

The Project Manual is bound in three separate volumes as follows:

Volume 1:	Project Specifications, Division 00 to Division 19
Volume 2:	Project Specifications, Division 20 to Division 29
Volume 3:	Project Specifications, Division 30 to Division 49

VOLUME 1

PROCUREMENT AND CONTRACTING REQUIREMENTS GROUP

Division 00 Procurement and Contracting Requirements

Introductory Information

00 01 01	Project Title Page
00 01 05	List Of Consultants
00 01 07	Seals Page
00 01 10	Table of Contents
00 01 15	List Of Drawings
00 01 20	List Of Schedules

Procurement Requirements

00 30 00	Available Information
----------	-----------------------

Contracting Requirements

Not Used

SPECIFICATIONS GROUP

GENERAL REQUIREMENTS SUBGROUP

Division 01 General Requirements

01 10 00	General Instructions
01 21 00	Allowances
01 29 00	Payment Procedures
01 30 00	Administrative Requirements
01 33 00	Submittal Procedures
01 35 43	Environmental Procedures
01 40 00	Quality Requirements
01 42 00	References
01 45 00	Testing And Inspection Services
01 45 16	General Requirements For Sound Control
01 50 00	Temporary Facilities And Controls
01 55 26	Traffic Control And Procedures
01 56 00	Temporary Barriers And Enclosures
01 57 00	Temporary Erosion And Sediment Control
01 60 00	Product Requirements
01 70 00	Execution Requirements
01 71 00	Examination And Preparation
01 77 00	Closeout Procedures
01 83 16	Exterior Enclosure Performance And Testing
01 95 00	Post Construction Survey

FACILITY CONSTRUCTION SUBGROUP

Division 02

Not Used

Division 03 Concrete

03 35 00 Concrete Floor Finishing

Division 04 Masonry

04 05 00 Common Work Results For Masonry
04 05 13 Masonry Mortar And Grout
04 05 19 Masonry Anchorage And Reinforcing
04 05 23 Masonry Accessories
04 22 00 Concrete Unit Masonry
04 26 13 Masonry Veneer

Division 05 Metals

05 41 00 Structural Steel Stud Framing System
05 50 00 Metal Fabrications

Division 06 Wood, Plastics, and Composites

06 10 00 Rough Carpentry
06 16 00 Exterior Gypsum Sheathing
06 40 00 Architectural Woodwork
06 61 16 Solid Polymer Fabrications
06 90 00 General Installations

Division 07 Thermal and Moisture Protection

07 11 00 Dampproofing
07 11 10 Underslab Vapour Retarder
07 21 00 Building Insulation
07 27 14 Impermeable Air Barriers
07 42 33 Solid Phenolic Panels
07 42 43 Aluminum Composite Panel System
07 42 46 Insulated-Core Metal Wall Panels (Non-Fire-Rated)
07 52 00 Modified Bituminous Sheet Roofing
07 61 13 Standing Seam Metal Roof Panels
07 62 00 Sheet Metal Flashing And Trims
07 84 10 Firestopping And Smoke Seals
07 92 00 Joint Sealants

Division 08 Openings

08 11 13 Steel Doors And Frames
08 14 16 Flush Wood Core Doors
08 34 16 Bi-Fold Hangar Doors
08 36 13 Exterior Sectional Overhead Doors
08 44 00 Curtain Wall
08 71 00 Finish Hardware
08 80 00 Glass And Glazing
08 91 00 Louvres

Division 09 Finishes

09 21 16 Gypsum Board
09 30 13 Ceramic Tile
09 51 00 Acoustic Tile Ceilings
09 65 13 Rubber Tile Flooring
09 65 30 Resilient Base And Accessories
09 65 36 Static Dissipative Resilient Flooring
09 65 66 Athletic Flooring

09 66 23	Seamless Resin Flooring
09 68 13	Carpet Tile
09 77 13	Acoustic Wall Panels
09 91 00	Painting

Division 10 Specialties

10 21 15	Phenolic Toilet Compartments
10 26 00	Wall Protection
10 28 00	Accessories
10 71 13	Exterior Sun Control Devices
10 75 00	Flagpoles

Division 11

Not Used

Division 12 Furnishings

12 23 14	Manual Roller Window Shades
12 35 71	Stainless Steel Casework

Division 13 Special Construction

13 34 24	Pre-Engineered Buildings
13 48 50	Seismic Control Assemblies For Operational And Functional Components

Division 14 to Division 19

Not Used

VOLUME 2

FACILITY SERVICES SUBGROUP

Division 20 Common Mechanical Requirements

20 05 00	Common Work Results for Mechanical
20 05 01	Pre-Tendered Mechanical Equipment
20 05 10	Mechanical Work General Instructions
20 05 13	Common Motor Requirements for Mechanical Equipment
20 05 13.13	Variable Frequency Drives for Mechanical Equipment
20 05 17	Sleeves and Sleeve Seals for Mechanical Piping
20 05 19	Meters and Gauges for Mechanical Systems
20 05 29	Hangers and Supports for Mechanical Piping and Equipment
20 05 33	Heat Tracing for Mechanical Piping
20 05 48.13	Vibration Controls for Mechanical Systems
20 05 48.16	Seismic Controls for Mechanical Systems
20 05 53	Identification for Mechanical Piping and Equipment
20 05 93	Testing, Adjusting, and Balancing for Mechanical Systems
20 07 00	Mechanical Systems Insulation
20 08 00	Commissioning of Mechanical Systems

Division 21 Fire Suppression

21 11 16	Facility Fire Hydrants
21 13 00	Fire-Suppression Sprinkler Systems
21 21 00	Carbon-Dioxide Fire-Extinguishing Systems

Division 22 Plumbing

22 05 69	Facility Plumbing Services
22 11 00	Facility Water Distribution
22 11 19.13	Potable Water Copper-Silver Ionization Systems
22 13 00	Facility Sanitary Sewerage
22 15 00	General Service Compressed-Air Systems
22 33 13	Instantaneous Electric Domestic Water Heaters
22 33 33	Electric Domestic Water Heaters
22 42 00	Commercial Plumbing Fixtures

Division 23 Heating, Ventilating, and Air Conditioning

23 09 13.51	Carbon Monoxide and Nitrogen Dioxide Detection Systems
23 11 23	Facility Natural-Gas Piping
23 11 23.13	Facility Natural-Gas Metering
23 21 00	Hydronic Piping and Pumps
23 23 00	Refrigerant Piping
23 25 00	HVAC Water Treatment
23 30 00	HVAC Air Distribution
23 33 19	Duct Silencers
23 34 00	HVAC Fans
23 51 19	Fabricated Stacks
23 51 23	Gas Vents
23 52 16	Condensing Boilers
23 57 00	Heat Exchangers for HVAC
23 74 13	Packaged, Outdoor, Central-Station Air-Handling Units
23 74 23	Packaged, Outdoor, Heating-Only Makeup-Air Units
23 81 26	Split-System Air-Conditioners
23 81 29	Variable Refrigerant Flow HVAC Systems

23 81 43	Air-Source Unitary Heat Pumps
23 82 16	Air Coils
23 83 16.16	In-Floor Radiant-Heating Hydronic Piping
23 83 17	Snow Melt Radiant-Heating Hydronic Piping
23 84 00	Humidity Control Equipment

Division 24

Not Used

Division 25 Integrated Automation

25 05 01	Automatic Control Systems
25 05 02	Building Automation System
25 96 00	Integrated Automation Control Sequences for Electrical Systems

Division 26 Electrical

26 05 00	Common Work Results for Electrical
26 05 19	Low-Voltage Electrical Power Conductors and Cables
26 05 23	Control-Voltage Electrical Power Cables
26 05 26	Grounding and Bonding for Electrical Systems
26 05 29	Hangers and Supports for Electrical Systems
26 05 33.13	Conduit for Electrical Systems
26 05 33.16	Boxes for Electrical Systems
26 05 43	Underground Ducts and Raceways for Electrical Systems
26 05 44	Sleeves and Sleeve Seals for Electrical Raceways and Cabling
26 05 44.13	Firestopping for Electrical Systems
26 05 48.13	Vibration Controls for Electrical Systems
26 05 48.16	Seismic Controls for Electrical Systems
26 05 53	Identification for Electrical Systems
26 05 73.16	Coordination Studies
26 05 73.19	Arc-Flash Hazard Analysis
26 05 83	Wiring Connections
26 08 00	Commissioning of Electrical Systems
26 08 32.16	Performance Checklist for Natural-Gas Generators
26 08 36	Performance Checklist for Automatic Transfer Switches
26 08 50	Commissioning of Lighting
26 09 19	Enclosed Contactors
26 09 23	Lighting Control Devices
26 22 13	Low-Voltage Distribution Transformers
26 24 16	Panelboards
<u>26 27 13</u>	<u>Electricity Metering</u>
26 27 16	Electrical Cabinets and Enclosures
26 27 26	Wiring Devices
26 27 26.13	Floor Box Assemblies
26 28 13	Fuses
26 28 16.02	Molded Case Circuit Breakers
26 28 16.16	Enclosed Switches
26 29 13	Enclosed Controllers
26 32 13.16	Gas-Engine-Driven Generator Sets
26 36 23.13	Bypass-Isolation Automatic Transfer Switches
26 43 13	Surge Protective Devices for Low-Voltage Electrical Power Circuits
26 51 19	LED Interior Lighting
26 52 13.13	Emergency Lighting
26 52 13.16	Exit Signs
26 56 19	LED Exterior Lighting

Division 27 Communications

27 05 28	Pathways for Communications Systems
27 05 28.01	Pathways for Communications Systems - Innerduct
27 05 28.61	Pathways for Access Control and Intrusion Detection
27 05 28.63	Pathways for Video Surveillance
27 05 36	Cable Trays for Communications Systems
27 05 44	Sleeves and Sleeve Seals for Communications Pathways and Cabling

Division 28 Electronic Safety and Security

28 08 46	Commissioning of Fire Detection and Alarm
28 46 13	Fire-Alarm Systems
28 46 15	Fire-Alarm System Sequences of Operation
28 46 21.12	Fire-Alarm Control Units
28 46 21.22	Fire-Alarm Remote Annunciators
28 46 21.24	Supervising Station Alarm Systems Communications Equipment
28 46 25	Fire-Alarm System Accessories
28 46 31	Fire-Alarm Initiating Devices
28 46 31.18	Carbon Monoxide Detection Sensors
28 46 31.31	Fire-Alarm Manual Initiating Devices
28 46 31.41	Fire-Alarm Supervisory Signal Initiating Devices
28 46 41	Fire-Alarm Notification Appliances
28 46 51	Fire-Alarm Supervised Interface Hardware
28 46 51.08	Fire-Alarm Supervised Interface Hardware for Openings
28 46 51.23	Fire-Alarm Supervised Interface Hardware for HVAC Systems
28 49 26	Emergency Call Systems for Universal Washrooms

Division 29

Not Used

VOLUME 3

SITE AND INFRASTRUCTURE SUBGROUP

Division 30

Not Used

Division 31 Earthwork

31 00 99	Earthwork For Minor Work
31 05 16	Aggregate For Earthwork
31 22 13	Rough Grading
31 22 16	Topsoil & Finish Grading
31 22 19	Finish Grading
31 23 33.01	Excavating, Trenching, And Backfilling
31 32 19.16	Geotextile Soil Stabilisation
31 63 30	Sewer Video Inspections

Division 32 Exterior Improvements

32 11 16.01	Granular Sub-Base
32 12 16	Asphalt Paving
32 16 00	Concrete Sidewalks, Curbs And Gutters
32 31 00	Fences And Gates
32 91 00	Sodding
32 92 00	Mechanical Seeding
32 92 23	Sodding
32 93 00	Trees, Shrubs & Groundcover

Division 33 Utilities

33 05 16	Maintenance Holes And Catch Basin Structures
33 14 16	Site Water Utility Distribution Piping
33 14 16	Subdrainage Piping
33 31 11	Site Sanitary Sewerage Gravity Piping
33 41 00	Storm Utility Drainage Piping

Division 34 to Division 39

Not Used

PROCESS EQUIPMENT SUBGROUP

Not Used

END OF DOCUMENT

PART 1 - GENERAL

1.1 SUBMITTALS

- .1 Submit shop drawings/product data sheets for all products specified in this section, except piping and valves.

