## Part 1 General

### 1.1 RELATED SECTIONS

.1 Sections 21, 22, 23 and 44

### 1.2 SUBMITTALS

.1 Submittals: in accordance with E4.

.2 Shop drawings; submit drawings stamped and signed by Professional Engineer registered or licensed in Province of Manitoba, Canada.

.3 Shop drawings to show:

- .1 Mounting arrangements.
- .2 Operating and maintenance clearances.

.4 Shop drawings and product data accompanied by:

- .1 Detailed drawings of bases, supports, and anchor bolts.
- .2 Acoustical sound power data, where applicable.
- .3 Points of operation on performance curves.
- .4 Manufacturer to certify current model production.
- .5 Certification of compliance to applicable codes.

.5 Closeout Submittals:

- .1 Provide operation and maintenance data for incorporation into manual specified in Section 01 78 00 - Closeout Submittals.
- .2 Operation and maintenance manual approved by, and final copies deposited with, Contract Administrator before final inspection.
- .3 Operation data to include:
  - .1 Control schematics for systems including environmental controls.
  - .2 Description of systems and their controls.
  - .3 Description of operation of systems at various loads together with reset schedules and seasonal variances.
  - .4 Operation instruction for systems and component.
  - .5 Description of actions to be taken in event of equipment failure.
  - .6 Valves schedule and flow diagram.
  - .7 Colour coding chart.
- .4 Maintenance data to include:
  - .1 Servicing, maintenance, operation and trouble-shooting instructions for each item of equipment.
  - .2 Data to include schedules of tasks, frequency, tools required and task time.
- .5 Performance data to include:

.1 Equipment manufacturer's performance datasheets with point of operation as left after commissioning is complete.

.2 Equipment performance verification test results.

.3 Special performance data as specified.

.4 Testing, adjusting and balancing reports as specified in Section 22 05 93 - Testing, Adjusting and Balancing for HVAC.

.6 Approvals:

.1 Submit 2 copies of draft Operation and Maintenance Manual to Contract Administrator for approval. Submission of individual data will not be accepted unless directed by Contract Administrator

.2 Make changes as required and re-submit as directed by Contract Administrator.

.7 Additional data:

.1 Prepare and insert into operation and maintenance manual additional data when need for it becomes apparent during specified demonstrations and instructions.

.8 Site records:

.1 Provide sets of white prints as required for each phase of work. Mark changes as work progresses and as changes occur. Include changes to existing mechanical systems, control systems and low voltage control wiring.

.2 Transfer information daily to reproducibles, revising reproducibles to show work as actually installed.

.3 Use different colour waterproof ink for each service.

.4 Make available for reference purposes and inspection.

.9 As-built drawings:

.1 Prior to start of Testing, Adjusting and Balancing for HVAC, finalize production of as-built drawings.

.2 Identify each drawing in lower right hand corner in letters at least 12 mm high as follows: - "AS CONSTRUCTED” DRAWINGS: THIS DRAWING HAS BEEN REVISED TO SHOW MECHANICAL SYSTEMS AS INSTALLED" (Signature of Contractor) (Date).

.3 Submit to Contract Administrator for approval and make corrections as directed.

.4 Perform testing, adjusting and balancing for HVAC using as-built drawings.

.5 Submit completed reproducible as-built drawings with Operating and Maintenance Manuals.

.10 Submit copies of as-built drawings for inclusion in final TAB report.

## 1.3 QUALITY ASSURANCE

.1 Quality Assurance: in accordance with Section 01 45 00 - Quality Control.

**1.4 MAINTENANCE**

.1 Furnish spare parts in accordance with Section 01 78 00 - Closeout Submittals as requested.:

.2 Provide one set of special tools required to service equipment as recommended by manufacturers and in accordance with Section 01 78 00 - Closeout Submittals.

**1.5 DELIVERY, STORAGE, AND HANDLING**

.1 Waste Management and Disposal:

.1 Construction/Demolition Waste Management and Disposal: separate waste materials for reuse and recycling.

**Part 2 Products**

**2.1 MATERIALS**

.1 Not Used.

**Part 3 Execution**

**3.1 PAINTING REPAIRS AND RESTORATION**

.1 Do painting in accordance with Section 09 91 00 - Interior Painting.

.2 Prime and touch up marred finished paintwork to match original.

.3 Restore to new condition, finishes which have been damaged.

**3.2 CLEANING**

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

**3.3 FIELD QUALITY CONTROL**

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

.2 Manufacturer's Field Services:

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

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

.3 Schedule site visits, to review Work.

## 3.4 DEMONSTRATION

.1 Supply tools, equipment and personnel to demonstrate and instruct operating and maintenance personnel in operating, controlling, adjusting, trouble-shooting and servicing of all systems and equipment during regular work hours, prior to acceptance.

.2 Use operation and maintenance manual, as-built drawings, and audio visual aids as part of instruction materials.

.3 Instruction duration time requirements as specified in appropriate sections.

.4 Contract Administrater will record these demonstrations on video tape for future reference.

## 3.5 PROTECTION

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

**END OF SECTION**

## Part 1 General

### 1.1 SUMMARY

.1 Balance, adjust, and test air and liquid systems and equipment and submit reports using identical units to those shown on contract documents.

### 1.2 QUALIFICATIONS OF TAB PERSONNEL

.1 Work specified in this section shall be performed by an Independent Agency by provide documentation confirming qualifications and successful experience in air and hydronic system balancing.

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

- .1 Associated Air Balance Council, (AABC) National Standards for Total System Balance, MN-1 – 2002.
- .2 National Environmental Balancing Bureau (NEBB) TAB STANDARDS, Procedural Standards for Testing, Adjusting, Balancing of Environmental Systems – 1998.
- .3 Sheet Metal and Air Conditioning Contractors' National Association (SMACNA), SMACNA 1780, HVAC Systems – Testing, Adjusting and Balancing – 2002.

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

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

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

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

.7 TAB Standard quality assurance provisions such as performance 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 DEFINITION

.1 TAB is used throughout this Section to describe the process, methods and requirements of testing, adjusting and balancing for HVAC system.

.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.

### 1.4 APPROVED AGENCIES

.1 AABC

**1.5 SITE VISITS**

.1 Total of 3 site visits shall be made to correspond with the general monthly site meetings held by the Contractor. After each site visit, a written report shall be submitted to the Contractor and Contract Administrator. Site visits shall commence after the start of air and liquid distribution work and be spread over the construction period to the start of the balancing work.

.2 A review of the installation and access to all valves, dampers, and equipment shall be made at the specified site visits and any additional dampers or valves required for proper balancing shall be forwarded in writing to be reviewed by the Contract Administrator.

.3 Begin balancing after equipment start-up and testing and after systems have been completed and are in full working order. Place systems and equipment into full operation and continue operation during each working day of balancing.

**1.6 BALANCING AGENDA**

.1 General: Submit balancing agenda to the Contract Administrator and commissioning contractor for review at least thirty (30) days prior to the start of balancing work. Start balancing work only after agenda has been approved. Include descriptive data, procedure data, and sample forms in agenda.

.2 Descriptive Data: General description of each system including associated equipment and different operation cycles, listing of flow and terminal measurements to be performed.

.3 Procedure Data: Procedures for converting test measurements to establish compliance with requirements, specify type of instrument to be used, method of instrument application (by sketch) and correction factors.

.4 Sample Forms: Form showing application of procedures to typical systems.

**1.7 BALANCE REPORT**

.1 Submit two (2) copies of rough balancing reports to the Contract Administrator for review, prior to on-site verification and acceptance of Project.

.2 Provide four (4) copies of final reports to contractor for inserting in Operating and Maintenance Manuals.

.3 Include types, serial number, and dates of calibration of instruments in the reports.

**1.8 SYSTEM DATA**

.1 Air Handling Equipment

.1 Designed Data:

.1 Fan total static pressure;
.2 System static pressure;
.3 Motor kW (HP), r/min, amps, Volts, Phase;
.4 Outside air flow rate L/s (cfm);
.5 Fan wheel r/min;
.6 Fan/kW (HP);
.7 Inlet and outlet, dry and wet bulb temperatures.

.2 Installation Data:

.1 Manufacturer and model;
.2 Size;

.3 Arrangement discharge and class;
.4 Motor type, kW (HP), r/min, voltage, phase, cycles, and load amperage;
.5 Location and local identification data.

.3 Recorded Data:
.1 Supply Air Fan
.1 Fan @ 100% Outside Air
.2 Air flow rate;
.3 Fan total static pressure;
.4 System static pressure;
.5 Fan @ Full Return/Min O/A
.6 Air flow rate;
.7 Fan total static pressure;
.8 System static pressure;
.2 Fan wheel rpm with drive motor @ 60Hz;
.3 For Axial Fans, note blade pitch angle
.4 Motor operating amperage;
.5 Inlet and outlet, dry and wet bulb temperatures.

.2 Duct Air Quantities - All mains supplying more than 10% of Volume, outside air and exhaust (maximum and minimum) major return air openings back to duct shafts.
.1 Duct sizes;
.2 Number of pressure readings;
.3 Sum of velocity measurements;
.4 Average velocity;
.5 Duct recorded air flow rate;
.6 Duct design air flow rate.

.3 Air Inlet and Outlets:
.1 Outlet identification location and designation;
.2 Manufacturers catalogue identification and type;
.3 Design and recorded velocities;
.4 Design and recorded air flow rates;
.5 Deflector vane or diffuser cone settings.

.4 Pumps
.1 Design Data
.1 Fluid flow rate;
.2 Total Head;
.3 r/min;
.4 kW (HP), r/min, amps, volts, phase.
.5 Manufacturer and model;
.6 Size;
.7 Type drive;
.8 Motor type, kW (HP), r/m, voltage, phase, and full load amperage.
.2 Recorded Data:
.1 Discharge and suction pressures with secondary systems on both bypass and full circulation (full flow and no flow);
.2 Operating head;
.3 Operating water flow rate (from pump curves if metering not provided);
.4 Motor operating amps (full flow and no flow);
.5 r/min.

.5 Expansion Tank

.1 Design Data:
- .1 Size;
- .2 Capacity;
- .3 Pressure rating;
- .4 Installation Data:
- .5 Manufacturer, size, capacity;
- .6 Pressure reducing valve setting;
- .7 Pressure relief valve setting.

.6 Heating Equipment (Boilers, Unit heaters, Heating coil, etc.)

.1 Design Data:
- .1 Heat transfer rate;
- .2 Fluid flow rate;
- .3 Entering and leaving fluid temperatures;
- .4 Fluid pressure drop.

.2 Installation Data:
- .1 Manufacturer, Model, Type;
- .2 Entering and leaving fluid temperatures;
- .3 Capacity;
- .4 Pressure drops;
- .5 Flow rates.

.3 Recorded Data:
- .1 Element type and identification (location and designation);
- .2 Entering and leaving fluid temperature (for varying outdoor temperatures);
- .3 Fluid pressure drop;
- .4 Fluid flow rate;
- .5 Pressure relief valve setting.

## Part 2 Products

### 2.1 INSTRUMENTS

.1 Provide calibration histories for each instrument. Recalibration or use of other instruments may be requested when accuracy of readings is questionable.

## Part 3 Execution

### 3.1 GENERAL PROCEDURE

.1 Permanently mark, by stick-on labels and/or fluorescent paint, settings on valves, splitters, dampers, and other adjustment devices.

.2 Subsequent to correctional work, take measurements to verify balance has not been disrupted or that any such disruption has been rectified.

.3 Where vane anemometer is used to measure supply, return or exhaust air grilles, AK factors shall be determined as follows:
- .1 Determine and tabulate similar sized grilles being balanced for AK schedule.
- .2 Traverse all ducts serving grilles (outlined in AK schedule) to verify AK factors.
- .3 AK factor from schedule, must be approved by C. A during initial review with balancer on site. (Balancer shall include written procedure for determination of AK factors).
- .4 No flow hoods are to be used for measurement of exhaust or return air grilles.

.4 Balancing shall be performed to the following accuracies:

| | | |
|---|---|---|
| .1 | Air - terminal outlets | ±10% (outlets less than 200 L/s (425 cfm) |
| .2 | Air - terminal outlets | ±5% (outlets greater than 200 L/s (425 cfm) |
| .3 | Air - central equipment | ±5% |

.5 Balancing contractor shall advise mechanical contractor of required revised pulleys, sheaves and impeller shavings to allow proper balancing of systems.

.6 Where axial fans require blade pitch changes, this shall be the responsibility of the balancing contractor.

.7 Where pump impellers require shaving, this shall be the responsibility of the mechanical contractor. All adjustments shall be by qualified millwright. All changes shall be documented and included as part of the balancing report.

## 3.2 AIR SYSTEM PROCEDURE

.1 Perform balancing, adjusting, and testing with building doors and windows in their normal operation position.

.2 The following procedure shall be adopted for central systems:
- .1 Ensure dampers or volume control devices are in fully open position.
- .2 Balance central apparatus to ±5% air flow.
- .3 Balance branches and mains in accordance with 3.1.4.
- .4 Recheck central apparatus.
- .5 Balance all terminal air outlets in accordance with 3.1.4.
- .6 Re-balance central apparatus to ±5%.
- .7 Recheck all air outlets.

.3 When balancing air outlets:
- .1 Rough balance furthest outlets and then balance sequentially back to source.
- .2 Fine balance furthest outlet back to source.

.4 Make air quantity measurements in ducts by "Pitot Tube" traverse of entire cross sectional area. Take minimum of 16 for rectangular ducts, and 10 on each vertical and horizontal axis for round ducts, traverse readings. If readings are inconsistent across duct, try to obtain straight run of six (6) diameters widths upstream and re-do traverse.

.5 Use volume control devices to regulate air quantities only to extent that adjustments do not create objectionable air motion or sound levels. Effect volume control only by duct internal devices such as dampers and splitters.

.6 Vary total system air quantities by adjustment of fan speeds. Vary branch air quantities by damper regulation.

.7 Where modulating dampers are provided, take measurements and balance at extreme conditions. (Balance variable volume systems at maximum air flow rate - full cooling, and at minimum air flow rate - full heating).

.8 Verify all terminal unit factory settings for maximum air flow (and minimum if applicable). Adjust terminal unit controller if required. Record adjusted units.

.9 The final balanced condition of each area shall include testing and adjusting of pressure conditions. Test and record building pressurization levels in variable volume systems throughout full range of fan delivery rates, under both heating and cooling conditions. For multi-storey building test pressure conditions at ground, intermediate and upper levels. Front doors, exits, elevator shafts, should be checked for air flow so that exterior conditions do not cause excessive or abnormal pressure conditions. Document abnormal building leakage conditions noted.

.10 Complete balancing to achieve positive building pressure unless otherwise instructed. A positive pressure relative to outside of 10 Pa (0.04”WG) minimum and 20 Pa (0.08”WG) maximum shall be achieved, measured with negligible outside wind velocity.

## 3.3 BALANCING REPORT

.1 Submit draft copies of rough balancing reports prior to final acceptance of project.

.2 Include types, serial number and dates of calibration of instruments.

.3 Record test data on a sepia made from the latest available revised set of mechanical drawings and submit three (3) copies upon completion of the balancing contract for inclusion in equipment and maintenance manuals.

.4 Submit with report, fan and pump curves with operating conditions plotted. Submit grille and diffuser shop drawings and diffusion factors.

.5 Report shall be indexed as follows:

.1 Air
- .1 Summary
- .2 Procedure
- .3 Instrumentation
- .4 Drawings
- .5 Equipment Summary
- .6 Fan Sheets
- .7 Fan Curves
- .8 Fan Profile Data
- .9 Static Data
- .10 Traverse Data and Schedule
- .11 Terminal Unit Summary
- .12 Outlet Data Summary and Schematics (per system)
- .13 Building Schematic
- .14 Building Pressurization Data
- .15 Weather Conditions at Time of Test
- .16 Diagnostic
- .17 Millwright Reports

.2 Liquid
- .1 Summary
- .2 Procedure
- .3 Instrumentation
- .4 Drawings
- .5 Pump Data
- .6 Pump Curves
- .7 Coils

.8 Equipment Data
.9 Element Data Summary and Schematics (per system)
.10 Diagnostic

**END OF SECTION**

## Part 1 General

### 1.1 SUMMARY

.1 Duct thermal insulation.

.2 Duct acoustic insulation.

.3 Adhesives, tie wires, tapes.

.4 Recovery.

### 1.2 RELATED SECTIONS

.1 Entire Specification – All areas of common work.

### 1.3 REFERENCES

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

- .1 ASTM C335-05ae1, Standard Test Method for Steady-State Heat Transfer Properties of Horizontal Pipe Insulation.
- .2 ASTM C411-05, Standard Test Method for Hot-Surface Performance of High-Temperature Thermal Insulation.
- .3 ASTM C449-07, Standard Specification for Mineral Fiber Hydraulic-Setting Thermal Insulating and Finishing Cement.
- .4 ASTM C533-07, Standard Specification for Calcium Silicate Block and Pipe Thermal Insulation.
- .5 ASTM C547-07e1, Standard Specification for Mineral Fiber Pipe Insulation.
- .6 ASTM C553-08, Standard Specification for Mineral Fiber Blanket Thermal Insulation for Commercial and Industrial Applications.
- .7 ASTM C612-04e1, Standard Specification for Mineral Fiber Block and Board Thermal Insulation.
- .8 ASTM C795-08, Standard Specification for Thermal Insulation for Use in Contact with Austenitic Stainless Steel.
- .9 ASTM C921-03a, Standard Practice for Determining the Properties of Jacketing Materials for Thermal Insulation.

.2 Canadian General Standards Board (CGSB)

- .1 CGSB 51-GP-52MA-89, Vapor Barrier, Jacket and Facing Material for Pipe, Duct and Equipment Thermal Insulation.
- .2 CAN/CGSB 51.53-95, Poly (Vinyl Chloride) Jacketing Sheet, for Insulated Pipes, Vessels and Round Ducts.

