METROLINX

Glycol Solution Snow Melting System Specification

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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
Various	January 2025	Revised to clarify piping, manifold, and installation requirements. Added requirements for further code compliance.

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1. GENERAL

1.1. SCOPE OF WORK

1.1.1. A glycol solution snow melting system shall be provided as detailed on Drawings and as specified herein.

1.2. DESIGN REQUIREMENTS

1.2.1. General

a) A class 3 hydronic snow melting system shall be supplied and installed in accordance with this specification;

b) This specification shall be read and applied in conjunction with Hydronic Radiant Floor Heating specification;

c) The snow melting system shall be capable of melting the snow as fast as it falls and quickly evaporating it so that the surface is dry at the end of the cycle;

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

1) For the Toronto area, the typical design climatic data considered shall be: outdoor temperature, wind speed, and an estimated maximum hourly rate of snowfall.

e) The hydronic snow melting system shall consist of multiple hot fluid tubes embedded in (or under) the surface required to be clean of snow. The temperature differential between the hot fluid entering and leaving the area to be protected shall not exceed 14°C (25°F) to avoid thermal shock;

f) 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 pipe erosion;

g) The fluid shall contain inhibited antifreeze to maintain the solution in a pumpable fluid state of a minimum of 3°C (5°F) below the lowest anticipated ambient air temperature. A non-toxic antifreeze such as food-grade propylene glycol shall be used; and

h) When outdoor temperature goes below -20 °C (-4°F), the snow melting system switches to cold weather cut-off mode.

1.2.2. Embedded Plastic Tubing

a) The snow melting system shall be “idle” during no-snow conditions, maintaining the protected surface at a temperature just above freezing. It is desirable to use the earth beneath the protected surface as a heat sink, by installing vertical insulation at the edges of the surface, down to a minimum of 1.2 m (4 ft);

b) There shall be no splicing of plastic tubing; each circuit shall be contiguous. The layout of circuits shall consider the configuration of the area to be protected, any expansion joints, column footings, etc.;

c) If located directly below asphalt, domestic cold water shall be circulated at a rate of 1.0 gpm per circuit, only when applying the asphalt to the platform topping, until the platform surface cools to 65°C (150°F);

d) Standard Grade hydrostatic pressure ratings shall be from the Plastics Pipe Institute in accordance with TR-3 as listed in TR4;

e) The following three standard grade PEX hydrostatic ratings shall be used for the slab:

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

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

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

f) A certification of flame spread/smoke development shall be provided with a rating of 25/50 in accordance with ASTM E84 for the following PEX tubing sizes when encased with 12.7 mm (½ ") fibreglass 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 "); and

9) 50.8 mm (2 ").

g) A hydronic snow melting system shall be provided that is manufactured, fabricated, and 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;

h) Shall be in compliance with ASTM F877;

i) Shall be in compliance with DIN 4726 regarding oxygen diffusion concerns where

applicable; and

j) Shall be in compliance with ASTM E119 and ANSI/UL 263 through certification listings 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 as follows:

1) Independent dedicated systems for each snow-melting system and radiant floor heating system shall be provided. (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 shall not be interconnected in any way, as they should be designed to run independently of each other. Note exception as indicated in 1.2.7 Digital Controls.

b) The heat source for the snow melting system shall be a gas-fired boiler plant that includes a pair of boilers, each sized at 60% of the total heating demand;

c) The piping arrangement shall contain a primary loop and two secondary loops as follows:

1) The primary loop shall circulate the heating fluid through the boilers, ensuring that they remain hot, and no thermal shock shall 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). The temperature shall be adjustable and shall require Metrolinx approval to be modified.

2) Fluid circulation in the primary loop shall be provided by:

i) Inline circulators (one per boiler) for total primary loop fluid flows of 200 gpm or less. Each pump assembly shall include a strainer upstream, a balancing valve downstream, and pressure gauges on the suction and discharge sides. Pumps shall be interlocked with the boilers serve; and

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.

3) The snow melting system shall have one secondary loop serving the snow melting systems. This loop shall interface with the primary loop via a 4-way mixing valve. Fluid circulation in the secondary snow melting loop shall be provided by vertical inline 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; and

4) The radiant floor heating system shall have one secondary loop serving the indoor radiant floor heating systems. 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 inline 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.

d) All piping in the boiler plant shall be schedule 40 black iron steel pipes, insulated per code and standards, identified, and protected by a canvas or PVC jacket;

e) For vibration isolation purposes, the boilers and the pumps shall be supported by neoprene ribbed pads, rated for the weight. The piping connections to the pumps shall include braided flexible connectors;

f) All equipment shall be located on concrete pads, a minimum of 100 mm (4 ") high and 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;

g) Drainage shall be provided in close proximity to the pumps and boiler's pressure relief valves such that there is no ponding of liquids;

h) The boiler plant shall be heated by an electric unit heater operated by wall-mounted thermostats. The default setting shall be 10 °C (50 °F); and

i) CO monitoring system shall:

1) Be installed in the boiler plant;

2) Have sensors installed in the breathing zone (4-6 ft above the floor);

3) Have the default alarm setting at 50 ppm; and

4) Have local alarm equipment 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 snow melting PEX tube circuits shall be connected to 50 mm (2 ") diameter type 304 stainless steel manifolds for commercial/industrial applications, each circuit equipped with independent supply and return isolation valves. The manifolds shall be located in recessed chambers, 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);

b) The number of manifolds contained in each chamber shall be limited by the number and lengths of tubing circuits;

c) Maintenance clearances shall be provided around the manifolds and valves, and access or egress measures such as a permanent ladder shall be provided;

d) All hot fluid piping inside the manifold chamber shall be type 304 stainless steel, welded, insulated, and identified. Each manifold chamber shall have general shut-off valves capable of isolating the contained manifolds. Each manifold shall be complete with a flow balancing valve;

e) Piping drainage ports, equipped with isolation valves shall be provided at the low points. Drainage shall be provided to ensure that any leak in the manifold chambers shall be disposed of by gravity and no ponding shall occur;

f) Each manifold chamber shall be equipped with a metallic lockable access hatch, equipped with recessed handles; and

g) Manifold chamber shall have a minimum 2.44 m clearance from the edge of the platform (track side).