1.2 CLOSEOUT SUBMITTALS

- .1 Submit a letter from compressor manufacturer/supplier to certify proper compressor set installation as specified in Part 3 of this section.
- .2 Training attendance records.

1.3 QUALITY ASSURANCE

- .1 Compressed air piping system work is to be in accordance with the following:
 - .1 CSA B51, Boiler, Pressure Vessel, and Pressure Piping Code;
 - .2 ASME B31, Standards of Pressure Piping;
 - .1 ASME-B31.1 – Power Piping.
 - .3 ASME/ANSI B16 - Standards for Pipes and Fittings.
 - .4 and governing Provincial and/or Municipal Codes and Regulations.
 - .1 O.Reg. 220/01 - Boiler and Pressure Piping Regulation.

PART 2 - PRODUCTS

2.1 PIPE, FITTINGS AND JOINTS

- .1 Galvanized Steel
 - .1 Schedule 40 mild steel, galvanized, ASTM A53, screwed, complete with Class 125 galvanized cast iron screwed fittings and screwed joints.
- .2 Copper
 - .1 Type "L" hard drawn seamless copper to ASTM B88, complete with forged solder type fittings to suit pipe, and soldered joints using 95% tin / 5% Antimony solder.

2.2 PIPING UNIONS

- .1 Screwed Steel Piping
 - .1 Malleable iron, galvanized, ground joint, brass to iron or bronze to bronze seat unions and union elbows with a minimum pressure rating of 1725 kPa (250 psi) steam at 260°C (500°F).
- .2 Soldered Copper Piping
 - .1 Solder-on forged copper or bronze screwed unions suitable in all respects for the application.

2.3 LOW PRESSURE SHUT-OFF VALVES

- .1 Class 600, 4140 kPa (600 psi) WOG rated full port ball valves, each complete with a forged brass or bronze body with solder joint or screwed joint ends as required, forged brass cap and blowout-proof stem, forged brass chrome plated ball, "Teflon" or "PTFE" seat, and a removable lever handle.
- .2 Manufacturers:
 - .1 Toyo Valve Co. Fig. 5049A solder or Fig. 5044A screwed;
 - .2 Watts Industries (Canada) Ltd. #FBV-3 or #FBVS-3;
 - .3 Kitz Corporation Code 59 solder or Code 58 screwed;
 - .4 Apollo Valves #70-100 screwed or #70-200 solder.

2.4 HIGH PRESSURE SHUT-OFF VALVES

- .1 Equal to Apollo Valves #70-100-27, 4140 kPa (600 psi) rated Class 600, screwed bronze ball valve with a PTFE seat, automatic relief vent, and removable lever handle.

2.5 DRAIN VALVES

- .1 Minimum 2070 kPa (300 psi) water rated, 20 mm ($\frac{3}{4}$ ") dia. straight pattern full port bronze ball valves, each complete with a threaded outlet suitable for coupling connection of 20 mm ($\frac{3}{4}$ ") dia. garden hose, and a cap and chain.
- .2 Manufacturers:
 - .1 Toyo Valve Co. Fig. 5046;
 - .2 Kitz Corporation Code 58CC;
 - .3 Apollo Valves #78-100 or #78-200;
 - .4 Watts Industries (Canada) Ltd. #B6000-CC.

2.6 AIR COMPRESSOR SET

- .1 "Campbell Hausfeld", CE5002 compressor features a cast iron, oil lubricated 2 stage pumps. 175 PSI max pressure, 7.6 SCFM @ 90 PSI. 60-gallon ASME vertical tank design. Induction engine. ASME, UL, CSA certified.
- .2 Compressor set model number, performance and electrical characteristics as follows:
 - .1 model number: WBB2764020
 - .2 motor characteristics: 3.7 HP, 230 volts, 1 phase;
 - .3 tank capacity: 60 GAL
- .3 Each compressor complete with:
 - .1 cast iron cylinders, heads, crankcase, and cast iron connecting roads with replaceable automotive type insert bearings;
 - .2 cast iron crankshaft supported on both ends by oversized tapered roller bearings;
 - .3 pressure type oil lubrication with oil sight gauge;
 - .4 steel inlet and discharge valves, and a high efficiency intercooler with steel fins on copper tubes;
 - .5 heavy-duty dry type inlet filter-silencer;

- .6 high volume, statically balanced flywheel/cooing fan;
- .7 motor conforming to requirements specified in Section 20 05 00 – Common Work Results for Mechanical, on an adjustable support base, and V-belt drive with OHSA type steel belt guard, also as specified in Basic Mechanical Materials and Methods.
- .4 Welded steel receiver including an ASME rated tank in accordance with CSA B51 and TSSA requirements, complete with welded steel support feet, and following:
 - .1 ASME rated safety relief valve;
 - .2 positive seating ball type outlet valve, a screwed union, and a length of braided metallic flexible connection;
 - .3 pressure gauge with gauge cock;
 - .4 adjustable pressure switch for automatic start-stop operation of the compressors;
 - .5 valved manual tank drain, and an automatic tank drain;
 - .6 properly sized neoprene-steel-neoprene vibration isolating mounting pads;
 - .7 braided stainless steel flexible pipe connectors supplied loose.
- .5 Surface wall mounting power and control panel in a NEMA 1 (NEMA 2 if room is sprinklered) enamelled steel enclosure with a hinged (piano hinge) lockable front door, door interlock disconnect switch, and following:
 - .1 overload protected across-the-line, non-reversing magnetic starter, and a door mounted H-O-A switch for each motor, in accordance with Section 20 05 00 – Common Work Results for Mechanical;
 - .2 fused control transformer;
 - .3 electronic alternator to automatically alternate lead compressor after each start cycle, and to automatically start lag compressor should the lead compressor fail to start;
 - .4 door mounted "power on" LED for panel and door mounted "run" LED for each compressor;
 - .5 terminal block and strips for power and control wiring connections, including control wiring from receiver mounted pressure switch.
- .6 Manufacturers:
 - .1 CompAir Kellog;
 - .2 Atlas Copco Compressors Canada;
 - .3 DeVair Systems.
 - .4 Campbell Hausfeld.

PART 3 - EXECUTION

3.1 INSTALLATION OF AIR COMPRESSOR SET

- .1 Provide an air compressor set.
- .2 Secure set in place on vibration isolation on a concrete housekeeping pad.
- .3 Ensure housekeeping pad is keyed to structure, and compressor assembly is secured to structure by slack cable restraints. Refer to Section 20 05 48.16 - Seismic Controls for Mechanical Systems.
- .4 Install accessories shipped loose with set, except power and control panel.

- .5 Extend type DWV soldered hard copper drainage piping from tank drain assemblies to nearest floor drain.
- .6 Hand power and control panel to electrical trade at site for mounting and power wiring connections as part of electrical work.
- .7 Connect receiver pressure switch to starter and control panel with wiring in conduit to the standards of the electrical work and in accordance with panel supplier's instructions.
- .8 Touch-up paint any damage to the factory finish.

3.2 INSTALLATION OF PIPING AND PIPING SYSTEM COMPONENTS

- .1 Provide required compressed air piping. Unless otherwise specified, install horizontal piping to outlets 1.5 m (5 feet) above finished floor level.
- .2 Pipe is to be Schedule 40 mild galvanized steel, screwed, or type "L" hard copper, soldered.
- .3 Support and secure piping generally as specified in Section 20 05 00 – Common Work Results for Mechanical, but with extra support and securing hardware as required to prevent drumming. Provide rigid supports at each side of outlets.
- .4 Arrange piping so condensate will drain from mains and branches into drip legs. Provide drip legs at bottom of risers, every 30 m (100') of pipe run, and at the end of each branch piping run, whether indicated on drawings or not.
- .5 Drip legs are to extend down from bottom of pipe and consist of a piping tee and 250 mm (10") long pipe nipple same size as main or branch pipe, then a reducing fitting (if required) and 12 mm (½") dia. piping extended down to floor level and terminated with a ball valve. Ensure drain points are easily accessible and identified.
- .6 Extend branch piping to outlets and/or equipment off the top of the main(s).
- .7 Provide shut-off valves in piping at all equipment connections, to isolate piping components for removal or maintenance, and wherever else specified or shown. Provide vented type valves between air compressor set and pressure reducing stations.
- .8 Provide unions in piping at connections to equipment.
- .9 When piping is complete and has been pressure tested, but before connection of outlets, blowout piping to remove oil and foreign matter.
- .10 Provide adjustable pressure regulators, filters, compressed air outlets, etc. Unless otherwise indicated locate outlets 1.5 m (5 feet) above floor and properly secured in place. Provide a hose hanger at each outlet location. Confirm exact location of piping components prior to roughing-in.

3.3 SYSTEM STARTUP

- .1 For equipment/system start-up requirements, refer to Section 20 05 00 – Common Work Results for Mechanical.
- .2 For equipment/system manufacturer certification requirements, refer to Section 20 05 00 – Common Work Results for Mechanical. Submit a copy of the letter prior to Substantial Performance of the Work.

3.4 CLOSEOUT ACTIVITIES

- .1 Include for 4 hours of on-site training for 2 groups of 6 people. Training is to be a full review of all components including but not limited to a full operation and maintenance demonstration, with abnormal events.

END OF SECTION

PART 1 - GENERAL

1.1 RELATED REQUIREMENTS

- .1 Section 23 21 00 – Hydronic Piping and Pumps.

1.2 DESCRIPTION OF WORK

- .1 Supply and install a complete hydronic snow melting system consisting of (but not limited to) the following main components:
 - .1 A gas-fired heating plant including boilers, pumps, expansion tanks, glycol fill equipment and accessories serving snow melting system and floor radiant heating system;
 - .2 Snow melting embedded tubing;
 - .3 Piping distribution for the heating agent, including manifolds, valves, gauges and accessories;
 - .4 Valve and manifold concrete chambers;
 - .5 A digital control system to be tied into the Owner's building automation;
 - .6 Ancillary drainage, water make-up and accessories; and
 - .7 All power supply and control wiring required to make the system fully operational.
- .2 Complete design of the snow melting system, including calculation, layouts and schematic drawings to show control sequence, equipment layout, tubing patterns, manifold locations, appropriate cross-sections and special installation techniques to suit final architectural requirements and layout as required by code, standards and Authorities Having Jurisdiction.
- .3 Misinterpretation of any requirement of the drawings and specifications will not relieve the contractor of responsibility. If in any doubt, the contractor shall contact the Consultant for written clarification prior to submitting a bid for the Work.
- .4 Wherever differences occur between specifications, plans, schematics and drawings, the maximum conditions shall govern and the bid shall be based on whichever indicates the greater cost
- .5 In addition to the Work specifically mentioned in the Specifications and shown on the drawings, provide all other items that are obviously necessary to make a complete working installation, including those required by the Authorities Having Jurisdiction over the Work.