.3 Thermal Insulation Association of Canada (TIAC)

- .1 National Insulation Standards 1992 (R1999).

### 1.4 QUALITY ASSURANCE

.1 The Contractor should submit, within three (3) Business days of a request by the Contract Administrator, proof satisfactory to the Contract Administrator of the qualifications of the proposed Sub-Contractor completing the Work in this Section.

.2 Materials shall meet or exceed fire and smoke hazard ratings as stated in this section and defined in applicable building codes.

**1.5 SHOP DRAWINGS**

.1 Submit shop drawings in accordance with E4.

.2 Submit shop drawings which indicate complete material data, "K" value, temperature rating, density, finish, recovery jacket of materials proposed for this project and indicate thickness of material for individual services.

.3 Submit samples of proposed insulating and recovering materials.

**1.6 JOB CONDITIONS**

.1 Deliver material to job site in original non-broken factory packaging, labeled with manufacturer's density and thickness.

.2 Perform work at ambient and equipment temperatures as recommended by the adhesive manufacturer. Make good separation of joints or cracking of insulation due to thermal movement or poor workmanship.

**1.7 ALTERNATIVES**

.1 Alternative insulations are subject to approval. Alternatives shall provide the same thermal resistance within 5% at normal conditions as material specified.

**Part 2 Products**

**2.1 ACCEPTABLE MANUFACTURERS**

.1 Owen's Corning/Fiberglas Canada Inc., Manson, Knauf Fiberglass.

**2.2 GENERAL**

.1 Insulation Materials, Recovery Jackets, Vapor Barrier Facings, Tapes and Adhesives shall be In accordance with CAN/ULC-S102:
- .1 Maximum flame spread rating: 25.
- .2 Maximum smoke developed rating: 50.

.2 Insulating materials and accessories shall withstand service temperatures without smoldering, glowing, smoking or flaming.

.3 All insulation materials shall meet Building Code Standards, and packages or containers of such materials shall be appropriately labeled.

**2.3 MATERIALS**

.1 Exposed Rectangular Ducts: Rigid fibrous glass or mineral fiberboard insulation, "K" value maximum 0.035 W/m. °C at 24°C (0.24 btu in/hr/ft2 at 75°F). Factory applied reinforced aluminum foil vapor barrier for cold ducts. Hot duct service temperature 20°C (68°F) to 65°C (149°F). Cold ducts service temperature -40°C (-40°F) to 65°C (149°F).

.2 Round Ducts and Concealed Rectangular Ducts: Flexible fibrous glass or mineral fiber insulation, "K" value maximum 0.035 W/m. °C at 24°C (0.24 btu in/hr/ft2 at 75°F). Factory applied reinforced aluminum foil vapor barrier for cold ducts. Hot duct service temperature 20°C to 65°C (68°F to 149°F). Cold duct service temperature -40°C (-40°F) to 65°C (149°F).

.3 Acoustic Lining: Fibrous glass or mineral fiberboard insulation with "K" value maximum 0.035 W/m. °C, at 24°C (0.24 btu in/hr/ft2 at 75°F). Absolute roughness of exposed surface not to exceed 0.58 mm (26 gauge), coated to prevent fiber erosion at air velocities up to 25.4 m/s, 24 kg/m2 (5000 ft/m, 5 lb/ft2 ) minimum density for ductwork and plenums. Substrate must not be dark in color. Service temperature -40°C (-40°F) to 65°C (149°F).

.4 Recovery Jackets: Polyvinyl Chloride (PVC)
- .1 One-piece moulded type and sheet to CAN/CGSB 51.53 with pre-formed shapes as required.
- .2 Colours: white (not painted)
- .3 Minimum service temperatures: -20 degrees C.
- .4 Maximum service temperature: 65 degrees C.
- .5 Moisture vapour transmission: 0.02 perm.
- .6 Thickness: 0.020 mm.

## Part 3 Execution

### 3.1 PREPARATION

.1 Do not install covering before ductwork and equipment has been tested and approved.

.2 Ensure surface is clean and dry prior to installation. Ensure insulation is dry before and during application. Finish with systems at operating conditions, where possible.

### 3.2 INSTALLATION

.1 Ensure insulation is continuous through floor and wall sleeves etc. Pack around ducts with fireproof self-supporting insulation materials, properly sealed.

.2 Finish insulation neatly at hangers, supports and other protrusions.

.3 Locate insulation or cover seams in least visible locations. Locate seams on ductwork in ceiling spaces on the underside of the duct.

.4 Provide recovering jackets on exposed insulation throughout, including equipment rooms. Insulation located in crawl spaces, shafts and suspended ceiling spaces is not considered exposed. Make smooth any uneven insulated surface before recovering.

.5 Cover insulation exposed to outdoors with aluminum jacket secured with aluminum bands on 200 mm (8”) centre. Longitudinal slip joints, lap circumferential joints 75 mm (3”) minimum and seal all joints with compatible waterproof lap cement.

.6 Exposed Rectangular Ducts: Secure rigid insulation with galvanized anchors, or weld pins on 400 mm (16”) centre. Secure in place with retaining clips. Seal all insulation joints and breaks with joint tape. Use vapor barrier tape for insulation joints or breaks on cold ducts.

.7 Round Ducts and Concealed Rectangular Ducts: Adhere flexible insulation to ductwork with adhesive applied in 150 mm (6”) wide strips on 400 mm (16” )centers. Provide annealed tie wire tied at 400 mm (16”) centers for securing duct insulation. Butt insulation and seal joints and breaks with lap seal adhesive; cover joints with joint tape. Use vapor barrier tape for cold ducts.

.8 Acoustic Lining: Apply to interior of ducts where shown. Secure to ductwork with adhesive using 50% coverage and anchors or weld pins on 400 mm (16") centers. Secure in place with retaining clips. Cut off excess fastener length and cover with brush coat of mastic over protrusions and all raw edges. Use 25 mm (1") thick insulation unless otherwise noted. Provide vapor barrier located on the warm side for outside air intakes. Bevel corners at joints and butt together. Install acoustic gauze over all cut corners and joints and brush coat with lap seal adhesive.

.9 Where duct velocities exceed 10 m/s (2000 ft/m), cover insulation with 0.8 mm perforated galvanized steel with 24% free area.

.10 Fasten aluminum recovery jacket in place with aluminum banding on 200 mm (8") centre or screws or rivets on 150 mm (6") centre. Longitudinal slip joints and 50 mm (2") lap joints.

## 3.3 INSULATION INSTALLATION THICKNESS SCHEDULE

| | Ducts & Equipment | Insulation Thickness mm (in) | Recovery Jacket |
|---|---|---|---|
| .1 | Relief Duct | 50 (2") | PVC |
| .2 | Exhaust Ducts within 3 m (10'-0") of Exterior Walls or Openings. | 25 (1") | PVC |
| .3 | Outside Air Intake Ducts | 50 (2") | PVC |
| .4 | Ductwork exposed to outdoors | 50 (2") | Aluminum |
| .5 | Supply Ducts (Heating System) | 25 (1") | PVC |
| .6 | Supply Ducts Ventilation Systems | 25 (1") | PVC |
| .7 | Ventilation Equipment Casings | 25 (1") | PVC |
| .8 | Acoustic Lining (where indicated) | 25 (1") | - |

**END OF SECTION**

## Part 1 General

### 1.1 SUMMARY

.1 Commissioning of mechanical equipment and systems operations.

.2 Demonstration of mechanical equipment and systems to City personnel.

### 1.2 GENERAL

.1 This section describes the commissioning of the mechanical system and outlines the duties.

.2 It is the full responsibilities of the Contractor to perform the commissioning and satisfied the City.

.3 The commissioning of the mechanical system shall be in accordance with the Code of Practice for Commissioning Mechanical Systems in Buildings and as described in this section.

.4 The commissioning process shall be applied to all products, equipment and systems provided under this Section.

.5 This section is to be used as a guide by the Contractor to allow and include for the necessary co-ordination.

.6 Contract Administrator may review the commissioning procedure and witness the commissioning performance upon request.

## Part 2 The Commissioning Process

### 2.1 PROCEDURE OF THE COMMISSIONING

.1 Prepare a detailed plan identifying the orderly progression of the prestart commissioning check and subsequent commissioning performance check of each system, leading up to the ultimate commissioning of entire systems.

.2 Prepare a schedule for the commissioning phase of the work. This schedule shall show:

- .1 Completion dates for each major section of the building.
- .2 Timing of the various phases of the commissioning, testing, balancing and demonstration process.
- .3 Prepare a commissioning statement in which each of the four (4) phases that the process is perceived to be worked through. In sequence, the phases are expected to be:
  - .1 Phase 1 - System Readiness.
  - .2 Phase 2 - System Start-up, Testing, Balancing, Etc.
  - .3 Phase 3 - Verification of System Commissioning.
  - .4 Phase 4 - Demonstration and Instruction.
- .4 With the commissioning schedule noted above, prepare a copy of all commissioning worksheets to be used during the commissioning process.
- .5 Each phase is applicable to each major and separate system making up the work in Section 21, 22, 23 including controls and Section 26 interface as applicable.

## 2.2 COMMISSIONING PHASES

.1 Phase 1 - Before starting any of the separate systems, provide written verification stating that the specific system is ready for start-up and the following conditions have been met:
- .1 All safety controls installed and fully operational (dry run test).
- .2 Flushing, chemical cleaning (as required), charging, fluid operating (as required), are complete.
- .3 Equipment lubrication and pre-start checks are complete.
- .4 Air system cleaning complete.
- .5 Filter systems installed and sealed in place.
- .6 Adjusting vibration isolation completed.
- .7 Alignment of drives (direct and belt) completed.
- .8 Control functional checks, including all alarms performed.
- .9 Start-up verification checks by manufacturers representatives completed.
- .10 All deficiencies and OHS related issues to be recorded, subsequently corrected before proceeding to the next phase, Phase 2.

.2 Phase 2 - System Commissioning shall include but not necessarily be limited to:
- .1 Activation of all systems.
- .2 Testing and adjustment of all systems.
- .3 Phase 2 is concluded when the installation is in full working order and acceptable for use. The work will include the following:
  - .1 Position all balance dampers in ductwork.
  - .2 Position all balance valves in piping systems.
  - .3 Make provisions for testing air pressures and flow rates.
  - .4 Set up air diffusers, registers and grilles.
  - .5 Set up all automatic temperature control devices.
  - .6 Set up constant volume and variable volume fans.
  - .7 Plug all air pressure and flow measuring holes.
  - .8 Adjust vibration isolators as necessary.
  - .9 Air and water balance complete.
- .4 Fine Tuning:
  - .1 Setting up automatic controls for accurate response and precise sequencing.
  - .2 Correction of problems revealed by Balancing Agency and change of fan speed and pitch as necessary.

.3 Phase 3 - Verification of Commissioning.
- .1 Verification of commissioning shall not commence until the commissioning process, Phase 2, has been totally completed. The verification process will include the demonstration of the following:
  - .1 Location of and opening and closing of all access panels.
  - .2 Operation of all automatic control dampers and automatic temperature/volume adjustment controls.
  - .3 Proper response of all variable air volume valves to thermostats and volume adjustment controls.
  - .4 Operation of all equipment and systems, under each mode of operation, including:
    - .1 DCS control features.
    - .2 Automatic controls.
    - .3 Exhaust fans.
    - .4 Pumps.
    - .5 Unit heaters.

.6 Air handling systems.
.7 Coils.
.8 Tanks-expansion.

.4 Phase 4 - Demonstration and Acceptance shall not commence until the commissioning process Phase 3 has been successfully completed - verification certificate issued and Substantial Performance declared. The demonstration process is a statement of satisfaction from the City upon completion. Construction Completion will not be accomplished without this achievement.

## Part 3 Execution

### 3.1 GENERAL

.1 The Contractor shall arrange presentation and demonstration of mechanical equipment and systems appropriate specialists and shall ensure that required manufacturer's representatives are in attendance.

### 3.2 THE FOLLOWING SYSTEMS ARE TO BE COMMISSIONED:

.1 Plumbing
- .1 Domestic hot and cold water systems - system pressure tests, flush and clean lines, system pressures at fixtures, water delivery at each fixture; identification of piping systems.
- .2 Domestic hot water heater - capacity flow tests, combustion controls verification.
- .3 Sanitary drainage - system pressure tests, pipe identification.
- .4 Fixtures - cleaning, test hot and cold water and drain, installation.

.2 Fire protection systems
- .1 Confirm fire extinguisher location and charge. Verify that all tags are filled out and signed.

.3 HVAC Systems
- .1 Hydronic Systems - piping, pressure test, temperature sensors, water conditioning.
- .2 Boilers - check out by manufacturer's representative, gas and water piping connections, burner and controls, flue connections, boil out, chemical treatment, capacity tests, expansion tank pressures and capacity.
- .3 Pumps - alignment, rotation, motor current draw, piping connections, flow and pressure test.
- .4 Piping System - pressure tests, insulation, identification, water balance, hangers, and expansion.
- .5 Duct System - pressure tests, insulation, identification, air balance identification.
- .6 Exhaust Fans - installation, rotation, motor current draw, accessories dampers, etc., air balance, identification.
- .7 Air Handling Units - installation vibration isolation, water and duct connections, motor rotation, and air balance, filters, capacity identification, controls.
- .8 Control Valves - installation, controls, capacity modulation, connection to BMS, identification.
- .9 Control Dampers - installation, operation, identification, capacity modulation, connection to DCS.

.10 Controls-commissioning of controls by Controls Contractor under the supervision of the commissioning co-coordinator.

## 3.3 DEMONSTRATIONS

.1 Provide one (1) working day for demonstration of equipment to the City.

.2 Demonstrate specific starting and general maintenance requirements for each major piece of equipment. Ensure all labeling and identification is completed.

.3 Demonstrate the following systems and contractor-guided tour of the facility.
- .1 Hydronic Heating Systems;
- .2 Air Systems;
- .3 Fire Protection Systems;
- .4 Plumbing Systems;
- .5 Control Systems;

.4 Demonstrate the following pieces of equipment:
- .1 Boilers;
- .2 Fans/Air Handling Unit;
- .3 Unit Heaters;
- .4 Domestic Water Heater;
- .5 Pumps;

.5 Answer all questions raised by City at demonstrations; if unable to satisfactorily answer questions immediately, provide written response within three (3) days.

END OF SECTION

## Part 1 General

### 1.1 SUMMARY

.1 Section includes:
- .1 Temperature Sensors
- .2 Temperature Transmitters
- .3 Pressure Transmitters
- .4 Differential Pressure Transmitters
- .5 Static Pressure Sensors
- .6 Static Pressure Transmitters
- .7 Pressure and Differential Pressure Transmitters
- .8 Control Panels
- .9 Wire
- .10 Conduit and Cables
- .11 Related Accessories
- .12 Control Dampers
- .13 Electric Control Damper Operators
- .14 Control Valves
- .15 Electronic actuators

.2 Related Sections:
- .1 Section 23 09 23 - Direct-Digital Control System
- .2 Section 23 09 93 - Sequence of Operations for HVAC Controls

### 1.2 GENERAL

.1 Complete and fully operational system of automatic controls, including all materials and labor.

.2 Submissions of technical system data.

.3 Demonstration of proposed installed controls system.

### 1.3 QUALITY ASSURANCE

.1 Install all components in accordance with the latest regulations of the Canadian Electrical Code, applicable Municipal and Provincial Codes and Regulations, and latest CSA Electrical Bulletins.

.2 The equipment manufacturer shall have trained service representatives resident in the Province where project is located.

### 1.4 SHOP DRAWINGS

.1 Submit shop drawings in accordance with E4.

.2 Provide operating and maintenance manuals with complete description of installation and operation specified in Section 01 78 00 – Closeout Submittals.

## Part 2 Products

### 2.1 GENERAL

.1 Provide control system components consisting of thermostats, control valves, dampers, actuators, indicating devices, and interface equipment required to operate mechanical equipment and perform functions specified.

.2 Provide all materials and labor required to connect control components.

.3 Provide electric/pneumatic and pneumatic/electric devices as part of this contract.

.4 No splicing or extending of wiring will be accepted.

.5 Maintain integrity of all fire protection and smoke evacuation systems.

### 2.2 TEMPERATURE SENSORS

.1 General: Including room sensors to be resistance or thermocouple type to the following requirements:

- .1 Thermocouples: limit to temperature range of 200 degrees C.
- .2 100 or 1000 ohm at 0 degrees C (plus or minus 0.2 ohms) platinum element with strain minimizing construction, 3 integral anchored leadwires. Coefficient of resistivity: 0.00385 ohms/ohm degrees C.
- .3 Sensing element: hermetically sealed.
- .4 Stem and tip construction: copper or type 304 stainless steel.
- .5 Time constant response: less than 3 seconds to a temperature change of 10 degrees C.
- .6 Range of device to be selected so as to provide reasonable representation of process being controlled.

.2 Immersion wells: NPS 3/4, stainless steel spring loaded construction, with heat transfer compound compatible with sensor. Insertion length 100 mm as indicated.

.3 The sensor shall be constructed in a manner that will prevent the sensor from becoming dysfunctional or failed when used in direct contact with moisture droplets that may occur in the air stream in which it is applied.

- .1 Room temperature sensors and display wall modules.
- .2 Temperature sensing and display wall module.
- .3 LCD display to show space temperature and temperature set-point in areas designated in the Control Point I/O Summary: Site Requirements, Applications and Systems Sequences Of Operation.
- .4 Buttons for occupant selection of temperature set-point and occupied/unoccupied modes.
- .5 Jack connection for plugging in laptop personal computer contractor supplied zone terminal unit for access to zone bus.
- .6 Integral thermistor sensing element 10,000 ohm at 24 degrees C.
- .7 Accuracy 0.2 degrees C over range of 0 to 70 degrees C.
- .8 Stability 0.02 degrees C drift per year.
- .9 Separate mounting base for ease of installation.
- .10 Room temperature sensors.
- .11 Wall mounting, in slotted type covers.
- .12 Element 10-50 mm long RTD with ceramic tube or equivalent protection or thermistor, 10,000 ohm, accuracy of plus or minus 0.2 degrees C.