1.2.5. Manifold Cabinets

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

1.2.6. Hot Fluid Underground Distribution

a) 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 shall be oriented in the direction of flow through the pre-insulated pipes;

1) 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 to meet the requirements for the surface above (pedestrian traffic, vehicular traffic, track right of way, etc.).

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

c) When leaving the boiler plant and entering the manifold chambers, the pre-insulated piping and associated sleeves shall 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) 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 melting system 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 the snow melting system and the radiant floor heating system exist on the same site. In scenarios where only one system (i.e., snow melting 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 melting system shall be independent of the operation of the radiant floor heating system. Each system shall operate under its 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 melting system and the radiant floor heating system can be common. Therefore, a dedicated outdoor air temperature sensor is not necessary for each system;

f) The system shall provide a 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 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 and graphical user interface at each location and shall have the ability to communicate with the local control panels to adjust parameters, modify schedules, receive alarms, etc.;

h) 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) Full access to the BAS parameters, schedules, and programming shall be available through local control panels connectors to specialized Metrolinx staff using portable computers (laptops, notebooks or similar);

j) Wiring between the snow and slab-mounted sensors, and the boiler plant shall be located in a separate 100mm (4 " Ø) schedule 40 PVC sleeve, running parallel to the hot fluid distribution piping; and

k) For installation and wiring details of the snow melting sensor, refer to the Metrolinx 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; and

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

1.4. REFERENCE STANDARDS

1.4.1. Standards and codes shall be latest editions adopted by and enforced by local governing 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 A53 Standard Specification for Pipe, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless;

1.4.5. ASTM A234 Carbon and Alloy Steel Pipe Fittings;

1.4.6. ASTM B61 Standard Specification for Steam or Valve Bronze Castings;

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

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

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

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

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

1.4.12. ASTM F876 Standard Specification for Cross-linked Polyethylene (PEX) Tubing;

1.4.13. ASTM F877 Standard Specification for Cross-linked Polyethylene (PEX) Plastic Hot- and Cold-Water Distribution Systems;

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

1.4.15. ASTM F1545 Standard Specification for Plastic-Lined Ferrous Metal Pipe, Fittings and Flanges

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

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

1.4.18. CSA B51 Boiler Pressure Vessel and Pressure Piping Code;

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

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

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

1.4.22. C22.2 NO. 83- Electrical Metallic Tubing;

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

1.4.24. CSA W48 Series Electrode and Filler Materials Certification;

1.4.25. CSA W117.2 Safety in Welding, Cutting and Allied Processes;

1.4.26. DIN 4726 Warm water surface heating systems and radiator connecting systems - Plastic piping systems and multilayer piping systems;

1.4.27. EMC Directive 89/336/EEC;

1.4.28. International Electrical Code IEC No. 61010;

1.4.29. T530 Commercial Building Standard for Telecommunications Pathways and Spaces; and

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

1.5. TRAINING

1.5.1. Train the Owner’s personnel about the operation and maintenance of the installed system. Provide manufacturer’s installation, operation, and maintenance instructions for installed components within the system.

1.5.2. Training shall be a full review of all components, including but not limited to a full operation and maintenance demonstration with abnormal events.

1.5.3. A proposed training and lesson plan for each session shall be submitted to Metrolinx for review and approval.

1.5.4. A minimum of 3 training sessions shall be conducted spanning a duration of a maximum of 7 hours for 10 Metrolinx staff per session.

1.5.5. 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 a defect in material or workmanship, beginning with the date of substantial completion of work.

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

1.6.4. Minimum of 2 years for other product and labour requirements.

1.7. DELIVERY, STORAGE AND HANDLING

1.7.1. Handle and store products in accordance with the manufacturer's instructions in locations approved by Metrolinx. Include one copy of these instructions with product at time of shipment.

1.7.2. PEX tubing shall be stored in cartons or under cover to avoid dirt or foreign material from entering the tubing.

1.7.3. Do not expose PEX tubing to direct sunlight for more than 30 days. The tubing shall be covered if exposed to direct sunlight for more than 30 days.

1.8. SUBMITTALS

1.8.1. Refer to submittal requirements in Section 20 05 05.

1.8.2. Submit a copy of the system manufacturer's counterflow method loop layout design indicating water flows and temperatures, heated surface profiles, and heating outputs.

1.8.3. Submit a certified tubing and piping layout and schematic for each system zone.

1.8.4. Submit a certified power wiring schematic and a certified control wiring schematic with the sequence of operation for each system zone.

1.8.5. Submit a letter from the system component manufacturer stating system components proposed to meet all requirements of Specification.

1.8.6. Submit a copy of the manufacturer's training certificate.

1.8.7. Submit, prior to application for Substantial Performance of the Work, start-up, and test data.

1.8.8. Submit letters of installation certification from the system manufacturer's representative.

1.8.9. Product Data

a) Submit the manufacturer's Product data indicating:

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

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

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

4) Product identification in accordance with Metrolinx requirements.