1.3 SUBMITTALS

- .1 Submit shop drawings and/or product data sheets for following:
 - .1 cross-linked polyethylene (PEX) floor heating grid tubing, fittings and accessories, manifold assembly, control components and controls;
 - .2 copies of system manufacturer's loop layout design printouts indicating water flows and temperatures, floor profiles with floor covering(s), and heating outputs;
 - .3 certified tubing and piping layout and schematic for each system zone;
 - .4 certified power wiring schematic and a certified control wiring schematic with sequence of operation for each system zone;
 - .5 letter from system component manufacturer stating system components proposed meet all requirements of the Specification.

- .2 Submit to the Consultant shop drawings, calculation and report for the snow melting system. Further details and special requirements called for in these specifications shall be shown on the shop drawings.
- .3 Submit Product data of all mechanical equipment including but not limit to:
 - .1 Boilers;
 - .2 Burners;
 - .3 Boiler Controls;
 - .4 Glycol automatic fill station;
 - .5 Expansion tank; and
 - .6 Pumps.
- .4 Provide mechanical layout and schematic drawing indicating heat source, mechanical piping and accessories from heat source to manifolds, circulators, water tempering and zone controls. Indicate primary loop and second loop's supply and return water temperatures and flow rates to manifolds.
- .5 Provide installation drawings indicating tubing layout, manifold locations, zoning requirements and manifold schedules with details required for installation of the snow melting system.
- .6 Indicate piping, valves and fittings shipped loose by packaged equipment supplier, showing their final location in field assembly. Submit selection and verification samples of piping.
- .7 Provide control schematic drawing and detailed sequence of operation for snow melting system.
- .8 Provide samples of mechanical equipment as requested in the Specification at the same time as the shop drawing submission.
- .9 Ensure that copies of all reviewed shop drawings are available on the job site for reference.

1.4 CLOSEOUT SUBMITTALS

- .1 Submit, prior to Substantial Performance of the Work, start-up or test data specified in Part 3 of this section.
- .2 Submit letters of installation certification from system manufacturer's representative as specified in Part 3 of this section.
- .3 Training attendance records.

1.5 AS-BUILT DRAWINGS

- .1 Maintain up to date "as built" drawings on site and submit to the Consultant at completion of the Project as specified in this Section
- .2 Any subsequent changes found by the Consultant shall remain the responsibility of the Contractor at no charge to the Owner.

1.6 QUALITY ASSURANCE

- .1 Radiant heating system is to be installed by journeyman tradesmen with a minimum of 3 years successful installation of PEX radiant floor system components supplied by manufacturer of components.

- .2 Prior to installation of system components, meet on-site with system component manufacturer's representative and trades whose work is related to successful installation of system(s) to confirm floor areas involved are ready for tubing installation.
- .3 Unless a written order reviewed by the Consultant and countersigned or otherwise approved by the Owner, no additional work shall be undertaken by the Contractor.

1.7 WARRANTY

- .1 Submit, at Substantial Performance of the Work, a non-prorated transferable repair or replacement warranty in name of Owner, issued by and signed by system component manufacturer covering materials against failure due to defects in material and/or workmanship as follows:
 - .1 PEX tubing, 25 years;
 - .2 manifold assemblies, 5 years;
 - .3 controls and electrical components, 2 years.
- .2 All tubes, supply lines, and return lines shall carry a twenty-five (25) year non-prorated warranty against failure due to defect in material and/or workmanship.
- .3 The complete system shall be covered by a two (2) year warranty against failure due to defect in materials and/or workmanship.
- .4 The complete system shall be covered by a ten (10) year limited system performance warranty. This warranty requires that the system detailed design, supervision, commissioning, and witnessing all pressure tests shall be performed by Authorized personnel employed by system supplier.
- .5 All warranty periods are measured from date of Substantial Performance of the Work.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- .1 Uponor Inc.;
- .2 Wirsbo;
- .3 Stadler

2.2 CROSSLINKED POLYETHYLENE TUBING

- .1 Cross-linked polyethylene (PEX) manufactured by the "Engle method". Manufactured in accordance with ASTM F876 and ASTM F877 and tested for compliance by an independent third-party agency. Show compliance with ASTM E119 and ANSI/UL 263 through certification listings through UL.
- .2 Standard grade hydrostatic design and pressure ratings as issued by the Plastics Pipe Institute (PPI), a division of the Society of the Plastics Industry (SPI).
- .3 Minimum bend radius (cold bending) shall be no less than six times the outside diameter. Manufacturer's bend supports must be used if radius is less than stated.
- .4 Oxygen Diffusion Barrier:
 - .1 Not exceed an oxygen diffusion rate of 0.10 grams per cubic meter per day at 40°C (104°F) water temperature in accordance with German DIN 4726;

.2 Provide tubing with nominal inside diameter in accordance with ASTM F876, as indicated.

.1 12.7 mm ($\frac{1}{2}$ ").

.2 19 mm ($\frac{3}{4}$ ").

.3 25 mm (1").

2.3 HEATING AGENT DISTRIBUTION PIPING

- .1 All piping between the exterior wall of the boiler room and the interior wall of the distribution manifolds chamber(s) to be pre-insulated pipe system for buried commercial hydronic heating applications.
- .2 Pipes to be Cross linked polyethylene (PEX-a) Engel-method tubing with an EVOH oxygen barrier that conforms to German DIN 4726; smoothness value of 0.02 mil; NSF certified SDR-9.
- .3 Pipes insulated with Multilayered, closed-cell, PEX-foam insulation with a thermal conductivity of 0.26 BTU in./sq. ft./hour/°F; vapor permeability of 0.1g/100 sq. in./day
- .4 Cover jacket for insulated piping to be Corrugated seamless high-density polyethylene (HDPE), UV- protected.
- .5 Operating Limits:
 - .1 -50°C to 95°C (58°F to 203°F) at 87 psig.

2.4 MAIN HOT WATER PIPING AND FITTING

- .1 Exposed hot water heating piping inside the boiler room shall be standard black carbon steel schedule 40 to ASTM A-53. Up to 50 mm (2") threaded with 1,050 kPa (150 psi) malleable iron fittings, 65 mm (2 $\frac{1}{2}$ ") and up shall be welded, Victaulic grooved or flanged 150 psi welded.
- .2 All fittings, elbows, steel copper brass transitions, shrink caps, and miscellaneous items to be compression type and supplied by the pipe manufacturer.

2.5 MANIFOLDS (COMMERCIAL, VALVED COPPER)

- .1 Use 2" valved copper manifolds manufactured from Type L copper material, offered by the respective PEX tubing manufacturer. Valving shall include ball isolation valves.
- .2 Ensure manifold end cap offers tapping for $\frac{1}{8}$ " FNPT and $\frac{1}{2}$ " FNPT for vent and drain.
- .3 Install supply and return piping to the manifold in a reverse-return configuration to ensure self-balancing.
- .4 Use manifolds with an isolation valve on each outlet.
- .5 Use manifolds that support PEX tubing.
- .6 If the supply and return piping is in direct-return configuration, install and balance flow setters on the return leg of each manifold to the mains.

2.6 HEPEX SNOW MELTING TUBING

- .1 Section Includes: Hydronic snow and ice melting systems for various slab constructions and control strategies, using cross-linked polyethylene (PEX) tubing and applicable fittings.
- .2 Material: Cross-linked polyethylene (PEX) manufactured by the "Engle method".

- .3 Material Standard: Manufactured in accordance with ASTM F876 and ASTM F877 and tested for compliance by an independent third-party agency
- .4 Pressure Ratings: Standard grade hydrostatic design and pressure ratings as issued by the Plastics Pipe Institute (PPI), a division of the Society of the Plastics Industry (SPI).
- .5 Show compliance with ASTM E119 and ANSI/UL 263 through certification listings through UL.
- .6 Minimum Bend Radius (Cold Bending): No less than six times the outside diameter. Use the PEX tubing manufacturer's bend supports if radius is less than stated.
- .7 Standard of Acceptance: Upnor, Wirsbo, Stadler or approved equivalent
- .8 Oxygen Diffusion Barrier:
 - .1 The oxygen diffusion barrier does not exceed an oxygen diffusion rate of 0.10 grams per cubic meter per day at 40°C (104°F) water temperature in accordance with German DIN 4726; and
 - .2 Nominal Inside Diameter: Provide tubing with nominal inside diameter in accordance with ASTM F876, as indicated.
 - .1 12.7 mm (½").
 - .2 19 mm (¾").
 - .3 25 mm (1").
- .9
- .10 Insulation:
 - .1 Use a 100 mm (4") rigid layer of Styrofoam insulation under the tubing ([per structural drawings](#))
- .11 Installer's Experience:
 - .1 The installing Contractor shall have a minimum of ten (10) years of demonstrated experience on projects of similar size and complexity in Ontario.
- .12 Glycol/Water Solution:
 - .1 The heating fluid shall be premixed glycol/water solutions. PEX tubing manufacturer allows site-mixed solutions if mixed to the proper concentration before entering the system.
 - .2 Mix the glycol/water solution to proper concentration levels to protect the system freezing during operation shutdown.
 - .3 System circulators must operate continuously for a minimum of thirty (30) days after the system is filled to ensure the glycol and water does not separate in a static system.
 - .4 Do not use ethylene glycol due to toxicity issues. Instead, use of propylene glycol. Also, refer to the boiler manufacturer's recommendations.
- .13 Field Quality Control:
 - .1 Site Tests:
 - .1 To ensure system integrity, pressure test the system before covering tubing in concrete or when other trades are working in the vicinity of the tubing.
 - .2 Test all electrical controls in accordance with respective installation manuals.
- .14 Cleaning:
 - .1 Remove temporary coverings and protection of adjacent work areas.

- .2 Repair or replace damaged installed products.
- .3 Clean installed products in accordance with manufacturer's instructions prior to owner's acceptance.
- .4 Remove construction debris from project site and legally dispose of debris.
- .15 Demonstration:
 - .1 Demonstrate operation of hydronic snow and ice melting system to Owner's personnel.
 - .2 Advise the Owner about the type and concentration of glycol/water solution used in the hydronic snow and ice melting system.
 - .3 The Owner monitors the solution effectiveness through an established maintenance program as outlined by the glycol manufacturer.
- .16 Protection:
 - .1 Protect installed work from damage caused by subsequent construction activity.

2.7 FITTINGS

- .1 Use fittings, connectors, wall sleeves and other accessories offered by the PEX tubing manufacturer, including connectors to metallic piping
- .2 The fitting assembly must comply with ASTM F877 and CAN/CSA-B137.5 requirements
- .3 Fitting assembly manufactured from UNS C3600 series brass material.
- .4 Fitting assembly consists of a barbed insert, a compression ring and a compression nut. The barbed insert is manufactured with an o-ring to facilitate air pressure testing.
- .5 Fittings manufactured in accordance with ASTM F1960.
- .6 Fitting assembly manufactured from material listed in paragraph 5.1 of ASTM F1960.
- .7 The fitting assembly consists of a barbed adapter and an applicable sized PEX ring. The barbed insert may include an o-ring to facilitate pressure testing with air.

2.8 MANIFOLD CHAMBER

- .1 Pre-cast or poured in place concrete. Footprint and depth sized to avoid classification as "confined space". Coordinate with Structural Division.
- .2 Access doors
 - .1 Cover and frame to be constructed out of 6.35mm (1/4") aluminum. Cover to be checkered plate type, reinforced for 150 psf (732 kg/m²), live load. Frame to be extruded aluminum with built-in anchor flange around the perimeter.
 - .2 Continuous heavy-duty type 316 stainless steel hinges.
 - .3 Type 316 stainless steel slam lock latch with fixed interior handle and removable exterior turn/lift handle. Latch release is protected by a flush, gasketed, removable screw plug.
 - .4 Engineered composite compression spring operators enclosed in telescopic tubes. Automatic hold-open arm with grip handle release. Steel compression springs with electro coated acrylic finish
 - .5 Access doors to be finished with mill finish aluminum with a bituminous coating applied to the exterior of the frame.