.4 Duct temperature sensors:
- .1 General purpose duct type: suitable for insertion into ducts at various orientations, insertion sensor length shall be selected to traverse the width or height of the duct without extending the sensor past the dimensions of the duct or distorted from a forced fit.
- .2 Averaging duct type: shall provide one indication representative of the average temperature measured across the entire length of the sensing element.
- .3 Both rigid and serpentine style sensors shall be installed in accordance to manufacturer recommendations

.5 Outdoor air temperature sensors:
- .1 Outside air type: complete with probe, non-corroding sun shield to minimize solar and wind effects, threaded fitting for mating to 13 mm conduit, weatherproof construction in NEMA 4 enclosure.

.6 Immersion temperature sensors:
- .1 General Purpose immersion type: suitable for insertion into an immersion well and supplied with thermal conductivity improving and sealing compound to be applied to the sensor before setting in place in immersion well. To be provided with a protection pocket and a matched stainless steel immersion sensing well.

## 2.3 TEMPERATURE TRANSMITTERS

.1 The sensor may be either real time data or thermistor type providing the following minimum performance requirements are met:
- .1 Accuracy: ± 0.5°C (± 1.0°F).
- .2 Operating Range: 2°C to 46°C (35°F to 115°F).
- .3 Setpoint Adjustment Range: 2°C to 30°C (3°F to 54°F).
- .4 Setpoint Modes: Heating, Cooling, Night Setback.
- .5 Calibration Adjustments: None required.

.2 Each room temperature sensor shall include a terminal jack integral to the sensor assembly. The terminal jack shall be used to connect a portable operator's terminal to control and monitor all hardware and software points in the system.

.3 Each room sensor shall also include the following auxiliary devices:
- .1 Setpoint adjustment dials.
- .2 Temperature indicator.
- .3 Override Switch.

.4 The setpoint adjustment dial shall allow for modification of the temperature by the City.

.5 The temperature indicator shall be a bi-metal or mercury thermometer and shall be visible without removing the sensor cover.

.6 An override switch shall initiate override of the night setback mode to normal (day) operation when activated by the City.

.7 The setpoint adjustment and night setback override switch may be locked out, overridden or limited through software, at the DCS central terminal, or portable operator’s terminal.

.8 Provide tamper proof thermostat guards for all areas. Temperature indication would be visible through the guard, but a key would be required to access temperature adjustment.

## 2.4 PRESSURE TRANSMITTERS

.1 Pressure Transmitters shall be designed for industrial environment conditions. The technical data as following:
- .1 0-100 PSIG pressure ranges.
- .2 9-30 VDC input.
- .3 4-20 mA output.
- .4 Temperature -40°C - 260°C.
- .5 Vibration: 20g

.2 Acceptable Manufacturers: Setra DPT 209.

## 2.5 DIFFERENTIAL PRESSURE TRANSMITTERS

.1 Internal materials: suitable for continuous contact with industrial standard instrument air, compressed air, water, steam, as applicable.

.2 Output signal: 4-20 mA into 500 ohm maximum load.

.3 Output variations: less than 0.2% full scale for supply voltage variations of plus or minus 10%.

.4 Combined non-linearity, repeatability, and hysteresis effects: not to exceed plus or minus 0.5% of full scale output over entire range.

.5 Integral zero and span adjustment.

.6 Temperature effects: not to exceed plus or minus 1.5% full scale/50 degrees C.

.7 Over-pressure input protection to at least twice rated input pressure.

.8 Output short circuit and open circuit protection.

.9 Unit to have 12.5 mm N.P.T. conduit connection. Enclosure to be integral part of unit.

## 2.6 STATIC PRESSURE SENSORS

.1 Multipoint element with self-averaging manifold.

.2 Maximum pressure loss: 160 Pa at 10 m/s. (Air stream manifold).

.3 Accuracy: plus or minus 1% of actual duct static pressure.

## 2.7 STATIC PRESSURE TRANSMITTERS

.1 Output signal: 4-20 mA linear into 500 ohm maximum load.

.2 Calibrated span: not to exceed 150% of duct static pressure at maximum flow.

.3 Accuracy: 0.4% of span.

.4 Repeatability: within 0.5% of output.

.5 Linearity: within 1.5% of span.

.6 Deadband or hysteresis: 0.1% of span.

.7 External exposed zero and span adjustment.

.8 Unit to have 12.5 mm N.P.T. conduit connection. Enclosure to be integral part of unit

## 2.8 PRESSURE AND DIFFERENTIAL PRESSURE SWITCHES

.1 Internal materials: suitable for continuous contact with compressed air, water, steam, etc., as applicable.

.2 Adjustable set-point and differential.

.3 Switch: snap action type, rated at 120V, 15 amps AC or 24 VDC.

.4 Switch assembly: to operate automatically and include a manual reset. Over-pressure input protection to at least twice rated input pressure.

.5 Accuracy: within 2% repetitive switching.

.6 Provide switches with isolation valve and snubber, where code allows, between sensor and pressure source.

.7 Switches on steam and high temperature hot water service: provide pigtail syphon.

## 2.9 CONTROL PANELS

.1 Mount DDC controllers in control panels and field interface equipment (i.e. relays, transducers, etc.) in separate field interface control panels.

.2 Control panels are to be of unitized cabinet type construction, fabricated from 2.5 mm rolled sheet metal sheet with baked enamel finish, flush fitting, gasketted doors hung on piano type hinges and three point latches and locking handles. CSA approved for line voltage applications.

.3 Mount pressure gauges, pilot lights, push buttons and switches flush on cabinet panel face.

.4 Mount panels on vibration free walls or free standing angle iron supports. Provide engraved plastic nameplates for instruments and controls inside cabinet and on cabinet face.

.5 Provide pans and rails for mounting terminal blocks, relays, wiring and other necessary devices.

.6 Provide an individual switch for disconnection and a fuse for isolation of all panel mounted instruments requiring a 120 volt supply.

.7 Make all wiring connections in the shop from the equipment mounted on the panel to numbered terminal blocks conveniently located in the panel, including the power supply for all instruments.

.8 Identify all wiring by means of stamped markings on heat shrinkable tubing that is permanently fastened to wiring. Install all wiring neatly and laced or bunched into cable form using plastic wire clips, where practical, contained in plastic wiring channels with covers. Maximum 25 conductors to each wire bundle.

.9 Provide terminal blocks, tabular clamp, 300 V, complete with track. Each terminal shall be clearly indelibly marked with the wire number connection to it. Each field connecting conductor shall be served by one terminal. Provide 20% spare unit terminals, with a minimum of two spare terminals. Provide all necessary terminal block accessories such as manufacturer jumpers and marking tape.

.10 Install "Hand-Off-Auto" selector switches such that safety controls and electrical over current protection are not overridden when selector switch is in the "Hand" position. "Hand-Off-Auto" selector switches shall be provided for all ventilation fans and sump pumps.

.11 Control Power for control panel shall be 120 Volts A.C. from panel circuits provided by Section 26.

.12 Install bonding conductor between main control and auxiliary panels complete with grounding lugs, in addition to CSA grounding requirements.

.13 When fabrication of first panel is completed arrange for inspection and approval by Contract Administrator before proceeding with further panel construction.

.14 Provide panel heaters in the panel used in humid and exterior locations

**2.10 WIRE**

.1 Control wiring for digital functions shall be 20 AWG minimum with 300 Volt insulation.

.2 Control wiring for analog functions shall be 20 AWG minimum with 300 Volts insulation, twisted and shielded, 2 or 3 wire to match analog function hardware.

.3 Sensor wiring shall be 20 AWG minimum twisted and shielded, 2 or 3 wire to match analog function hardware or 16 AWG as required by code.

.4 Transformer current wiring shall be 16 AWG minimum.

.5 Identify all wiring and cabling by means of stamped markings on heat shrinkable tubing that is permanently fastened to wiring.

**2.11 CONDUITS AND CABLES**

.1 All wiring shall be in conduit or trays. Flexible conduit may be used for final connection of control devices. Maximum length of flexible conduit to be 1 m. Conform to Section 26 requirements for conduit and trays specifications.

.2 Seal conduit where such conduit leaves heated areas and enters unheated area.

.3 In the field panel, run low level signal lines in separate conduit from high level signal and power transmission lines.

.4 Identify each cable and wire at every termination point by means of stamped markings on heat shrinkable tubing that is permanently fastened to wiring.

.5 Provide instrumentation complete with standard electrical conduit box for termination unless otherwise noted.

.6 Separate conduits shall be provided for pneumatic tubing and electrical wiring runs.

.7 Color code all conductors and conduits by permanently applied color bands. Color code shall follow base building schedule.

.8 All wiring for terminal equipment controllers including network communications, sensors and actuator wiring must be in conduit.

.9 Sensor and actuator wiring for room controllers run within enclosed ceiling spaces or walls of drywall construction may be installed without conduit, provided that it adheres to the following installation requirements:

.1 Plenum rated cabling is used;

.2 Cabling is run perpendicular to building lines and is supported using proper tyraps either to the building structure or to conduit and intervals of no more than two (2) feet;
.3 Cabling follows ductwork where practical and is installed on top of ductwork;
.4 all splices and terminations are made within junction boxes; and
.5 Strain relief is provided for all wiring entering junction boxes.
.6 The use of plaster rings for mounting of space sensors on drywall will be an acceptable alternative to junction boxes when splices and terminations can be made within the sensor enclosures.

## 2.12 RELATED ACCESSORIES

.1 Provide and install all necessary transducers, interposing relays, interface devices, contactors, starters and EP's to perform control functions required.

.2 It is the responsibility of the Contractor to identify, prior to tender submission, all additional items not specified that are required to meet the operational intent specified.

## 2.13 CONTROL DAMPERS

.1 Refer to Section 23 33 00 – Air Duct Accessories.

## 2.14 ELECTRONIC CONTROL DAMPER ACTUATORS

.1 Provide electronic proportional damper actuators with spring return to “fail-safe” in normally open or normally closed position.

.2 Damper operator’s spring return shall have sufficient torque to provide tight shut off in the most extreme expected operating condition.

.3 Damper 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. All actuators shall provide a 2 to 10 VDC position feedback signal.

.4 Provide sufficient damper motors to achieve unrestricted movement, with a minimum of one damper operator per damper section. The damper area driven by each damper operator shall not exceed 1.6 meters.

.5 Positioning time for full closed to full open not to exceed 90 seconds.

.6 Positioning time for full open to full closed not to exceed 45 seconds.

.7 Where multiple damper actuators are utilized for one damper or multiple damper sections, or where multiple dampers are controlled in unison, all damper actuators shall be controlled by one DCS analog output signal.

.8 Where possible do not mount actuators outdoors or in the air stream.

.9 Where damper operators are located in battery rooms and OWSB, an explosion proof enclosure shall be provided.

.10 Standard of Acceptance – Belimo, Johnson Control

## 2.15 CONTROL VALVE (GLOBE 3-WAY)

.1 Construction:
.1 Body: Bronze
.2 Seat: Stainless steel
.3 Stem: Stainless steel

.4 Plug: Stainless steel
.5 Packing: Spring loaded TFC

.2 Media temperature 20°F to 250°F (-7°C to 120°C)

.3 Ambient temperature 32°F to 122°F (0°C to 50°C)

.4 Maximum fluid pressure 35 psi (241kPa)

**2.16 ELECTRONIC VALVE ACTUATORS**

.1 Spring return, electronic actuator

.2 Power supply: 24 VAC/VDC.

.3 Control signal: 2-10 VDC or 4-20 mA.

.4 Positioning time: to suit application. 90 sec maximum.

.5 Fail open for heating, and fail-closed for cooling

.6 Scale or dial indication of actual control valve position.

.7 Size actuator to meet requirements and performance of control valve specifications.

.8 For interior and perimeter terminal heating and cooling applications floating control actuators are acceptable.

.9 Supplied with open/close limit switches.

**Part 3 Execution**

**3.1 INSTALLATION**

.1 Verify location of thermostats and other exposed control sensors with drawings before installation. Locate thermostats 1500 mm above floor.

.2 Install damper motors on outside of ducts.

.3 Wire "hand/off/auto" selector switches such that only automatic operating controls and not safety controls and electrical over current protection shall be overridden when switch is in the "hand" position.

.4 Fans that are to be sequenced with intake or discharge dampers through a single output point shall be wired such that operation of damper end switch alone will not start fan. I.E. The end switch and DDC “ON” command must both be required to start the fan when the "hand/off/auto" selector switch is in the auto position.

.5 Unless specified otherwise, install all outdoor air sensors on the north exposure of the building.

.6 Install all safety limits at the operator’s level.

.7 Safety devices including but not limited to freeze stats and pressure switches shall be hardwired to trip fan starters on alarm condition. Auxiliary contacts shall be wired back to the DCS for monitoring where identified on the points list.

.8 Install pressure gauges on branch lines and actuator excepting individual room thermostats.

.9 Provide air lines, checks, charging valves and pressure gauges to expansion tanks. Charging valves to be located at operator’s level.

.10 Control System Power

.1 Provide emergency power to all control system components as necessary to provide continued monitoring and control from the control room operator's workstation of all equipment supplied with emergency power.

.2 Provide separate power circuits for:

.3 The central computer workstation,

.4 Each SCU and

.5 Each ASC.

.6 ASC's for, digital room control and other terminal equipment devices may be powered from a common circuit provided that:

.1 Circuit loading does not exceed 900 VA,

.2 A minimum of one circuit per air system is provided for the terminal equipment controllers associated with the air system, and

.3 Terminal equipment controllers for different air systems are not powered from the same circuit.

**END OF SECTION**

## Part 1 General

### 1.1 SUMMARY

.1 Section includes:
- .1 Complete and fully operational system of automatic controls, including all materials and labor.
- .2 Demonstration of proposed installed controls system.

.2 Related Sections:
- .1 Section 23 09 13 - Instrumentation and Control Devices
- .2 Section 23 09 93 - Sequence of Operations for HVAC Controls

### 1.2 DEFINITIONS

.1 Analog: A continuously variable system or value not having discrete levels. Typically exists within a defined range of limiting values.

.2 Binary: A two-state system where an “ON” condition is represented by one discrete signal level and an “OFF” condition is represented by a second discrete signal level.

.3 Control Contractor: The single Contractor to provide the work of this Section. This Contractor shall be the primary manufacturer, installer, commissioner and ongoing service provider for the DCS work.

.4 Control Sequence: An pre-programmed arrangement of software algorithms, logical computation, target values and limits as required to attain the defined operational control objectives.

.5 Direct Digital Control: The digital algorithms and pre-defined arrangements included in the control software to provide direct closed-loop control for the designated equipment and controlled variables. Inclusive of Proportional, Derivative and Integral control algorithms together with target values, limits, logical functions, arithmetic functions, constant values, timing considerations and the like.

.6 Provide: The term “Provide” and its derivatives when used in this Section shall mean to furnish, install in place, connect, calibrate, test, commission, warrant, document and supply the associated required services ready for operation.

.7 Install: The term “Install” and its derivatives when used in this Section shall mean receive at the jobsite and mount.

.8 Protocol: The term “protocol” and its derivatives when used in this Section shall mean a defined set of rules and standards governing the on-line exchange of data between DCS network nodes.

.9 Software: The term “software” and its derivatives when used in this Section shall mean all of programmed digital processor software, preprogrammed firmware and project specific digital process programming and database entries and definitions as generally understood in the DCS industry for real-time, on-line, integrated DCS configurations.

.10 The use of words in the singular in these Section documents shall not be considered as limiting when other indications in these documents denote that more than one such item is being referenced.

.11 Headings, paragraph numbers, titles, shading, bolding, underscores, clouds and other symbolic interpretation aids included in the Section documents are for general information only and are to assist in the reading and interpretation of these Documents.

.12 The following abbreviations and acronyms may be used in describing the work of this Section:

| | |
|---|---|
| ADC | Analog to Digital Converter |
| AI | Analog Input |
| AN | Application Node |
| AO | Analog Output |
| CPU | Central Processing Unit |
| CRT | Cathode Ray Tube |
| DAC | Digital to Analog Converter |
| DDC | Direct Digital Control |
| DI | Digital Input |
| DO | Digital Output |
| EEPROM | Electronically Erasable Programmable Read Only Memory |
| EMI | Electromagnetic Interference |
| FAS | Fire Alarm Detection and Annunciation System |
| GUI | Graphical User Interface |
| HOA | Hand-Off-Auto |
| I/O | Input/Output |
| LAN | Local Area Network |
| LCD | Liquid Crystal Display |
| LED | Light Emitting Diode |
| MCC | Motor Control Center |
| OWS | Operator Workstation |
| PC | Personal Computer |
| RAM | Random Access Memory |
| RF | Radio Frequency |
| RFI | Radio Frequency Interference |
| ROM | Read Only Memory |
| RTD | Resistance Temperature Device |
| SPDT | Single Pole Double Throw |
| SPST | Single Pole Single Throw |
| XVGA | Extended Video Graphics Adapter |
| TBA | To Be Advised |
| TCP/IP | Transmission Control Protocol/Internet Protocol |
| TTD | Thermistor Temperature Device |
| UPS | Uninterruptible Power Supply |
| VAC | Volts, Alternating Current |
| VDC | Volts, Direct Current |
| WAN | Wide Area Network |
| CCU | Central Computer Unit |
| CP | Control Panel |
| HMI | Human-Machine Interface |
| IP | Current (I) - Pressure (P), as in IP transducer |
| OIU | Operator Interface Units |
| PLC | Programmable Logic Controller |
| SCU | Standalone Control Unit |

**1.3 SHOP DRAWINGS**

.1 Submit shop drawings in accordance with E4.

.2 Provide operating and maintenance manuals with complete description of installation and operation specified in Section 01 78 00 – Closeout Submittals.

