METROLINX

Glycol Solution Snow Melting System Specification

Specification 23 21 18

Revision 04
Date: March 2023

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Metrolinx,

an Agency of the Government of Ontario

Amendment Record Sheet

Amendment in Clause No.	Date of Amendment	Description of Changes
Various	Sept. 20, 2018	Revised to coordinate with corresponding specifications.
Item 1.2.4 (f)	Dec. 2020	Revised to clarify manifold chamber's clearance distance
Various	June 2022	Revised sentence structure to coordinate with Commercial Quality Assurance, warranty section modified to point to contract warranty Added requirement for mechanical protection of above-grade manifold cabinets
Item 3.4.6 (c) (7)	Mar. 2023	Revised to clarify limestone's depth
Various	Mar. 2023	Revised to ensure provision and operation of snow melting system is independent of radiant floor heating system

LIST OF CONTENT

1. GENERAL

1.1. SCOPE OF WORK

1.1.1. The Contractor shall provide glycol solution snow melting system as detailed on Drawings and as specified herein.

1.2. DESIGN REQUIREMENTS

1.2.1. General

a) The Contractor shall supply and install a class 3 hydronic snowand ice melting system in line with this specification.

b) This specification shall be read by the Contractor and applied in conjunction with HydronicRadiant Floor Heating specification.

c) The Contractor shall supply and install a class 3 snow and ice melting system capable of melting the snow as fast asfalls and quickly evaporate it so that surface is dry at the end of the cycle.

d) The Contractor shall ensure the heat requirement shall be determined by rate of snowfall, dry bulb temperature, humidity, wind speed and apparent sky temperature. This information is available from the National Climate Data Center or other publications such as the ASHRAE Handbooks.

1) Example: For the Toronto area, the typical design climatic data considered shall be: -20°C (-4°F) outdoor temperature, 32 km/hr (20 mph), estimated maximum hourly rate of snowfall 2.8 to 4.5 cm/hr (1.1 to 1.8"/hr). Under such circumstances, the typical value for a class 3 snow and ice melting system serving an unsheltered surface in the Toronto andGTA area is between 185 and 200 (BTU/hr. ft²) (Roads and Transportation Association of Canada).

e) The Contractor shall ensure hydronic snow and ice melting system uses multiple hot fluid tubes embeddedin (or under) the surface required to be clean of ice. The temperature differential between the hot fluid entering and leaving the area to be protectedshould not exceed 14°C (25°F) to avoid thermal shock.

f) The Contractor shall ensure the flow of hot fluid shall be determined by selecting a pipe velocity of between 1 to 1.5 m/s (3 and 5 ft/s) to avoid excessive pressure drop and pipeerosion.

g) The Contractor shall ensure the fluid to be used shall contain sufficient inhibited antifreeze to maintain thesolution in a pumpable fluid state at least 3°C (5°F) below the lowest anticipated ambient air temperature. A non-toxic antifreeze such as food- grade propylene glycol shall be used.

1.2.2. Embedded plastic tubing

a) The snow and ice melting system to be designed by the Contractor shall be "idle" during no-snow condition, maintaining the protected surface at a temperature just above freezing. It is desirable to use the earth beneath the protected surface as a heatsink, by installing vertical insulation at the edges of the surface, down minimum 1.2 m (4 ft).

b) The Contractor shall ensure there will be no splicing of plastic tubing; each circuit shall be contiguous. Thelayout of circuits shall consider the configuration of area to be protected, any expansion joints, column footings, etc. If located directly below asphalt, circulate domestic cold water at a rate of 1.0 gpm per circuit, until the platform surface cools to 65°C (150°F).

c) The Contractor shall use standard Grade hydrostatic pressure ratings from Plastics Pipe Institute inaccordance with TR-3 as listed in TR4.

d) The Contractor is required to use the following three standard grade hydrostatic ratings:

1) 93 °C (200 °F) at 551 kPa (80 psi);

2) 82 °C (180 °F) at 689 kPa (100 psi);

3) 23 °C (73.4 °F) at 1102 kPa (160 psi).

e) The Contractor shall provide a certification of flame spread/smoke development rating of 25/50 in accordance with ASTM E84 for the following PEX tubing sizes when encasedwith 12.7 mm (½ ") fiberglass insulation at tube spacing of not less than 4 inches apart:

1) 7.94 mm (5/16");

2) 9.53 mm (3/8");

3) 12.7 mm (½ ");

4) 15.88 mm (5/8");

5) 19.05 mm (¾");

6) 25.4 mm (1");

7) 31.75 mm (1 ¼");

8) 38.1 mm (1 ½");

9) 50.8 mm (2").

f) The Contractor shall provide hydronic snow and ice melting system that is manufactured, fabricatedand installed to comply with regulatory agencies and authorities with jurisdiction, and maintain performance criteria stated by the PEX tubing manufacturer without defects, damage or failure.

g) The Contractor shall show compliance with ASTM F877.

h) The Contractor shall show compliance with DIN 4726 regarding oxygen diffusion concerns whereapplicable.

i) The Contractor shall show compliance with ASTM E119 and ANSI/UL 263 through certificationlistings with Underwriters Laboratories, Inc. (UL).

1.2.3. Heating Plant

a) The provision of the heating plant and associated primary and secondary distribution loops as described here in this specification shall be provided by the Contractor as follows:

1) Independent dedicated systems for each snow melt system and radiant floor heating system. (One heating plant and distribution system shall be provided to serve only the snow melting system and another heating plant and distribution system shall be provided to serve only the radiant floor heating system); and

2) The two system types are not to be interconnected in anyway as they should be designed to run independently of each other. Note exception as indicated in 1.2.7 Digital Controls.

b) The Contractor shall ensure the heat source for the snow and ice melting system shall be a gas-fired boilerplant that includes a pair of boilers, each sized at 60% of the total heating demand.

c) The Contractor shall ensure the total heating demand shall be defined as the sum of: The total heatingdemand of the snow melting system.

d) The Contractor shall ensure the piping arrangement shall contain a primary loop and two secondary loopsas follows:

1) The primary loop shall circulate the heating fluid through the boilers, ensuring that they remain hot, and no thermal shock will occur. The average temperature of the primary loop shall not drop below 54.4°C (130°F) (adjustable), with a differential between supply and return of 14°C (25°F). Fluid circulation in the primary loop shall be provided by:

i) In-line circulators (one per boiler) for total primary loop fluid flowsof 200 gpm or less. Each pump assembly to include a strainer upstream, a balancing valve downstream and pressure gauges on

the suction and discharge sides. Pumps to be interlocked with the boilers serve.

ii) Vertical-in line centrifugal pumps working in a lead/lag sequence for primary loop total fluid flow in excess of 100 gpm (each pump sized for the full flow of the primary loop). Each pump shall be equipped with a suction guide and a discharge triple-duty valve.

2) Applicable only for snow melting systems: One secondary loop serving the snow melting system. This loop shall interface with the primary loop via a 4-way mixing valve. Fluid circulationin the secondary snow melting loop shall be provided by vertical-in line centrifugal pumps working in a lead/lag sequence (each pump sized for the full flow of the snow melting loop). Each pump shall be equipped with a suction guide and a discharge triple-duty valve.

3) Applicable only for radiant floor heating systems: One secondary loop serving the indoor radiant floor heating. This loop shall interface with the primary loop via a 3-way mixing valve. Fluid circulation in the secondary radiant floor heating loop shall be provided by vertical-in line centrifugal pumps working in a lead/lag sequence (each pump sized for the full flow of the snow melting loop). Each pump shall be equipped with a suction guide and a discharge triple-duty valve.For details, refer to Metrolinx radiant floor heating standards.

e) The Contractor shall ensure all piping in the boiler plant shall be copper, adequately insulated, identifiedand protected by a canvas or PVC jacket.

f) For vibration isolation purposes, the Contractor shall ensure the boilers and the pumps shall be supportedby neoprene ribbed pads, suitable for the weight. The piping connections to the pumps shall include braided flexible connectors.

g) The Contractor shall ensure all equipment shall be located on concrete pads, minimum 100mm (4") highand shall be provided with isolation valves. Clearances shall be provided for access and maintenance work; in particular, the burners' gas trains shall not interfere with the maintenance clearances around the boilers.

h) The Contractor shall ensure adequate means of drainage shall be provided in close proximity of thepumps and boilers pressure relief valves.

i) The Contractor shall ensure the boiler plant shall be heated by electric unit heater operated by wall-mounted thermostats. The default setting shall be 10°C (50°F)

j) The Contractor shall ensure a CO monitoring system shall be installed in the boiler plant. The sensors shallbe installed in the breathing zone (4-6 ft above the floor). The default alarm setting shall be 50 ppm. The local alarm equipment

shall include both visual and audio means; a separate alarm signal shall be relayed to the BAS monitoring and the security supervisory alarm system.