1.8.10. Shop Drawings

a) 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 shall be used; and

4) A certified power wiring schematic and a certified control wiring schematic with the sequence of operation for each system zone are as follows;

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., lamicoid) with proposed software names and point descriptions;

iv) Wiring diagram, 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; and

vii) Automatic control devices and sensors.

1.8.11. Commissioning Package

a) 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; and

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

1.8.12. Commissioning Closeout Package

a) Submit the following in accordance with Section 20 05 05:

1) Deficiency Report;

2) Commissioning Closeout Report; and

3) Submit the following for each Product for incorporation into the Operation 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; and

ix) Commissioning Report.

1.9. QUALITY ASSURANCE

1.9.1. Manufacturers Qualifications

a) The manufacturer shall be ISO 9000, 9001 or 9002 certified. Manufacturer of the product shall have produced a similar product for a minimum period of five years. When requested by consultant, an acceptable list of installations with similar products shall be

provided, demonstrating compliance with this requirement; and

b) The manufacturer shall arrange an authorized representative to perform onsite inspection, provide a report and issue a certificate of approvals, prior to concrete or thermal mass embedment.

1.9.2. Installers Qualifications

a) The installer shall have experience on projects of similar size and complexity and possess documentation proving successful completion of snow melting training by the PEX tubing manufacturer;

b) Provide letters of certification as follows:

1) Installer is trained by the PEX tubing manufacturer to install the snow 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) Installers shall work under a licensed Mechanical Contractor and supervision of manufacturer or supplier's representative; and

d) Where manufacturers provide training sessions to installers and certificates upon successful completion, installers to have obtained such certificates and submit copies with Shop Drawings.

1.9.3. Regulatory Requirements

a) Products and Work comply with applicable local governing authority regulations, bylaws, and directives; and

b) Include required inspections and certificates of approval of installation work from local governing authorities.

2. PRODUCTS

2.1. HEATING PLANT BOILERS

2.1.1. Refer to Near Condensing Hot Water Boilers specification and Condensing Hot Water Boilers specification.

2.2. PUMPS

2.2.1. Vertical Inline Centrifugal Pumps for glycol mixed solutions

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

b) Furnish and install, as indicated on the plans and specifications, inline 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 150 °F (65 °C) and Ductile Iron with 250 psig ANSI/PN25 flanges for working pressures to 375 psig (25 bar) at 150 °F (65°C). 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, totally 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 shall be designed to be removed on site to reveal a space between the pump and motor shafts to remove all mechanical seal components for servicing and shall 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 plates. Provide factory-installed flush line with manual vent;

h) All split coupled pumps shall be provided with a lower seal chamber throttle bushing such that to ensure seals maintain positive 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; and

j) Filters shall be changed by the installing contractor after the system is flushed according to the manufacturer's recommendations 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 mesh start-up strainer;

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

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 for adjustment with an open-end wrench;

b) PN25 ductile iron flanges with antirotating 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 Iron with PN25 flanged ports;

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

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; and

2) There shall be mineral fibreglass insulation provided to meet ASHRAE 90.1-1989 specifications in operating conditions with a maximum Fluid Design Operating Temperature Range of 141 °F to 200 °F(60 °C to 93 °C and Mean Rating Temperature of 125 °F (52 °C).

2.2.4. Inline 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, a 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; and

3) Pump shall be equipped with a watertight, long-life, "ARMSEAL" mechanical seal and shall be rated for 225 ^{o}F, 125 psi.

2.2.5. Circulator Pump Circuit Balancing Valve

a) Furnish and install downstream of each inline circulator pump, a circuit balancing valves. Valves shall be of the 'Y' pattern, equal percentage globe-style and provide three functions:

1) Precise flow measurement;

2) Precision flow balancing; and

3) Positive drip-tight shut-off.

b) Valve shall provide multi-turn, 360^{o} adjustment with micrometre-type indicators located on the valve hand wheel. Valves shall have a minimum of five full 360^{o} hand wheel turns. 90^{o} 'circuit-setter' style ball valves are not acceptable;

c) Valve handle shall have a hidden memory feature, which shall provide a means for locking the valve position after the system is balanced;

d) 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; and

e) 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. Includes: all piping from the manifold header to/from platform snow melting piping circuit.

2.3.2. Material: Cross-linked polyethylene (PEX-a) manufactured by peroxide cross-linking (Engel method).

2.3.3. Material Standard: Manufactured in accordance with ASTM F876 and ASTM F877 and tested for compliance by an independent third-party agency.

2.3.4. 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).

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

2.3.6. 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.

2.3.7. 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 in accordance with German DIN 4726.

2.3.8. Nominal Inside Diameter:

a) Provide tubing with nominal inside diameter in accordance with ASTM F876, as indicated:

1) 12.7 mm (½ ");

2) 19.05 mm (¾ "); and

3) 25.4 mm (1 ").

2.3.9. Fittings (PEX Pipe)

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 shall 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; and

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.

2.4. HEATING AGENT DISTRIBUTION PIPING

2.4.1. Includes: all piping in the boiler room, and from the boiler room to the distribution manifolds chamber(s).

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

2.4.3. System Description

a) Insulated schedule 40 steel pipe within boiler room;

b) Pre-insulated pipe system for underground or buried commercial hydronic heating applications. Service pipes are made from durable “Engel-method” cross-linked polyethylene (PEX-a) tubing and, protected by multilayer PEX-foam insulation and covered by a corrugated, waterproof HDPE jacket;

c) The system can use Dezincification Resistant (DZR) brass compression fittings to interface between the steel and the PEX piping. Saline and electronic cross-linking methods are not acceptable;

d) Above ground Service Pipe in Boiler Room

1) Service pipes are made from black carbon steel to ASTM A53, Grade B.

e) Underground 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. Piping shall be protected by multilayer PEX foam insulation and covered by a corrugated, waterproof HDPE jacket.