**1.4 QUALITY ASSURANCE**

.1 Install all components in accordance with the latest regulations of the Canadian Electrical Code, applicable Municipal and Provincial Codes and Regulations, and latest CSA Electrical Bulletins.

.2 The equipment manufacturer shall have trained service representatives resident in the Province where project is located.

**Part 2 Products**

**2.1 GENERAL**

.1 The Building Management System shall consist of the following:
- .1 Standalone Network Automation Control Engine(s)
- .2 Field Equipment Controller(s)
- .3 Input/Output Module(s)

.2 The system shall be modular in nature, and shall permit expansion of both capacity and functionality through the addition of sensors, actuators, controllers and operator devices, while re-using existing controls equipment.

.3 The failure of any single component or network connection shall not interrupt the execution of control strategies at other operational devices.

.4 The System shall maintain all settings and overrides through a system reboot.

.5 System architectural design shall eliminate dependence upon any single device for alarm reporting and control execution.

.6 Standard of Acceptance: Johnson Controls Metasys

**2.2 NETWORK CONTROL ENGINE**

.1 The Network Control Engine (NCE) shall be a fully user-programmable, supervisory controller. The NCE shall monitor the network of distributed application-specific controllers, provide global strategy and direction, and communicate on a peer-to-peer basis with other Network Automation Engines.

.2 The Network Control Engine (NCE) shall be a fully user-programmable, digital controller that includes a minimum of 33 I/O points.

.3 Automation Network – The NCE shall reside on the automation network and shall support a subnet of 32 Field controllers.

.4 User Interface – Each NCE shall have the ability to deliver a web based User Interface (UI) as previously described. All computers connected physically or virtually to the automation network shall have access to the web based UI.
- .1 The web based UI software shall be imbedded in the NCE. Systems that require a local copy of the system database on the user's personal computer are not acceptable.
- .2 The NCE shall support a minimum of two (2) concurrent users.

.3 The NCE shall have the capability of generating web based UI graphics. The graphics capability shall be imbedded in the NCE.

.4 Systems that support UI Graphics from a central database or require the graphics to reside on the user's personal computer are not acceptable.

.5 The web based UI shall support the following functions using a standard version of Microsoft Internet Explorer:

.1 Configuration
.2 Commissioning
.3 Data Archiving
.4 Monitoring
.5 Commanding
.6 System Diagnostics

.6 Systems that require workstation software or modified web browsers are not acceptable.

.7 The NCE shall allow temporary use of portable devices without interrupting the normal operation of permanently connected modems.

.5 The NCE shall employ a finite state control engine to eliminate unnecessary conflicts between control functions at crossover points in their operational sequences. Suppliers using non-state based DDC shall provide separate control strategy diagrams for all controlled functions in their submittals.

.6 The NCE shall be factory programmed with a continuous adaptive tuning algorithm that senses changes in the physical environment and continually adjusts loop tuning parameters appropriately. Controllers that require manual tuning of loops or perform automatic tuning on command only, shall not be acceptable.

.7 The NCE shall be assembled in a plenum-rated plastic housing with flammability rated to UL94-5VB.

.8 The NCE shall support the following number and types of inputs and outputs:

.1 Ten Universal Inputs - shall be configured to monitor any of the following:

.1 Analog Input, Voltage Mode
.2 Analog Input, Current Mode
.3 Analog Input, Resistive Mode
.4 Binary Input, Dry Contact Maintained Mode
.5 Binary Input, Pulse Counter Mode

.2 Eight Binary Inputs - shall be configured to monitor either of the following:

.1 Dry Contact Maintained Mode
.2 Pulse Counter Mode

.3 Four Analog Outputs - shall be configured to output either of the following

.1 Analog Output, Voltage Mode
.2 Analog Output, Current Mode

.4 Seven Binary Outputs - shall output the following:

.1 24 VAC Triac

.5 Four Configurable Outputs - shall be configured to output either of the following:

.1 Analog Output, Voltage Mode
.2 Binary Output, 24 VAC Triac Mode

.9 The NCE shall have the ability to monitor and control a network of sensors and actuators over a Sensor-Actuator Bus (SA Bus).

.1 The SA Bus shall be a Master-Slave/Token-Passing (MS/TP) Bus supporting BACnet Standard protocol SSPC-135, Clause 9.

.2 The SA Bus shall support a minimum of 10 devices.
.3 The SA Bus shall operate at a maximum distance of 1,200 Ft. between the NCE and the furthest connected device.

.10 The NCE shall have the capability to execute complex control sequences involving direct wired I/O points as well as input and output devices communicating over the Field Trunk or the SA Bus.

.11 The NCE shall support, but not be limited to, the following applications:
.1 Central Equipment including chillers and boilers
.2 Lighting and electrical distribution
.3 Built-up air handling units for special applications
.4 Power generation and energy monitoring equipment
.5 Interfaces to security and fire detection systems

.12 The NCE shall be microprocessor-based with a minimum word size of 32 bits. The NAE shall be a multi-tasking, multi-user, and real-time digital control processor. Standard operating systems shall be employed. NCE size and capability shall be sufficient to fully meet the requirements of this Specification.

.13 The NCE shall employ an industrial single board computer.

.14 Each NCE shall have sufficient memory to support its own operating system, databases, and control programs, and to provide supervisory control for all control level devices.

.15 The NCE shall include an integrated, hardware-based, real-time clock.

.16 The NCE shall employ nonvolatile Flash memory to store all programs and data. The NCE shall employ a data protection battery to save data and power the real time clock when primary power is interrupted.

.17 The NCE shall provide removable, color coded, screw terminal blocks for 24 VAC power, communication bus and I/O point field wiring.

.18 The NCE shall include troubleshooting LED indicators to identify the following conditions:
.1 Power
.2 Fault
.3 SA Bus
.4 FC Bus
.5 Modem TX
.6 Modem RX
.7 Battery Fault
.8 Ethernet
.9 10 LNK
.10 100 LNK
.11 Run
.12 Peer Com

.19 Communications Ports – The NCE shall provide the following ports for operation of operator Input/Output (I/O) devices, such as industry-standard computers, modems, and portable operator's terminals.
.1 USB port
.2 RS-232 serial data communication port
.3 RS-485 port
.4 RJ-45 Ethernet port
.5 RJ-12 jack

.20 Diagnostics – The NCE shall continuously perform self-diagnostics, communication diagnosis, and diagnosis of all panel components. The Network Control Engine shall provide both local and remote annunciation of any detected component failures, low battery conditions, or repeated failures to establish communication.

.21 Power Failure – In the event of the loss of normal power, The NCE shall continue to operate for a user adjustable period of up to 10 minutes after which there shall be an orderly shutdown of all programs to prevent the loss of database or operating system software.

.1 During a loss of normal power, the control sequences shall go to the normal system shutdown conditions. All critical configuration data shall be saved into Flash memory.

.2 Upon restoration of normal power and after a minimum off-time delay, the controller shall automatically resume full operation without manual intervention through a normal soft-start sequence.

.22 Certification – The NCE shall be listed by Underwriters Laboratories (UL).File E107041, CCN PAZX, UL 916, Energy Management Equipment. FCC Compliant to CFR47, Part 15, Subpart B, Class A

.23 Field Controller Bus – The NCE shall support the following communication protocols on the Field Controller Bus:

.1 The NCE shall support BACnet Standard MS/TP Bus Protocol ASHRAE SSPC-135, Clause 9 on the controller network.

.1 The NCE shall be BACnet Testing Labs (BTL) certified and carry the BTL Label.

.2 A BACnet Protocol Implementation Conformance Statement shall be provided for the NCE.

.3 The NCE shall support a minimum of 32 control devices.

.2 The NCE shall support LonWorks enabled devices using the Free Topology Transceiver FTT10 on the Field Controller Bus (LonWorks Network).

.1 All LonWorks controls devices shall be LonMark certified.

.2 The NCE shall support a minimum of 32 LonWorks enabled control devices.

.3 The NCE shall support the N2 devices on the Field Controller Bus (Johnson Controls N2 Bus).

.1 The NCE shall support a minimum of 32 N2 control devices.

.2 The Bus shall conform to Electronic Industry Alliance (EIA) Standard RS-485.

.3 The Bus shall employ a master/slave protocol where the NCE is the master.

.4 The Bus shall employ a four (4) level priority system for polling frequency.

.5 The Bus shall be optically isolated from the NCE.

.6 The Bus shall support the Metasys Integrator System.

## 2.3 DDC SYSTEM CONTROLLERS

.1 Field Equipment Controller **(FEC)**

.1 The Field Equipment Controller (FEC) shall be a fully user-programmable, digital controller that communicates via BACnet MS/TP protocol.

.1 The FEC shall support BACnet Standard MS/TP Bus Protocol ASHRAE SSPC-135, Clause 9 on the controller network.

.1 The FEC shall be BACnet Testing Labs (BTL) certified and carry the BTL Label.
.2 The FEC shall be tested and certified as a BACnet Application Specific Controller (B-ASC).
.3 A BACnet Protocol Implementation Conformance Statement shall be provided for the FEC.
.4 The Conformance Statement shall be submitted 10 days prior to bidding.

.2 The FEC shall employ a finite state control engine to eliminate unnecessary conflicts between control functions at crossover points in their operational sequences. Suppliers using non-state based DDC shall provide separate control strategy diagrams for all controlled functions in their submittals.

.3 Controllers shall be factory programmed with a continuous adaptive tuning algorithm that senses changes in the physical environment and continually adjusts loop tuning parameters appropriately. Controllers that require manual tuning of loops or perform automatic tuning on command only shall not be acceptable.

.4 The FEC shall be assembled in a plenum-rated plastic housing with flammability rated to UL94-5VB.

.5 The FEC shall include a removable base to allow pre-wiring without the controller.

.6 The FEC shall include troubleshooting LED indicators to identify the following conditions:
.1 Power On
.2 Power Off
.3 Download or Startup in progress, not ready for normal operation
.4 No Faults
.5 Device Fault
.6 Field Controller Bus - Normal Data Transmission
.7 Field Controller Bus - No Data Transmission
.8 Field Controller Bus - No Communication
.9 Sensor-Actuator Bus - Normal Data Transmission
.10 Sensor-Actuator Bus - No Data Transmission
.11 Sensor-Actuator Bus - No Communication

.7 The FEC shall accommodate the direct wiring of analog and binary I/O field points.

.8 The FEC shall support the following types of inputs and outputs:
.1 Universal Inputs - shall be configured to monitor any of the following:
.1 Analog Input, Voltage Mode
.2 Analog Input, Current Mode
.3 Analog Input, Resistive Mode
.4 Binary Input, Dry Contact Maintained Mode
.5 Binary Input, Pulse Counter Mode
.2 Binary Inputs - shall be configured to monitor either of the following:
.1 Dry Contact Maintained Mode
.2 Pulse Counter Mode
.3 Analog Outputs - shall be configured to output either of the following
.1 Analog Output, Voltage Mode
.2 Analog Output, current Mode
.4 Binary Outputs - shall output the following:
.1 24 VAC Triac

.5 Configurable Outputs - shall be capable of the following:
.1 Analog Output, Voltage Mode
.2 Binary Output Mode

.9 The FEC shall have the ability to reside on a Field Controller Bus (FC Bus).
.1 The FC Bus shall be a Master-Slave/Token-Passing (MS/TP) Bus supporting BACnet Standard protocol SSPC-135, Clause 9.
.2 The FC Bus shall support communications between the FECs and the NAE.
.3 The FC Bus shall also support Input/Output Module (IOM) communications with the FEC and with the NAE.
.4 The FC Bus shall support a minimum of 100 IOMs and FECs in any combination.
.5 The FC Bus shall operate at a maximum distance of 15,000 Ft. between the FEC and the furthest connected device.

.10 The FEC shall have the ability to monitor and control a network of sensors and actuators over a Sensor-Actuator Bus (SA Bus).
.1 The SA Bus shall be a Master-Slave/Token-Passing (MS/TP) Bus supporting BACnet Standard Protocol SSPC-135, Clause 9.
.2 The SA Bus shall support a minimum of 10 devices per trunk.
.3 The SA Bus shall operate at a maximum distance of 1,200 Ft. between the FEC and the furthest connected device.

.11 The FEC shall have the capability to execute complex control sequences involving direct wired I/O points as well as input and output devices communicating over the FC Bus or the SA Bus.

.12 The FEC shall support, but not be limited to, the following:
.1 Hot water, chilled water/central plant applications
.2 Built-up air handling units for special applications
.3 Terminal units
.4 Special programs as required for systems control

.2 Field Devices

.1 Input/Output Module **(IOM)**

.1 The Input/Output Module (IOM) provides additional inputs and outputs for use in the FEC.
.2 The IOM shall communicate with the FEC over the FC Bus or the SA Bus.
.3 The IOM shall support BACnet Standard MS/TP Bus Protocol ASHRAE SSPC-135, Clause 9 on the controller network.
.1 The IOM shall be BACnet Testing Labs (BTL) certified and carry the BTL Label.
.2 The IOM shall be tested and certified as a BACnet Application Specific Controller (B-ASC).
.3 A BACnet Protocol Implementation Conformance Statement shall be provided for the FEC.
.4 The IOM shall be assembled in a plenum-rated plastic housing with flammability rated to UL94-5VB.
.5 The IOM shall have a minimum of 4 points to a maximum of 17 points.
.6 The IOM shall support the following types of inputs and outputs:
.1 Universal Inputs - shall be configured to monitor any of the following:

.1 Analog Input, Voltage Mode
.2 Analog Input, Current Mode
.3 Analog Input, Resistive Mode
.4 Binary Input, Dry Contact Maintained Mode
.5 Binary Input, Pulse Counter Mode

.2 Binary Inputs - shall be configured to monitor either of the following:
.1 Dry Contact Maintained Mode
.2 Pulse Counter Mode

.3 Analog Outputs - shall be configured to output either of the following
.1 Analog Output, Voltage Mode
.2 Analog Output, current Mode

.4 Binary Outputs - shall output the following:
.1 24 VAC Triac

.5 Configurable Outputs - shall be capable of the following:
.1 Analog Output, Voltage Mode
.2 Binary Output Mode

.7 The IOM shall include troubleshooting LED indicators to identify the following conditions:
.1 Power On
.2 Power Off
.3 Download or Startup in progress, not ready for normal operation
.4 No Faults
.5 Device Fault
.6 Normal Data Transmission
.7 No Data Transmission
.8 No Communication

.2 Network Sensors **(NS)**

.1 The Network Sensors (NS) shall have the ability to monitor the following variables as required by the systems sequence of operations:
.1 Zone Temperature
.2 Zone Humidity
.3 Zone Setpoint
.4 Discharge Air Temperature

.2 The NS shall transmit the information back to the controller on the Sensor-Actuator Bus (SA Bus) using BACnet Standard protocol SSPC-135, Clause 9.

.3 The NS shall be BACnet Testing Labs (BTL) certified and carry the BTL Label.
.1 The NS shall be tested and certified as a BACnet Smart Sensors (B-SS).
.2 A BACnet Protocol Implementation Conformance Statement shall be provided for the NS.

.4 The Network Zone Sensors shall include the following items:
.1 A backlit Liquid Crystal Display (LCD) to indicate the Temperature, Humidity and Setpoint
.2 An LED to indicate the status of the Override feature

.3 A button to toggle the temperature display between Fahrenheit and Celsius
.4 A button to initiate a timed override command
.5 Available in either surface mount or wall mount
.6 Available with either screw terminals or phone jack

.5 The Network Discharge Air Sensors shall include the following:
.1 4 inch or 8 inch duct insertion probe
.2 10 foot pigtail lead
.3 Dip Switches for programmable address selection
.4 Ability to provide an averaging temperature from multiple locations
.5 Ability to provide a selectable temperature from multiple locations

.3 System Tools

.1 System Configuration Tool **(SCT)**

.1 The Configuration Tool shall be a software package enabling a computer platform to be used as a stand-alone engineering configuration tool for a Network Automation Engine (NAE) or a Network Integration Engine (NIE).

.2 The configuration tool shall provide an archive database for the configuration and application data.

.3 The configuration tool shall have the same look-and-feel at the User Interface (UI) regardless of whether the configuration is being done online or offline.

.4 The configuration tool shall include the following features:
.1 Basic system navigation tree for connected networks
.2 Integration of Metasys N1, LonWorks, and BACnet enabled devices
.3 Customized user navigation trees
.4 Point naming operating parameter setting
.5 Graphic diagram configuration
.6 Alarm and event message routing
.7 Graphical logic connector tool for custom programming
.8 Downloading, uploading, and archiving databases

.5 The configuration tool shall have the capability to automatically discover field devices on connected buses and networks. Automatic discovery shall be available for the following field devices:
.1 BACnet Devices
.2 LonWorks devices
.3 N2 Bus devices
.4 Metasys N1 networks

.6 The configuration tool shall be capable of programming the Field Equipment Controllers.
.1 The configuration tool shall provide the capability to configure, simulate, and commission the Field Equipment Controllers.
.2 The configuration tool shall allow the FECs to be run in Simulation Mode to verify the applications.
.3 The configuration tool shall contain a library of standard applications to be used for configuration.

.7 The configuration tool shall be capable of programming the field devices.
- .1 The configuration tool shall provide the capability to configure, simulate, and commission the field devices.
- .2 The configuration tool shall allow the field devices to be run in Simulation Mode to verify the applications.
- .3 The configuration tool shall contain a library of standard applications to be used for configuration

.8 A wireless access point shall allow a wireless enabled portable PC to make a temporary Ethernet connection to the automation network.
- .1 The wireless connection shall allow the PC to access configuration tool through the web browser using the User Interface (UI).
- .2 The wireless use of configuration tool shall be the same as a wired connection in every respect.
- .3 The wireless connection shall use the Bluetooth Wireless Technology.