2.9 GLYCOL AUTOMATIC FILL STATION

- .1 Install in accordance to the manufacturer's instruction. Provide concrete support pad.
- .2 Connect to power supply and controls; including tie-in to the Owner's building automation system.
- .3 Start-up and adjustment: by equipment manufacturer. Cost to be covered by the Contractor.

2.10 CONCRETE

- .1 All concrete work required to complete this Project, whether shown on the drawings or not, shall be the Contractor's responsibility.

2.11 METALS

- .1 All steel construction required for the completion of this Project, whether shown on the drawings or not, shall be the Contractor's responsibility.

2.12 CUTTING, PATCHING, ROOFING AND X-RAY

- .1 All cutting, patching, roofing and X-Rays required for the completion of this Project whether shown on the drawings or not, shall be the Contractor's responsibility. The cutting and patching work shall be performed in accordance with the following.

2.13 ACCESSORIES

- .1 Non-ferrous sleeves shall be provided wherever tubing enters and exits the floor.
- .2 Bend supports shall be provided for all 90° elbows.

2.14 VALVES

- .1 Asbestos packing is not acceptable
- .2 All valves of the same type shall be products of a single manufacturer. Provide gate and globe valves with packing that can be replaced with the valve under full working pressure.
- .3 Provide chain operators for valves 100 mm (4") and larger when the centerline is located 2,400 mm (8') or more above the floor or operating platform.
- .4 Standard of Acceptance: Crane, Jenkins, Toyo, Kitz or approved equivalent.
- .5 Gate Valves:
 - .1 50 mm (2") and smaller: MSS SP80, bronze, 1,034 kPa (150 lb.), wedge disc, rising stem, union bonnet.
 - .2 65 mm (2 ½") and larger: Flanged, outside screw and yoke.
 - .3 MSS SP 70, iron body, bronze mounted, 861 kPa (125 psig) wedge disc.
- .6 Globe, Angle and Swing Check Valves:
 - .1 50 mm (2") and smaller: MSS SP 80, bronze, 1034 kPa (150 lb.) Globe and angle valves shall be union bonnet with metal plug type disc.
 - .2 65 mm (2 ½") and larger: 861 kPa (125 psig), flanged, iron body, bronze trim, MSS SP 85 for globe valves and MSS SP 71 for check valves.

- .3 Non Slam or Silent Check Valve: Spring loaded double disc swing check or internally guided flat disc lift type check for bubble tight shut off. Provide where check valves are shown in chilled water and hot water piping.
- .4 Body: Cast iron, ASTM A126, Class B, or steel, ASTM A216, Class WCB, or ductile iron, ASTM 536, flanged, grooved, or wafer type.
- .5 Seat, disc and spring: 18-8 stainless steel, or bronze, ASTM B62. Seats may be elastomer material.
- .7 Butterfly Valves:
 - .1 May be used in lieu of gate valves. Provide stem extension to allow 50 mm (2") of pipe insulation without interfering with valve operation.
 - .2 MSS SP 67, flange lug type (for end of line service) or grooved end rated 1205 kPa (175 psig) working pressure at 93°C (200°F).
 - .3 Body: Cast iron, ASTM A126, Class B. Malleable iron, ASTM A47 electro-plated, or ductile iron, ASTM A536, Grade 65 45 12 electro-plated.
 - .4 Trim: Bronze, aluminum bronze, or 300 series stainless steel disc, bronze bearings, 316 stainless steel shaft and manufacturer's recommended resilient seat. Resilient seat shall be field replaceable, and fully line the body to completely isolate the body from the product. A phosphate coated steel shaft or stem is acceptable, if the stem is completely isolated from the product.
 - .5 Actuators: Field interchangeable. Valves for balancing service shall have adjustable memory stop to limit open position.
 - .6 Valves 150 mm (6") and smaller: Lever actuator with minimum of seven (7) locking positions, except where chain wheel is required.
 - .7 Valves 200 mm (8") and larger: Enclosed worm gear with handwheel, and where required, chain wheel operator.
- .8 Ball Valves:
 - .1 Brass or bronze body with chrome-plated ball with full port and Teflon seat at 2,760 kPa (400 psig) working pressure rating. Screwed or solder connections. Provide stem extension to allow operation without interfering with pipe insulation.
- .9 Water Flow Balancing Valves:
 - .1 For flow regulation and shut off. Valves shall be line size rather than reduced to control valve size and be one of the following types.
 - .2 Butterfly valve as specified herein with memory stop.
 - .3 Eccentric plug valve: Iron body, bronze or nickel plated iron plug, bronze bearings, adjustable memory stop, operating lever, rated 861 kPa (125 psig) and 121°C (250°F).
- .10 Circuit Setter Valve:
 - .1 A dual purpose flow balancing valve and adjustable flow meter, with bronze or cast iron body, calibrated position pointer, valved pressure taps or quick disconnects with integral check valves and preformed polyurethane insulating enclosure. Provide a readout kit including flow meter, readout probes, hoses, flow charts or calculator, and carrying case.
- .11 Automatic Balancing Control Valves:
 - .1 Factory calibrated to maintain constant flow ($\pm 5\%$) over system pressure fluctuations of at least ten (10) times the minimum required for control. Provide standard pressure taps and four sets of capacity charts. Valves shall be line size and be one of the following designs.

- .2 Gray iron (ASTM A126) or brass body rated 1205 kPa (175 psig) at 93°C (200°F), with stainless steel piston and spring.
- .3 Brass or ferrous body designed for 2067 kPa (300 psig) service at 121° C (250°F), with corrosion resistant, tamper proof, self-cleaning piston/spring assembly that is easily removable for inspection or replacement.
- .4 Brass or ferrous body designed for 2067 kPa (300 psig) service at 121°C (250°F), with corrosion resistant, tamper proof, self-cleaning piston/spring assembly that is easily removable for inspection or replacement.
- .5 Provide a readout kit including flow meter, probes, hoses, flow charts and carrying case.

PART 3 - EXECUTION

1.1 DESCRIPTION OF WORK

- ~~.1 Supply and install a complete hydronic snow melting system consisting of (but not limited to) the following main components:~~
 - ~~.1 A gas-fired heating plant including boilers, pumps, expansion tanks, glycol fill equipment and accessories serving snow melting system and floor radiant heating system;~~
 - ~~.1 Snow melting embedded tubing;~~
 - ~~.1 Piping distribution for the heating agent, including manifolds, valves, gauges and accessories;~~
 - ~~.1 Valve and manifold concrete chambers;~~
 - ~~.1 A digital control system to be tied into the Owner's building automation;~~
 - ~~.1 Ancillary drainage, water make up and accessories; and~~
 - ~~.1 All power supply and control wiring required to make the system fully operational.~~
- ~~.1 Complete design of the snow melting system, including calculation, layouts and schematic drawings to show control sequence, equipment layout, tubing patterns, manifold locations, appropriate cross sections and special installation techniques to suit final architectural requirements and layout as required by code, standards and Authorities Having Jurisdiction.~~
- ~~.1 Misinterpretation of any requirement of the drawings and specifications will not relieve the contractor of responsibility. If in any doubt, the contractor shall contact the Consultant for written clarification prior to submitting a bid for the Work.~~
- ~~.1 Wherever differences occur between specifications, plans, schematics and drawings, the maximum conditions shall govern and the bid shall be based on whichever indicates the greater cost.~~
- ~~.1 In addition to the Work specifically mentioned in the Specifications and shown on the drawings, provide all other items that are obviously necessary to make a complete working installation, including those required by the Authorities Having Jurisdiction over the Work.~~

3.1 INSTALLATION

- .1 Comply with manufacturer's product data, including product technical bulletins, installation instructions and design drawings.

- .2 Verify that site conditions are acceptable for installation of the snow melting system. Do not proceed with installation of the snow and ice melt system until unacceptable conditions are corrected.
- .3 Slab-on-grade Construction with Edge and Under-slab Insulation:
 - .1 When using high-density foam insulation board, install the tubing by [wire tie to rebar](#).
 - .2 The submitted snow-melt design shall specify the tubing on-center distance(s) and loop lengths, based on output and tubing diameter. On-center distances will not exceed 305 mm (12").
 - .3 Do not install tubing closer than 152 mm (6") from the edge of the heated slab.
 - .4 Install the tubing at a consistent depth below the surface elevation as determined by the Consultant. Tubing installation will ensure sufficient clearance for all control joint cuts.
 - .5 Fibrous expansion joints may be penetrated following the PEX tubing manufacturer's and structural engineer's recommendation.
 - .6 Metal or plastic bend supports will be used to support the tubing when departing from the slab in a 90° bend.
- .4 Ensure grid tubing has been successfully pressure tested prior to concealment. Be present when covering is being placed over grid tubing to ensure integrity of tubing is not compromised during placement of remainder of floor construction.
- .5 Heating Agent Distribution Piping:
 - .1 Piping shall be installed in a schedule 40 PVC pipe sleeve; the sleeve size shall be two diameter sizes larger than the combined diameter of the distribution piping plus insulation plus jacket.
 - .2 Maintain minimum 4" horizontal distance between the PVC sleeves.
 - .3 [Coordinate with the site services discipline the depth of the sleeves and the back-filling material, depending on the nature of the surface above \(landscape, pedestrian traffic, vehicular traffic, train right of way, etc.\).](#)
 - .4 [Respect the minimum bending radius recommended by the manufacturer.](#)
- .6 Where tubing and/or piping penetrates fire rated construction, provide firestopping in accordance with requirements specified in Section 20 05 17 – Sleeves and Sleeve Seals for Mechanical Piping.
- .7 Provide snow melt radiant heating zones and piping manifold assemblies. System installation is to be in strict accordance with manufacturer's instructions.
- .8 Provide a strainer in piping to manifold supply header and clean strainer screen when system balancing is to commence.
- .9 Prior to system flow balancing, ensure all air is purged from system and system operates successfully at design temperatures and pressure for a minimum of 2 days. Supply system manufacturer's software for final balancing flow adjustment settings.
- .10 Balancing Across the Manifold:
 - .1 Balance all loops across each manifold for equal flow resistance based on actual loop lengths and total **manifold** flow.
 - .2 Balancing is unnecessary when all loop lengths across the manifold are within 3% of each other in length. Install the supply and return piping to the manifold in a reverse-return configuration to ensure self-balancing.

- .3 Balancing between manifolds is accomplished with a flow control device installed on the return piping leg from each manifold when direct return piping is used for the supply and return mains.
- .4 Adjust all boiler and system controls after the system has stabilized to ensure proper operation in accordance with the system design.

3.2 SYSTEM STARTUP

- .1 For equipment/system start-up requirements, refer to Section 20 05 00 – Common Work Results for Mechanical.
- .2 For equipment/system manufacturer certification requirements, refer to Section 20 05 00 – Common Work Results for Mechanical. Ensure system manufacturer inspects grid tubing installation prior to concealment and certifies each zone correct in writing. Submit a copy of each certification letter prior to Substantial Performance of the Work.
- .3 After all equipment has been installed, adjusted, balanced and started up, subject equipment to a series of performance tests, as soon as conditions permit.
- .4 The timing of the tests shall be arranged to suit the convenience of the Consultant, and the manner and duration shall be as the Consultant deems necessary. Record the daily start and stop times, operating hours and functions performed. Ensure that the performance tests are witnessed by the Consultant.
- .5 All major equipment including but not limited to boilers, and pumps, are to be inspected by the manufacturer to ensure that the equipment has been installed in accordance with their recommendations.
- .6 Operate equipment under varying load conditions, demonstrate start-up sequence, normal shutdown, simulated emergency shutdown, operation of temperature, etc., and safety controls. Operate switches and electrical devices for correct wiring sequences. Adjust components to achieve a proper functional relationship among all the components of all the systems. Repeat these functions as many times as deemed necessary by the Consultant to achieve reliable operation.
- .7 Repair defects and repeat tests as necessary. During test maintain lubrication schedule, set, align and tension drives.
- .8 At the successful completion of Performance Tests and all testing and balancing, make the systems ready for final inspection and subsequent acceptance of the Owner. Replace and clean filters, flush out lines and equipment, remove and clean strainers, fill liquid systems and purge air as required by the codes. Disinfect all domestic water as required by current by-laws and Authorities Having Jurisdiction.