1.2.4. Manifold Chambers

a) The Contractor shall ensure:

1) The snow and ice melting plastic tubes circuits shall be connected to brass manifolds, each circuit equipped with independent supply and return isolationvalves. The manifolds shall be located in recessed chambers, fully accessible;the number of chambers shall be determined by the area of the surface to be served and the respective number of circuits. The typical manifold can supply up to 12 circuits, with the length of each circuit not exceeding 60 m (200 ft).

2) The number of manifolds contained in each chamber shall be limited not onlyby the number and lengths of tubing circuits, but also by the physical size anddepth of the chamber, which should not be classified as a confined space. Adequate maintenance clearances shall be provided around the manifolds and valves.

3) All hot fluid piping inside the manifold chamber shall be copper, adequatelyinsulated and identified. Each manifold chamber shall have general shut-off valves, capable of isolating the contained manifolds.

4) Piping drainage ports, equipped with isolation valves shall be provided at the low points. Adequate means of drainage shall be provided, to ensure that any leak in the manifold chambers will be disposed of by gravity.

5) Each manifold chamber shall be equipped with a metallic lockable accesshatch, equipped with recessed handles.

6) Manifold chamber shall be minimum 2.44 m clearance from edge of platform (track side).

1.2.5. Manifold Cabinets

a) When the above grade manifold cabinets are provided in parking area or near driveway, mechanical protection from vehicle shall be provided accordingly.

1.2.6. Hot Fluid Underground Distribution

a) The Contractor shall ensure all underground hot fluid distribution between the boiler plant and the manifold chambers, or between various chambers shall be through pre- insulated flexible piping installed in scheduled 40 PVC sleeves; bell and spigot of sleeves to be oriented in the direction of flow through the

pre-insulated pipes. Due to its all-plastic construction, the pre-insulated pipe compensates for thermal movement and there is no requirement for expansion joints. The sleeves shall be 2 diameter sizes larger than the combined diameter of the flexible piping, insulation and protection jacket, and buried at a depth suitable for the surface above (pedestrian traffic, vehicular traffic, track right of way, etc).

b) Due to diameter limitations of the pre-insulated piping, the Contractor shall if required, provide multiple circuits between the boiler plant and the manifold chambers, to limit thehot fluid velocity at 1 to 1.5 m/s (3 to 5 ft/s).

c) When leaving the boiler plant and entering the manifold chambers, the Contractor shall ensure the pre-insulated piping and associated sleeves will respect the minimum bending radiuses recommended by the manufacturer. Manufacturer-supplied connectors and unions shall be provided where the pre-insulated plastic piping connects to the copper piping in the boiler room and manifold chambers.

1.2.7. Digital Controls

a) The Contractor shall supply, install, test and commission a complete microprocessor- based programmable control system including all components as described herein and as necessary to make the snow-meltingsystem operate in accordance with the sequences described in these specifications.

b) The control system as described here in this specification shall also have the capacity to control the radiant floor heating system in cases where both snow melt system and radiant floor heating system exists on the same site. In scenarios where only one system (i.e. snow melt system or radiant floor heating system) exists, the control system shall be provided to only control that one system.

c) The radiant floor heating system shall operate in accordance with the sequence of operation described in the Hydronic Radiant Floor Heating specification 23 21 12.

d) The operation of the snow melt system shall be independent of the operation of the radiant floor heating system. Each system shall operate under their respective sequence of operation and programming which controls and monitors their respective components (i.e. heating plant, distribution pumps, control valves, sensors, manifolds etc.) independently of each other.

e) The outdoor air temperature sensor provided for the operation of the snow melt system and the radiant floor heating system can be common. This means a dedicated outdoor air temperature sensor is not necessary for each system.

f) The system provided by the Contractor shall provide seamless interface with LONWORKS and BACNET such that the operation of the new snow melting system may be controlled, monitored and adjusted remotely or locally.

g) The system provided by the Contractor shall have access to the Metrolinx main server using the available WAN. Operators using the main server shall have full access to the BAS software, graphical user interface at each location and shall have the ability tocommunicate with the local control panels to adjust parameters, modify schedules, receive alarms, etc.

h) The Contractor shall ensure local workstations shall mirror the Graphical User Interface available on the main server and show on a read-only basis the operating parameters of the systems.

i) The Contractor shall ensure full access to the BAS parameters, schedules and programming shall be available through local control panels connectors to specialized Metrolinx staffusing portable computers (laptops, notebooks or similar).

j) The Contractor shall ensure wiring between the snow and slab mounted sensors and the boiler plant shall bælocated in a separate 100mm (4"Ø) schedule 40 PVC sleeve, running parallel to the hot fluid distribution piping.

k) For installation and wiring details of the snow melting sensor, the Contractor shall refer to theMetrolinx Snow Melting Sensor Installation detail.

1.2.8. Design requirements are based on Part 2 specified requirements of products.

1.3. RELATED WORKS

1.3.1. Section 20 05 05 - Mechanical Work General Instructions.

1.3.2. Section 20 05 10 - Basic Mechanical Materials and Methods.

1.3.3. Section 20 05 40 – Mechanical Work Commissioning.

1.3.4. Section 23 52 22 – Condensing Hot Water Boilers

1.3.5. Section 23 25 23 – Near Condensing Hot Water Boilers

1.3.6. Section 23 21 12 – Hydronic Radiant Floor Heating System

1.4. REFERENCE STANDARDS

1.4.1. Standards and codes to be latest editions adopted by and enforced by localgoverning authorities.

1.4.2. ANSI/UL 263 Standard for Safety for Fire Tests of Building Construction and Materials.

1.4.3. ANSI/TIA-568C Family of Telecommunications Standards.

1.4.4. ASTM B61 Standard Specification for Steam or Valve Bronze Castings.

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

1.4.6. ASTM E84 Standard Test Method for Surface Burning Characteristics of Building Materials.

1.4.7. ASTM E119 Standard Test Methods for Fire Tests of Building Construction and Materials.

1.4.8. ASTM136 Standard Test Method for Behavior of Materials in a Vertical Tube Furnace at 750 °C.

1.4.9. ASTM E814 Standard Test Method for Fire Tests of Through-Penetration Fire Stops.

1.4.10. ASTM F876 Standard Specification for Crosslinked Polyethylene (PEX) Tubing.

1.4.11. ASTM F877 Standard Specification for Crosslinked Polyethylene (PEX) Plastic Hot- and Cold-Water Distribution Systems.

1.4.12. ASTM D1784 - MEA #7-87, Standard Specification for Rigid Poly (Vinyl Chloride) (PVC) Compounds and Chlorinated Poly (Vinyl Chloride) (CPVC).

1.4.13. ASTM F1960 Standard Specification for Cold Expansion Fittings with PEXReinforcing Rings for Use with Cross-linked Polyethylene (PEX) Tubing.

1.4.14. American National Standards Institute (ANSI)/Underwriters Laboratories, Inc. (UL).

1.4.15. CAN/CSA B137.5 Cross-Linked Polyethylene (PEX) Tubing Systems for Pressure Applications.

1.4.16. CSA C22.2 No.56 - Flexible Metal Conduit and Liquid Tight Flexible Metal Conduit.

1.4.17. CSA C22.2 No 18 Outlet Boxes, Conduit Boxes, Fittings and Associated Hardware.

1.4.18. C22.2 NO. 83- Electrical Metallic Tubing.

1.4.19. CSA C22.2 No. 211.2 Rigid PVC (Unplasticized) Conduit.

1.4.20. DIN 4726 Warm water surface heating systems and radiator connecting systems - Plastics piping systems and multilayer piping systems.

1.4.21. EMC Directive 89/336/EEC.

1.4.22. International Electrical Code IEC No. 61010.

1.4.23. T530 Commercial Building Standard for Telecommunications Pathways and Spaces.

1.4.24. TIA/EIA-TSB-67: Transmission Performance Specifications for Field Testing of Unshielded Twisted-Pair Cabling Systems.

1.5. TRAINING

1.5.1. The Contractor shall train Owner's personnel about operation and maintenance of installed system. Provide manufacturer's installation, operation and maintenance instructions forinstalled components within the system.

1.5.2. The Contractor shall ensure training is to be a full review of all components including but not limited to a full operation and maintenance demonstration, with abnormal events.

1.5.3. The Contractor shall submit a proposed training lesson plan for each session the Metrolinx for review andapproval.

1.5.4. The Contractor shall include for 3 training sessions of maximum 7 hours duration per session for 10 Metrolinx people per session.

1.5.5. The Contractor shall refer to Section 20 05 05 for additional general requirements.

1.6. WARRANTY

1.6.1. Warranty shall be in line with Contractual Requirements.

1.6.2. Warranty Period for PEX Tubing: 25 years, non-prorated warranty against failure due to defect in material or workmanship, beginning with date of substantial completion of work.

