditioning Units

.1 Packaged units shall be CETL, ETLUS approved and operate down to 50°F (10°C) as standard. Refrigeration circuits shall be complete with liquid line filter-driers, and service ports fitted with Schraeder fittings. Units with over 6 Ton hermetic compressors and all units with semi-hermetic compressors shall also incorporate load compensated thermal expansion valves with external equalizers and combination sight glass moisture indicators. Each system shall be factory run and adjusted prior to shipment.

.2 Packaged units shall be supplied with R-410 refrigerant.

.3 Provide single stage digital scroll compressor.

.4 Provide five minute anti-cycle timers.

.5 Provide interstage time delay timers.

.6 Compressor shall be located on the side of the unit in a service enclosure complete with hinged access doors for ease of service.

.7 C-TRAC3 Controller

.1 The controller shall automatically start in heating, economizer, or cooling mode based on continuously monitored ambient temperature and load requirements.

.2 The controller shall include an adjustable low limit set point for freeze protection to cease equipment operation in the event of low discharge temperature. If the discharge air temperature falls below the adjusted set point, the blowers will shut down and the outside air dampers shall close.

.3 Dual sensors shall be used in the discharge air for precise temperature control.

.1 In Occupied/Unoccupied mode the controller shall be capable of unoccupied heating with adjustable temperature setback with intermittent blower operation.

.2 The C-TRAC3 electronic temperature control system shall provide cooling control to maintain discharge (room) temperature.

.3 When in heating mode, the C-TRAC3 shall provide a signal to the DJM2 programmed logic heating controller for series DJ gas fired heater.

.4 Communication

.1 The C-TRAC3 shall have indication and troubleshooting LED lights, multi-meter set point and sensor temperature test points, and a common alarm contact in the event of equipment failure. Information can be accessed from a PDA (personal digital assistant) or laptop computer for improved access to control settings using Engineered Air SMC software.

.5 C-TRAC with Carel Controller

.1 The Carel Controller will provide the following functions: status, monitoring, command and reset

signals. Based on EMS Communication of BACnet MSTP.

.6 Normal operation of the unit shall allow the BACnet controller to reset the discharge air temperature, start/stop the unit

.10 Factory Supplied Controls / Wiring

.1 Provide a system of motor control, including all necessary terminal blocks, motor contactors, motor overload protection, grounding lugs, control transformers, auxiliary contactors and terminals for the connection of external control devices or relays.

.2 Gas fired units shall also include high limit and combustion airflow switch.

.3 Fire alarm circuits (where required) shall be powered from a relay in unit circuitry.

.11 Acceptable Product: “Engineered Air” model FWE61/DJX20/O/MV

## Part 3 Execution

### 3.1 EXAMINATION

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

.1 Visually inspect substrate in presence of Contractor Administrator.

.2 Inform Contractor Administrator of unacceptable conditions immediately upon discovery.

.3 Proceed with installation only after unacceptable conditions have been remedied.

### 3.2 INSTALLATION

.1 Install as per manufacturers' instructions on roof curbs provided by manufacturer as indicated.

.2 Manufacturer to certify installation, supervise start-up and commission unit.

.3 Run drain line from cooling coil condensate drain pan to discharge over roof drain.

### 3.3 FIELD QUALITY CONTROL

.1 Manufacturer's Field Services:

.1 Have manufacturer of products supplied under this Section review work involved in handling, installation/application, protection and cleaning of its products, and submit written reports, in acceptable format, to verify compliance of Work with Contract.

.2 Provide manufacturer's field services, consisting of product use recommendations and periodic Site visits for inspection of product installation, in accordance with manufacturer's instructions.

.2 Performance Verification:

.1 General:

.1 In accordance with Section 23 08 02 - Cleaning and Start-up of Mechanical Piping System, supplemented as specified herein.

.2 Packaged Outdoor Air Handling Units:

.1 Set zone mixing dampers for full cooling, except that where diversity factor forms part of design set that percentage of zone dampers to full heating.

.2 Set outside air and return air dampers for minimum outside air.

.3 Set face and bypass dampers so face dampers are fully open and bypass dampers are fully closed.

.4 Check for smooth, vibration less correct rotation of supply fan impeller.

.5 Measure supply fan capacity.

.6 Adjust impeller speed as necessary and repeat measurement of fan capacity.

.7 Measure pressure drop each component of air handling unit.

.8 Set outside air and return air dampers for the percentage of outside air required by design and repeat measurements of fan capacity.

.9 Reduce differences between fan capacity at minimum and maximum outside air less than [5]%.

.10 Set face and bypass dampers to full bypass and repeat measurement of fan capacity.

.11 Reduce difference between fan capacity with F BPD fully closed to bypass and fully open to bypass to less than 5%.