## Part 3 Execution

### 3.1 INSTALLATION

.1 DCS Wiring
- .1 All conduit, wiring, accessories and wiring connections required for the installation of the Building Management System, as herein specified, shall be provided by the DCS Contractor unless specifically shown on the Electrical Drawings under Division 26 Electrical. All wiring shall comply with the requirements of applicable portions of Section 16 and all local and national electric codes, unless specified otherwise in this section.
- .2 All DCS wiring materials and installation methods shall comply with DCS manufacturer recommendations.
- .3 The sizing, type and provision of cable, conduit, cable trays, and raceways shall be the design responsibility of the DCS Contractor. If complications arise, however, due to the incorrect selection of cable, cable trays, raceways and/or conduit by the DCS Contractor, the Contractor shall be responsible for all costs incurred in replacing the selected components.
- .4 Class 2 Wiring
  - .1 All Class 2 (24VAC or less) wiring shall be installed in conduit unless otherwise specified.
  - .2 Conduit is not required for Class 2 wiring in concealed accessible locations. Class 2 wiring not installed in conduit shall be supported every 1.520 m from the building structure utilizing metal hangers designed for this application. Wiring shall be installed parallel to the building structural lines. All wiring shall be installed in accordance with local code requirements.
- .5 Class 2 signal wiring and 24VAC power can be run in the same conduit. Power wiring 120VAC and greater cannot share the same conduit with Class 2 signal wiring.
- .6 Provide for complete grounding of all applicable signal and communications cables, panels and equipment so as to ensure system integrity of operation. Ground cabling and conduit at the panel terminations. Avoid grounding loops.

.2 DCS Line Voltage Power Source

.1 120-volt AC circuits used for the Building Management System shall be taken from panel boards and circuit breakers provided by Section 26.
.2 Circuits used for the DCS shall be dedicated to the DCS and shall not be used for any other purposes.
.3 DDC terminal unit controllers may use AC power from motor power circuits.

.3 DCS Raceway
.1 All wiring shall be installed in conduit or raceway except as noted elsewhere in this specification. Minimum control wiring conduit size 15 mm.
.2 Where it is not possible to conceal raceways in finished locations, surface raceway (Wiremold) may be used as approved by the Architect.
.3 All conduits and raceways shall be installed level, plumb, at right angles to the building lines and shall follow the contours of the surface to which they are attached.
.4 Flexible Metal Conduit shall be used for vibration isolation and shall be limited to 3 feet in length when terminating to vibrating equipment. Flexible Metal Conduit may be used within partition walls. Flexible Metal Conduit shall be UL listed.

.4 Penetrations
.1 Provide fire stopping for all penetrations used by dedicated DCS conduits and raceways.
.2 All openings in fire proofed or fire stopped components shall be closed by using approved fire resistive sealant.
.3 All wiring passing through penetrations, including walls shall be in conduit or enclosed raceway.
.4 Penetrations of floor slabs shall be by core drilling. All penetrations shall be plumb, true, and square.

.5 .DCS Identification Standards
.1 Node Identification. All nodes shall be identified by a permanent label fastened to the enclosure. Labels shall be suitable for the node location.
.2 Cable types specified in Item A shall be color coded for easy identification and troubleshooting.

.6 DCS Panel Installation
.1 The DCS panels and cabinets shall be located as indicated at an elevation of not less than 2 feet from the bottom edge of the panel to the finished floor. Each cabinet shall be anchored per the manufacturer's recommendations.
.2 The DCS contractor shall be responsible for coordinating panel locations with other trades and electrical and mechanical contractors.

## 3.2 DEMONSTRATIONS

.1 The controls contractor shall arrange for a demonstration of an operating system that meets the technical submittal and Specification requirements.

.2 The demonstration shall include representative(s) from the Contract Administrator and representative(s) from the City.

.3 The controls contractor shall submit to the Contract Administrator a demonstration plan prior to conducting the demonstration.

.4 The controls contractor shall demonstrate to the Contract Administrator that the equipment, networks, installation programs and services as proposed for this Contract meet the requirements of the Contract Documents.

.5 The Contractor shall complete all necessary documentation and testing forms prior to scheduling any tests, of the operating system being demonstrated.

.6 The Contract Administrator shall have the option of additional special testing to ensure the proper functioning of the control system at no extra cost to this Contract.

**END OF SECTION**

## Part 1 General

### 1.1 SUMMARY

.1 Section includes:

.1 The control sequences contain a general description of the intent of the operation of the systems to be controlled. The Contractor shall review individual systems to ensure equipment and life safety interlocks are not overridden.

.2 The relationships between the points, systems and building are described in the control sequences.

.3 Review with the Contract Administrator during the shop drawing stage to finalize the control sequences for each system.

.2 Related Sections:

.1 Section 23 09 13 - Instrumentation and Control Devices

.2 Section 23 09 23 - Direct-Digital Control System

## Part 2 Products

.1 Not Applicable

## Part 3 Execution

.1 Provide data base for all hardware points listed for system operation to meet specification operating sequences.

.2 Control Sequences:

.1 Heat Recovery Equipment (HRV-1)

.1 The heat recovery ventilator will provide space heating and ventilation for the building.

.2 System is controlled by building DCS terminal panel.

.3 The supply fan and exhaust fans are equipped with two speed motor to vary the flow in different modes. Hydronic heating coil will provide heating to maintain desired discharge air temperature setpoint 16.7ºC (62ºF) by modulating a 3-way control valve CV-2.

.4 Winter Mode:

.1 The unit runs continuously at low speed in 24/7.

.5 Summer Mode:

.1 Day time: Schedule unit run continuously at high speed from 7.00 am to 7.00 pm from Monday to Friday.

.2 Night, weekends and holiday: Schedule unit run continuously at low speed.

.6 Fan controls: When the fan status indicates the fan started, the control sequence will be enabled. When either supply or exhaust fails, send alarm to building DCS terminal panel.

.7 HRV-1 control will allow for manual override of the system for 100% of flow.

.8 When the discharge air thermostat falls to 4.4C (40F), send an alarm to building DCS terminal panel.

.9 When differential pressure of both prefilter and return filter reaches 62 pa, send an alarm to building DCS terminal panel.

.10 Control Points:

| Type | Name | Description |
|---|---|---|
| AI | DA-T | Discharge Air Temperature |
| AI | OA-T | Outdoor Air Temperature |
| DI | PFILT-O | PreFilter Status by pressure sensor |
| DI | RFILT-R | ReturnFilter Status by pressure sensor |
| DI | HX | Bypass and defrost system monitor |
| DO | SF-S/S | Supply Fan Start/Stop |
| AO | SF-F | Supply Fan Failure, Send an alarm |
| AI | SF-S | Supply Fan Speed |
| DO | EF-S/S | Exhaust Fan Start/Stop |
| AO | EF-F | Exhaust Fan Failure, Send an alarm |
| AI | EF-S | Exhaust Fan Speed |
| AO | AF-O | Air Flow Switch |

.2 Hydronic Heating System

.1 Boilers

.1 Boiler controls are provided by the boiler manufacturer to tie-in points to building DCS terminal panel.

.2 Provide all safety or operational interlocks to boiler control panels as required.

.3 Boilers generate heat for the glycol heating system at a maximum supply setpoint temperature of 62.8°C (145°F). Temperature control is achieved by modulating and staging of the two boilers.

.4 Boiler shall be locked out by safety features such as Low water cut-out, and low flow condition at flow switch.

.5 When outdoor temperature drops below 5°C (41°F), boiler shall start.

.6 Supply temperature GHS to hydronic heating loop is initially reset as follows:

| O/A Temperature | GHS |
|---|---|
| -30°C (-22°F) or less | 62.8°C (145°F) |
| 5°C (41°F) | 37.8°C (120°F) |

.7 Provide an alarm to building DCS terminal panel if the glycol supply temperature GHS drops below 29.4C (85F) during the heating season (when the OAT is below 3°C).

.2 Heating Pumps (P-1)

.1 P-1 starts and runs continuously when the boiler is on and stop when the boiler is off.

.2 Both P-1 are 100% capacity each in a duty / standby arrangement. They are normally activated via building DCS terminal panel and rotate pump weekly.

.3 Exhaust Fans (EF-1, 2)

.1 Schedule fans to start and run continuously and stop manually.

.2 When the fans fails, send an alarm to building DCS terminal panel.

.4 Unit Heater (UH-1)

.1 When unit built-in thermostat calls for heat, the motor is energized. At the same time, a 2-way control valve CV-1 is opened allowing the heating fluid to enter the unit heater.

.2 Placing an aquastat to the supply or return piping will prevent motor operation until coil is properly heated to avoid the delivery of cold air.

.3 After the thermostat is reached 18.3ºC (65ºF). The CV-1 closes and motor is de-energized.

.4 The thermostat setpoint shall be field adjustable, but initially set to 15ºC (60ºF).

.5 Sump Pump (SMP-1)

.1 Provide sump pit high level alarms and pump running indication to the building DCS terminal panel.

.6 Snow melting control

.1 Snow melting control is provided by the Snow melting contractor to maintain concrete manhole pad clear of ice and snow by a 3-way control valve CV-3 and P-2 to respond buried sensors in the pad.

.2 Send an alarm to the building DCS terminal panel when concrete manhole pad covered by ice or snow.

.3 Control/Monitor System

.1 Provide input/outputs on all controls and wire to the building DCS terminal panel. See drawing 1-0101/2-A0016-001 for control/monitoring of HVAC control points.

**END OF SECTION**

## Part 1 General

### 1.1 SUMMARY

.1 Gas Fired Condensing Boiler

.2 Snow melting Package

.3 Circulate Pumps

.4 Specialty

### 1.2 RELATED SECTIONS

.1 Entire Specification – All areas of common work.

### 1.3 REFERENCES

.1 American Society of Mechanical Engineers (ASME).
- .1 ANSI/ASME Boiler and Pressure Vessel Code-2007.

.2 American Society for Testing and Materials, (ASTM).
- .1 ASTM A47/A47M-99(2004), Standard Specification for Ferritic Malleable Iron Castings.
- .2 ASTM A278/A278M-01(2006), Standard Specification for Gray Iron Castings for Pressure-Containing Parts for Temperatures up to 650 degrees F (345 degrees C).
- .3 ASTM A516/A516M-06, Standard Specification for Pressure Vessel Plates, Carbon Steel, for Moderate- and Lower-Temperature Service.
- .4 ASTM A536-84(2004)e1, Standard Specification for Ductile Iron Castings.
- .5 ASTM B62-02, Standard Specification for Composition Bronze or Ounce Metal Castings.
- .6 ASTM A53/A53M-07, Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated Welded and Seamless.
- .7 ASTM A105/A105M-05, Standard Specification for Carbon Steel Forgings, for Piping Applications.
- .8 ASTM F876 Standard Specification for Cross-linked Polyethylene (PEX) Tubing
- .9 ASTM F877 Standard Specification for Cross-linked Polyethylene (PEX) Plastic Hot- and Cold-Water Distribution Systems.
- .10 ASTM F2165 Standard Specification for Flexible Pre-Insulated Piping

.3 American National Standards Institute (ANSI)/National Sanitation Foundation (NSF)
- .1 ANSI/NSF Standard 14 Plastics Piping System Components and Related Materials
- .2 ANSI/NSF Standard 61 Drinking Water System Components - Health Effects

.4 Canadian Standards Association (CSA International).
- .1 CSA B51-09, Boiler, Pressure Vessel, and Pressure Piping Code.
- .2 National Standard of Canada CAN/CSA-B149.1-05 Natural Gas and Propane Installation Code.

.5 Manitoba Gas Notices-2007

**1.4 GENERAL REQUIREMENTS**

.1 Provide materials, equipment and labor to install Air Handling Unit as required by Provincial and Local Codes as specified herein.

**1.5 SHOP DRAWINGS**

.1 Submit shop drawings in accordance with E4.

.2 Submit shop drawings indicating capacity rating, physical dimensions, wiring diagrams, materials of construction, code compliance, etc. As indicated on schedules.

.3 Provide operating and maintenance manuals with complete description of product for incorporation into manual specified in Section 01 78 00 – Closeout Submittals.

**1.6 QUALITY ASSURANCE**

.1 The products shall be the product of manufacturer regularly engaged in production of such units who issues complete catalogue data on such products.

**Part 2 Products**

**2.1 ACCEPTABLE MANUFACTURERS**

.1 Gas Fired Condensing Boiler: Camus, AERCO, Super Hot, Gasmaster

.2 Snow Melting Package: Wirsbo, Rehau, Kitec, Heatlink

.3 In-line Circulator Armstrong, B & G, Taco, Grundfos

**2.2 GAS FIRED CONDENSING BOILER**

.1 The boiler are CSA approved for Hydronic Heating

.2 The Natural Gas Fired Condensing Boiler can fully modulate in 5:1 Turndown to maintain the desired temperature

.3 Boiler can be mounted on floor with Low Nox emission.

.4 The Stainless Steel combustion chamber shall be sealed and completely enclosed, independent of the outer jacket assembly and to drain condensation to the bottom of the heat exchanger assembly. A condensate collection box shall be employed to trap and neutralize flue product condensate.

.5 Burner shall be a premix design and constructed of high temperature Stainless Steel with knitted metal fiber outer covering to provide modulating firing rates. The burner shall provide equal distribution of heat through the entire heat exchanger. A window view port shall be provided for visual inspection of the boiler during firing.

.6 The heat exchanger shall be inspected and tested to A.S.M.E. Section IV requirements. The A.S.M.E. Section IV seal of approval will not be provided as standard for jurisdictions not requiring the A.S.M.E Section IV seal of approval. The heat exchanger shall be a multi-pass stainless steel all welded construction heat exchanger with maximum working pressure of 1100 kPa (160 PSI) with up to 150 PSI pressure relief .

.7 Fail safe high limit with manual reset

.8 C/w Flow Switch, Pressure Gauge, Outdoor sensor, S.S. Water Surfaces, Internal Boiler Pump, Miller Low Water Cut-off (Probe Style), neutralizer kit and CPVD flue pipe.

.9 Digit operating modulating two stage controller with I/O.

.10 Vent: CPVC 100mm Schedule 80 BH Class II B pipe and fitting Rated for 90C (194F)

.11 Refer to Boiler Schedule and vent layout on drawings.

## 2.3 PIPING AND FITTINGS

.1 Hrdronic inside building:
- .1 Pipe: Schedule 40, ASTM A53, Grade B.
- .2 Fitting: 15 mm dia. to 50 mm diameter screwed malleable iron or steel, 65 mm dia. and over, welded steel with same schedule of pipe.

.2 Boiler vent pipe: CPVC 100mm Schedule 80 BH Class II B pipe and fitting Rated for 90C (194F).

.3 Snow melting:
- .1 1/2" HePEX plus tubing and fitting in pad
- .2 Ecoflex Flexible Pre-Insulated Piping and fitting between building and pad

## 2.4 SNOW MELTING PACKAGE

.1 HePex Plus Coil

.2 TruFLOW Manifold Supply and Return Ball Valves,

.3 Manifold bushing

.4 Q & E FTG Assembling

.5 Quick & Easy Ring

.6 50 VA Transformer

.7 Climate Control - Multifunction

.8 Boiler Control, On-Off

.9 Dual Sensor, Supply and Return

.10 3-way modulating control valve

.11 Pump Relay Box

.12 Snow Melting Control

.13 Automatic Snow/Ice Sensor (Include cup & sensor)

.14 PVC Bend Support

.15 Cat5 patch cables

.16 Ecoflex Flexible Pre-Insulated Piping System (Between buildings and manhole pads)

## 2.5 CIRCULATE PUMPS

.1 General
- .1 Refer to Pump Schedule for technical data.

.2 Circulate Pump
- .1 The pumps shall be close-coupling centrifugal type.
- .2 Stainless Steel construction to be suitable for pumping fluids over 107°C (225°F) at 862 Kpa (125 psig) working pressure.
- .3 Stainless steel impeller, seal house, drain, vent plug and connections.
- .4 TEFC Motor with built-in overload protection.

.5 Supply with suction guide and all required accessories.

**2.6 EXPANSION TANK**

.1 The expansion tank shall be welded steel, constructed, tested and stamped in accordance with Section VIII, Division 1 of the ASME Code for a maximum working pressure of 862 kPa and maximum 93 degrees C operating temperature.

.2 Air pre-charged.

.3 The tank shall be supported by steel legs or a base (integral ring mount) for a vertical installation or steel saddles for horizontal installations.

.4 Each tank will have a heavy- duty butyl/EPDM diaphragm with code approvals ANSI/NSF 61.

**2.7 DIRT AND AIR SEPARATOR**

.1 Dirt & Air Separator must be designed with a blow-down valve, skim valve, removable end cover, and automatic air vent.

.2 The separator must also utilize a stainless steel coalescing medium to aid in the separation of air and dirt in the system entrained water.

.3 The separator must be constructed in accordance with the latest revision of the ASME Boiler and Pressure Vessel Code and stamped for 862 kPa working pressure.

**2.8 AIR VENT**

.1 Automatic

.1 Standard float vent: brass body and 3mm connection and rated at 690 kPa working pressure.

.2 Industrial float vent: cast iron body and 15mm connection and rated at 860 kPa working pressure.

.3 Float: solid material suitable for 115 degrees C working temperature.

.2 Manual

.1 Manual air vents with 25 mm or line diameter pipe which ever is greater to form air collection chamber. Collection chamber to be 150 mm high.

**2.9 GLYCOL FILL TANK**

.1 Glycol feed tank shall be 208 litre with a storage-mixing tank with level gauge; pump suction hose with inlet strainer; pressure pump with fuse protection; integral low fluid cut-out switch; integral check valve; power supply adapter; manual diverter valve for purging air and agitating contents of storage tank; pressure switch with two sets of SPST contacts, each adjustable from 35 kPA to 380 kPA cut-out pressure; 12 mm flexible hose connection. Power supply 115 V, 1 phase, 60 Hz.

.2 Pressure pump shall be capable of running dry without damage.

.3 Unit shall be completely pre-assembled and certified by a recognized testing agency to CSA standard C22.2 No.68.

.4 Supply with a stainless steel pan.

.5 AXIOM model SF100 is acceptable.