1.6.3. Warranty Period for system performance: min. 10 year limited, non-prorated warranty against failure due to defect in material or workmanship, beginning withdate of substantial completion of work.

1.6.4. Minimum 2 years for other product and labor requirements.

1.7. DELIVERY, STORAGE AND HANDLING

1.7.1. The Contractor shall handle and store products in accordance with manufacturer's instructions, in locations approved by Metrolinx. Include one copy of these instructions with productat time of shipment.

1.7.2. The Contractor shall ensure store PEX tubing in cartons or under cover to avoid dirt or foreign material from entering the tubing.

1.7.3. The Contractor shall not expose PEX tubing to direct sunlight for more than 30 days.

If constructiondelays are encountered, cover the tubing that is exposed to direct sunlight.

1.8. SUBMITTALS

1.8.1. The Contractor shall ensure refer to submittal requirements in Section 20 05 05.

1.8.2. The Contractor shall submit a copy of system manufacturer's counterflow method loop layout designindicating water flows and temperatures, heated surface profiles, and heating outputs.

1.8.3. The Contractor shall submit a certified tubing and piping layout and schematic for each system zone;

1.8.4. The Contractor shall submit a certified power wiring schematic and a certified control wiring schematicwith sequence of operation for each system zone.

1.8.5. The Contractor shall submit a letter from system component manufacturer stating system componentsproposed meet all requirements of Specification.

1.8.6. The Contractor shall submit a copy of manufacturer's training certificate.

1.8.7. The Contractor shall submit, prior to application for Substantial Performance of the Work, start-up andtest data.

1.8.8. The Contractor shall submit letters of installation certification from system manufacturer's representative.

1.8.9. Product Data

a) The Contractor shall submit manufacturer's Product data indicating:

1) technical data, supplemented by bulletins, component illustrations, detailed views, technical descriptions of items, and parts lists;

2) performance criteria, compliance with appropriate reference standards; characteristics, limitations, and troubleshooting protocol;

3) product transportation, storage, handling, and installation requirements;

4) product identification in accordance with Metrolinx requirements.

1.8.10. Shop Drawings

a) The Contractor shall submit Shop Drawings/Product data sheets for products. Include following:

1) capacity and ratings;

2) dimensions;

3) mounting details to suit locations shown, indicating methods and hardware to be used;

4) a certified power wiring schematic and a certified control wiringschematic with sequence of operation for each system zone;

i) System Architecture indicating the type and model number for all BAS components, the proposed interconnection and location of all panels, network connection and key peripheral devices (workstations, modems, printers, repeaters, etc)

ii) BAS Points List indicating the panel ID, panel location, hardware address, point acronym, point description, field device type, point type (i.e. AO/DO/AI/DI), end device fail position, end device manufacture and model number and wire tag ID.

iii) Provide a list of field labels (i.e. lamicoids) with proposed software names and point descriptions.

iv) Wiring diagrams including complete power system, interlocks, control and data communications.

v) Programming code listing for all controllers

vi) Manufacturers' data/specification sheets and catalogue cuts for all material and equipment supplied.

vii) Automatic control devices and sensors

1.8.11. Commissioning Package

a) The Contractor shall submit the following in accordance with Sections 20 05 05 and 20 05 40:

1) Commissioning Plan;

2) Commissioning Procedures;

3) Certificate of Readiness;

4) complete test sheets specified in Section 20 05 40 and attach them to the Certificate of Readiness;

5) Source Quality Control inspection and test results and attach to the Certificate of Readiness.

1.8.12. Commissioning Closeout Package

a) The Contractor shall submit the following in accordance with Section 20 05 05:

1) Deficiency Report;

2) Commissioning Closeout Report;

3) Submit the following for each Product for incorporation into theOperation and Maintenance Manuals in accordance with Section 20 05 05:

i) Identification: manufacturer's name, type, year, serial number, number of units, capacity, and identification to related systems;

ii) functional description detailing operation and control of components;

iii) performance criteria and maintenance data;

iv) safety precautions;

v) operating instructions and precautions;

vi) component parts availability, including names and addresses of spare part suppliers;

vii) maintenance and troubleshooting guidelines/protocol;

viii) product storage, preparation, handling, and installation requirements;

ix) Commissioning Report.

1.9. QUALITY ASSURANCE

1.9.1. Manufacturers Qualifications

a) The Contractor shall ensure manufacturer is ISO 9000, 9001 or 9002 certified. Manufacturer of product shall have produced similar product for a minimum period of five years. When requested by Consultant, an acceptable list of installations withsimilar product shall be provided demonstrating compliance with this requirement.

b) Where manufacturers provide after installation onsite inspection of product installations, the Contractor shall include for manufacturer's authorized representative to performonsite inspection and certificate of approvals.

1.9.2. Installers Qualifications

a) The Contractor shall use an installer with demonstrated experience on projects of similar size and complexity and possessing documentation proving successful

completion of snow and ice melting training by the PEX tubing manufacturer.

b) The Contractor shall provide letters of certification as follows:

1) Installer is trained by the PEX tubing manufacturer to install the snow and ice melting system; and

2) Installer uses skilled workers holding a trade qualification license or equivalent, or apprentices under the supervision of a licensed tradesperson.

c) The Contractor shall ensure installers for work to be performed by or work under licensed MechanicalContractor and supervision of manufacturer or supplier's representative.

d) Where manufacturers provide training sessions to installers and certificates upon successful completion, the Contractor shall ensure installers to have obtained such certificates andsubmit copies with Shop Drawings.

1.9.3. Regulatory Requirements

a) The Contractor shall ensure Products and Work comply with applicable local governing authorityregulations, bylaws and directives.

b) The Contractor shall include for required inspections and certificate of approvals of installation workfrom local governing authorities.

2. PRODUCTS

2.1. HEATING PLANT BOILERS

2.1.1. The Contractor shall refer to Near Condensing Hot Water Boilers specification and Condensing HotWater Boilers specification.

2.2. PUMPS

2.2.1. Vertical In-Line Centrifugal Pumps

a) Applicable: primary loop flow larger than 200 gpm, all secondary loops

b) Furnish and install, as indicated on the plans and specifications, in-line split couple vertical centrifugal pumps. Capacity and power supply: as indicated on the equipment schedule.

c) Pump Casing - Cast Iron with 125 psig ANSI/PN16 flanges for working pressure below 175 psig (12 bar) at 150F° (65C°) and Ductile Iron with 250 psig ANSI/PN25 flanges for working pressures to 375 psig (25 bar) at 150F° (65C°). Suction and discharge connections shall be flanged and the same size and shall be drilled and tapped for seal flush and gauge connections.

d) Impeller - Bronze, fully enclosed type. Dynamically balanced. Two-plane balancing is required where installed impeller diameter is less than 6 times the impeller width.

e) Shaft - Provide Stainless Steel pump shaft.

f) Coupling - Rigid spacer type of high tensile aluminum alloy. Coupling to be designed to be easily removed on site to reveal a space between the pump and motor shafts sufficient to remove all mechanical seal components for servicing and to be replaced without disturbing the pump or motor.

g) Mechanical Seals - Shall be Stainless Steel multi-spring outside balanced type with Viton secondary seal, carbon rotating face and silicon carbide stationary seat. Provide 316 stainless steel gland plate. Provide factory installed flush line with manual vent.

h) All split coupled pumps shall be provided with a lower seal chamber throttle bushing to ensure seals maintain positively cooling and lubrication.

i) Seal flush line accessories, if required to improve seal chamber cleanliness: Supply in the flush line to the mechanical seal a 50 micron cartridge filter and sight flow indicator, to suit the working pressure encountered.

j) Filters shall be changed, by the installing contractor, after system is flushedand on a regular basis until turned over to the Board.

2.2.2. Suction Guides

a) Furnish and install on the suction of each pump a suction guide, with outlet flow stabilizing guide vanes, removable stainless steel strainer and fine meshstart-up strainer.

b) For 150 psig flanged pipe: Supply valve with Cast Iron body with 125 psig flanged ports.

c) For 300 psig flanged pipe: Supply valves with Ductile Iron body and 250 psig flanged ports.

2.2.3. Triple Duty Valves

a) The valve stem shall be stainless steel with flat surfaces provided foradjustment with open-end wrench.

b) PN25 ductile iron flanges with antirotation lugs and EPT gaskets.

c) For Welded Flange Piping: For 10 bar flanges: Valve body shall be Cast Iron with PN16 flanged ports. For 20 bar flanges: Valve body shall be Ductile Ironwith PN25 flanged ports.

d) The valve shall be selected and installed in accordance with the manufacturer's instructions and be suitable for the pressure and temperature specified.

e) Insulation

1) Each triple-duty valve shall be furnished with a pre-formed removable PVC insulation jacket to meet ASTM D1784 Class 14253- C, MEA #7-87, ASTM-E- 84 and ASTM136 with a flame spread rating of 25 or less and a smoke development rating of 50 or less. There will be provided sufficient mineral fiberglass insulation to meet ASHRAE 90.1-1989 specifications in operating conditions with maximum Fluid Design Operating Temperature Range of 141F°-200F° (60C°-93C°) and Mean Rating Temperature of 125F°(52C°).