3.3 OPERATING AND MAINTENANCE MANUALS

- .1 Provide minimum of four (4) copies of Mechanical Maintenance Manuals. Mechanical Maintenance Manuals to be delivered to the Consultant's office ten (10) days prior to the Substantial Completion of the Contract.
- .2 Manuals to be bound in a hard cover neatly labeled: "OPERATING AND MAINTENANCE INSTRUCTIONS".
- .3 The Maintenance Manuals shall be divided into sections with neatly labeled and tabbed dividers between each section. The sections to be included in the manual and the information contained within each section are:
 - .1 Section I-General:

- .1 A list giving name, address and telephone number of the Consultant, Engineers, and Contractor, Mechanical Trade and Controls Trade.
- .2 Warranty certificates for the Mechanical Systems.
- .3 A copy of the valve directory giving number, valve location, normal valve position, and purpose of valve (a framed copy of valve directory to be hung in the boiler room).
- .4 Equipment lists and certificates shall be provided - certificates shall be signed and sealed by the appropriate suppliers.
- .2 Section II & III-Metallic piping and pump Systems, plumbing fixtures and snow and ice melting plastic tubing/In-floor radiant heating tubing:
 - .1 A copy of all pressure tests and operational tests, a copy of Gas Operational Tests for gas fired equipment. A list giving the name, address and telephone number of all suppliers. A copy of all reviewed shop drawings for the mechanical equipment.
- .3 Section IV-Automatic controls;
 - .1 Complete Control Diagrams, Wiring Diagrams and description of Control system and the functioning sequence of the system.
- .4 Section V-Hydronic Balancing Reports:
 - .1 Complete results of the hydronic balancing.

3.4 TESTING, ADJUSTING AND BALANCING (TAB)

- .1 Coordinate with the mechanical Contractor the TAB activity such that it does take place before the insulation is installed on ductwork and piping.
- .2 In the absence of such coordination, the mechanical contractor shall be responsible for the repair to the ductwork and or piping insulation removed for TAB purposes, including the integrity of the vapor barrier material and the insulation jacket.
- .3 General:
 - .1 Obtain applicable Contract Documents and copies of approved submittals for HVAC equipment and automatic control systems.
- .4 Systems Inspection Report:
 - .1 Inspect equipment and installation for conformance with design.
 - .2 The inspection and report is to be done after air distribution equipment is on site and duct installation has begun, but well in advance of performance testing and balancing work. The purpose of the inspection is to identify and report deviations from design and ensure that systems will be ready for TAB at the appropriate time.
 - .3 Verify that all items such as ductwork piping, ports, terminals, connectors, etc., that is required for TAB are installed. Provide a report to the Consultant.
 - .4 Reports: Follow check list format developed by Associated Air Balance Council (AABC) or Sheet Metal and Air Conditioning Contractors' National Association (SMACNA), supplemented by narrative comments
- .5 Tab Report:
 - .1 Format to be in accordance with referenced standard listed above, but using design drawing units.
 - .2 Produce "as-built" full system schematics. Use as-built drawings for reference.

- .3 Submit 1 copy of preliminary TAB reports, each in "D" ring binders, complete with index tabs for verification and approval of Consultant.
- .4 Submit copies of final TAB reports after approval by the Consultant, to be incorporated into the Maintenance and Operations Manual, as indicated in section 15010 General Mechanical Requirements.
- .6 Procedures:
 - .1 Tab shall be performed in accordance with the requirement of the Standard under which TAB agency is certified.
 - .2 Start final TAB only when building is essentially completed, including: normal operation of mechanical systems affecting TAB.
 - .3 General: During TAB all related system components shall be in full operation. Fan and pump rotation, motor loads and equipment vibration shall be checked and corrected as necessary before proceeding with TAB. Set controls and/or block off parts of distribution systems to simulate design operation of variable volume air or water systems for test and balance work.
- .7 Water Balance and Equipment Test:
 - .1 Include all circulating pumps, heat exchangers, boilers, coils, chillers, coolers and condensers, as applicable to this Project.
 - .2 Adjust flow rates for equipment to the values indicated on the Contract Drawings and schedules. Set balancing valves and circuit setters to the values on indicated on the equipment schedules.
 - .3 Record final measurements for hydronic equipment on performance data sheets. Include entering and leaving water temperatures for heating and cooling coils, and for heat exchangers. Include entering and leaving air temperatures for all equipment (boilers, manifolds, mixing valves, etc).
- .8 Verification:
 - .1 Reported measurements shall be subject to verification by Consultant. Provide instrumentation and manpower to verify results of up to 30 % of all reported measurements. Number and location of verified measurements to be at discretion of Consultant.
 - .2 Bear costs to repeat TAB, as required, to satisfaction of Consultant.
- .9 Marking Of Settings:
 - .1 Following approval of TAB final Report, the setting of all HVAC adjustment devices including valves, splitters and dampers shall be permanently marked by the TAB Specialist so that adjustment can be restored if disturbed at any time. Style and colours used for markings shall be coordinated with the Consultant

3.5 DIGITAL CONTROLS

- .1 System Hardware:
 - .1 The system architecture will be comprised of PCUs (Primary Control Units), PACs (Programmable Application Controllers), ASCs (Application Specific Controllers) and any required communications or interface components networked together.
 - .2 All required site database and graphics files shall reside on the owner's central server. The connection between the central server and the BAS controllers (to be reserved for future) serving a specific building shall be through the WAN.

- .3 The building Staff shall be able to log into the local workstation, access and review on a read-only basis the graphical user interface showing the system layout and operational parameters.
- .4 The owner specialized trades shall be capable of accessing and modifying the parameters and schedules using direct connectors at the control panels and portable computers (laptops, notebooks, etc.).
- .5 Supply PCU's, PAC's and ASC's as required to interface to all specified equipment.
- .6 Allow for a minimum of 25% spare program and trend memory capacity in each PCU and PAC.
- .7 For each specified control point, the contractor shall supply the hardware point type (e.g. AI, AO, DI, DO) as indicated on the controls points list. The use of alternate hardware point types or the use of external interface cards or devices to simulate the function of a specified hardware point type is not acceptable. For example, the use of a DO point and an external PWM card to simulate the function of a physical AO point shall not be accepted.
- .2 Primary Control Units (PCU):
 - .1 Use only Primary Control Units to directly control any major mechanical equipment. Major mechanical equipment includes air handling units, boiler plants, chiller plants, cooling towers, roof-top units and other critical equipment.
 - .2 Each PCU shall contain a real time clock and sufficient memory to store its own application database, operating parameters, user programs and trend data storage.
 - .3 Battery backup shall be provided to support the real-time clock and all volatile memory for a minimum of seventy-two (72) hours to eliminate operating data reload in case of power failure.
 - .4 Each PCU output shall include a Hand/Off/Auto (HOA) selector switch for each analog and digital output.
 - .5 Each PCU shall have a minimum of 10% spare capacity for each type of input and output channels and 10%.
- .3 Programmable Application Controllers (PAC):
 - .1 Programmable Application Controllers (PAC) are fully programmable controllers used for controlling distributed equipment including, but not limited to pumps, exhaust fans, VAV boxes, heat pumps, force flow units and unit ventilators.
 - .2 PACs shall not be used for controlling major mechanical equipment as described above.
 - .3 Each PAC shall contain a real time clock and sufficient RAM to store its own application database, operating parameters, user programs and trend data storage.
 - .4 Battery backup shall be provided to support the real-time clock and all volatile memory for a minimum of seventy-two (72) hours to eliminate operating data reload in case of power failure.
- .4 System Software:
 - .1 Trend Data:
 - .1 Provide trend logs for all hardware inputs and outputs.
 - .2 All trends should be accessible via the graphical interface.

- .3 Trends should contain all related variables of a control loop (i.e. setpoint, measured variable and control output) and have the ability to be plotted simultaneously on the same graph.
- .4 Field Devices individual trends should provide an appropriate “snapshot” of the variable. Slow reacting variables such as space temperatures should be sampled every thirty (30) to sixty (60) minutes while other variables such as mixed air or boiler water temperatures should be sampled every five (5) to ten (10) minutes.
- .5 Provide the maximum number of trend samples within the controller while maintaining the requirement for spare memory capability.
- .6 The primary input sensor for all control loops must physically be wired to the same panel containing the control loop output (e.g. boiler water temperature and burner control output).
- .7 Trend data storage must be in the same panel as the hardware or logical points being trended.
- .5 User Access:
 - .1 Provide the Owner-standard user IDs and passwords for operations, maintenance and engineering staff.
- .6 Alarms:
 - .1 Alarms shall be assigned the following categories:
 - .1 Maintenance Alarms;
 - .2 Mismatch of equipment control and status for more than thirty (30) minutes; and
 - .3 Any other miscellaneous alarm not specifically noted herein.
 - .2 Alarms shall not require any acknowledgment before automatic reset by the system.
 - .3 An alarm notification shall not be issued when an alarm condition returns to normal.
 - .4 The Contractor shall provide additional alarms as directed by the Consultant and specified in this Section and customize the alarms to the operating characteristics of the specific the systems being controlled.
- .7 Dynamic Graphics:
 - .1 Provide customized, site specific dynamic graphics to meet the requirements of the Consultant and/or the Owner.
- .8 Sequence Of Operation:
 - .1 The heating plant shall serve the snow melting system and floor radiant heating system.
 - .2 The heating plant shall be enabled/disabled based on outdoor of temperature 12°C.
 - .3 The snow melting system shall be enabled/disabled based on outdoor air temperature 4°C.
 - .4 With the system enabled, the lead primary boiler pump shall start, while the lag pump shall be energized and in stand-by mode. The lead/lag status of the primary pumps shall alternate at one-hundred-sixty-eight (168) hour intervals (adjustable).
 - .5 Upon proof of flow in the primary loop, the boiler (B-3) shall start at minimum firing rate, while one of boilers (B-1 &2) shall be energized and another one shall be in stand-by mode. The lead/lag status of the boilers between B-1 & 2 shall alternate at 168 hour intervals (adjustable).