**2.10 PIPE LINE STRAINER**

.1 15 mm to 50 mm: bronze: bronze body to ASTM B62, screwed connections, Y-pattern.

.2 65 mm to 300 mm: cast steel body to ASTM A278M, Class 30, flanged connections.

.3 50 mm to 300 mm: T type with malleable iron body to ASTM A47M, grooved ends.

.4 Blowdown connection: 25 mm.

.5 Screen: stainless steel with 1.19 mm perforations.

.6 Working pressure: 860 kPa.

**2.11 RELIEF VALVE**

.1 Provide ASME rated direct spring loaded type, lever operated non-adjustable factory set discharge pressure as indicated.

**2.12 GLYCOL SOLUTION**

.1 Provide a 50% DOWFROST HD pre-mixed propylene glycol solution to be suitable for heating complete with appropriate corrosion inhibitors.

**2.13 CHEMICAL POT FEEDER**

.1 150 mm diameter x 550 mm long feeder, suitable for 860 kPa operating pressure complete with isolation valves on 20 mm inlet and outlet lines. 20 mm drain valve 40 mm fill complete with filling funnel.

**2.14 BALANCE VALVES**

.1 Body and Bonnet: Brass alloy CW617.

.2 Stem and Disc: Brass alloy B16.

.3 Elastomers: EPDM.

.4 Handwheel: Reinforced nylon ABS.

.5 Y-pattern and equal percentage globe-style with three functions:

.6 Precise flow measurement.

.7 Precision flow balancing.

.8 Positive drip-tight shut-off.

.9 Maximum working pressure: 2070 kPa.

**Part 3 Execution**

**3.1 GENERAL INSTALLATION**

.1 Install all as indicated and to manufacturer's recommendations and instructions.

.2 Install boiler on minimum 100mm thick concrete pad or steel frame in accordance with manufacturer’s Installation & Maintenance instructions.

.3 Insulate all piping as per Section 22 07 19.

.4 Run drain lines and blow off connections with minimum 2% grade to terminate above nearest floor drain.

.5 Maintain proper clearance to permit piping removal, service and maintenance.

.6 All in floor piping shall be pressure tested for a 24 hour period at 500 kPa and witnessed by Concrete Administrator, prior to the concrete pour.

.7 A pressure of 400 kPa shall be maintained in the underslab piping system during the concrete pour of 400 kPa. If pressure loss is observed during the concrete pour, the leak shall be located and corrected before the concrete hardens.

.8 Install expansion joints with cold setting. Make record of cold settings.

.9 Install expansion joints and flexible connections where necessary.

.10 Install pipe anchors and guides. Anchors to withstand 150% of axial thrust.

.11 Provide minimum 100 mm concrete housekeeping pads or primer and epoxy painted steel frames for all equipment mounted on the floor.

**3.2 BOILER**

.1 Follow CAN/CSA-B149.1-05 Natural Gas and Propane Installation Code and Manitoba Gas Notices-2007

.2 Follow manufacturers recommended installation guidelines.

.3 The relief pressure of the PRV shall be set at 345 kPa.

.4 Provide a discharge pipe for the PRV and route pipe to nearest funnel floor drain. Discharge pipe cross-sectional area shall not be less than the area of the boiler PRV outlet.

.5 Provide condensate drainage through neutralization kit as per manufacturer’s guidelines.

.6 Guy wire support boiler vent pipe if it is applicable.

**3.3 AIR VENTS**

.1 Install at high points of systems.

.2 Install gate valve on automatic air vent inlet. Run discharge to nearest drain.

**3.4 AIR ELIMINATOR**

.1 Install Dirt & Air Separator with an isolation valve at inlet and outlet.

**3.5 EXPANSION TANKS**

.1 Adjust expansion tank pressure as indicated.

**3.6 GLYCOL FILL TANK**

.1 Install a stainless steel pan under glycol fill tank.

**3.7 RELIEF VALVES**

.1 Provide relief valves on pressure tanks, low pressure side of reducing valves, expansion tanks and where indicated.

.2 Drain relief valve in glycol line to glycol fill tank. Do not waste glycol to floor drains.

.3 System relief valve capacity shall equal make-up pressure reducing valve capacity. Equipment relief valve capacity shall exceed input rating of connected equipment.

.4 Where one line vents serves several relief valves, cross sectional areas shall exceed sum of individual vent areas.

**3.8 STRAINERS**

.1 Install in horizontal or down flow lines.

.2 Ensure clearance for removal of basket.

.3 Install ahead of each pump.

.4 Install ahead of each automatic control valve as indicated.

**3.9 CHEMICAL POT FEEDER**

.1 Install one chemical pot feeder for each glycol system.

**3.10 BALANCE VALVES**

.1 Install balance valve as indicated.

**3.11 GLYCOL SOLUTION**

.1 Thoroughly clean and flush system before glycol solution is filled.

**3.12 CIRCULATOR PUMPS**

.1 Circulator pumps: install as indicated by flow arrows. Support at inlet and outlet flanges or unions. Install with bearing lubrication points accessible.

.2 Stack two pumps on self support frame if possible, the frame is made by 50x50x6 steel tubing with primer and epoxy painting.

.3 Ensure that pump body does not support piping or equipment. Provide stanchions or hangers for this purpose. Refer to manufacturer's installation instructions for details.

.4 Pipe drain tapping to floor drain, except for pipes in glycol pipe circuits which shall be piped to glycol reclaim.

.5 Decrease from line size, with long radius reducing elbows or reducers. Support piping adjacent to pump such that no weight is carried on pump casings. Provide supports under elbows on pump suction and discharge line sizes 100 mm and over.

.6 Install volute venting pet cock in accessible location.

.7 Check rotation and align-up pumps prior to start-up.

**END OF SECTION**

## Part 1 General

### 1.1 SUMMARY

.1 Ductwork and plenums.

.2 Fasteners.

.3 Sealants.

### 1.2 RELATED SECTIONS

.1 Duct Insulation - Section 23 07 13

.2 Air Duct Accessories - Section 23 33 00

### 1.3 REFERENCES

.1 American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc. (ASHRAE).

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

.1 ASTM A480/A480M-08b, Standard Specification for General Requirements for Flat-Rolled Stainless and Heat-Resisting Steel Plate, Sheet and Strip.

.2 ASTM A635/A635M-08, Standard Specification for Steel, Sheet and Strip, Heavy-Thickness Coils, Carbon, Hot Rolled.

.3 ASTM A653/A653M-08, Standard Specification for Steel Sheet, Zinc Coated (Galvanized) or Zinc-Iron Alloy Coated (Galvannealed) by the Hot-Dip Process.

.3 National Fire Protection Association (NFPA).

.1 NFPA (Fire) 90A-2009, Standard for the Installation of Air-Conditioning and Ventilating Systems.

.2 NFPA (Fire) 90B-2009, Standard for the Installation of Warm Air Heating and Air-Conditioning Systems.

.3 NFPA (Fire) 96-2008, Standard for Ventilation Control and Fire Protection of Commercial Cooking Operations.

.4 Sheet Metal and Air Conditioning Contractors' National Association (SMACNA).

.1 SMACNA 1966-2005, HVAC Duct Construction Standards – Metal and Flexible, 3rd Edition.

.2 SMACNA 1143-1985, HVAC Air Duct Leakage Test Manual, 1st Edition.

.3 IAQ Guideline for Occupied Buildings Under Construction 2007, 2nd Edition.

### 1.4 DEFINITIONS

.1 Low Pressure: Static pressure in duct less than 500 Pa (2 in WG) and velocities less than 10 m/s (2000 fpm).

.2 Medium Pressure: Static pressure in duct less than 1500 Pa (6 in WG) and velocities greater than 10 m/s (2000 fpm).

.3 High Pressure: Static pressure over 1500 Pa (6 in WG) and less than 2500 Pa (10 in WG) and velocities greater than 10 m/s (2000 fpm).

.4 Duct sizes shown on plans are inside clear dimensions. For acoustically lined or internally insulated ducts, maintain sizes inside ducts.

**1.5 QUALITY ASSURANCE**

.1 Ductwork shall meet the requirements of NFPA No. 90A - Air Conditioning and Ventilating Systems; NFPA No. 90B, Standard for the Installation of Warm Air Heating and Air Conditioning Systems.

.2 Fabricate in accordance with SMACNA duct manuals and ASHRAE handbooks as a minimum where more stringent requirements are not identified in the contract documents. Straight tap fittings and dovetail joints are not permitted.

**1.6 SHOP DRAWINGS**

.1 Submit shop drawings in accordance with E4.

.2 Submit shop drawings and samples of duct fittings for approval, including particulars such as gauge sizes, welds and configurations prior to start of work.

**1.7 ALTERNATIVES**

.1 Obtain written permission from the Contract Administrator prior to making variations in duct configuration or sizes. Size alternatives using ASHRAE table for circular equivalents of rectangular ducts.

**Part 2 Products**

**2.1 MATERIALS**

.1 Ducts: stainless steel Type 304 lock forming quality of 380 g/m2 for both sides.

.2 Fasteners: Use rivets and bolts throughout and material to match duct.

.3 Sealant: Water resistant, fire resistive, compatible with mating materials.

.4 Gauges as per SMACNA for pressure rating.

.5 Joints: to ASHRAE and SMACNA and/or proprietary manufactured duct joint. Proprietary manufactured flanged duct joint to be considered to be a class a seal.

**2.2 DUCTWORK**

.1 Construction – round:
- .1 Ducts: factory fabricated, spiral wound, with matching fittings and specials to SMACNA.
- .2 Transverse joints up to 900 mm: slip type with tape and sealants.
- .3 Transverse joints over 900 mm: Vanstone.
- .4 Fittings:
- .5 Elbows: smooth radius. Centreline radius: 1.5 x diameter.
  - .1 Branches: conical transition with conical branch at 45 degrees and 45 degrees elbow.

.2 Construction – rectangular:
- .1 Ducts: to SMACNA.
- .2 Transverse joints: SMACNA seal Class A and B.
- .3 Fittings:
  - .1 Elbows: smooth radius; centreline radius 1.5 x width of duct without vanes or rectangular connection with turning vanes.
  - .2 Branches: with conical branch at 45 degrees and 45 degrees elbow.

## 2.3 PLENUM GAUGES

.1 Fabricate fan plenums and plenums downstream of fan in accordance with SMACNA manual.

.2 Fabricate plenums between fan and upstream apparatus of 1.6 mm (16 ga) thick material.

.3 Fabricate plenums between filters and upstream apparatus of 1.3 mm (18 ga) thick material.

## 2.4 DUCT SEALING

.1 All supply, return and exhaust duct joints, longitudinal as well as transverse, shall be sealed using,

.1 Low Pressure Ductwork:

.1 Slip Joints: Apply heavy brush-on high pressure duct sealant. Apply second application after the first application has completely dried out. Where metal clearance exceeds 1.5 mm (16 gauge) use heavy mastic type sealant.

.2 Flanged Joints: Soft elastomer butyl or extruded form of sealant between flanges followed by an application of heavy brush-on high pressure duct sealant.

.3 Other Joints: Heavy mastic type sealant.

.2 Medium and High Pressure Ductwork: Combination of woven fabrics and sealing compound followed by an application of high pressure duct sealant.

.2 Duct tapes as sealing method are not permitted.

.3 Surfaces to receive sealant should be free from oil, dust, dirt, moisture, rust and other substances that inhibit or prevent bonding.

.4 Prior to sealing all ductwork, demonstrate sealing of a section of each type of duct and obtain approval from the C. A.

.5 Do not insulate any section of the ductwork until it has been inspected and approved of duct sealant application.

.6 Seal classification as follows:

| Maximum Pressure Pa | SMACNA Seal Class |
|---|---|
| 2500 | A |
| 1500 | A |
| 1000 | A |
| 750 | B |
| 500 | C |
| 250 | C |
| 125 | C |

.1 Class A: longitudinal seams, transverse joints, duct wall penetrations and connections made airtight with sealant and tape.

.2 Class B: longitudinal seams, transverse joints and connections made airtight with sealant and tape.

.3 Class C: transverse joints and connections made air tight with gaskets, sealant and tape. Longitudinal seams unsealed.

## Part 3 Execution

### 3.1 INSTALLATION

.1 Fabricate ductwork from field measurements and not from plans and shop drawings exclusively. Failure to do so will not constitute an extra to the Contract.

.2 Complete metal ducts within themselves with no single partition between ducts. Where width of duct exceeds 450 mm (18") crossbrace for rigidity. Open corners are not acceptable.

.3 Construct tees, bends and elbows with radius of not less than 1-1/2 times width of duct on centre line. Where not possible and where rectangular elbows are specified, provide double wall air foil type turning vanes. Where acoustical lining is provided, provide turning vanes of perforated metal type with fiberglass inside.

.4 Increase duct sizes gradually, not exceeding 15 deg. divergence wherever possible. Maximum divergence upstream of equipment to be 30 deg. and 45 deg. convergence downstream.

.5 Rigidly construct metal ducts with joints mechanically tight, substantially airtight, braced and stiffened so as not to breathe, rattle, vibrate or sag. Caulk duct joints and connections with sealant as ducts are being assembled. Seal seams on fresh air and exhaust ducts watertight with mastic or high velocity duct sealant.

.6 Set plenum doors 150 mm (6") above floor. Arrange door swings so that fan static holds door in closed position.

.7 Locate ducts with sufficient space around equipment to allow normal operation and maintenance activities.

.8 Interrupt duct linings at fire, balancing, backdraft and smoke dampers so as not to interfere with operation of devices. Provide sheet metal edge protection over linings on both side of damper device.

.9 Shield ductwork from dust and construction material during construction. Clean any ductwork found to be dirty at no extra cost to the Contract.

.10 Install ducts associated with fans subject to forced vibration with flexible connections immediately adjacent to equipment. Refer to Section 23 33 00 "Air Duct Accessories."

.11 Do not use flexible duct to change direction. Provide a minimum of three (3) duct diameters of straight metal duct between box inlet and flexible connector.

.12 Connect diffusers to low pressure ducts with 300 mm (12") maximum stretched length of flexible duct. Hold in place with caulking compound and strap or clamp.

.13 Prove that ductwork is substantially air tight before covering or concealing.

.14 Lap metal ducts in direction of air flow. Hammer down all edges and slips to leave smooth duct interiors.

.15 Clean duct systems and force air at high velocity through duct to remove accumulated dust. To obtain sufficient air, clean half the system at a time. Protect equipment which may be harmed by excessive dirt with filters, or bypass during cleaning.

**END OF SECTION**

## Part 1 General

### 1.1 SUMMARY

.1 When the duct systems are completed and before any fan systems are operated, all ductwork, plenums, coils and air handling equipment shall be cleaned by compressed air and mechanical equipment; or compressed air and high power suction equipment. No special cleaning is required for general exhaust ductwork systems that convey air directly to the outside at all times without recirculation. A letter shall be submitted by the cleaning company to the Contract Administrator certifying that all systems have been completely cleaned, and all access doors, access ports and covers are in place.

.2 After approval of duct cleaning, the complete system shall be disinfected with a chemical directly applied to the ductwork.

.3 After approval of duct cleaning, the operating ductwork system shall be disinfected with an approved chemical directly applied to the ductwork, grilles, diffusers and registers downstream from the supply box and upstream from the exhaust box.

### 1.2 RELATED SECTIONS

.1 Duct Insulation - Section 23 07 13

.2 Air Duct Accessories - Section 23 33 00

### 1.3 REFERENCES

.1 American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc. (ASHRAE).

.2 Department of Justice Canada (Jus).
- .1 Canadian Environmental Protection Act (CEPA), 1999, c. 33.

.3 Health Canada/Workplace Hazardous Materials Information System (WHMIS).
- .1 Material Safety Data Sheets (MSDS).

.4 Sheet Metal and Air Conditioning Contractors' National Association (SMACNA).
- .1 IAQ Guideline for Occupied Buildings Under Construction 2007, 2nd Edition.

### 1.4 QUALITY ASSURANCE

.1 Firms to be specialists in this field. Submit list of equipment, capacities, method and sequence of cleaning to the C. A for approval prior to beginning work.

.2 Any ductwork delivered to the site which in the C. A's opinion is dirty, shall be removed from the site and cleaned by the sheet metal contractor.

.3 Approved Agencies: Don’s Power Vac, Modern PowerVac, Carson Pow.R.Vac.

## Part 2 Products

### 2.1 MATERIALS

.1 The sheet metal subtrade shall provide all necessary access doors to facilitate efficient ductwork cleaning as listed under installation.

.2 Provide approved filters to protect equipment during cleaning operation. Submit shop drawings indicating which type of filters are to be utilized to protect equipment during construction and cleaning operation.

.3 The Contractor shall sample and analyze the contamination in the ductwork as requested by the Contract Administrator. The results may be verified by an independent laboratory, paid for by the Contractor, specializing in this type of work.

## Part 3 Execution

### 3.1 INSTALLATION

.1 Ductwork access doors for ductwork cleaning and inspection, shall be installed as follows:
- .1 At 10 m (30'-0") intervals or as required in all applicable duct systems.

.2 Ductwork access doors for ductwork cleaning and inspection, shall be installed as follows
- .1 At the base of all duct risers.
- .2 Both sides of turning vanes in all ducts.
- .3 At each fire damper location.
- .4 At each side of all heating or cooling coils.
- .5 At all locations of internally duct mounted equipment or devices including balancing dampers, automatic dampers, damper motors and controls.

.3 Access doors shall be as specified in Section 23 33 00 Air Duct Accessories. Access panels with screws are not acceptable.

.4 Access door size shall be minimum 450 mm x 350 mm or 50 mm18" x 14" or 2" smaller than duct dimension for inspection and 150 mm x 150 mm6" x 6" for cleaning equipment.

.5 For duct cleaning system utilizing compressed air and mechanical brush, suitably sized access ports with positive locking cover and zero flame spread rating, shall be installed at 3 m (10'-0") intervals in the duct work and on both sides of dampers, coils, turning vanes, etc.