2.2.4. In-Line Circulator Pump

a) Applicable: primary loop flow per boiler smaller than 100 gpm

b) General:

1) For size, flow and head, refer to the equipment schedules.

2) Pump shall be BF (Bronze Fitted) construction, three-piece design featuring the Armstrong shaft and bearing module which shall fit all models S25 through S57 and H32 through H54. The shaft oil-lubricated bronze sleeve bearing. Pump to be equipped with a water-tight, long life, "ARMSEAL" mechanical seal and be suitable for 225 F°, 125 psi

2.2.5. Circulator Pump Circuit Balancing Valve

a) Furnish and install downstream of each in-line circulator pump, a circuit balancing valves. Valves are to be of the 'Y' pattern, equal percentage globe-style and provide three functions: 1) Precise flow measurement, 2) Precision flow balancing, 3) Positive drip-tight shut-off.

b) Valve shall provide multi-turn, 360° adjustment with micrometer type indicators located on the valve hand wheel. Valves shall have a minimum of five full 360° hand wheel turns. 90° 'circuit-setter' style ball valves are not acceptable. Valve handle shall have hidden memory feature, which will provide a means for locking the valve position after the system is balanced.

c) Valves shall be furnished with precision machined venturi built into the valve body to provide highly accurate flow measurement and flow balancing. The venturi shall have two, ¼" threaded brass metering ports with check valves and gasketed caps located on the inlet side of the valve. Valves shall be furnished with flow smoothing fins downstream of the valve seat and integral to the forged valve body to make the flow more laminar. The valve body, stem and plug shall be brass. The hand wheel shall be high-strength resin.

2.3. PEX SNOW MELTING TUBING

2.3.1. Material: Cross-linked polyethylene (PEX) manufactured by the Engle method.

2.3.2. Material Standard: Manufactured in accordance with ASTM F876 and ASTM F877and tested for compliance by an independent third-party agency.

2.3.3. 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).

2.3.4. Show compliance with ASTM E119 and ANSI/UL 263 through certification listings through UL.

2.3.5. 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.

2.3.6. Oxygen Diffusion Barrier

a) 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 inaccordance with German DIN 4726.

b) Nominal Inside Diameter: Provide tubing with nominal inside diameter in accordance with ASTM F876, as indicated:

1) 12.7 mm (½");

2) 19.05 mm (¾");

3) 25.4 mm (1").

2.3.7. Heating Agent Distribution Piping

a) Includes: all piping between the exterior wall of the boiler room and theinterior wall of the distribution manifolds chamber(s).

b) All piping between the interior wall of the manifold chamber and the manifolds themselves to be in accordance with section HVAC Piping and Pumps.

c) System Description

1) Pre-insulated pipe system for buried commercial hydronic heating applications.

2) Service pipes are made from durable "Engel-method" crosslinked polyethylene (PEX-a) tubing and protected by multilayer PEX-foam

insulation and covered by a corrugated, waterproof HDPE jacket. The system can use Uponor ProPEX® fittings or WIPEX™ dezincification resistant (DZR) brass compression fittings. Saline and electronic cross linking methods are not acceptable.

d) Service Pipe

1) 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.

e) Insulation

1) 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.

f) Jacket

1) Corrugated seamless high-density polyethylene (HDPE), UV-protected.

g) Operating Limits

1) -50°C to 95°C (-58°F to 203°F) at 87 psig.

h) Pipe Sizes: 25.4 mm (1") to 38.1 mm (1 ½") diameter.

i) Standard of quality assurance manufacturer is Ecoflex or approved equivalent.

2.3.8. Manifolds (Commercial, Valved Copper)

a) For system compatibility, use 2-inch valved copper manifolds manufactured from Type L copper material, offered by the respective PEX tubing manufacturer. Valving shall include ball isolation valves and balancing valves.

b) Install valved copper manifolds primarily for wall-hung or boxed applications.

c) Use manifolds with an isolation valve or a combination isolation and balancing valve on each outlet.

d) Use manifolds that support 15.88 mm (5/8") or 19.05 mm (¾") PEX tubing.

e) Ensure manifold end cap offers tapping for 3.175 mm (1/8") FNPT and 12.7 mm (½ ") FNPT for vent and drain.

f) Install supply and return piping to the manifold in a reverse-returnconfiguration to ensure self-balancing.

g) 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.

2.3.9. Fittings

a) For system compatibility, use fittings, connectors, wall sleeves and other accessories offered by the PEX tubing manufacturer, including connectors to metallic piping.

b) The fitting assembly must comply with ASTM F877 and CAN/CSA B137.5 requirements.

c) Fitting assembly manufactured from UNS C3600 series brass material.

d) The 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.

e) Fittings manufactured in accordance with ASTM F1960.

f) Fitting assembly manufactured from material listed in paragraph 5.1 of ASTM F1960.

g) 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.

2.3.10. Manifold Chamber

a) Construction

1) Pre-cast or cast in place concrete pit. A minimum overall 1,800x1,800 footprint or as indicated in drawings and a depth sized to avoid classification as "confined space" but deep enough to house all the manifolds, main GHWS/GHWR, complete with access lather and individual protected drainage system or sump pump. Coordinate withStructural Division for pit size, location, and type prior installation.

b) Access door

1) Material: Cover and frame shall be aluminum.

2) Cover: Smooth plate reinforced for 732 kg/m^2 (150 psf) live load. Cover designed with 25.4 mm (1") fillable pan for field installation of flooring material (specify flooring material including type, thickness, and weight).

3) Frame: Heavy-duty aluminum frame with built in anchor flange aroundthe perimeter.

4) Hinges: Continuous heavy-duty type 316 stainless steel piano hinge.

5) Latch: Type 316 stainless steel slam lock with fixed interior handle and

removable exterior turn/lift handle. Latch release is protected by a flush, gasketed, removable screw plug.

6) Lift Assistance: Compression spring operators enclosed in telescopic tubes. Automatic hold-open arm with grip handle release.

7) Hardware: Engineered composite compression spring tubes. Steel compression springs with electro coated acrylic finish. Type 316 Stainless steel hinges. All other hardware is zinc plated/chromate sealed.

2.4. DIGITAL CONTROLS

2.4.1. System Hardware

a) The Contractor shall ensure 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 to provide a system of connected controllers that operateas a single BAS for the entire project.

b) The Contractor shall read this specification in conjunction with the Hydronic Radiant FloorHeating specification.

c) The Contractor shall ensure all required site database and graphics files shall reside on Metrolinx central BAS server. The connection between the central server and the BAS controllersserving a specific building shall be through the WAN.

d) The Contractor shall ensure the building Staff shall be able to log into the local Workstation, access and review on a read-only basis the graphical user interface of the BAS showing thesystem layout and operational parameters.

e) The Contractor shall ensure the Metrolinx specialized trades shall be capable of accessing and modifyingthe BAS parameters and schedules using direct connectors at the control panels and portable computers (laptops, notebooks, etc).

f) The Contractor shall supply PCU's, PAC's and ASC's as required to interface to all specifiedequipment.

g) The Contractor shall allow for a minimum of 25% spare program and trend memory capacity ineach PCU and PAC.

h) For each specified BAS control point, the Contractor shall supply the hardware point type (e.g. AI, AO, DI, DO) as indicated on the controls points list. The useof 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.

2.4.2. Primary Control Units (PCU)

a) The Contractor shall:

1) Use only Primary Control Units to directly control any major mechanical equipment. Major mechanical equipment includes air handling units, boilerplants, chiller plants, cooling towers, roof-top units and other critical equipment.

2) Ensure each PCU shall contain a real time clock and sufficient memory to store itsown application database, operating parameters, user programs and trend data storage.

3) Provide battery backup to support the real-time clock and all volatile memory for a minimum of 72 hours to eliminate operating data reload in case of power failure.

4) Ensure each PCU output shall include a Hand/Off/Auto (HOA) selector switch for each analog and digital output.

5) Ensure each PCU shall have a minimum of 10% spare capacity for each type of inputand output channels and 10%.

2.4.3. Programmable Application Controllers (PAC)

a) The Contractor shall ensure 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 andunit ventilators.

b) The Contractor shall ensure PACs shall not be used for controlling major mechanical equipment asdescribed above.

c) The Contractor shall ensure 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.

d) Battery backup shall be provided by the Contractor to support the real-time clock and all volatilememory for a minimum of 72 hours to eliminate operating data reload in case of power failure.