2) Insulation

i) Multilayered, closed-cell, PEX-foam insulation with a thermal conductivity of 0.26 BTU in./sq. ft./hour/°F; vapour permeability of 0.1g/100 sq. in./day.

3) Jacket

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

4) Operating Limits

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

5) Pipe Sizes: 25.4 mm (1 ") to 110 mm (4 ") diameter.

2.4.4. Manifolds (Commercial, Valved Copper)

a) For system compatibility, use 2 " 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) The manifold end cap shall offer 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-return configuration to ensure self-balancing; and

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.

2.4.5. Manifold Chamber

a) Cast in place concrete pit. Concrete mixture shall be min. 35MPa concrete with 6% air content, and with corrosion inhibitors and crystalline waterproofing admixture. Stainless steel rebar for rust and corrosion protection;

b) A minimum overall 1,800x1,800 footprint or as indicated in drawings and a depth from 1.2 m to 1.5 m with an access ladder and individual protected drainage system or sump pump. Coordinate with the Structural Division for pit size, location, and type prior to installation;

c) Make watertight penetrations of membranes, such as pipes, services, and other

protrusions. This includes surface preparation as well as detailing and installation around openings and edges;

d) Access door

1) Material: Cover and frame shall be aluminum;

2) Cover: Acid resistant, powder epoxy coated, gasketed, 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 around the 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; and

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.

2.5. DIGITAL CONTROLS

2.5.1. System Hardware

a) The system architecture shall 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 operate as a single BAS for the entire project;

b) This specification shall be read in conjunction with the Hydronic Radiant Floor Heating System specification;

c) All required site database and graphics files shall reside on Metrolinx central BAS server. The connection between the central server and the BAS controllers serving a specific building shall be through the WAN;

d) The building Staff shall able to log into the local workstation, and access and review on a read-only basis the graphical user interface of the BAS showing the system layout and operational parameters;

e) The Metrolinx specialized trades are capable of accessing and modifying the BAS

parameters and schedules using direct connectors at the control panels and portable computers (laptops, notebooks, etc.);

f) Supply PCU's, PAC's and ASC's as required to interface to all specified equipment;

g) Allow for a minimum of 25% spare program and trend memory capacity in each PCU and PAC; and

h) For each specified BAS control point, supply the hardware point type (e.g., AI, AO, DI, DO) as indicated on the control 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.

2.5.2. Primary Control Units (PCU)

a) 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, rooftop units, and other critical equipment;

b) Each PCU shall contain a real-time clock and memory to store its own application database, operating parameters, user programs, and trend data storage;

c) 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;

d) Each PCU output shall include a Hand/Off/Auto (HOA) selector switch for each analog and digital output; and

e) Each PCU shall have a minimum of 10% spare capacity for each type of input and output channel and 10%.

2.5.3. Programmable Application Controllers (PAC)

a) Programmable Application Controllers (PAC) are 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;

b) PACs shall not be used for controlling major mechanical equipment as described above;

c) Each PAC shall contain a real-time clock and RAM to store its own application database, operating parameters, user programs and trend data storage; and

d) Battery backup shall be provided 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.

2.5.4. System Software

a) BAS Workstation Software

1) Site licenses shall not be required.

b) Trend Data

1) Provide trend logs for all hardware inputs and outputs;

2) All trends shall be accessible via the graphical interface;

3) Trends shall 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) Field Devices individual trends shall 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) 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 shall physically be wired to the same panel containing the control loop output (e.g., boiler water temperature and burner control output); and

7) Trend data storage shall be in the same panel as the hardware or logical points being trended.

2.5.5. User Access

a) Provide Metrolinx user IDs and passwords for operations, maintenance, and engineering staff.

2.6. ALARMS

2.6.1. The alarms shall be assigned the following categories:

a) Maintenance Alarms;

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

c) Any other miscellaneous alarm not specifically noted herein.

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

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

2.6.4. Additional alarms shall be provided as directed by the Consultant and specified in this section and customize the alarms to the operating characteristics of the specific systems being controlled.

2.7. BAS DYNAMIC GRAPHICS

a) Provide customized, site-specific dynamic graphics to meet the requirements of the Consultant and/or Metrolinx.

2.8. SENSORS AND DEVICES

2.8.1. Snow Slab Sensor

a) 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 shall be installed directly in the snow melting slab, halfway between the heating elements or pipes.

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

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

2.8.2. In-Slab Sensor

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

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

2.8.3. Outdoor Air Temperature Sensors

a) Provide outdoor air temperature sensors with the following minimum characteristics:

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

2) Minimum of two sensors shall be installed for each site;

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

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

2.8.4. Immersion Temperature Sensors

a) Use immersion temperature sensors with thermowells for all applications where temperature of a fluid in a pipe is being sensed; and

b) Provide well-mounted water temperature sensors with the following minimum characteristics:

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; and

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

2.8.5. Current Sensors (Analog)

a) Current sensors (CT) shall be used for status monitoring of all motor-driven equipment, where specified;

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

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

2.8.6. CO Monitoring Sensor

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

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

c) 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;

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

e) Sensor Zero-maintenance electrochemical;

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

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

h) 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;

i) Self-test on activation (auto) and daily (auto);

j) Warranty Two (2) years (3-year operational life); and

k) Ratings and Certifications;

1) Conforms to an Ordinary locations International Electrical Code: IEC No. 61010; and

2) EMI/RFI Complies with EMC Directive 89/336/EEC.