- .6 After the boiler starts, its firing rate shall modulate as required to maintain the primary loop return temperature at 52°C (125°F), and subject to a maximum primary loop supply temperature of 66°C (150°F).
- .7 If the boiler (B-3) fires at maximum rate for ten (10) minutes and cannot maintain the primary loop return temperature setpoint, another boiler shall start at minimum firing rate. If these two (2) boilers fire at maximum rate for ten (10) minutes and still cannot maintain the primary loop return temperature setpoint, the third boiler shall start at minimum firing rate, its burner shall ramp as required to achieve the maximum primary loop supply temperature of 66°C (150°F). The lead pump's capacity shall be changed by VFD panel to suit for the required water flow rate and pressure.
- .8 With the snow melting system enabled, the lead secondary snow melting loop pump shall start, while the lag pump shall be energized and in stand-by mode. The lead/lag status of the secondary snow melting loop pumps shall alternate at one hundred sixty-eight (168) hour intervals (adjustable).
- .9 With the floor radiant heating system enabled, the lead secondary pump shall start, while the lag pump shall be energized and in stand-by mode. The lead/lag status of the secondary snow melting loop pumps shall alternate at one hundred sixty-eight (168) hours intervals (adjustable), for detail refer to Section 15520 Hydronic Radiant Floor Heating System.
- .10 The four-way mixing valve shall modulate as required to maintain the snow- melting slab temperature at the following temperatures:
 - .1 0°C (+32°F) if no snow or ice is detected on the surface of the slab by the respective sensor
 - .2 +4°C (+40°F) if snow or ice is detected on the surface of the slab.
- .11 Additional settings for the operation of the 4-way mixing valve:
 - .1 Maintain the minimum primary loop return temperature of 52°C (125°F)
 - .2 Maintain the maximum temperature differential in the snow melting loop of 14°C (25°F) to prevent slab thermal shock.
- .12 The system shall generate alarms in case of:
 - .1 Any pump failure (while automatically enabling the stand-by pump).
 - .2 Any boiler failure (while automatically enabling the stand-by boiler).
 - .3 Primary loop temperatures 6°C (±10°F) departure from the setpoint.
 - .4 Slab temperature 3°C (±5°F) departure from the setpoint.
- .9 Installation of Snow Sensor:
 - .1 The installation of the snow sensor shall conform to the detail drawing.
 - .2 The contractor shall be responsible for the fabrication of the steel frame required to install the sensor at the prescribed elevation and maintain its position during the concrete pour.
 - .3 The installation procedure described on the detail drawing shall be followed accurately; at the conclusion of the installation work, a report shall be issued by the Contractor confirming that all installation steps have been followed and the installation of the sensor is in conformance with the detail.

- .4 Installation of all wiring and tubing in the area of the sensor shall be as indicated on the detail.
- .10 Installation Of Temperature Sensors In Piping:
 - .1 The Contractor shall ensure that thermowells are installed as described herein.
 - .2 For each immersion sensor, provide a compatible thermowell to the Mechanical Contractor for installation. Provide stainless steel thermowells where installed in piping carrying corrosive or chemically reactive fluids.
 - .3 Install thermowells in piping such that the bottom of the well does not make contact with the pipe. Install the well at a 90° elbow or tee where the pipe diameter is less than the well length.
- .11 Cutting And Patching:
 - .1 All cutting, patching, painting and making good for the installation of the work shall be done by the Contractor. All cutting shall be performed in a neat and true fashion, with proper tools and equipment
- .12 Identification And Labeling of Control Equipment:
 - .1 All panels must have a lamicaid tag (minimum 3"x1") affixed to the front face indicating panel designation and function (i.e. "Panel 1" or "Relay Panel 3").
 - .2 All field sensors or devices must have a lamicaid tag (minimum 3"x1") attached with tie-wrap or adhesive indicating the point software name and hardware address (i.e. AHU1_MAT, 2.IP4). Tags must be secured by screws where mounted outside of the building, in unheated spaces, in high humidity areas or where subject to vibration.
 - .3 All devices within a field enclosure shall be identified via a label or tag.
 - .4 All panel power sources must be identified by a label (minimum 3"x1") indicating the source power panel designation and circuit number (i.e. "120vac fed from LP-2A cct #1).
 - .5 All field control equipment panels fed from more than one power source must have a warning label on the front cover.
 - .6 All wires shall be identified with the hardware address with a band-type self-adhesive strips or clip-on plastic wire markers at both ends.
 - .7 All rotating equipment shall have a tag or label affixed indicating that the equipment may start without warning.
 - .8 All panels will be supplied with a point's list sheet (within a plastic sleeve) attached to the inside door.
 - .9 The points list shall identify the following for each point:
 - .1 Panel number;
 - .2 Panel location;
 - .3 Hardware address;
 - .4 Software name;
 - .5 Point description;
 - .6 Field device type;
 - .7 Point type (i.e. AI or DO);
 - .8 Device fail position;

- .9 Device manufacturer;
- .10 Model number or reference; and
- .11 Wire tag reference.
- .10 Provide laminated wiring diagrams for all field mounted relay enclosures. Securely attach to the inside door. Identify power panels and circuit numbers of the equipment being controlled.
- .11 Provide laminated wiring diagrams or modify existing equipment wiring diagrams. Securely attach to the inside of the respective control cabinet.
- .12 Provide lamcoid labels indicating the required operating sequences, on the boilers and valves, where the boiler plants have manual or automatic isolating valves. Submit actual wording to the Consultant for approval prior to fabrication and installation.
- .13 Provide lamcoid or machine labels (as outlined above) for all interposing relays or contactors used in control circuits. The labels shall include the related point software name and hardware address.
- .14 Provide a lamcoid label to identify the location of concealed devices above the ceiling space. Mount the label on the ceiling grid t-bar or a permanent surface adjacent to the devices.
- .15 Provide lamcoid labels for all auxiliary HVAC equipment (e.g. force flow cabinets, unit ventilators, unit heater, window AC units, etc.). Mount the labels in the vicinity of the existing thermostat or power switch for the unit.
- .16 Where directed by the Consultant, provide any and all additional labeling, diagrams, schematics or instructions as may be required to facilitate the correct operation and maintenance of controlled building systems.
- .13 Systems Hardware Commissioning
 - .1 The Contractor shall be responsible for the “end to end” commissioning, testing, verification and start-up of the complete control system hardware including panels, sensors, transducers, end devices, relays and wiring. Where applicable, this shall include any points from an existing and/or re-used automation system in the building.
 - .2 The Contractor shall prepare a hardware commissioning report containing the following information and test results:
 - .1 Analogue inputs (i.e. temperatures, pressure, etc.) shall be verified with an approved calibration device. All actual temperature readings should be with $\pm 1^{\circ}\text{C}$ of the readings observed at the workstation. Record calibration adjustments and settings.
 - .2 Analogue outputs shall be verified by manually commanding the output channel from the operator workstation to two or more positions within the 0-100% range and verifying the actual position of the actuator or device. All devices shall operate over their entire 0-100% range from a minimum control range of 10-90%. Record the actual output scale range (channel output voltage versus controller command) for each analogue end device.
 - .3 Digital outputs shall be verified by witnessing the actual start/stop operation of the equipment under control.
 - .4 Digital inputs shall be verified by witnessing the status of the input point as the equipment is manually cycled on and off.

- .5 Record all out-of-season or unverified points in the commissioning report as "non-commissioned".
 - .6 Identify any existing equipment (valves, dampers, fan starters, etc.) that are inoperative or require maintenance or repair.
 - .7 The panel power source shall be toggled on and off to ensure reboot functionality and power down memory retention of all parameters. During the power down test, all controlled system outputs shall go to their fail-safe position.
 - .8 Verify PID loop tuning parameters by applying a step change to the current setpoint and observing the response of the controlled device. Setpoint should be reached in an acceptable period of time without excessive cycling or hunting of the controlled device. Provide a graph of the trend response to setpoint change for important controlled devices (e.g. valves 1" or larger, dampers on major air handlers, etc.)
 - .9 Provide confirmation that a series of test alarms has been successfully received at designated remote monitoring workstations.
 - .10 Include with the hardware commissioning report a site floor plan indicating the location of all equipment installed in concealed or recessed locations (e.g. interposing relays in ceiling spaces).
 - .11 Provide testing of all LAN cabling to ensure that 100Mb bandwidth is supported.
 - .12 Verify conformance with TIA /EIA TSB-67 - Basic Link Test using a Level 2, bi-directional tester. Provide all equipment necessary to carry out the required tests.
 - .13 The hardware commissioning report must be signed and dated by the Contractor's technician performing the tests and participating Owner's trades staff.
 - .14 At the completion of site commissioning, submit four (4) copies of hardware commissioning report to the Owner.
- .14 Substantial Completion Inspection:
- .1 At the completion of the site hardware inspection, the Contractor shall test and verify that the system programming, graphics and alarm software is operating correctly and is in compliance all requirements of the Specifications.
 - .2 The Contractor shall provide written notification to the Owner that the site is ready for the Substantial Completion Inspection by the Consultant
 - .3 Issue a comprehensive site deficiency report to the Contractor for their immediate action.
 - .4 The Contractor shall correct all items noted in the site deficiency report within ten (10) business days of receipt.
 - .5 The Contractor shall provide written notification to the Owner that all items on the Consultant's site deficiency report have been corrected

3.6 SENSORS AND DEVICES

- .1 Snow Slab Sensor:
- .1 The snow/ice sensor and socket are used with the main controller to automatically detect snow or ice on a driveway or walkway. The snow/ice sensor socket must be installed directly in the snow melt slab, halfway between the heating elements or pipes.
 - .2 Sensor weight: 2,000 g (4.4 lb), silicon brass. 20 m (65 ft) jacketed cable

- .3 Socket weight: 830 g (1.8 lb), silicon brass
- .4 Dimensions (sensor): 45 x 80 x 80 mm (1¾" H x 3-1/8" W x 3-1/8" D)
- .5 Dimensions (socket): 96 x 89 x 89 mm D (3¾" H x 3½" W x 3½")
- .6 Operating range: -50 to 80°C (-60 to +175°F)
- .7 Sensor: NTC thermistor, 10 kΩ @ 25°C ±0.2°C (77°F), β=3892
- .8 Standard of Acceptance: Tekmar type 094 in socket type or approved equivalent.
- .2 In-Slab Sensor:
 - .1 Slab sensor has a PVC plastic sleeve which is designed for use in soils or concrete. The sensor is supplied with 40ft (12m) of 2 conductor cable.
 - .2 Packaged Weight: 0.7 lb. (320 g), PVC sleeve. 12 m ' (40) jacketed wire
 - .3 Dimensions: 13 o.d. x 51 mm (½" OD x 2")
 - .4 Operating range: -50 to 60°C (-60 to 140°F)
 - .5 Sensor-NTC thermistor, 10 kΩ @ 25°C ±0.2°C (77°F), β=3892
 - .6 Standard of Acceptance: Tekmar 073 or approved equivalent.
- .3 Outdoor Air Temperature Sensors:
 - .1 Provide outdoor air temperature sensors with the following minimum characteristics:
 - .2 Each sensor shall be a 6", 10K thermistor probe;
 - .3 Minimum two (2) sensors shall be installed for each site;
 - .4 Both sensors shall be mounted inside a heavy-duty (blow-proof) solar shield; and
 - .5 Provide a heavy-duty, metal, wire guard.
 - .6 Standard of Acceptance: Enercorp TS-O-T-10K, Honeywell, Johnson Controls or approved equivalent.
- .4 Immersion Temperature Sensors:
 - .1 Use immersion temperature sensors with thermowells for all applications where a temperature of a fluid in a pipe is being sensed.
 - .2 Provide well-mounted water temperature sensors with the following minimum characteristics:
 - .1 The sensors shall be 10k ohm thermistor encapsulated in a 6 mm o.d., 50 m long probe, with screw fitting for insertion into a standard thermowell;
 - .2 Operating range -10 to +100°C;
 - .3 End-to-end accuracy ± 0.3°C over the entire operating range;
 - .4 The sensors shall be complete with brass thermowell;
 - .5 Provide a stainless steel thermowell where exposed to corrosive liquids;
 - .6 Use conductive gel when mounting the sensor in the thermowell; and
 - .7 The sensors to be mounted on insulated piping shall be installed clear of the insulation.
 - .3 Standard of Acceptance: Enercorp TS-P-4-T-10K, Honeywell, Johnson Controls or approved equivalent.