.12 Reduce difference between fan capacity at full cooling and fan capacity at full heating to less than [5]%.

.13 OAD: verify for proper stroking, interlock with RAD.

.14 Measure DBT, WBT of SA, RA, EA.

.15 Measure air cooled condenser discharge DBT.

.16 Measure flow rates (minimum and maximum) of SA, RA, EA, relief air.

.17 Simulate maximum cooling load and measure refrigerant hot gas and suction temperatures and pressures.

.18 Use smoke test to verify no short-circuiting of EA, relief air to outside air intake or to condenser intake.

.19 Simulate maximum heating load and:

.1 Verify temperature rise across heat exchanger.

.2 Perform flue gas analysis. Adjust for peak efficiency.

.3 Verify combustion air flow to heat exchanger.

.4 Simulate minimum heating load and repeat measurements.

.20 Measure radiated and discharge sound power levels under maximum heating demand and under maximum cooling demand with compressors running.

.21 Verify operating control strategies, including:

.1 Heat exchanger operating and high limit.

.2 Early morning warm-up cycle.

.3 Freeze protection.

.4 Economizer cycle operation, temperature of change-over.

.5 Alarms.

.6 Voltage drop across thermostat wiring.

.7 Operation of remote panel including pilot lights, failure modes.

.22 Set zone mixing dampers for full heating and repeat measurements.

.23 Measure leakage past zone mixing dampers by taking temperature measurements. Reduce leakage to less than [5]%.

.24 Measure return fan capacity.

.25 Adjust impeller speed as necessary and repeat measurement of return fan capacity.

.26 Check capacity of heating unit.

.27 Refer to other sections of these specifications for PV procedures for other components.

.3 Start-Up:

.1 General: in accordance with Section 23 08 02 - Cleaning and Start-up of Mechanical Piping Systems.

.4 Verify accessibility, serviceability of components including motorized dampers, filters coils, fans, motors, operators, humidifiers, sensors, electrical disconnects.

.5 Verify accessibility, clean ability, drainage of drain pans for coils, humidifiers.

.3 Commissioning Reports:

.1 In accordance with Section 01 91 13 - General Commissioning (Cx) Requirements: reports supplemented as specified herein. Include:

.1 Report forms as specified Section 01 91 13 - General Commissioning (Cx) Requirements: Report Forms and Schematics.

## 3.4 DEMONSTRATION

.1 Training: in accordance with Section 01 91 13 - General Commissioning (Cx) Requirements: Training of O M Personnel, supplemented as specified.

## 3.5 CLEANING

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

.1 Leave Work area clean at end of each day.

.2 Final Cleaning: upon completion remove surplus materials, rubbish, tools and equipment in accordance with Section 01 74 00 - Cleaning.

.3 Perform cleaning operations in accordance with manufacturer's recommendations.

.4 Waste Management: In accordance with 01 74 21 Construction Waste Management.

AHU Performance Schedule:

| Equipment Tag: | AHU-1 | AHU-2 |
|---|---|---|
| Manufacturer: | Engineered Air | Engineered Air |
| Model number: | FWE1208/DJX140/C/K/HRP/O/MV | FWE61/DJX20/O/MV |
| Supply Air Fan: | | |
| Airflow (cfm): | 28,800 | 2,400 |

| Equipment Tag: | AHU-1 | AHU-2 |
|---|---|---|
| E.S.P. (in. w.c.): | 1.00 | 1.00 |
| VFD: | Yes | Yes |
| Motor (HP): | 40.0 | 3.0 |
| Operating Power (BHP): | 35.43 | 2.10 |
| Operating fan RPM: | 1,568 | 1,764 |
| Return Air Fan: | | |
| Airflow (cfm): | 28,800 | 2,400 |
| E.S.P. (in. w.c.): | 1.00 | 1.00 |
| VFD: | Yes | Yes |
| Motor (HP): | 30.0 | 3.0 |
| Operating Power (BHP): | 25.13 | 1.74 |
| Operating fan RPM: | 621 | 1,594 |
| Gas Heating Performance: | | |
| Maximum input (Btu/hr): | 1,400,000 | 100,000 |
| Efficiency (%): | 90% (minimum) | 90% (minimum) |
| Modulation: | 15:1 | 15:1 |
| Temperature rise (°F): | 40.5 | 34.7 |
| Electric Heating Performance: | | |
| Airflow (Through Heat Pipe) (cfm): | 16,000 | - |
| Maximum input (kW): | 50.0 | - |
| Control Type: | SCR | - |
| Temperature rise (°F): | 10 | - |
| Cooling Performance: | | |
| Refrigerant: | R-410a | R-410a |
| CSA C746 EER | 9.7 | 11.20 |
| Total Capacity (Btu/hr): | 1,369,800 | 73,900 |
| Air EDBT / EWBT (°F): | 80.6 / 67.3 | 80.6 / 67.3 |
| Air LDBT / LWBT (°F): | 51.0 / 50.6 | 60.2 / 58.3 |
| No. of compressors: | 8 | 1 |
| Heat Pipe Performance: | | |
| Energy Recovery (Btu/hr): | 1,102 | - |
| Recovery Factor, including defrost (%): | 57.6 | - |
| *Supply Air:* | | - |
| Airflow (cfm): | 16,000 | - |
| Air EDBT / EWBT (°F): | -30.0 / -30.0 | - |
| Air LDBT / LWBT (°F): | 33.7 / 23.2 | - |
| *Exhaust Air:* | | - |
| Airflow (cfm): | 16,000 | - |
| Air EDBT / EWBT (°F): | 80.6 / 67.3 | - |