2.8.7. Status Relays (Solid State)

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

2.8.8. Automatic Control Valves

a) Automatic control valves shall be supplied by the Controls Contractor and installed by the Mechanical Contractor;

b) Automatic control valves, unless otherwise specified, shall be globe-type valves. Valves and actuators shall be ordered as one factory-assembled and tested unit;

c) A valve schedule containing the following information for each valve shall be submitted to the Consultant for review:

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;

d) Calves 2 " (50 mm) and smaller shall be constructed of bronze. Valves 2 ½ " (65 mm) and larger shall have iron bodies and bronze mountings;

e) All control valves shall have stainless steel stems;

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

g) The bodies and bonnets of iron body valves shall conform to ASTM A126, Class B;

h) 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 control valves shall have tight shut-off. Flat disk valves are not acceptable;

j) Control valves 2 " (50 mm) 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 2 " (50 mm) 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 water control valves shall be sized for a pressure drop of 6 ft. water column or as indicated on mechanical Drawings;

l) Each automatic control valve shall provide the design output and flow rates at pressure drops compatible with equipment selected;

m) Each automatic control valve shall be rated for the particular system working pressure;

n) Each automatic control valve shall be fitted with a position indicator;

o) All the same type of control valves shall be products of a single manufacturer and have the manufacturer's name, pressure rating and size clearly marked on the outside of the body; and

p) 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.

2.8.9. Automatic Control Valve Actuators

a) Each automatic control valve shall be fitted with a "fail-safe" operator capable of tight shut-off against the differential imposed by the system;

b) Operators for valves in electric-electronic control systems shall be single-phase AC, 24V electric motor operators;

c) Valve actuators on valves 3 " in diameter and larger shall be provided with a manual position override;

d) Valve actuators shall accept a 0-10 VDC or 4-20 mA control signal for all proportional applications; and

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

2.8.10. Local Service Ports

a) Every DDC panel shall be provided with a local network access port to connect to a 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) Where BAS points (4 or more) are located in a mechanical room that does not have 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 a key-lock set and lamicoid ID label.

c) LAN Cabling

d) 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;

e) 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 used unless otherwise required to meet building codes or bylaws;

f) Data outlets shall be RJ45, 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;

g) Provide one RJ45 data outlet adjacent to each terminated (e.g., workstation PC, DDC panel, hub, etc.) device. Use a flexible patch cable to connect from the data outlet to the end device;

h) Provide protection from EMI sources in accordance with CSA-T530 article 4;

i) Test all cabling to verify conformance with TIA /EIA TSB-67 - Basic Link Test using a Level 2, bi-directional tester. See commissioning requirements;

j) Where there are more than 2-90° bends in a conduit run, provide a pull box between sections so that there are two bends or less in any one section;

k) 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°; and

l) 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. Pull box shall not be used in lieu of a conduit bend. Align conduits that enter a pull box from opposite ends with each other.

3. EXECUTION

3.1. PRE-INSTALLATION MEETINGS

3.1.1. Verify project requirements, substrate conditions, floor coverings, manufacturer’s installation instructions and warranty requirements.

3.1.2. Review the project construction timeline to ensure compliance or discuss modifications as required.

3.1.3. Interface with other trade representatives to verify areas of responsibility.

3.1.4. Establish the frequency and construction phase in which the project engineer intends to conduct site visits and inspections by the tubing manufacturer's representative.

3.2. HEATING PLANT BOILERS

3.2.1. Refer to Near Condensing Hot Water Boilers specification and Condensing Hot Water Boilers specification.

3.3. PUMPS

3.3.1. Install with bearing lubrication points accessible. Check rotation.

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

3.3.3. Provide vibration isolation between the pumps and pipes, and between the pumps and the concrete curbs. Refer to Basic Mechanical Materials and Methods specification.

3.3.4. Pipe drain tapping to floor drain.

3.3.5. Install volute venting pet cock in an accessible location.

3.3.6. Change cartridge filter according to the manufacturer's recommendation prior to and at turn over to the owner.

3.3.7. Provide strainers, isolating valves, balancing valves, and check valves as indicated on the drawings.

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

3.3.9. Install a triple-duty valve on the discharge of each vertical inline pump.

3.3.10. Provide and install one pressure gauge, piped to pump suction, pump discharge and strainer inlet. Pressure gauge tapping with necessary isolating valves to enable differential pressure reading across the pump and strainer shall be taken.

3.3.11. The motor shall be covered during construction and have area clean of construction debris before starting the motor.

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

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

3.3.14. The pump manufacturer shall coordinate with the hydronic balancer to balance the system to the required flows.

3.3.15. Provide a drip pan that is piped to the nearest drain for each pump. Drip pan shall be sized to suit pump dimensions.

3.4. PEX SNOW MELTING TUBING

3.4.1. Comply with manufacturer's site supervision and installation guidelines or Instructions.

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

3.4.3. Insulation

a) 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 installing contractor shall have a minimum of 10 years of demonstrated experience on projects of similar size and complexity in Ontario.

3.4.5. Examination

a) Verify that site conditions are acceptable for installation of the snow melting system; and

b) The snow melting system shall not be installed until unacceptable conditions are corrected.

3.4.6. Installation

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

1) When using a high-density foam insulation board, install the tubing by stapling the tubing to the insulation board with manufacturer-recommended foam stapler;

2) The under-slab insulation shall be rigid 50.8 mm (2 ") polystyrene rated for underground applications;

3) 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;

4) The submitted snow melting design specifies the tubing on-centre distance(s) and loop lengths, based on output and tubing diameter. On-centre distances shall not

exceed 305 mm (12 ");

5) On a 609.6 mm (24 ") wide band along the platform edge, 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 tubing shall not be installed closer than 152 mm (6 ") from the edge of the heated slab;

7) The tubing shall be installed at a depth in accordance with the manufacturer's installation guidelines/instructions.