- .5 Current Sensors (Analog):
 - .1 Current sensors (CT) shall be used for status monitoring of all motor-driven equipment, where specified.
 - .2 Technical Performance-Output should be only 4-20mA only. Voltage output will not be accepted. End-to-end accuracy $\pm 1\%$ of full scale at each range.
 - .3 The current sensors shall be mounted inside the starter cabinets whenever possible. If this is not possible due to space limitation, provide an enclosure to house the sensor.
 - .4 Standard of Acceptance: Enercorp SA200, Honeywell, Johnson Controls or approved equivalent.
- .6 Automatic Control Valve Actuators:
 - .1 Each automatic control valve shall be fitted with a "fail-safe" operator capable of tight shut-off against the differential imposed by the system.
 - .2 Operators for valves in electric-electronic control systems shall be single phase
 - .3 AC, 24V electric motor operators.
 - .4 Valve actuators on valves 3" diameter and larger shall be provided with a manual position override.
 - .5 Valve actuators shall accept a 0-10VDC or 4-20mA control signal for all proportional applications
 - .6 Floating point control of valves is not acceptable under any circumstances.
 - .7 Installed by the Contractor, unless specified otherwise.
 - .8 Each control valve shall be equipped with its own actuator.
 - .9 The Contractor shall ensure that each control valve assembly is properly connected and installed.
 - .10 The Contractor shall test, adjust and verify the operation of each control valve to ensure that it is properly functioning, as required and left in safe working order.
- .7 Local Service Ports:
 - .1 Every DDC panel shall be provided with a local network access port to connect to laptop computer. A user connected to the local access port shall have the same level of system access and functionality as being connected to the networked Owner's workstation
 - .2 Where points (four (4) or more) are located in a mechanical room that does not have a local panel installed, a remote network access port shall be provided. The access port shall be installed in a hinged metal enclosure with key-lock set and lamicoid ID label.
- .8 LAN Cabling:
 - .1 All LAN cabling shall be Category V as defined by EIA/TIA 568A. The Contractor shall test all cabling to verify that 100Mb bandwidth is supported. See commissioning requirements.
 - .2 Cabling shall be four (4) pair, 100 Ω UTP, #24 AWG solid copper conductor PVC insulated, with blue or grey colour coded jacket. FT6 rated cable shall be used unless otherwise required to meet building codes or by-laws.
 - .3 Data outlets shall be RJ45, eight (8) pin connectors, with 50 microns of hard gold over nickel, minimum durability of 750 mating cycles and contact pressure of 100 grams per contact. Transmission characteristics shall meet TSB-40 Category V.

- .4 Provide one RJ45 data outlet adjacent to each device to be terminated (e.g. workstation PC, DDC panel, hub, etc.) Use a flexible patch cable to connect from the data outlet to the end device.
- .5 Provide protection from EMI sources in accordance with CAN/CSA-T530 article 4.
- .6 The contractor shall test all cabling to verify conformance with TIA/EIA TSB-67 Basic Link Test using a Level 2, bi-directional tester. See commissioning requirements.
- .7 Where there are more than 2-90° in a conduit run, provide a pull box between sections so that there are two (2) bends or less in any one (1) section.
- .8 Where a conduit run requires a reverse bend, between 100° and 180°, insert a pull box at each bend having an angle from 100° to 180°.
- .9 Ream all conduit ends and install insulated bushings on each end. Terminate all conduits that protrude through the structural floor 2" above the concrete base. Do not use a pull box in lieu of a conduit bend. Align conduits that enter a pull box from opposite ends with each other.
- .9 Automatic Control Valves:
 - .1 Automatic control valves shall be supplied by the Controls Contractor and installed by the Mechanical Contractor.
 - .2 Automatic control valves, unless otherwise specified, shall be globe type valves.
 - .3 Valves and actuators shall be ordered as one factory-assembled and tested unit.
 - .4 Submit to the Consultant for review, a valve schedule containing the following information for each valve:
 - .1 Valve type and size;
 - .2 Connection type;
 - .3 Line size;
 - .4 Valve manufacturer and model number;
 - .5 Valve flow coefficient;
 - .6 Design flow;
 - .7 Pressure drop across valve;
 - .8 Maximum close-off pressure;
 - .9 Actuator manufacturer and model number; and
 - .10 Actuator maximum torque.
 - .5 Valves 50 mm (2") and smaller shall be constructed of bronze. Valves 65 mm (2½") and larger shall have iron bodies and bronze mountings.
 - .6 All control valves shall have stainless steel stems.
 - .7 The bronze in bodies and bonnets of all bronze valves shall conform to ASTM B62 for valves rated up to 150psig (1,035 Kpa) working pressure and to ASTM B61 for valves rated at 200 psig (1,380 Kpa) working pressure.
 - .8 The bodies and bonnets of iron body valves shall conform to ASTM A126, Class B.
 - .9 Control valve discs and seats shall be of bronze for 100°C or less fluid temperature and of stainless steel for fluid temperatures above 100 °C.

- .10 The control valves shall have tight shut-off. Flat disk valves are not acceptable.
- .11 Control valves 50 mm (2") and smaller shall be complete with screwed ends type, except for bronze valves installed in soldered copper piping which shall be complete with soldering ends. Control valves larger than 50 mm (2") shall be complete with flanged end type and proper flanged adapters to copper shall be provided where flanged valves are installed in copper piping.
- .12 The water control valves shall be sized for a pressure drop of 6 ft. water column or as indicated on mechanical drawings.
- .13 Each automatic control valve must provide the design output and flow rates at pressure drops compatible with equipment selected.
- .14 Each automatic control valve must be suitable for the particular system working pressure.
- .15 Each automatic control valve shall be fitted with a position indicator.
- .16 All the same type control valves shall be the products of a single manufacturer and have the manufacturer's name, pressure rating and size clearly marked on the outside of the body.
- .17 Unless otherwise indicated, control valves for proportional operation shall have equal percentage characteristics, while the control valves for open/shut two- position operation shall have straight line flow characteristics.
- .18 Standard of Acceptance:
 - .1 Siemens.
 - .2 Danfoss.
 - .3 Honeywell.
 - .4 Or approved equivalent.

3.7 TRAINING

- .1 Include for 4 hours of on-site training for 2 groups of 6 people. Training is to be a full review of all components including but not limited to a full operation and maintenance demonstration, with abnormal events.
- .2 Prior to providing training perform system demonstration as per requirements of Section 01800 Project Closeout.
- .3 Supply certified personnel to instruct the Owner on operation of new mechanical equipment. Supply maintenance specialist personnel to instruct operating staff on maintenance and adjustment of mechanical equipment and any changes or modification in equipment made under terms of warranty.
- .4 Provide minimum four (4) hours of instruction time during regular work hours prior to acceptance and turn-over to operating staff for regular operation.
- .5 Use operation and maintenance data manual for instruction purposes. On completion of instruction, turn manuals over to the Consultant.
- .6 Scheduling of the timing for the training of the operating staff shall be arranged with the Consultant ten (10) days prior to the completion of the Project.

END OF SECTION

PART 1 - GENERAL

1.1 REFERENCES

- .1 ANSI/IEEE C12.20 – American National Standard for Electricity Meters
- .2 NEMA C12.1 – Electric Meters; Code for Electricity Metering.
- .3 IEEE C57.13 – Standard Requirements for Instrument Transformers
- .4 Ontario Electrical Safety Code c/w Bulletins and Amendments.
- .5 Ontario Building Code and its referenced standards.
- .6 Underwriters Laboratories UL 1283 and UL 1449 (most recent edition).
- .7 Canadian Standards (cUL or cETL).

1.2 SCOPE

- .1 Install and commission a power monitoring, analysis and control system that employs computer technologies to provide a robust, reliable, and secure data network.
- .2 The system shall be complete with web-enabled Power Monitoring and Control (PMAC) software package intended to monitor the entire data centre electrical distribution infrastructure.
- .3 The system shall be designed to monitor and manage energy consumption throughout an enterprise, to improve energy availability and reliability, and manage and measure energy efficiency.

1.3 SUBMITTALS

- .1 Shop Drawings:
 - .1 Sufficient information, clearly presented, shall be included to determine compliance with drawings and specifications.
 - .2 Include devices, locations, connections, conduit runs, wiring type, details, and attachments to other work.
- .2 Product Data: Provide dimensions, ratings, and performance data.
- .3 Submit manuals, simultaneously with the shop drawings, companion copies of complete maintenance and operating manuals including technical data sheets, wiring diagrams, and information for ordering replacement parts.
 - .1 Wiring diagrams shall have their terminals identified to facilitate installation, maintenance, and operation.
 - .2 Wiring diagrams shall indicate internal wiring for each item of equipment and the interconnection between the items of equipment.
 - .3 Provide a clear and concise description of operation, which gives, in detail, the information required to properly operate the equipment.
 - .4 Approvals will be based on complete submissions of manuals together with shop drawings.

1.4 CLOSEOUT SUBMITTALS

- .1 Submit manufacturer's operation and maintenance instructions for each product.
- .2 Software installation CD's, etc.

- .3 Manuals:
 - .1 The manuals submitted for review shall be updated to include any information necessitated by shop drawing approval.
 - .2 Complete "As Installed" wiring and schematic diagrams shall be included which show all items of equipment and their interconnecting wiring.
 - .3 Show all terminal identification.
 - .4 Include information for testing, repair, troubleshooting, assembly, disassembly, and recommended maintenance intervals.
 - .5 Provide a replacement part list with current prices. Include a list of recommended spare spares, tools, and instruments for testing and maintenance purposes.
- .4 Certification by the contractor that assemblies have been properly installed, adjusted, and tested.
- .5 Certified copies of all factor design and production tests, and field test data sheets and reports for the assemblies.

1.5 SUMMARY

- .1 The specifications in this section describe the performance, furnishing, installation and connection of a digital electric metering system installed on electrical equipment such as low voltage switchboards, distribution panels and/or low voltage branch circuit panelboards of the power system. The specified system shall provide effective revenue quality metering of the loads indicated on the single line diagram. The system shall be accessible either at the meter(s) located in the data centre, or remotely by computer.

1.6 ENVIRONMENTAL REQUIREMENTS

- .1 The operating temperature range shall be -40°C to 70°C (-40°F to 160°F).

1.7 QUALITY ASSURANCE AND WARRANTY

- .1 The meter and supporting components shall be guaranteed by the manufacturer to be free of defects in material and workmanship for a period of three (3) years from the date of substantial completion of service and activation of the system to which the meter(s) are attached.
- .2 Warranty service may be performed by the manufacturer or authorized representative.
- .3 The contractor shall support the system for two years after commissioning.

1.8 MANUFACTURER QUALIFICATIONS

- .1 The meter shall be manufactured by a manufacturer that has been regularly engaged in the design, manufacturing and testing of digital meters of the types and ratings required for a period of not less than five years. Manufacturers requesting product approval must meet or exceed the written specification contained herein. Manufacturers requesting approval must receive written verification of product acceptance by the specifying engineer 10 days prior to the bid date.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- .1 The Digital Power Instrumentation Package shall be a complete system from one of the following:
 - .1 The Digital Power Instrumentation Package shall be a 7330 ION series as Manufactured by Power Measurement Limited.
 - .1 Model P7330R0B0B0E0A0A or approved equal.
 - .2 The PMAC Software shall be ION Enterprise V6.0 or latest version with a 10 device license as manufactured by Power Measurement Ltd.
 - .2 Eaton.
 - .3 Intellimeter
 - .4 Siemens.
 - .5 Electro Industries/GaugeTech.

2.2 REGULATORY REQUIREMENTS

- .1 Products: Listed and classified by CSA (Canadian Standards Association), ULC (Underwriters' Laboratories of Canada), or CUL.