| Equipment Tag: | AHU-1 | AHU-2 |
|---|---|---|
| Air LDBT / LWBT (°F): | 42.5 / 42.5 | - |
| Electrical (Summer Condition): | | |
| Voltage: | 575/3/60 | 575/3/60 |
| Unit MCA (A): | 295.3 | 21.6 |
| Maximum Breaker (A): | 300.0 | 25.0 |
| Weight (lbs): | 40,000 | 2,332 |
| Overall Dimensions (mm): | 12192 L x 6985 W x 4242 H | 4166 L x 1702 W x 1067 H |

**END OF SECTION**

## Part 1 General

### 1.1 REFERENCES

.1 LEED Canada 2009 for Design and Construction, LEED Canada 2009 for Design and Construction Leadership in Energy and Environmental Design Green Building Rating System Reference Guide.

### 1.2 ACTION AND INFORMATIONAL SUBMITTALS

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

.2 Product Data:

.1 Submit manufacturer's instructions, printed product literature and data sheets for [forced air heaters] and include product characteristics, performance criteria, physical size, finish and limitations.

.2 Manufacturer's Instructions: provide to indicate special handling criteria, installation sequence and cleaning procedures.

.3 Sustainable Design Submittals:

.1 Submittals: in accordance with Section 01 47 15 - LEED Sustainable Requirements.

### 1.3 CLOSEOUT SUBMITTALS

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

.2 Operation and Maintenance Data: submit operation and maintenance data for forced air heaters for incorporation into manual.

### 1.4 DELIVERY, STORAGE AND HANDLING

.1 Deliver, store and handle materials in accordance with Section 01 60 00 - Common Product Requirements and with manufacturer's written instructions.

.2 Delivery and Acceptance Requirements: deliver materials to Site in original factory packaging, labelled with manufacturer's name and address.

.3 Storage and Handling Requirements:

.1 Store materials in accordance with manufacturer's recommendations in clean, dry, well-ventilated area.

.2 Store and protect forced air heaters from damage.

.3 Replace defective or damaged materials with new.

.4 Waste Management: In accordance with 01 74 21 Construction Waste Management.

## Part 2 Products

### 2.1 HYDRONIC CABINET UNIT HEATER, CUH-1:

.1 Performance: 42,681 Btu/hr, 4.34 gpm, 2.59 ft pressure drop, 120°F EWT, 20°ΔT, 485 nominal cfm, 1/20 HP motor, 1075 motor RPM, 120V/1ph, 1.2 motor amps.

.2 Casings shall be constructed of 16 gauge satin coat steel throughout with electrostatically applied powder coat prime finish. Casing shall incorporate an integral piping pocket, removable front panel and hinged access door to electrical junction box. Recessed units shall be furnished with a recessing frame.

.3 Coils shall be ½" copper tube with rippled aluminum fins and seat connections. Coils to be factory tested with air at 300 psig.

.4 Fans shall be double width, double inlet, forward curved centrifugal type, balanced for quiet vibration free operation.

.5 Motors shall be 3-speed permanent split capacitor, open type, resiliently mounted, incorporating sleeve bearings and internal automatic rest overload protection. Units must be CSA approved.

.6 Provide low voltage thermostat to be remote mounted by the controls contractor.

.7 Acceptable Product: "Engineered Air" model CUH-5.

## Part 3 Execution

### 3.1 INSTALLATION

.1 Install heaters in accordance with manufacturer's written recommendations.

.2 Make power and control connections.

### 3.2 FIELD QUALITY CONTROL

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

### 3.3 CLEANING

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

.1 Leave Work area clean at end of each day.

.2 Final Cleaning: upon completion remove surplus materials, rubbish, tools and equipment in accordance with Section 01 74 00 - Cleaning.

.3 Waste Management: In accordance with 01 74 21 Construction Waste Management.

### 3.4 PROTECTION

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

.2 Repair damage to adjacent materials caused by forced air heaters installation.

**END OF SECTION**