8) Install the tubing at a consistent depth below the surface elevation as determined by the project engineer. Tubing installation shall provide clearance for all control joint cuts;

9) In areas where tubing crosses metal expansion joints that occur in the concrete, the tubing passes below the metal expansion joints;

10) Fibrous expansion joints may be penetrated following the PEX tubing manufacturer's and structural engineer's recommendation;

11) Metal or plastic bend supports shall be used to support the tubing when departing from the slab in a 90° bend; and

12) During the installation of the thermal mass, the pipe shall be pressurized with an attendant watching the pressure gauge for a sudden loss of pressure due to a leak in the system. Also, the materials making up the thermal mass shall not damage the pipe during any compaction processes that may occur after the installation of the mass.

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

1) When using a high-density foam insulation board, install the tubing by stapling the tubing to the insulation board with manufacturer-supplied staples;

2) The under-slab insulation shall be rigid 50.8 mm (2 ") polystyrene rated for underground applications;

3) 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;

4) The submitted snow melting design shall specify the tubing on-centre distance(s) and loop lengths, based on output and tubing diameter. On-centre distances shall not exceed 229 mm (9 ");

5) On a 609.6 mm (24 ") wide band along the platform edge, 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 tubing shall not be installed closer than 152mm (6 ") from the edge of the heated slab;

7) 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 shall be void of any sharp material. The pavers are then installed over the compacted soil bed;

8) The backfill material required depth and level of compaction shall be in accordance with geotechnical recommendations for the project, and backfilling of all pipes shall be well compacted by means of jetting or other approved methods to eliminate settling. Any completed areas that show settlement shall be promptly re-backfilled with compacted clean earth;

9) Metal or plastic bend supports shall be used to support the tubing when departing from the slab in a 90° bend; and

10) During the installation of the thermal mass, the pipe shall be pressurized with an attendant watching the pressure gauge for a sudden loss of pressure due to a leak in the system. Also, the materials making up the thermal mass shall not damage the pipe during any compaction processes that may occur after the installation of the mass.

c) Asphalt Construction with Edge and Under-slab Insulation

1) When using a high-density foam insulation board, install the tubing by stapling the tubing to the insulation board with manufacturer-recommended foam stapler;

2) The under-slab insulation shall be rigid 50.8 mm (2 ") polystyrene rated for underground applications;

3) 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;

4) The submitted snow melting design shall specify the tubing on-centre distance(s) and loop lengths, based on output and tubing diameter. On-centre distances shall not exceed 229 mm (9 ");

5) On a 609.6 mm (24 ") wide band along the platform edge, 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 tubing shall not be installed closer than 152 mm (6 ") from the edge of the heated slab;

7) 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 shall be void of any sharp material. The pavers are then installed over the compacted soil bed;

8) The backfill material, required depth, and level of compaction shall be in accordance with geotechnical recommendations for the project, and backfilling of all pipes shall be well compacted by means of jetting or other approved methods to eliminate settling. Any completed areas that show settlement shall be promptly re-backfilled with compacted clean earth;

9) Metal or plastic bend supports shall be used to support the tubing when departing from the slab in a 90° bend;

10) During the installation of the thermal mass, the pipe shall be pressurized with an attendant watching the pressure gauge for a sudden loss of pressure due to a leak in the system. Also, the materials making up the thermal mass shall not damage the pipe during any compaction processes that may occur after the installation of the mass; and

11) Proper steps shall be taken to protect the pipe from the extreme exposure temperatures. Installation should take place at a lower temperature (110 °C [230 °F]). Also, flush cold water through the pipe during the installation to minimize the chance of damage occurring. If the pipe is flushed with water, any water left in the pipe subject to freezing shall be removed.

d) Poured-in-place Stair Construction

1) Fasten the tubing to flat wire mesh or reinforcing bar in accordance with the tubing manufacturer's installation recommendations;

2) The submitted snow melting design specifies the tubing on-centre distance(s) and loop lengths. On-centre distances shall not exceed 229 mm (9 ");

3) Install the tubing parallel to the step tread;

4) Install the supply side of the loop along the step's edge. Install the tubing shall be within 76 mm (3 ") of the step's edge;

5) The under-slab insulation shall be 50.8 mm (2 ") polystyrene rated for underground applications;

6) 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) Install the tubing at a consistent depth below the surface elevation as determined by the consultant;

8) Metal or plastic bend supports shall be used to support the tubing when departing from the slab in a 90° bend; and

9) During the installation of the thermal mass, the pipe shall be pressurized with an attendant watching the pressure gauge for a sudden loss of pressure due to a leak in the system. Also, the materials making up the thermal mass shall not damage

the pipe during any compaction processes that may occur after the installation of the mass.