2.4.4. System Software

a) BAS Workstation Software

1) Site licenses are not required by the Contractor.

b) Trend Data

1) The Contractor shall provide trend logs for all hardware inputs and outputs.

2) The Contractor shall ensure all trends should be accessible via the graphical interface.

3) The Contractor shall ensure trends contain all related variables of a control loop (i.e. setpoint, measured variable and control output) and can be plotted simultaneously on the same graph.

4) The Contractor shall ensure Field Devices individual trends provide an appropriate "snapshot"of the variable. Slow reacting variables such as space temperatures should be sampled every 30 - 60 minutes while other variables such as mixed air or boiler water temperatures should be sampled every 5 to 10 minutes.

5) The Contractor shall provide the maximum number of trend samples within the controllerwhile maintaining the requirement for spare memory capability.

6) The Contractor shall ensure the primary input sensor for all control loops must physically be wired tothe same panel containing the control loop output (e.g. boiler water temperature and burner control output).

7) The Contractor shall ensure trend data storage must be in the same panel as the hardware or logicalpoints being trended.

2.4.5. User Access

a) The Contractor shall provide Metrolinx user IDs and passwords for operations, maintenance andengineering staff.

2.5. ALARMS

2.5.1. The Contractor shall ensure alarms shall be assigned the following categories:

a) Maintenance Alarms

b) Mismatch of equipment control and status for more than 30 minutes

c) Any other miscellaneous alarm not specifically noted herein

2.5.2. Alarms shall not require any acknowledgment before automatic reset by the system.

2.5.3. An alarm notification shall not be issued when an alarm condition returns to normal.

2.5.4. 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.

2.6. BAS DYNAMIC GRAPHICS

a) The Contractor shall provide customized, site specific dynamic graphics to meet the requirementsof the Consultant and/or Metrolinx

2.7. SENSORS AND DEVICES

2.7.1. Snow Slab Sensor

a) The Contractor shall ensure 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 betweenthe heating elements or pipes.

1) Operating range - minus 50°C to 80°C (minus 60°F to plus 175°F).

2) Sensor - NTC thermistor, 25°C ±0.2°C (10 kΩ @ 77°F), ß=3892.

2.7.2. In-Slab Sensor

a) Operating range – minus 50°C to 60°C (- 60 to 140°F).

b) Sensor - NTC thermistor, 25°C ±0.2°C (10 kΩ @ 77°F), ß=3892.

2.7.3. Outdoor Air Temperature Sensors

a) The Contractor shall provide outdoor air temperature sensors with the following minimumcharacteristics:

1) each sensor shall be a 150 mm (6"), 10K thermistor probe;

2) minimum two sensors shall be installed for each site;

3) both sensors shall be mounted inside a heavy-duty (blow-proof) solar shield;

4) provide a heavy-duty, metal, wire guard.

2.7.4. Immersion Temperature Sensors

a) The Contractor shall use immersion temperature sensors with thermwells for all applications wherea temperature of a fluid in a pipe is being sensed.

b) The Contractor shall provide well-mounted water temperature sensors with the following minimumcharacteristics:

1) the sensors shall be 10k ohm thermistor encapsulated in a 6 mm (15/64") OD, 50 m (167 ft) long probe, with screw fitting for insertion into a standard thermowell;

2) operating range -10°C 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. Provide a stainless steel thermowell where exposed to corrosive liquids;

5) use conductive gel when mounting the sensor in the thermowell;

6) the sensors to be mounted on insulated piping shall be installed clear of the insulation.

2.7.5. Current Sensors (Analog)

a) The Contractor shall ensure current sensors (CT) shall be used for status monitoring of all motor-drivenequipment, where specified.

b) The Contractor shall ensure Technical Performance – Output should be only 4-20mA only. Voltage outputwill not be accepted. End-to-end accuracy +/- 1% of full scale at each range.

c) The Contractor shall ensure the current sensors shall be mounted inside the starter cabinets whenever possible. If this is not possible due to space limitation, provide an enclosure tohouse the sensor.

2.7.6. CO Monitoring Sensor

a) The Contractor shall ensure CO Monitoring Sensor adheres to the following requirements:

1) Two-wire transmitter providing continuous monitoring for carbon monoxide inambient air (0-500 ppm). Linear 4-20 mA output with two factory-set alarm levels and two alarm outputs.

2) Cover Aluminum cover mounting plate fits standard single outlet electrical box

3) Power Supply 50 mA; Supply Voltage 10 to 28 Vdc; (24 Vdc nominal) Power Consumption Maximum: 24 mA @ 24 Vdc. Nominal: 4 mA @ 24 Vdc

4) Temperature Range 0 to 50°C (32 to 122°F) Humidity 15 to 90% non-condensing

5) Sensor Zero-maintenance electrochemical

6) Self-test fail: 2 mA signal; Sensor expired: 2 mA signal; Over range gas alarm:24 mA signal (maximum). Power off: 0 mA signal

7) LED Indicator Advice Power on: On. No power: Off

8) Self-test fail: fast flash (1 flash every 0.5 seconds). Life ending warning: slow flash (1 flash every 2 seconds) - Provides one month warning prior to expiry date. Operational Life Ended: Off

9) Self-test On activation (auto) and daily (auto)

10) Warranty Two (2) year (3 year operational life)

11) Ratings and Certifications

i) Conforms to an Ordinary locations International Electrical Code: IECNo. 61010

ii) EMI/RFI Complies with EMC Directive 89/336/EEC

2.7.7. Status Relays (Solid State)

a) The Contractor shall ensure the status relays shall be mounted inside newly provided enclosures mountednear the respective equipment starter cabinets.

2.7.8. Automatic Control Valves

a) The Contractor shall ensure automatic control valves shall be supplied by the Controls Contractorand installed by the Mechanical Contractor.

b) The Contractor shall ensure automatic control valves, unless otherwise specified, shall be globe type valves. Valves and actuators shall be ordered as one factory-assembled andtested unit.

c) The Contractor shall submit to the Consultant for review, a valve schedule containing the followinginformation 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

10) Actuator maximum torque

d) The Contractor shall ensure valves 2″ (50mm) and smaller shall be constructed of bronze. Valves 2½″(65mm) and larger shall have iron bodies and bronze mountings.

e) The Contractor shall ensure all control valves shall have stainless steel stems.

f) The Contractor shall ensure the bronze in bodies and bonnets of all bronze valves shall conform to ASTM B62 for valves rated up to 150psig (1035 Kpa) working pressure and to ASTM B61 for valves rated at 200 psig (1380 Kpa) working pressure.

g) The Contractor shall ensure the bodies and bonnets of iron body valves shall conform to ASTM A126,Class B.

h) The Contractor shall ensure 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.

i) The Contractor shall ensure the control valves shall have tight shut-off. Flat disk valves are not acceptable.

j) The Contractor shall ensure control valves 2″ (50mm) and smaller shall be complete with screwed ends type, except for bronze valves installed in soldered copper piping which shallbe complete with soldering ends. Control valves larger than 2″ (50mm) shall be complete with flanged end type and proper flanged adapters to copper shall be provided where flanged valves are installed in copper piping.

k) The Contractor shall ensure the water control valves shall be sized for a pressure drop of 6 ft. water columnor as indicated on mechanical Drawings.

l) The Contractor shall ensure each automatic control valve must provide the design output and flow rates atpressure drops compatible with equipment selected.

m) The Contractor shall ensure each automatic control valve must be suitable for the particular system workingpressure.

n) The Contractor shall each automatic control valve shall be fitted with a position indicator.

o) The Contractor shall ensure all the same type of 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.

p) Unless otherwise indicated, the Contractor shall ensure control valves for proportional operation shall haveequal percentage characteristics, while the control valves for open/shut two- position operation shall have straight line flow characteristics.

2.7.9. Automatic Control Valve Actuators

a) The Contractor shall ensure each automatic control valve shall be fitted with a "fail-safe" operator capableof tight shut-off against the differential imposed by the system.

b) The Contractor shall ensure operators for valves in electric-electronic control systems shall be single phase AC, 24V electric motor operators.

c) The Contractor shall ensure valve actuators on valves 3" diameter and larger shall be provided witha manual position override.

d) The Contractor shall ensure valve actuators shall accept a 0-10VDC or 4-20mA control signal for allproportional applications

e) Floating point control of valves is not acceptable under any circumstances.

2.7.10. Local Service Ports

a) The Contractor shall ensure every DDC panel shall be provided with a local network access port to connectto 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 Metrolinx Workstation

b) The Contractor shall ensure where BAS points (4 or more) are located in a mechanical room that does nothave a local BAS 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.