.6 Access port system shall be reusable to allow for future inspection or cleaning.

.7 All ductwork outlets shall be sealed with suitable cover after ductwork has been cleaned. All plenums to be sealed after plenums have been cleaned.

.8 Prior to any work being started on the system, filter media shall be installed behind every supply grille or diffuser and on inlet side of duct or box reheat coils. This will act as a safety net for contamination which may be disturbed during cleaning. After a settling down period of two to five days, the filter media will be removed.

.9 Each aspect of a system shall be cleaned regardless of the size, type or configuration. Dirt clinging to the sides or top of ducting must be removed and left as clean as the bottom. Spiral ducting should be as clean as flat.

.10 After completion of cleaning and approval by the Contract Administrator, the noted systems shall be disinfected with a chemical directly applied to the ductwork. The chemical shall be applied using compressed air and spray wand that emits a 360° spray pattern. Mist or fog applications will not be allowed. Chemical to be used shall be submitted to the Contract Administrator for review and approval.

.11 The cleaning contractor shall be responsible for removing and replacing filter media in the pre-filter.

.12 The cleaning contractor shall mark damper positions before cleaning and return them to their original position when cleaning is completed, unless the system is still to be balanced.

.13 One sample air system shall be cleaned first prior to commencement of overall work, to determine standard of acceptance. The Contract Administrator and all representatives, mechanical and general contractors, having jurisdiction to inspect and accept completed work shall be present during this pre-quality acceptance inspection.

.14 The duct cleaning agent shall supply a minimum of 5% or 50 (which ever is less) replacement access port caps to the Contract Administrator.

.15 Once an air system is started after final cleanliness inspection and acceptance, for testing purposes, balancing and/or fine tuning, the maintaining of cleanliness is the responsibility of the Mechanical Contractor. Prior to Substantial Performance, the cleanliness of all ventilation systems shall be re-inspected. If the cleanliness is not acceptable, the Mechanical Contractor shall be responsible for recleaning.

.16 If the cleanliness of ventilation systems can be jeopardized due unclean and dusty conditions, the cleaning and start-up of ventilation system shall not be allowed.

.17 The contractor shall sample and analyze the contamination in the ductwork as requested by the Contract Administrator. The results will be verified by an independent laboratory, paid for by the Contractor, specializing in this type of work.

**1.2 INSPECTION**

.1 The cleanliness of ductwork shall be inspected using a borescope supplied by the contractor. This shall be made available to the City's request.

.2 Any ductwork found to be dirty shall be redone through its entire length.

**END OF SECTION**

## Part 1 General

### 1.1 SUMMARY

.1 Access doors.

.2 Motorized Dampers

.3 Flexible connections.

.4 Backdraft dampers.

### 1.2 RELATED SECTIONS

.1 Entire Specification – All areas of common work.

### 1.3 REFERENCES

.1 Sheet Metal and Air Conditioning Contractors' National Association (SMACNA).
- .1 SMACNA 1966-2005, HVAC Duct Construction Standards – Metal and Flexible, 3rd Edition.

.2 National Fire Protection Association (NFPA).
- .1 NFPA (Fire) 90A-2009, Standard for the Installation of Air-Conditioning and Ventilating Systems.
- .2 NFPA (Fire) 90B-2009, Standard for the Installation of Warm Air Heating and Air-Conditioning Systems.

### 1.4 QUALITY ASSURANCE

.1 Access doors shall be ULC labeled.

.2 Fire dampers shall be ULC listed and constructed in accordance with ULC Standard S 112 "Fire Dampers".

.3 Fusible links on fire dampers shall be constructed to ULC Standard S 505.

.4 Demonstrate re-setting of fire dampers to authorities having jurisdiction and Contract Administrator.

.5 Accessories shall meet the requirements of NFPA 90A, Air Conditioning and Ventilating Systems. Fabricate in accordance with ASHRAE Handbooks and SMACNA Duct Manuals.

### 1.5 SHOP DRAWINGS

.1 Submit shop drawings in accordance with E4.

.2 Closeout submittals: submit maintenance and engineering data for incorporation into manual specified in Section 01 78 00 – Closeout Submittals.

## Part 2 Products

### 2.1 ACCEPTABLE MANUFACTURERS

.1 Access Doors : Controlled Air, Nailor, Air-O-Metal, Titus.

| | | | |
|---|---|---|---|
| .2 | Dampers | : | Tamco |
| .3 | Flexible Connections | : | Thermaflex M-HKE |

## 2.2 DUCT ACCESS DOORS

.1 Fabricate rigid and close-fitting doors of galvanized steel with sealing gaskets and suitable quick fastening locking devices. Duct access panels with screws are not acceptable. Install minimum 25 mm (1") thick insulation with suitable sheet metal cover frame for insulated ductwork.

.2 Fabricated with two butt hinges and two sash locks for sizes up to 450 mm (18"), two hinges and two compression latches with outside and inside handles for sizes up to 600 mm x 1200 mm (24" x 48") and an additional hinge for larger sizes.

## 2.3 MOTORIZED DAMPERS

.1 Extruded 100 mm (4") deep aluminum frame with lower leak polystyrofoam insulated blades on four sides. Entire frame shall be thermally broken by means of polyurethane resin pockets, complete with thermal cuts.

.2 Blade and frame seals shall be of extruded silicone and be secured in an integral slot within the aluminum extrusions.

.3 Bearings are to be composed of a Celcon inner bearing fixed to aluminum hexagon blade pin, rotating within a polycarbonate outer bearing inserted in the frame, resulting in no metal-to-metal or metal-to-plastic contact.

.4 Linkage hardware shall be installed in the frame side and constructed of aluminum and corrosion-resistant, zinc-plated steel, complete with cup-point trunnion screws for a slip-proof grip.

.5 Dampers are to be designed for operation in temperatures ranging between -40°C (-40°F) and 85°C (185°F).

.6 Dampers shall be available with either opposed blade modulating action or parallel blade open/close action.

.7 Standard acceptance: Tamco series 9000BF.

.8 Operator: Refer to Section 23 09 13 – Instrumentation and Control Devices For HVAC.

## 2.4 BALANCING DAMPERS

.1 Fabricate of galvanized steel, minimum 1.6 mm (16 gauge). Full blade-length shafts of hollow square construction with blades rigidly fastened along entire blade length.

.2 Lockable quadrant type operating mechanism with end bearings on accessible rectangular ducts up to 400 mm (16") deep and on accessible round ducts.

.3 Wide pitch screw operating mechanism with crank operator and end bearings on accessible rectangular ducts 425 mm (17") and over in depth and on all inaccessible rectangular and round ducts.

.4 On rectangular ducts up to 275 mm (11") deep construct of single blade (butterfly) type.

.5 On rectangular ducts 300 mm to 400 mm (12" x 16") deep construct of two opposed blades mechanically interlocked with pivots at quarter points.

.6 On rectangular ducts over 425 mm (17") deep construct of multiple opposed blades, mechanically interlocked with blades no greater than 200 mm (8") deep and pivots equally spaced.

.7 On round ducts construct of single blade (butterfly) type. On 500 Pa (2 in WG) class and on all dampers over 300 mm (12") diameter fabricate with full blade-length shaft.

.8 Construct damper blades for medium and high pressure systems to block air passage 70% maximum. Provide complete with locking type handles.

.9 Provide over-ride limiting stops on all operating mechanisms.

.10 Identify the air flow direction and blade rotation and open and close positions on operating mechanism.

.11 On round ductwork, install operating mechanism on a steel mounted base firmly secured to the ductwork.

.12 On externally insulated ductwork, install operating mechanisms on a steel bridge type mounting base to permit continuity of insulation under the mechanism.

## 2.5 FLEXIBLE CONNECTIONS

.1 Fabricate of ULC approved neoprene coated flameproof glass fabric approximately 150 mm (6") wide tightly crimped into metal edging strip and attached to ducting and equipment by screws or bolts at 150 mm (6") intervals. Flexible connection airtight at 500 Pa (2 in WG).

.2 Fasteners: Use rivets and bolts throughout; sheet metal screws accepted on low pressure ducts.

.3 Sealant: Water resistant, fire resistive, compatible with mating materials.

## 2.6 BACKDRAFT DAMPERS

.1 Heavy duty counterbalanced industrial grade counterbalanced backdraft dampers.

.2 Frame shall be minimum 8" deep x 2" flanged 10 (203 x 51 x 35) gage galvanized steel channel. Frame shall be one piece construction.

.3 Sleeve or channel with innerframe is not acceptable. Damper blades shall be maximum 7" (178) wide, 18 (1.3) gage airfoil galvanized steel.

.4 Bearings shall be ball type pressed into frame. Axles shall be minimum 3/4" (19) diameter plated steel welded to blade. Linkage shall be minimum 3/16" (5) thick x 3/4" (19) plated steel tie bar with minimum 16 (1.6) gage galvanized linkage arms located on face of blades in the airstream. Pivot pins in linkage shall be stainless steel. Bronze pins or bushings are not acceptable.

.5 Dampers shall be equipped with blade and jamb seals for low leakage application. Blade seal shall be EPDM mechanically locked onto blade edge. Adhesive or clip on styles are not acceptable.

.6 Jambs seals shall be flexible stainless steel located between blade edge and jamb for maximum sealing compression.

.7 Standard acceptance: Rusky, Tamco

## Part 3 Execution

### 3.1 APPLICATION

.1 Provide access door minimum 450 mm x 350 mm or 50 mm (18" x 14" or 2") smaller than duct dimension for cleaning and inspection at positions indicated by drawings and as follows:

- .1 At 6.0 m (20'-0") intervals on all horizontal ducts.
- .2 At 12.0 m (40'-0") intervals in all vertical duct systems.
- .3 At the base of all duct risers.
- .4 Both sides of turning vanes in all ducts.
- .5 At each fire damper location.
- .6 At each side of all heating or cooling coils.
- .7 At all locations of internally duct mounted devices including automatic dampers, damper motors, duct mounted smoke detectors and heat detectors, and control sensors and devices.

.2 Provide fire dampers at locations shown on drawings, where ducts and outlets pass through fire rated components, and where required by authorities having jurisdiction. Fire dampers shall be complete with required perimeter mounting angles, sleeves, breakaway duct connections, corrosion resistant springs, bearings, bushings and hinges.

.3 Provide manual dampers at locations shown on drawings.

.4 Coordinate with other traders for correct size openings and proper fire guard sleeving for fire damper penetration.

.5 At each point where ducts pass through partitions, the opening around the duct shall be sealed with non-combustible material.

.6 Provide balancing dampers at points on low pressure supply, return and exhaust systems where branches are taken from larger ducts.

.7 Provide balancing dampers on medium and high pressure systems where indicated. Splitter dampers shall not be used on medium and high pressure system.

.8 Install ducts associated with fans and equipment subject to forced vibration with flexible connections, immediately adjacent to equipment and/or where indicated on drawing.

.9 For connections to medium and high pressure fans, install 15 mm (½") thick neoprene pad over fabric and hold in place with additional metal straps.

.10 All fire dampers and fire stop flaps are to be left in the closed position for balancing contractor to fix open.

.11 Support ceiling fire stops from the structure above the fire stop and not from air outlets on associated ductwork.

**END OF SECTION**

## Part 1 General

### 1.1 SUMMARY

.1 Exhaust Fans

### 1.2 RELATED SECTIONS

.1 Entire Specification – All areas of common work.

### 1.3 REFERENCES

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

.1 ANSI/AMCA 210-07, Laboratory Methods of Testing Fans for Aerodynamic Performance Rating

.2 ANSI/AMCA 300-08, Reverberant Room Method for Sound Testing of Fans.

### 1.4 GENERAL REQUIREMENTS

.1 Provide materials, equipment and labor to install HVAC fans as required by Provincial and Local Codes as specified herein.

.2 Conform to requirements NFPA (Fire) 90A-2009, Standard for the Installation of Air Conditioning and Ventilating Systems and Provincial and Municipal Codes.

### 1.5 SHOP DRAWINGS

.1 Submit shop drawings in accordance with E4.

.2 Submit shop drawings indicating capacity rating, physical dimensions, wiring diagrams, materials of construction, code compliance, etc. As indicated on schedules.

.3 Provide operating and maintenance manuals with complete description of product for incorporation into manual specified in Section 01 78 00 – Closeout Submittals.

### 1.6 QUALITY ASSURANCE

.1 HVAC fans shall be the product of manufacturer regularly engaged in production of such units who issues complete catalogue data on such products.

.2 Fans shall bear AMCA certified rating seal and CSA label

.3 Conform to AMCA Bulletins regarding construction and testing

## Part 2 Products

### 2.1 ACCEPTABLE MANUFACTURERS

.1 HVAC fans: Plasticair,

### 2.2 GENERAL

.1 Statically and dynamically balance fans so no objectionable vibration or noise is transmitted to areas of the building.

.2 Provide balanced variable sheaves for motors 11 kW (15 hp) and under and fixed sheave for 15 kW (20 hp) and over.

.3 Provide belt guards on belt driven fans complete with tachometer holes.

.4 Provide weatherproof housing where required or indicated.

**2.3 INLINE EXHAUST FANS**

.1 General

.1 The inline vane centrifugal fan is designed and constructed so that the corrosive gas stream only contacts solid FRP surfaces and minimal 316 stainless steel hardware as per AMCA Standards 99.

.2 Housing Construction:

.1 The fan housing shall be tubular flow through design.

.2 The method of construction is to be hand lay-up only. The entire surface of the inlet cone and housing exposed to the gas stream will be complete with a resin-rich corrosion barrier consisting of C-veil and a smooth finish minimum 90 mils thickness. All flanges are to have factory flat finishes. The outer surface of the housing will be of a heavy UV stabilised gel coat and grey in color.

.3 Fan housing shall be structurally designed to handle specified static pressure and reduce vibrations.

.4 The housing shall include a machined Teflon shaft seal to limit gas leakage.

.3 Impeller Construction:

.1 The impeller is to be of a high efficiency backward inclined, full width design. The material of construction is to be vinyl ester resin, premium quality Hetron 922, (option for 0-25 flame spread select Hetron FR992) and reinforcing glass throughout. The method of construction is to be hand lay-up only. The entire surface of the impeller exposed to the gas stream will be complete with a resin-rich corrosion barrier consisting of C-veil and a smooth finish minimum 90 mils thickness.

.2 Impellers must be constructed with clear resin to detect imperfections and ensure quality control. Pigmented impellers are not expectable unless graphite lined.

.3 The shaft is to be attached to the back-plate of the impeller by way of a taper lock bushing and a one-piece sprocket hub. The entire shaft attachment assembly is to be completely covered with a minimum 0.25"(6 mm) of FRP clear lay-up.

.4 Steel Fan Base:

.1 The bearing/shaft mounting assembly is to be constructed by forming heavy gauge steel. When forming is complete, steel is to be cleaned or sand blasted and coated with 4-5 mils of epoxy paint. Standard of acceptance: Intergard 345 two part epoxy – color to be grey.

.2 Threaded rod and fasteners shall be 316 stainless steel.

.5 Bearings:

.1 The type and mountings of Bearings shall be designed for a minimum of L10 – 115,000 hours. Bearings shall be ball or spherical roller type. Mountings shall be solid pillow block or split pillow block. The successful bidder shall supply with the submittal package, the bearing calculation.

.6 Shaft:

.1 Shaft material shall be; 316 stainless steel, complete with correct keyways to accept V-belt drive selections.

.2 The diameter of the shaft shall be sized to ensure that the critical speed of the fan is at least 25% above the fan operating speed.

.3 The impeller side of the shaft shall be complete with an FRP shaft sleeve, which is bonded to the back-plate of the impeller and protrudes through the housing. The outside diameter of the sleeve is machined to provide a minimum clearance gap with the Teflon shaft seal.

.7 Motor:

.1 Motor shall be EXP Explosion proof for 575/3/60.

.8 Belt Drive:

.1 V-belt drive shall be sized with a safety factor of 1.5 times the motor horsepower.

.2 An adjustable base will be provided under the motor to permit setting the belt tension.

.9 Guards:

.1 Weatherproof guards complying with OSHA standards will protect the shaft/bearings, motor and v-belt drives.

.10 Spark Resistant Construction

.1 Fan shall be constructed incorporating an electrically conductive layer of graphite within the gas contact corrosion barrier. Wheel and housing will be pigmented black.

.2 Grounding lugs and wire are to be used to provide a common grounding point for static electricity to safely purge.

.11 Balancing

.1 Balancing of the impeller shall be achieved only with the use of the identical material used to fabricate the impeller. Balancing shall be in accordance with ASTM D-4167.

.2 The fan shall be test run at operating speed and not shipped until vibration readings are within acceptable limits.

## Part 3 Execution

### 3.1 INSTALLATION

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

.2 Install fans complete with flexible electrical leads and flexible connections in accordance with Section 23 33 13 – Air Duct Accessories.

.3 Where inlet or outlet is exposed, provide safety screen.

.4 Supply and install sheaves as necessary for final air balancing.

**END OF SECTION**

## Part 1 General

### 1.1 SUMMARY

.1 Grilles and Diffusers

.2 Outside Louvers

### 1.2 RELATED SECTIONS

.1 Entire Specification – All areas of common work.

### 1.3 REFERENCES

.1 American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc. (ASHRAE).

### 1.4 QUALITY ASSURANCE

.1 Air flow tests and sound level measurement shall be made in accordance with applicable ADC equipment test codes, ASHRAE Standards and AMCA Standards.

.2 Unit rating shall be approved by ADC and AMCA.

.3 Manufacturer shall certify catalogued performance and ensure correct application of air outlet types.

.4 Outside louvers shall bear AMCA seal for free area and water penetration.

### 1.5 JOB CONDITIONS

.1 Review requirements of outlets as to size, finish and type of mounting prior to submitting shop drawings and schedules of outlets.

.2 Positions indicated are approximate only. Check locations of outlets and make necessary adjustments in position to conform to Architectural features, symmetry and lighting arrangement.