3.5. HEATING AGENT DISTRIBUTION PIPING

a) Sleeving

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 a minimum of 101.6 mm (4 ") horizontal distance between the PVC sleeves; and

3) The minimum bending radius shall be as per the recommendation of the manufacturer.

b) Piping Installation

1) Coordinate with the site services discipline the depth of the sleeves and the backfilling material, depending on the nature of the surface above (landscape, pedestrian traffic, vehicular traffic, train right of way, etc.);

2) The pipe manufacturer's instructions shall be followed when installing the pipe system, particularly with regard to piping elbows, expansion facilities, anchors, vents, and building wall penetrations;

3) Welded Steel Piping: Site bevel steel pipe may be welded or supply mill bevelled pipe. Remove all scale and oxide from the bevels and leave smooth and clean. Shop or site-fabricated fittings shall not be used unless written approval has been obtained; and

4) Welding Requirements:

i) Welded joints shall be made by CWB-certified, licensed journeyman welders qualified in accordance with CSA B51, and who are in possession of a proper certificate of qualification for each procedure shall be performed; and

ii) Each weld shall be identified with the welder's identification symbol, and welds shall not be concealed until they have been inspected and approved. Electrodes shall be in accordance with the CSA W48 series, and requirements of CSA W117.2 shall be followed.

c) Glycol/Water Solution

1) The heating fluid shall be premixed glycol/water solutions to maintain the solution in a pumpable fluid state of a minimum of 3 °C (5 °F) below the lowest anticipated ambient air temperature. 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 from freezing during operation shutdown;

3) System circulators shall operate continuously for a minimum of 30 days after the system is filled to test that the glycol and water do not separate in a static system; and

4) Ethylene glycol shall not be used due to toxicity issues. Instead, use of inhibited propylene glycol. Also, refer to the boiler manufacturer's recommendations.

d) Field Quality Control

1) Site Tests

i) Pressure tests the system with all circuit valves on the manifold completely open and all pipes and manifolds tested together, prior to and during the installation of the thermal mass such that PEX-a pipe and connections are leak-free 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.

e) Adjusting

1) Balancing Across the Manifold

i) Balance all loops across each manifold for equal flow resistance based 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. Install the supply and return piping to the manifold in a reverse-return configuration to provide self-balancing;

iii) 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; and

iv) Adjust all boiler and system controls after the system has stabilized for proper operation in accordance with the system design.

f) 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 the manufacturer's instructions prior

to the owner's acceptance; and

4) Remove construction debris from project site and legally dispose of debris.

g) Demonstration

1) Demonstrate the operation of hydronic snow melting system to the owner's personnel;

2) Advise the owner's representative about the type and concentration of glycol/water solution used in the hydronic snow melting system; and

3) The owner monitors the solution's effectiveness through an established maintenance program as outlined by the glycol manufacturer.

h) Protection

1) Protect installed work from damage caused by subsequent construction activity.

3.6. DIGITAL CONTROLS

3.6.1. Sequence of Operation

a) The heating plant shall serve snow melting systems. 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 comfort heating purposes before the snow melting secondary loop is energized. The heating plant shall be enabled/disabled by the BAS based on outdoor temperature (T1);

b) The snow melting system shall be enabled/disabled by the BAS based on outdoor air temperature (T2);

c) The default relationship between the two outdoor temperatures shall be T1>T2. The gradient shall be adjustable by Metrolinx;

d) With the system enabled, the lead primary boiler pump shall start, while the lag pump shall be energized and in standby mode. The lead/lag status of the primary pumps shall alternate at 168 hrs. intervals (adjustable);

e) Upon proof of flow in the primary loop, the lead boiler shall start at a minimum firing rate, while the lag boiler shall be energized and in standby mode. The lead/lag status of the boilers shall alternate at 168 hrs. intervals (adjustable);

f) 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 a maximum primary loop supply temperature of 66 °C (150 °F). All setpoints are adjustable;

g) If the lead boiler fires at a maximum rate for 10 minutes and cannot maintain the primary loop return temperature setpoint, the lag boiler shall start at a minimum firing rate; its

burner shall ramp as required to maintain the primary loop return setpoint, subject to the same maximum primary loop supply temperature of 66 °C (150 °F). Where applicable (individual boiler circulators), the energizing of the lag boiler shall be preceded by the start-up of the lag boiler circulator (primary flows of less than 200 gpm);

h) With the snow melting system enabled, the lead secondary snow melting loop pump shall start, while the lag pump shall be energized and in standby mode. The lead/lag status of the secondary snow melting loop pumps shall alternate at 168 hrs. intervals (adjustable);

i) 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; and

2) +4 °C (+40 °F) if snow or ice is detected on the surface of the slab.

j) Additional settings for the operation of the 4-way mixing valve:

1) Maintain the minimum primary loop return temperature of 51 °C (125 °F); and

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

k) The system shall generate alarms in case of:

1) Any pump failure (while automatically enabling the standby pump);

2) Any boiler failure (while automatically enabling the standby boiler);

3) Primary loop temperatures +/-6 °C (10 °F) departure from the setpoint; and

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

3.6.2. Installation of Snow Sensor

a) The installation of the snow sensor shall conform to the drawing detail;

b) A steel frame shall be fabricated to install the sensor at the prescribed elevation and maintain its position during the concrete pour; and

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

3.6.3. Installation of Temperature Sensors in Piping

a) The Controls Contractor shall supervise and direct the Mechanical Contractor so that thermowells are installed as described herein;

b) 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; and

c) 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;

3.6.4. Installation of Outdoor Air Temperature Sensors

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

b) Mount the sensors on the north-facing side of the building away from direct sunlight;

c) Mount the sensors in an easily serviceable location; and

d) The sensors shall be located away from building exhaust air or equipment air flows.

3.6.5. Installation Of Automatic Control Valves and Actuators.

a) Install Automatic Control Valves and Actuators, unless specified otherwise;

b) Each control valve shall be equipped with its own actuator;

c) The Controls Contractor, shall check that each control valve assembly is properly connected and installed; and

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

3.6.6. Cutting And Patching

a) 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 neatly and truly, with proper tools and equipment.