2.7.11. LAN Cabling

a) The Contractor shall ensure 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.

b) The Contractor shall ensure cabling shall be 4 pair, 100 ohm UTP, #24 AWG solid copper conductor PVC insulated, with blue or grey colour coded jacket. FT6 rated cable shall be usedunless otherwise required to meet building codes or by-laws.

c) The Contractor shall ensure data outlets shall be RJ45, 8 pin connectors, with 50 microns of hard gold overnickel, minimum durability of 750 mating cycles and contact pressure of 100 grams per contact. Transmission characteristics shall meet TSB-40 Category V.

d) The Contractor shall 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.

e) The Contractor shall provide protection from EMI sources in accordance with CSA-T530 article 4

f) 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.

g) Where there are more than 2-90 degree in a conduit run, the Contractor shall provide a pull boxbetween sections so that there are two bends or less in any one section.

h) Where a conduit run requires a reverse bend, between 100 degrees and 180 degrees, the Contractor shall insert a pull box at each bend having an angle from 100 degrees to 180 degrees.

i) The Contractor shall 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 entera pull box from opposite ends with each other.

3. EXECUTION

3.1. PRE-INSTALLATION MEETINGS

3.1.1. The Contractor shall verify project requirements, substrate conditions, floor coverings, manufacturer'sinstallation instructions and warranty requirements.

3.1.2. The Contractor shall review project construction timeline to ensure compliance or discuss modificationsas required.

3.1.3. The Contractor shall interface with other trade representatives to verify areas of responsibility.

3.1.4. The Contractor shall establish the frequency and construction phase the project engineer intends for sitevisits and inspections by tubing manufacturer's representative.

3.2. HEATING PLANT BOILERS

3.2.1. The Contractor shall refer to Near Condensing Hot Water Boilers specification and

Condensing HotWater Boilers specification.

3.3. PUMPS

3.3.1. The Contractor shall install with bearing lubrication points accessible. Check rotation.

3.3.2. The Contractor shall ensure that pump body does not support piping or equipment. Provide stanchionsor hangers for this purpose. Refer to drawings and manufacturer's installation instructions for details.

3.3.3. The Contractor shall provide vibration isolation between the pumps and pipes, and between the pumpsand the concrete curbs. Refer to Basic Mechanical Materials and Methods specification.

3.3.4. The Contractor shall pipe drain tapping to floor drain.

3.3.5. The Contractor shall install volute venting pet cock in accessible location.

3.3.6. The Contractor shall change cartridge filter on regular basis prior to, and at turn over to owner.

3.3.7. The Contractor shall provide strainers, isolating valves, balancing valves and check valves as indicated onthe drawings.

3.3.8. The Contractor shall install a suction guide upstream of each vertical in-line pump. The mechanical contractor shall inspect the strainer prior to activating the pump and, further, shallremove the fine mesh start-up strainer after a short running period. (24 hours maximum). Space shall provide for removal of the strainer and connection of a blow- down valve.

3.3.9. The Contractor shall install a triple duty valve on the discharge of each vertical in-line pump.

3.3.10. Contractor to provide and install one pressure gauge, piped to pump suction, pump discharge and strainer inlet. Pressure gauge tappings with necessary isolating valves to enable differential pressure reading across pump and strainer to be taken.

3.3.11. Contractor shall cover motor during construction and have area clean ofconstruction debris before starting the motor.

3.3.12. Contractor to follow the manufacturer's instructions for start-up and venting of mechanical seal.

3.3.13. If pump is used during temporary heating or flushing of system, contractor shall be responsible for changing mechanical seal or replacing motor bearings if so, instructed by the board representative.

3.3.14. The Contractor shall ensure the pump manufacturer coordinates with the hydronic balancer to balance thesystem to the required flows.

3.3.15. The Contractor shall provide drip pan and piped to nearest drain for each pump. Drip pan shall be sizedto suit pump dimensions.

3.4. PEX SNOW MELTING TUBING

3.4.1. Manufacturer's Instructions

3.4.2. The Contractor shall comply with manufacturer's product data, including product technical bulletins,installation instructions and design drawings.

3.4.3. Insulation

a) The Contractor shall provide a 50 mm (2") (R10 or greater) rigid layer of closed cell foam insulation under the tubing rated for outdoor use or equivalent.

3.4.4. Installer's Experience

a) The Contractor shall ensure the installing contractor shall have a min. of 10 years of demonstratedexperience on projects of similar size and complexity in Ontario.

3.4.5. Examination

a) The Contractor shall verify that site conditions are acceptable for installation of the snow and icemelt system.

b) The Contractor shall not proceed with installation of the snow and ice melt system untilunacceptable conditions are corrected.

3.4.6. Installation

a) Slab-on-grade Construction with Edge and Under-slab Insulation

1) When using high-density foam insulation board, the Contractor shall install the tubing by stapling the tubing to the insulation board with Uponor Foam Staples orapproved equivalent.

2) The Contractor shall ensure the under-slab insulation shall be rigid 50.8 mm (2") polystyrene suitablefor underground applications.

3) The Contractor shall install the vertical edge insulation along the perimeter of the slab anddown to a depth equal to the bottom of the horizontal under-slab insulation.

4) The Contractor shall ensure 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").

5) On a 609.6 mm (24") wide band along the platform edge, the Contractor

shall ensure the piping density shall be increased to the maximum allowed by the manufacturer(152 mm [6"] on centre) regardless of the size of the tubing.

6) The Contractor shall not install tubing closer than 152 mm (6") from the edge of theheated slab.

7) The Contractor shall install the tubing at a consistent depth below the surface elevation asdetermined by the project engineer. Tubing installation will ensure sufficient clearance for all control joint cuts.

8) In areas where tubing must cross metal expansion joints that occur in the concrete, the Contractor shall ensure the tubing shall pass below the metal expansion joints.

9) Fibrous expansion joints may be penetrated following the PEX tubing manufacturer's and structural engineer’s recommendation to the Contractor.

10) Metal or plastic bend supports will be used by the Contractor to support the tubing whendeparting from the slab in a 90-degree bend.

b) Pavers Over a Compacted Bed Construction with Edge and Under-slab Insulation

1) When using high-density foam insulation board, the Contractor shall install the tubing by stapling the tubing to the insulation board with manufacturer-suppliedstaples.

2) The Contractor shall ensure the under-slab insulation shall be rigid 50.8 mm (2") polystyrene suitablefor underground applications.

3) The Contractor shall install the vertical edge insulation along the perimeter of the slab anddown to a depth equal to the bottom of the horizontal under-slab insulation.

4) The Contractor shall ensure 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 229 mm (9").

5) On a 609.6 mm (24") wide band along the platform edge, the Contractor shall ensure the piping density shall be increased to the maximum allowed by the manufacturer(152 mm,6" on centre) regardless of the size of the tubing.

6) The Contractor shall not install tubing closer than 152mm (6") from the edge of the heatedslab.

7) The Contractor shall ensure bedding material for all tubing shall be layer

min. 6" deep of compacted#8 crushed limestone and screenings (9.53 mm,3/8" diameter). The fill over the PEX tubing must be void of any sharp material. The pavers are then installed over the compacted soil bed.

8) The Contractor shall ensure backfilling of all pipes shall be well compacted by means of jetting or other approved methods to eliminate settling. Any completed areas thatshow settlement shall be promptly re-backfilled with compacted clean earth.

9) Metal or plastic bend supports will be used by the Contractor to support the tubing whendeparting from the slab in a 90-degree bend.

c) Asphalt Construction with Edge and Under-slab Insulation

1) When using high-density foam insulation board, the Contractor shall install the tubing by stapling the tubing to the insulation board with Uponor Foam Staples orapproved equivalent.

2) The Contractor shall ensure the under-slab insulation shall be rigid 50.8 mm (2") polystyrene suitablefor underground applications.

3) The Contractor shall install the vertical edge insulation along the perimeter of the slab anddown to a depth equal to the bottom of the horizontal under-slab insulation.

4) The Contractor shall ensure 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 229 mm (9").

5) On a 609.6 mm (24") wide band along the platform edge, the Contractor shall ensure the piping density shall be increased to the maximum allowed by the manufacturer(152 mm (6") on centre) regardless of the size of the tubing.

6) The Contractor shall not install tubing closer than 152 mm (6") from the edge of theheated slab.

7) The Contractor shall ensure bedding material for all tubing shall be layer 50 mm (2") deep of compacted #8 crushed limestone and screenings (9.53 mm [3/8"] Dia.). The fill over the PEX tubing must be void of any sharp material. The pavers are then installed over the compacted soil bed.

8) The Contractor shall ensure backfilling of all pipes shall be well compacted by means of jetting or other approved methods to eliminate settling. Any completed areas thatshow settlement shall be promptly re-backfilled with compacted clean earth

9) Metal or plastic bend supports will be used by the Contractor to support

the tubing whendeparting from the slab in a 90-degree bend.

d) Poured-in-place Stair Construction

1) The Contractor shall fasten the tubing to flat wire mesh or reinforcing bar in accordance withtubing manufacturer's installation recommendations.