2.3 INSTRUMENT TRANSFORMERS

- .1 General
 - .1 Mount and brace transformers to withstand 100,000 A short circuit current.
 - .2 Install in feasible location near upstream overcurrent device.
 - .3 Meters shall be revenue grade.
- .2 Current Transformers (CTs)
 - .1 ANSI C57.13; 5 A secondary, with primary/secondary ratio as shown on drawings, to suit size of associated upstream overcurrent devices.
 - .2 All Current Transformers shall be split-core type with 80 mA secondary unless noted otherwise.
 - .1 Provide donut or square type to suit cable or bus, respectively.
 - .3 CTs shall be Measurement Canada type approved or have a minimum accuracy of 0.3%.
 - .4 One CT is required for each phase being metered.
- .3 Potential Transformers (PTs).
 - .1 ANSI C57.13, 120 V secondary.
 - .2 Burden and accuracy consistent with connected metering and relay devices, 60 Hz.
 - .3 Potential transformers are required for metering an all electrical systems above 120/208 V.
 - .4 Potential transformers on 347/600 V systems shall be rated 347-120 V, connected phase-to-neutral, and installed on each phase.
 - .5 PTs shall be wired line-neutral for Wye systems and line-line for delta systems.

- .6 CTs shall be Measurement Canada type approved or have a minimum accuracy of 0.3%.
- .7 Meter shall not be powered from the PT secondary.
- .8 Voltage inputs shall be fed from a dedicated 15 A breaker in distribution panel where practical.
- .9 Supply and install appropriate 1 A fuses.

2.4 DIGITAL POWER INSTRUMENTATION PACKAGE

- .1 The Digital Power Instrumentation Package shall be a true RMS, bi-directional, four quadrant meter capable of measuring, calculating and directly displaying on the front panel display the following information in user programmable groups.
 - .1 Voltage.
 - .2 Current.
 - .3 kW.
 - .4 kVAR.
 - .5 kVA Power Factor.
 - .6 Harmonics.
 - .7 Demand.
 - .8 minimums and maximums for each phase.
 - .9 minimum and maximum totals for all phases.
 - .10 KWh, kVARh, kVAh totals for all phases.
 - .11 Voltage and current unbalance.
 - .12 Frequency.
 - .13 k-factor.
 - .14 Harmonic distortion for each voltage and current input, up to the 15th harmonic.
- .2 The Digital Power Instrumentation Package shall:
 - .1 Perform continuous true RMS measurement based on 32 samples-per-cycle sampling on all voltage and current signals. Readings shall be updated once per second.
 - .2 Retain all setup data in non-volatile memory (NVRAM).
 - .3 The PMAC Instrument shall include 512 kB of non-volatile memory with two fully programmable 16-channel data recorders.
 - .4 The PMAC instrument shall support multiport communications that provides two ports for RS-485 communications. Interface via ION, DNP3.0, Modbus TCP, and Modbus RTU protocols, through serial or Ethernet communications.
 - .5 Include 10BaseT Ethernet communications port and Ethergate networking capabilities.
 - .6 Have an on-board WebMeter.
 - .7 The PMAC Instrument shall provide setpoint control to four digital output relays.
 - .8 Meet the following standards:
 - .1 Measurement Canada Revenue approved.
 - .2 Certified to CAN/CSA-C22.2 No.1010-1.

- .3 All inputs pass ANSI/IEEE C37.90-1989 surge withstand and fast transient tests.
- .4 Manufactured under ISO 9002 Quality Assurance Standard.
- .3 The Digital Power Instrumentation Package shall:
 - .1 Require no PTs on voltage inputs Wye (Star) for 120/208/240 V systems. PTs can be used on higher voltage systems.
 - .2 Must meet all ISO 9001 standards for quality control where all meters test to a minimum of +/-0.5% accuracy.
 - .3 The current transformers shall have a full scale output of 330 mV (split core), 80 mA (solid core donut) or 5 A (solid core or split-core donut) outputs for safety purposes.
 - .4 Meters to be complete with a Liquid Crystal Display (LCD) to access all energy measurements and phase diagnostics when needed.
 - .5 Meter to have backup storage power so no data is lost during power outages. Device must be capable of holding 2 years of interval data for a 20 year period. The system shall continue to function after resumption of power.
 - .6 Failure of the building electrical normal power system shall not result in loss of data and will not require manual restarting of the metering system.

2.5 METER ENCLOSURES

- .1 The digital meters shall be installed in pre-wired, NEMA 12, CSA approved enclosures.
 - .1 Multiple meters shall be installed in the same enclosure.
 - .2 Meters supplied from two different switchboards or different sources cannot be installed in the same enclosure.
 - .3 Meters shall be wired according to manufacturer's recommended method.
 - .4 Each meter shall be labeled.

2.6 COMMUNICATIONS AND NETWORKING COMPONENTS

- .1 RS485 communications for all meters shall be terminated in the enclosure according to manufacturer's recommended practice.
- .2 To enable the meters to communicate to the central monitoring software, a Lantronix UDS10 or equivalent RS485 to Ethernet serial server shall be provided in each enclosure.
- .3 Routers or other required networking components shall be provided according to Owner's standard.
- .4 The electrical contractor shall be responsible for providing all metering communication wiring between the meters and shall provide a single Ethernet communication point from the meters(s) to the data centre infrastructure patch panel. All Ethernet wiring shall be minimum Category 6A CMP rated. Ethernet wiring shall be installed in EMT conduit.
- .5 Coordinate with Division 27.

2.7 POWER MEASUREMENT AND CONTROL (PMAC), MONITORING AND REPORTING SOFTWARE

- .1 Supply and install all software to be installed on one server as directed by the Owner.

- .2 The metering system shall interface with a computing server component: Windows 7 operating system, 1 RU or 2 RU server, rack mountable form factor.
- .3 Hardware shall meet the Software manufacturer's recommended requirements.
- .4 Install and commission a power monitoring, analysis and control system that employs the latest computer technologies to provide a robust, reliable, and secure data network.
- .5 The PMAC Enterprise software shall have the following functionality:
 - .1 Server Workstations shall be used for connection to PMAC instruments located at monitoring as recommended by the manufacturer.
 - .1 Workstations shall have minimum hardware features as recommended by the manufacturer.
 - .2 The Communications Server shall support communication between software components and IEDs with an arbitrary number of IEDs, multiple concurrent serial and Ethernet communications links.
 - .3 Require no proprietary network communication hardware.
 - .4 Support automatic alarm call-back for any IED equipped with this capability.
 - .5 Support any combination of the following communication protocols directly to IEDs: ION; Modbus RTU; Modbus TCP; Serial or TCP/IP.
 - .2 Data Storage and Data Sharing
 - .1 The PMAC software shall support an arbitrary number of Windows-based Server Workstations, each running log acquisition software (Log Server) that provides the ability to:
 - .1 Autonomously retrieve, from any or all IEDs in the PMAC network, log records of the following type:
 - .1 Event log records containing device event information.
 - .2 Historical log records containing numerical and Boolean data.
 - .3 Historical log records containing waveform data.
 - .2 Dynamically manage database tables to reflect changes in the configuration of any IED's waveform log or data log, with no need to shutdown and restart any software.
 - .3 Report the occurrence of events to all user interface software components that are in use for event and alarm indication. To ensure fast event annunciation, all event information shall be made available to the user interface software and the database software concurrently.
 - .2 The PMAC software shall include a database management component that provides the ability to:
 - .1 Selectively remove a range of records from the database
 - .2 Archive database files on magnetic tape or other buyer-approved off-line storage media.
 - .3 Use the MS SQL Server database software as the database engine. If the license is less than 10 nodes the MSDE database that is included with the

software can be used. If there are more than 10 nodes communicating with the PMAC, then MS SQL Server DB license must be included.

.3 Integrated Object Processing Software

- .1 The PMAC software shall support an arbitrary number of Windows-based Server Workstations, each running an Integrated Object Processing software component.
- .2 The Integrated Object Processing software can be used to autonomously collate information (objects) that has been acquired from multiple sources, using diverse protocols, and allows the information to be processed for user-defined analysis and logging purposes. The Integrated Object Processing software shall be ION-compliant.
- .3 The software license shall be purchased to accommodate all nodes with communications to the software, plus an additional 10% nodes shall be included for future addition.

.4 User Interface

- .1 The PMAC software shall support an arbitrary number of each of the following types of Graphical User Interface components:
 - .2 User Display software.
 - .3 Device Configuration software.
 - .4 Network Configuration software.
 - .5 WebReach Browser based viewer using IIS.
- .6 The User Display component shall provide the graphical interface to power monitoring, analysis, and control functions through an arbitrary number of user diagrams.
- .7 There shall be a summary screen of the electrical single line diagram showing all energy monitoring nodes in real-time on the same screen, with drill-down icons for more detailed real-time data on each node. If it is not practical to show all nodes on one screen, multiple screens can be developed.

.5 Reports.

- .1 The PMAC software shall include a report generation tool written in Visual Basic Macros using MS Excel spreadsheets. The reports must allow for cost allocation, load aggregation and power quality.
- .2 The number and type of reports and will be defined by the owner before commissioning.
- .3 The software shall have the provision to include IMO real time pricing and shadow billing functionality that matches with the local utility billing structure to create accurate bills for comparison and verification. The future shadow billing package shall also support tenant billing or cost allocation based on the IMO real-time price structure and local utility rates.

2.8 LOCATIONS OF METERING DEVICES

- .1 Locate as shown on Drawings and as recommended by Manufacturer.

PART 3 - EXECUTION

3.1 INSTALLATION

- .1 All power supply and communications wiring connections shall be performed in accordance with the guidelines set out in the product documentation.
- .2 The meters shall be mounted in the locations indicated.
- .3 All unused openings shall be covered with a metal closure plate painted to match the existing enclosure.
- .4 Any extension of wiring needed to accommodate the meters shall be done using terminal blocks and 10 AWG stranded copper wire, 600 V type SIS insulation. Splices are not allowed.
- .5 Dangerous voltage will develop in the open circuit secondary windings of energized current transformers. De-energize the current transformers by short circuiting the secondary windings before disconnecting or connecting instruments to current transformers.
- .6 Verify the proper operation of all meters. Compare the meter display readings to measurements taken with a clamp on amp-meter and handheld volt meter.
- .7 This contractor shall provide all communication trunk wiring to provide for a single connection point to the data centre LAN.
- .8 All communications networking equipment, including hubs, routers, etc. required to enable a single connection to the owner's IT infrastructure shall be provided by this contractor. Provide local circuit from UPS source.
- .9 Communications networking shall be tested and proved to be working before acceptance.
- .10 All voltage sending connections to PMAC instrumentation shall be made with 2 A fuses.
- .11 Appropriately sized current transformers must be installed on each phase and must be installed with CT shorting blocks.
- .12 Meters must be powered from an auxiliary power supply, and not powered from the PTs.
- .13 The installation must be in accordance with the Ontario Electrical Safety Code.
- .14 The contractor is responsible for ensuring pulse inputs are wired properly to the meter.

3.2 COMMISSIONING AND CONSTRUCTION VERIFICATION

- .1 Contractor is responsible for utilizing construction verification checklists supplied under commissioning section.

3.3 SOFTWARE CONFIGURATION

- .1 Contractor shall ensure the software is properly configured and communicating to all meters and related devices specified and as noted on the drawings.
- .2 Provide system configuration documentation that can be used for an emergency recovery.

3.4 TRAINING

- .1 The contractor shall conduct a training course for meter configuration, operation, and maintenance of the system as specified. The training shall be oriented for all components and systems installed under this contract. The training shall include:
 - .1 Physical layout of each piece of hardware.

- .2 Meter configuration, troubleshooting and diagnostic procedures.
- .3 Repair instructions.
- .4 Preventative maintenance procedures and schedules.
- .5 Testing and calibration procedures.
- .6 Use of metering software.
- .2 Contractor shall include hands-on training with a factory trained representative or local integrator to ensure the end user is comfortable with the software. Schedule training during normal business hours.

END OF SECTION