3.6.7. 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); and

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

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

c) Install conduits and cable at right angles to building lines, securely fastened, and in accordance with current electrical codes and standards;

d) 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) Wires smaller than 18 gauge shall not be used and shall not be accepted on the project except for: wiring between terminal computer devices, wire in standard communication cables, such as printers and short-haul modems, wire used in communication networks, i.e., any cable transferring digital data, using twisted shielded pairs;

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

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

h) Mount transformers and other peripheral equipment in panels located in serviceable areas. Provide line-side breakers/fuses for each transformer.

i) Provide 120 VAC dedicated circuits to power any control equipment. Provide a breaker lock for each breaker used to supply the control system. Update the panel circuit directory;

j) A dedicated power circuit may be used to power DDC panels and equipment within 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 from the equipment that it is directly controlling (i.e., heat pump, rooftop unit) only if the controller controls no other equipment and the power supply to the controller remains energized independently of unit operation or status;

l) Provide all required code gauge boxes, connectors, and other wiring accessories; and

m) For all DC wiring, positive conductors shall be WHITE or RED in colour, while negative conductors shall be BLACK in colour.

3.6.8. Electrical Wiring and Accessories

a) Install all electrical materials and equipment conform to the Canadian Electrical Code as

amended to date and as specified below;

b) Provide conduit, electrical wiring, and fittings from the load side of starters and/or disconnects to motor or electrically connected items, including the connections to all mechanical equipment;

c) Provide control wiring, conduit, and relays to interlock starters and connect safety and operating controls as required;

d) Wire the final 12 " to 18 " of motor connections with flexible liquid tight conduit, with insulated throat connectors;

e) Use thin wall conduit up to and including 1¼ " size for wiring in ceiling, furred spaces and where not exposed to mechanical injury. Use rigid galvanized steel conduit for exposed wiring and conduit 1½ " size and larger;

f) Provide branch circuit wiring and an outlet for each motorized damper control;

g) 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 Flexible Metal Conduit; and

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

h) Install all wiring in conduit, unless otherwise specified;

i) Conduit accessories, conduits, and fittings shall conform to CSA Standard C22.2 No.18 - M1987;

j) Use thin wall conduit for branch circuit and signal wiring in ceiling, furred spaces and where not exposed to mechanical injury;

k) The conduit shall be sized to permit easy removal of conductors at any time. Conduit shall not be bent over sharp objects. Bends and fittings shall not be used together; and

l) 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 such enclosures.

3.6.9. Equipment Enclosures and Location

a) 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) 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 " 5'7"above the finished floor;

c) All transformers and power supplies for control equipment shall be installed in new dedicated metal cabinets with hinged, lockable covers located in the proximity of their dedicated controller cabinets;

d) 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" from the nearest wall receptacle;

e) Enclosures shall be 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. Other equipment shall not be mounted in a manner that may interfere with the future installation of expansion panels/boards; and

f) For enclosures containing pneumatic transducers or devices, provide one pressure gauge (1-1/2 ” dial, 0-30psi) for the main airline supply.

3.6.10. Identification And Labeling of Control Equipment

a) All panels shall have a lamicoid tag (min. 3 " x1 ") affixed to the front face indicating panel designation and function (i.e., “BAS Panel 1” or “Relay Panel 3 ");

b) All field sensors or devices shall have a lamicoid tag (min. 3 " x1 ") attached with tie-wrap or adhesive indicating the point software name and hardware address (i.e., AHU1_MAT, 2.IP4). Tags shall be secured by screws where mounted outside of the building, in unheated spaces, in high humidity areas or where subject to vibration;

c) All devices within a field enclosure shall be identified via a label or tag;

d) All BAS panel power sources shall be identified by a label (min. 3 " x1 ") indicating the source power panel designation and circuit number (i.e., “120 vac fed from LP-2A cct #1);

e) All field control equipment panels fed from more than one power source shall have a warning label on the front cover;

f) All wires shall be identified with the hardware address with band-type self-adhesive strips or clip-on plastic wire markers at both ends;

g) All rotating equipment controlled by the BAS shall have a tag or label affixed indicating that the equipment may start without warning;

h) All BAS panels shall be supplied with a point’s list sheet (within a plastic sleeve) attached to the inside door;

i) 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.

j) 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;

k) 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) Provide lamicoid 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;

m) Provide lamicoid 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;

n) Provide a lamicoid 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. The label shall contain the wording “BAS Devices Above;”

o) Provide lamicoid 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 switch for the unit. The label shall contain the wording “Under BAS Control;” and

p) Where directed by the Consultant, provide all additional labelling, diagrams, schematics, or instructions as may be required to facilitate the correct operation and maintenance of controlled building systems.

3.7. SYSTEMS HARDWARE COMMISSIONING

a) 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, shall be provided. Where applicable, this shall include any points from an existing and/or re-used automation system in the building;

b) A hardware commissioning report containing the following information and test results shall be prepared:

1) Analogue inputs (i.e., temperatures, pressure, etc.) shall be verified with an approved calibration device. All actual temperature readings should be with +/- 1 °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 BAS field panel power source shall be toggled on and off to test 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 within 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 a designated remote monitoring workstation;

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 and shall support 100Mb bandwidth;

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 shall be signed and dated by the Contractor's technician performing the tests and participating Metrolinx trades staff; and

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

3.8. SUBSTANTIAL COMPLETION INSPECTION

a) At the completion of the site hardware inspection, test and verify that the system programming, graphics, and alarm software are operating correctly and comply with all requirements of the specifications;

b) Provide written notification to 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 his immediate action;

d) Correct all items noted in the site deficiency report within ten (10) business days of receipt; and

e) Provide written notification to Metrolinx that all items on the Consultant's site deficiency report have been corrected.

END OF SECTION