2) The Contractor shall ensure the submitted snow-melt design specifies the tubing on-center distance(s) and loop lengths. On-center distances will not exceed229mm (9").

3) The Contractor shall install the tubing parallel to the step tread.

4) The Contractor shall install the supply side of the loop along the step's edge. Install the tubingwill be within 76 mm (3") of the step's edge.

5) The Contractor shall ensure the under-slab insulation shall be 50.8 mm (2") polystyrene suitable forunderground applications.

6) The Contractor shall install the vertical edge insulation along the perimeter of the slab and down to a depth equal to the bottom of the horizontal under-slab insulation.

7) The Contractor shall install the tubing at a consistent depth below the surface elevation asdetermined by the consultant.

8) Metal or plastic bend supports will be used by the Contractor to support the tubing whendeparting from the slab in a 90-degree bend.

e) Heating Agent Distribution Piping

1) The Contractor shall ensure piping shall be installed in a schedule 40 PVC pipe sleeve; the sleeve sizeshall be two diameter sizes larger than the combined diameter of the distribution piping plus insulation plus jacket.

2) The Contractor shall maintain min. 101.6 mm (4") horizontal distance between the PVCsleeves.

3) The Contractor shall coordinate with the site services discipline the depth of the sleeves andthe back-filling material, depending on the nature of the surface above (landscape, pedestrian traffic, vehicular traffic, train right of way, etc).

4) The Contractor shall respect the minimum bending radius recommended by themanufacturer.

f) Glycol/Water Solution

1) The Contractor shall ensure the heating fluid shall be premixed

glycol/water solutions (40%/60%). PEX tubingmanufacturer allows site-mixed solutions if mixed to the proper concentration before entering the system.

2) The Contractor shall mix the glycol/water solution to proper concentration levels to protect the system freezing during operation shutdown.

3) The Contractor shall ensure system circulators must operate continuously for a minimum of 30 days after the system is filled to ensure the glycol and water does not separatein a static system.

4) The Contractor shall not use ethylene glycol due to toxicity issues. Instead, use of inhibitedpropylene glycol. Also, refer to the boiler manufacturer's recommendations.

g) Field Quality Control

1) Site Tests

i) To ensure system integrity, the Contractor shall pressure test the system before covering tubing in concrete or when other trades are working inthe vicinity of the tubing.

2) The Contractor shall test all electrical controls in accordance with respective installationmanuals.

h) Adjusting

1) Balancing Across the Manifold

i) The Contractor shall balance all loops across each manifold for equal flow resistancebased on actual loop lengths and total manifold flow.

ii) Balancing is unnecessary when all loop lengths across the manifold are within 3 percent of each other in length. The Contractor shall install the supply and return piping to the manifold in a reverse-return configuration to ensure self-balancing.

iii) The Contractor shall ensure balancing between manifolds is accomplished with a flow control device installed on the return piping leg from each manifold whendirect return piping is used for the supply and return mains.

iv) The Contractor shall adjust all boiler and system controls after the system has stabilizedto ensure proper operation in accordance with the system design.

i) Cleaning

1) The Contractor shall remove temporary coverings and protection of adjacent work areas.

2) The Contractor shall repair or replace damaged installed products.

3) The Contractor shall clean installed products in accordance with manufacturer's instructionsprior to owner's acceptance.

4) The Contractor shall remove construction debris from project site and legally dispose ofdebris.

j) Demonstration

1) The Contractor shall demonstrate operation of hydronic snow and ice melting system toowner's personnel.

2) The Contractor shall advise the owner's representative 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.

k) Protection

1) The Contractor shall protect installed work from damage caused by subsequent constructionactivity.

3.5. DIGITAL CONTROLS

3.5.1. Sequence of Operation

a) The Contractor shall ensure:

1) The heating plant shall serve both snow melting systems. It is possible that one of the systems may be operational while the other remains idle. These specifications refer to the sequence of operation for the snow-melting system; this sequence does not preclude the energizing of the boiler plant for comfortheating purposes before the snow melting secondary loop is energized.

2) The heating plant shall be enabled/disabled by the BAS based on outdoor temperature (T_1)

3) The snow melting system shall be enabled/disabled by the BAS based on outdoor air temperature (T_2)

4) The default relationship between the two outdoor temperatures shall be $T_1 > T_2$.The gradient shall be adjustable by Metrolinx.

5) 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 theprimary pumps shall alternate at 168 hrs. intervals (adjustable).

6) Upon proof of flow in the primary loop, the lead boiler shall start at minimumfiring rate, while the lag boiler shall be energized and in stand-by mode. The lead/lag status of the boilers shall alternate at 168 hrs. intervals (adjustable).

7) After the lead boiler started, its firing rate shall modulate as required to maintain the primary loop return temperature at 51°C (125°F), and subject to amaximum primary loop supply temperature of 66°C (150°F). All setpoints adjustable.

8) If the lead boiler fires at max. rate for 10 minutes and cannot maintain the primary loop return temperature setpoint, the lag boiler shall start at minimum firing rate; its burner shall ramp as required to maintain the primary loop returnsetpoint, subject to the same maximum primary loop supply temperature of 66 °C (150 °F). Where applicable (individual boiler circulators), the energizingof the lag boiler shall be preceded by the start-up of the lag boiler circulator (primary flows of less than 200 gpm).

9) 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 168 hrs. intervals (adjustable).

10) The four-way mixing valve shall modulate as required to maintain the snow-melting slab temperature at the following temperatures:

    i) 0 °C (+32 °F) if no snow or ice is detected on the surface of the slab bythe respective sensor;

    ii) +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:

    i) Maintain the minimum primary loop return temperature of 51 °C (125 °F)

    ii) Maintain the maximum temperature differential in the snow melting loopof 14 °C (25 °F) to prevent slab thermal shock.

12) The system shall generate alarms in case of:

    i) any pump failure (while automatically enabling the stand-by pump);

    ii) any boiler failure (while automatically enabling the stand-by boiler);

iii) primary loop temperatures +/-6 °C (10 °F) departure from the setpoint;

iv) slab temperature +/-3 °C (5 °F) departure from the setpoint.

3.5.2. Installation of Snow Sensor

a) The Contractor shall ensure:

1) The installation of the snow sensor shall conform drawing detail.

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) Installation of all wiring and tubing in the area of the sensor shall be as indicated on the detail.

3.5.3. Installation of Temperature Sensors In Piping

a) The Contractor shall ensure the Controls Contractor shall supervise and direct the Mechanical Contractorto ensure that thermowells are installed as described herein.

b) For each immersion sensor, the Contractor shall provide a compatible thermowell to the Mechanical Contractor for installation. Provide stainless steel thermowellswhere installed in piping carrying corrosive or chemically reactive fluids.

c) The Contractor shall install thermowells in piping such that the bottom of the well does not make contact with the pipe. Install the well at a 90 degree elbow or tee where the pipe diameter is less than the well length.

3.5.4. Installation of Outdoor Air Temperature Sensors

a) The Contractor shall ensure:

1) The outdoor air sensors shall be mounted so that the ventilation slots on the solar shields are facing downward (when mounted horizontally) or towards thewall (when mounted vertically).

2) To mount the sensors on the north-facing side of the building away from direct sunlight.

3) To mount the sensors in an easily serviceable location.

4) that the sensors are located away from building exhaust air orequipment air flows.

3.5.5. Installation Of Automatic Control Valves And Actuators.

a) The Contractor shall ensure the Mechanical Contractor installs Automatic Control Valves and Actuators, unless specified otherwise.

b) The Contractor shall ensure each control valve shall be equipped with its own actuator.

c) The Contractor shall ensure the Controls Contractor shall ensure that each control valve assembly isproperly connected and installed.

d) The Contractor shall ensure the Controls Contractor shall test, adjust and verify the operation of each control valve to ensure that it is properly functioning, as required and left insafe working order.

3.5.6. Cutting And Patching

a) The Contractor shall ensure all cutting, patching, painting and making good for the installation of the BAS work shall be done by the BAS Contractor. All cutting shall be performed in a neat and true fashion, with proper tools and equipment.