### 1.6 SHOP DRAWINGS

.1 Submit shop drawings in accordance with E4.

.2 Submit color selection charts of finishes, for approval prior to fabrication.

.3 Submit shop drawings with complete catalogue information, materials of construction, dimensions and accessories for all air outlets, louvers and components in this specification section, and as scheduled.

## Part 2 Products

### 2.1 ACCEPTABLE MANUFACTURERS

.1 Diffusers, Grilles: Titus, Price, Nailor.

.2 Outside Louvers: Aerolite, Westvent, Ruskin

### 2.2 GENERAL

.1 Refer to Grille and Diffuser Schedule and Louver Schedule on drawings.

**2.3 GRILLES AND DIFFUSERS**

.1 Base air outlet application on space noise level of NC 30 maximum.

.2 Provide grilles with sponge rubber seal around the edge.

.3 Provide baffles to direct air away from walls, columns or other obstructions within the radius of diffuser operation.

.4 Provide plaster frame for diffusers located in plaster surfaces.

.5 Provide anti-smudge frames or plaques on diffusers located in rough textured surfaces such as acoustical plaster.

.6 To meet capacity, pressure drop, terminal velocity, throw, noise level, neck velocity as indicated.

.7 Frames: Full perimeter gaskets or plaster frames where set into plaster or gypsum board and as specified.

.8 Concealed fasteners: manual volume control damper operators

.9 Color: standard or as indicated.

**2.4 OUTSIDE LOUVERS**

.1 Louvers 150 mm (6") deep with blades on 40° slope with double drainable blade and drainable heavy channel frame, birdscreen with 15 mm (½") square mesh. Equivalent to Ruskin ELF375DD 100 mm (4"), Ruskin ELF6811DD 150 mm (6").

.2 Fabricate of 2.0 mm (14 gauge) extruded aluminum blades and frame. Where openings exceed 1800 mm (72") in height, jamb frames shall be 2.0 mm (14 gauge). Provide welded assembly.

.3 Finish in factory baked enamel finish.

.4 Fabricate louvered penthouses with mitered corners and sheet roof reinforced with structural angles.

**2.5 GOOSENECKS**

.1 Fabricate goosenecks of minimum 1.3 mm (18 gauge) stainless steel steel.

.2 Mount on minimum 300 mm (12") high curb base where size exceeds 225 mm x 225 mm (9" x 9").

**Part 3 Execution**

**3.1 INSTALLATION**

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

.2 Install in accordance with manufacturers instructions.

.3 Install with oval head, cadmium plated screws in countersunk holes where fastenings are visible, if required.

**END OF SECTION**

## Part 1 General

### 1.1 SUMMARY

.1 Provide complete ionization / oxidation odor control system to neutralize odors from a typical wastewater collection system and treatment plant. Odorous gases can include, but are not limited to, hydrogen sulfide ($H_2S$), and ammonia ($NH_3$). Odor control locations as specified in the Schedule are as shown on the Drawings.

.2 All oxidation equipment, ducts, and installation supports shall be provided & installed by the contractor. All electrical work and connections shall be in accordance with Section 26.

.3 Oxidation equipment to be mounted on a wall structure as shown on the drawings. All duct connections and roof penetrations to be sealed water tight.

### 1.2 RELATED SECTIONS

.1 Entire Specification – All areas of common work.

### 1.3 REFERENCES

.1 National Fire Protection Association (NFPA).

.1 NFPA (Fire) 820-2008, Standard for Fire Protection in Wastewater Treatment and Collection Facilities.

### 1.4 QUALITY ASSURANCE

.1 Factory test all generators, blowers, and controls furnished. Check these components for mechanical correctness, structural correctness, and capacity.

.2 Perform Startup Procedures as in this Section.

### 1.5 SHOP DRAWINGS

.1 Submit shop drawings in accordance with E4.

.2 Closeout submittals: submit maintenance and engineering data for incorporation into manual specified in Section 01 78 00 – Closeout Submittals.

## Part 2 Products

### 2.1 ACCEPTABLE MANUFACTURERS

.1 Engineered Air

### 2.2 ODOR REMOVAL PROCESS DESCRIPTION

.1 The oxidation equipment shall break down or alter the molecular structure of gases by mixing charged oxygen with gaseous compounds to neutralize the odor component. The generator shall create charged oxygen using the high output corona plate principal and be injected into the gaseous stream on the negative pressure side of the air pathway to be treated. The equipment will have output regulation either manual or automatic to provide output adjustments for load change.

**2.3 PERFORMANCE CRITERIA**

.1 The device shall be sized in respect to the quantity of air exchange, taking into account the air dilution rate as specified. The device will be capable of neutralizing odors from Hydrogen Sulfide, Ammonia, and / or Volitale Organic Compounds (VOC), at a minimum average rate of 90-95% as measured by olfactory senses.

**2.4 OZONE GENERATOR / EXHAUST SYSTEM**

.1 Type: Dual-sided corona plate type, consisting of an alumina ceramic di-electric and stainless steel charging grid.

.2 Refer to Oxidizer schedule for technical data.

**2.5 GENERATOR HEADS**

.1 High output modular type with Max Head Transformer.

.1 Electrical: Input 0-120 VAC.

.2 Max Head Transformer: Current drain 1.0 amp, single oil-filled center tap transformer, secondary voltage 5500 VAC.

.2 Automatic Control: If scheduled, the ionization process shall be regulated by utilizing a sensor in the subject area to sense gas levels and automatically adjust the output production to one of 3 levels. Each level shall be field adjustable and factory set at 60%, 80%, and 100% levels.

**2.6 ENCLOSURES:**

.1 18 gauge 304 Stainless Steel

.2 All enclosures shall be manufactured as weathertight with a weatherproof door for both indoor and outdoor units.

**2.7 ELECTRICAL**

.1 120 VAC, single phase, 60 Hz (hard-wired) to none fused disconnect.

**2.8 FEATURES**

.1 Filter replacement indicator light.

.2 Safety interlock filter door.

.3 Unit mounted ozone output control.

.4 Unit Mounted NEMA 4X disconnect switch.

.5 3 Minute Purge Timer

.6 Air flow sensor to de-energize generator heads if blower fails.

.7 Lever Lock Cabinet handles.

.8 Solid state variable speed fan control.

.9 85%, 6” pleated inlet particulate filter system.

.10 Run time hour meter.

.11 Relay for external monitoring of a system fault . To open only when system blower is not running due to conditions other than manual shut down.

**2.9 OXIDANT BLOWER**

.1 Squirrel cage type, size per model type as scheduled. Totally enclosed as required.

**2.10 CONTACT CHAMBER**

.1 LM/SI

.1 Material to be minimum 304 Stainless Steel

.2 Back draft damper with operator will close air flow to contact chamber when exhaust blower is not operating

.3 Air turbulator included for air mixing made of stainless steel.

.4 Balance damper (s) provide to provide air balance between oxidizer section and intake air duct

.5 Magnahelic provide to assist in air balance.

**2.11 SPARE PARTS**

.1 Two (2) Filter Sets per unit.

.2 One (1) Spare plate per unit.

**Part 3 Execution**

**3.1 INSTALLATION**

.1 General: Install the equipment in accordance with the drawings and manufacturer's written instructions and as specified in this Section.

.1 Lubricate moving parts as recommended by the manufacturer's written instructions.

.2 Make sure that each piece of equipment and ductwork is securely anchored to the wall, support or its foundation. Also, make certain that all duct connections are tight. All units shall be securely anchored with stainless steel anchors. All units shall be level and plumb.

.2 All units shall be electrically hard-wired at the locations shown on the drawings.

**3.2 START-UP SERVICE AND MONITORING**

.1 A Factory Authorized Start Up Representative "Rep" shall check the installation, perform the equipment start-up, observe the equipment in operation and to instruct operating personnel in the operation and maintenance of the equipment.

.2 After all odor control equipment and accessories are completely installed, and the normal function of the equipment is present, the contractor shall make arrangements for the "Rep" to do the start-up service and monitoring. The contractor shall give reasonable notice to allow for the manufacturer's "Rep" to make arrangements for visiting the site to conduct these tests. If the manufacturer's "Rep" deems the conditions are not satisfactory for start-up and observation to submit the required report, the contractor shall bear the expense of additional site visits as required by the manufacturer's "Rep.

.3 Prior to start-up service and monitoring, testing and balancing on all ductwork and air moving equipment must be completed, the structure and surrounding conditions must be operating similar to a plant work day.

.4 Included in the start up procedure, the manufacturer's "Rep" will in addition to system operating check of current draw, air delivery, proper voltage to the generating heads, will witness the units operation under normal plant operating conditions.

**3.3 CLEANING**

.1 All equipment, components, and subassemblies shall be thoroughly cleaned of all water, sand, grit, grease, oil, and other foreign materials before preparation for shipment. It is required that the equipment be delivered in a rust-free condition. All machined surfaces shall be protected against physical damage and exposure to the elements during shipment.

.2 Pack equipment components, and subassemblies to provide ample protection from damage during shipment, handling, and storage. Cap and seal all openings.

**END OF SECTION**

## Part 1 General

### 1.1 RELATED SECTIONS

.1 Entire Specification – All areas of common work.

### 1.2 REFERENCES

.1 American Society of Heating, Refrigeration and Air-Conditioning Engineers (ASHRAE)
  .1 ANSI/ASHRAE 84-2008, Method of Testing Air-to-Air Heat Exchangers (ANSI approved).

### 1.3 GENERAL REQUIREMENTS

.1 Provide materials, equipment and labor to install Air Handling Unit as required by Provincial and Local Codes as specified herein.

.2 Conform to requirements NFPA (Fire) 90A-2009, Standard for the Installation of Air Conditioning and Ventilating Systems and Provincial and Municipal Codes.

### 1.4 SHOP DRAWINGS

.1 Submit shop drawings in accordance with E4.

.2 Submit shop drawings indicating capacity rating, physical dimensions, wiring diagrams, materials of construction, code compliance, etc. As indicated on schedules.

.3 Provide operating and maintenance manuals with complete description of product for incorporation into manual specified in Section 01 78 00 – Closeout Submittals.

### 1.5 QUALITY ASSURANCE

.1 Heat Recovery Equipment shall be the product of manufacturer regularly engaged in production of such units who issues complete catalogue data on such products.

## Part 2 Products

### 2.1 ACCEPTABLE MANUFACTURERS

.1 Heat Recovery Unit: Circul Aire, NU Air, Venmar

### 2.2 HEAT RECOVERY VENTILATOR (HRV-1)

.1 Cabinet: constructed double wall 0.76 mm galvanized steel outer finish suitable for outside.

.2 Heat Exchanger: plate type polypropylene cross-flow core with sensible energy transfer

.3 Blowers: Belt drive performance blowers FC DWDI with two speeds. Exhaust fan shall be TEFC motor and motor is out of exhaust air stream.

.4 50 mm pleated filters shall be located in each 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.

.5 Unit shall be equipped with face and bypass damper defrost system.

.6 The unit shall be equipped with a hinged access door that can be completely removed for unit service.

.7 The unit shall be equipped with a built-in, positive slope, aluminum drain pan and shall have a minimum of two (2) condensate drains plugs.

.8 Access door shall be equipped with a disconnect switch to disengage the motors when the door is opened.

**2.3 HOT WATER COILS: CLEANABLE FINS**

.1 Tubes: copper.

.2 Fins: aluminum plate.

.3 Headers: cast brass.

.4 Pressure tests: 1.7 MPa.

## Part 3 Execution

**3.1 INSTALLATION**

.1 Units are to be shipped in one-piece and shall be shrink wrapped to protect from water, dirt and road salt during shipping.

.2 Install unit in accordance with manufacturer's instructions.

.3 Insulate all piping as per Section 22 07 19 Piping insulation.

.4 Do not operate units for any purpose, temporary or permanent, until ductwork is clean, filters are in place, bearings lubricated, and fan has been test run under observation.

.5 Refer to Heat Recovery Ventilation Schedule on drawings.

**END OF SECTION**

## Part 1 General

### 1.1 SUMMARY

.1 Heating Coil

### 1.2 RELATED SECTIONS

.1 Entire Specification – All areas of common work.

### 1.3 REFERENCES

.1 American National Standards Institute/National Fire Prevention Association (ANSI/NFPA)

- .1 NFPA (Fire) 90A-2009, Standard for the Installation of Air Conditioning and Ventilating Systems.
- .2 CAN/CGSB 1.181-99, Ready-Mixed Organic Zinc-Rich Coating.

### 1.4 QUALITY ASSURANCE

.1 Coils shall be product of manufacturer regularly engaged in production of such units who issues complete catalogue data on such products.

### 1.5 SHOP DRAWINGS

.1 Submit shop drawings in accordance with E4.

## Part 2 Products

### 2.1 ACCEPTABLE MANUFACTURERS

.1 Rittling, Engineered Air

### 2.2 GENERAL

.1 Cleanable tube type: steel or cast iron headers and straight tubes.

.2 Plate fin type: tubes mechanically bonded to fins. Spiral wound fin type: mechanically bonded to tubes.

.3 Non-ferrous tubes and headers: brazed assembly.

.4 Factory tested with air under water.

### 2.3 CAPACITIES:

.1 Refer to Heating Coil schedule for technical data.

### 2.4 RATINGS:

.1 Unless otherwise indicated, heat coils rated for 2.5 m/s face velocity.

.2 Fluid Pressure drop through heating coils: 30 kPa maximum.

.3 Water velocity: 1.2 m/s maximum. Under 0.6 m/s, turbulators may be used if stated in manufacturer's standard practice.

**2.5 COIL CASINGS**

.1 Mounting: designed for duct mounting.

.2 Steel: die formed 1.6 mm thick galvanized steel sheet.

.3 Tube supports: allow for expansion and contraction.

.4 Supports: steel channel or double angle frames or other approved support. Provide brass supports for copper coils.

.5 Blank-off plates: of similar material as casing to prevent air bypass. Seal openings where pipes pass through casing using methods recommended by SMACNA.

**Part 3 Execution**

**3.1 INSTALLATION**

.1 Install coil in accordance with manufacturer's instructions and drawings.

.2 Support coil sections on steel channel or double angle frames and secure to casings. Arrange galvanized steel casings for bolting to other section, ductwork or unit casings. Provide airtight seal between coils and duct or unit cabinets.

.3 Make necessary connections to coils, including valves, air vents, unions and connections from drip pans. Provide isolating valve on supply line and eccentric plug valve on return line to each water coil.

.4 Locate water supply at bottom of supply header and return water connection at top to provide self-venting and reverse return arrangement. Provide manual air vents at high points complete with stop valves. Ensure water coils are drainable and provide drain connection at low points.

.5 Protect coils so fins and flanges are not damaged. Replace loose and damaged fins. Comb out bent fins unless required to be replaced.

.6 Connect drain pipe to nearest floor drain.

**END OF SECTION**

## Part 1 General

### 1.1 SUMMARY

.1 Unit Heater

### 1.2 RELATED SECTIONS

.1 Entire Specification – All areas of common work.

### 1.3 REFERENCES

.1 American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc. (ASHRAE).

### 1.4 QUALITY ASSURANCE

.1 Conform to requirements of CGA, CSA, Provincial and Municipal Codes and be CSA listed.

.2 Units shall be products of manufacturers who provide local service personnel from factory representative, franchised dealer or certified maintenance service shop.

.3 The unit shall be fully assembled, wired and tested prior to shipment. A detailed pre-shipment test report shall be provided to the Contract Administrator.

### 1.5 SHOP DRAWINGS

.1 Submit shop drawings in accordance with E4.

.2 Shop drawings shall include all of the following information but not limited:

- .1 Product characteristics.
- .2 Performance criteria.
- .3 Mounting methods.
- .4 Physical size.
- .5 kW rating, voltage, phase.
- .6 Cabinet material thicknesses.
- .7 Limitations.
- .8 Color and finish.

.3 Provide operating and maintenance manuals with complete description of installation and operation specified in Section 01 78 00 – Closeout Submittals.

## Part 2 Products

### 2.1 ACCEPTABLE MANUFACTURERS

.1 Rittling, Engineered Air

**2.2 UNIT HEATER**

.1 Coil: Heating element is designed for two-pipe hot water heating system. Coils are made up of 15 mm (½") nominal diameter seamless copper tubing and aluminum fins (12 fins per inch) which are die-formed with a thickness of no less than 3 mm. The fins have integral collars, which provide maximum heat transfer between the tubes and fin. The tubes are mechanically bonded to the fins to ensure permanent contact. Fins are continuous across width and depth of coil and are vertically oriented to resist collection of dirt and foreign particles. Coils are of non-ferrous construction and serpentine design. Headers have external threaded NPT connections. Coils are tested at 275 psig air under water. Coils are suitable for operating up to 1517 Kpa (220 psig) water and 190°C (375°F). Coils to be complete with Heresite coating.

.2 Casing: Casings on all horizontal units are 18-gauge steel and consist of top/back and side halves. Both halves are joined on top and back with Philips head screws. Top casing is furnished with threaded hanger connections for suspension of unit. Fan venturi is die-formed on back half. Casings to be complete with Heresite coating.

.3 Motor/Fan: Motors to be 115/60/1, totally enclosed, explosion proof; permanent split capacitor with thermal overload protection. Motors are designed to handle up to 40°C (104°F) maximum constant ambient temperature. Motor/fan combination is carefully chosen to minimize noise while maximizing air delivery. Fans have non-conducting aluminum blades, with a steel hub. Each fan blade is balanced and designed specifically for the unit of which it is installed within. Motor on RH models are attached to a standard finger-proof fan guard, constructed of steel rod. Air diffusion on RH models is accomplished through horizontal louvers.

.4 Supply with built-in thermostat.

.5 Refer to Unit Heater Schedule for technical data.

**Part 3 Execution**

**3.1 INSTALLATION**

.1 Install unit heater in accordance with manufacturer's instructions and drawings.

.2 Make power and control connections.

.3 Connect drain pipe to nearest floor drain.

**END OF SECTION**