3.5.7. Power Sources And Wiring Methods

a) Exposed wiring is not allowed in any areas. All wiring shall be installed in conduit type as follows:

1) All conduit that is located in damp and wet spaces shall be RGSEC (Rigid Galvanized Steel Epoxy Coated)

2) Conduit that is exposed and in dry, indoor, temperature controlled spaces shall be RGS (Rigid Galvanized Steel)

b) The Contractor shall ensure wiring from DDC controllers to sensors and actuators and control system network and low voltage wiring running in accessible ceilings may be installedusing LVT cable. Where the ceiling is used as a return air plenum, plenum rated cable shall be used in lieu of LVT cable.

c) The Contractor shall install conduits and cable at right angles to building lines, securely fastened, and inaccordance with current electrical codes and standards.

d) The Contractor shall ensure power and control wiring shall be copper conductor (RW90). For power wiring, provide #12 AWG (minimum) with a 3% maximum voltage drop in accordance with CEC requirements. Control wiring shall be a minimum of #14 AWG, unless otherwise specified.

e) The Contractor shall ensure the wires smaller than 18 gauge shall not be used and will not be accepted onthe project except for: wiring between terminal computer devices, wire in standard communication cables, such as printers and

short haul modems, wireused in communication networks, i.e. any cable transferring digital data, using twisted shielded pairs.

f) The Contractor shall ensure the wiring from panels to devices shall be installed without splices. The use ofcrimp connectors is not allowed when connecting field wiring to sensor or device leads. The use of wire nuts is acceptable in this application.

g) The Contractor shall ensure power for control system shall not be obtained by tapping into miscellaneous circuits that could be inadvertently switched off. Only dedicated circuit(s) shallpower the control system. Provide additional breakers or electrical panels as required.

h) The Contractor shall ensure mount transformers and other peripheral equipment in panels located inserviceable areas. Provide line-side breakers/fuses for each transformer.

i) The Contractor shall all 120 VAC power for any controls equipment shall be from dedicated circuits. Provide a breaker lock for each breaker used to supply the controlsystem. Update the panel circuit directory.

j) A dedicated power circuit may be used by the Contractor to power DDC panels and equipmentwithin the same or adjoining mechanical rooms. The use of one power circuit to power DDC panels distributed throughout the building is not acceptable.

k) The controller may be powered by the Contractor from the equipment that it is directly controlling (i.e. heat pump, rooftop unit) only if the controller controls no otherequipment and the power supply to the controller remains energized independently of unit operation or status.

l) The Contractor shall provide all required code gauge boxes, connectors and other wiringaccessories.

m) For all DC wiring, the Contractor shall ensure positive conductors shall be WHITE or RED in colour whilenegative conductors shall be BLACK in colour.

3.5.8. Electrical Wiring And Accessories

a) The Contractor shall install all electrical materials and equipment conform to Canadian Electrical Code as amended to date and as specified below.

b) The Contractor shall provide conduit, electrical wiring and fittings from load side of starters and/or disconnects to motor or electrical connected item, including the connections to all mechanical equipment.

c) The Contractor shall provide control wiring, conduit and relays to interlock starters and connectsafety and operating controls as required.

d) The Contractor shall wire final 12 in to 18 in of motor connections with flexible liquid tight conduit, with insulated throat connectors.

e) The Contractor shall use thin wall conduit up to and including 1 ¼ in size for wiring in ceiling, furred spaces and where not exposed to mechanical injury. Use rigid galvanized steel conduit for exposed wiring and for conduit 1 ½ in size and larger.

f) The Contractor shall provide branch circuit wiring and an outlet for each motorized damper control.

g) The Contractor shall ensure conduit shall be in accordance with the following CSA standards:

1) CSA C22.2 NO. 45.1:22 Electrical rigid metal conduit – Steel (Trinational standard with UL 6 and NMX-J-534-ANCE-2022)

2) C22.2 No.56 - 1977 - Flexible Metal Conduit and Liquid Tight FlexibleMetal Conduit

3) C22.2 No.136 - 1966 - Rigid PVC Conduit

h) The Contractor shall install all wiring in conduit, unless otherwise specified.

i) The Contractor shall ensure conduit accessories, conduits and fittings shall conform to C.S.A. StandardC22.2 No.18 - M1987.

j) The Contractor shall use thin wall conduit for branch circuit and signal wiring in ceiling, furredspaces and where not exposed to mechanical injury.

k) The Contractor shall ensure conduit shall be of sufficient size to permit easy removal of conductors at anytime. Do not bend conduit over sharp objects. Do not use bends and fittings together.

l) The Contractor shall ensure all conduit connections made to enclosures housing electrical devices (e.g. DDC panels, transformers, etc.) shall be made on the sides or bottom end of the enclosure. No openings of any kind shall be made to the top side of suchenclosures.

3.5.9. Equipment Enclosures And Location

a) The Contractor shall provide new enclosures for all field equipment (e.g. DDC panels, transducers,relays, etc.). Enclosures shall be equipped with a hinged door and latch. Provide a Metrolinx standard key/lock set for each enclosure.

b) The Contractor shall mount all enclosures in serviceable areas of mechanical rooms, storage rooms or janitor closets. Obtain written approval of the Consultant prior to mounting any enclosure in ceiling spaces or more than 5′-6″ above the finished floor.

c) The Contractor shall ensure all transformers and power supplies for control equipment shall be installed innew dedicated metal cabinets with hinged, lockable covers located in the proximity of their dedicated controller cabinets.

d) The Contractor shall include within a DDC panel enclosure one 120 VAC duplex receptacle for portable PC power if the controller cabinet is located further than 5'-0" fromthe nearest wall receptacle.

e) The Contractor shall ensure that enclosures are sized to allow for ease of servicing of all equipment contained within. Enclosures containing DDC panels shall be sized to allow for the installation of the maximum allowable number of expansion panels/boards.Do not mount other equipment in a manner that may interfere with the future installation of expansion panels/boards.

f) For enclosures containing pneumatic transducers or devices, the Contractor shall provide onepressure gauge (1-1/2" dial, 0-30psi) for the main air line supply.

3.5.10. Identification And Labeling Of Control Equipment

a) The Contractor shall ensure all panels must have a lamacoid tag (min. 3"x1") affixed to the front face indicating panel designation and function (i.e. "BAS Panel 1" or "Relay Panel3").

b) The Contractor shall ensure all field sensors or devices must have a lamicoid tag (min. 3"x1") attached withtie-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 un-heated spaces, in high humidity areas or where subject to vibration.

c) The Contractor shall ensure all devices within a field enclosure shall be identified via a label or tag.

d) The Contractor shall ensure ll BAS panel power sources must be identified by a label (min. 3"x1") indicating the source power panel designation and circuit number (i.e. "120vacfed from LP-2A cct #1).

e) The Contractor shall ensure all field control equipment panels fed from more than one power source musthave a warning label on the front cover.

f) The Contractor shall ensure 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.

g) The Contractor shall ensure all rotating equipment controlled by the BAS shall have a tag or label affixedindicating that the equipment may start without warning.

h) The Contractor shall ensure all BAS panels will be supplied with a point's list sheet (within a plastic sleeve)attached to the inside door.

i) The Contractor shall ensure 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.

11) Wire tag reference.

j) The Contractor shall provide laminated wiring diagrams for all field mounted relay enclosures. Securely attach to the inside door. Identify power panels and circuit numbersof the equipment being controlled.

k) The Contractor shall provide laminated wiring diagrams or modify existing equipment wiring diagrams wherever the BAS interfaces to other equipment. (e.g. boilers, chillers, etc.). Securely attach to the inside of the respective control cabinet.

l) The Contractor shall provide lamcoid labels indicating the required operating sequences, on the boilers and valves, where the boiler plants have manual or automatic isolatingvalves. Submit actual wording to the Consultant for approval prior to fabrication and installation.

m) The Contractor shall provide lamcoid or machine labels (as outlined above) for all interposing relaysor contactors used in control circuits. The labels shall include the related point software name and hardware address

n) The Contractor shall provide a lamcoid label to identify the location of concealed devices above theceiling space. Mount the label on the ceiling grid T-bar or a permanent surface adjacent to the devices. The label shall contain

the wording "BAS Devices Above".

o) The Contractor shall provide lamcoid labels for all auxiliary HVAC equipment (e.g. force flow cabinets, unit ventilators, unit heater, window AC units, etc.) controlled by the BAS. Mount the labels in the vicinity of the existing thermostat or power switchfor the unit. The label shall contain the wording "Under BAS Control".

p) Where directed by the Consultant, the Contractor shall 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.

3.6. SYSTEMS HARDWARE COMMISSIONING

a) 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.

b) 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 shouldbe with +/- 1C 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 pointas 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.) thatare inoperative or require maintenance or repair.

7) The BAS field 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-inch or larger, dampers on major air handlers, etc.)

9) Provide confirmation that a series of test alarms has been successfully received at a 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 Metrolinx trades staff.

14) At the completion of site commissioning, submit four (4) copies of hardware commissioning report to Metrolinx.

3.7. SUBSTANTIAL COMPLETION INSPECTION

a) 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 complies all requirements of the specifications.

b) The Contractor shall provide written notification to the Metrolinx that the site is ready for the Substantial Completion Inspection by the Consultant

c) issue a comprehensive site deficiency report to the Contractor for hisimmediate action.

d) The Contractor shall correct all items noted in the site deficiency report within ten (10) business days of receipt.

e) The Contractor shall provide written notification to the Metrolinx that all itemson the Consultant's site deficiency report have been corrected.

END OF SECTION