METROLINX

Capital Projects Group

Hydronic Radiant Floor Heating Specification

Specification 23 21 12

Revision 0
Date: August 2018

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Amendment Record Sheet

Amendment in Clause No.	Date of Amendment	Description of Changes

LIST OF CONTENT

1. GENERAL

1.1. SCOPE OF WORK

1.1.1. Provide hydronic radiant floor heating as required, scheduled and specified herein.

1.2. DESIGN CRITERIA AND PRINCIPLES

1.2.1. General

a) The building's structure and the floor finish installation influences the decision regarding the best radiant heating construction method. For best results, the floor construction should be coordinated with the architect and structural engineer. Floor construction methods play an important role in the performance of the radiant heating system. The floor should allow for the heat from the pipes to dissipate readily and evenly to the heated space. Downward heat flow should be minimized by employing adequate insulation.

1.2.2. Heating Load

a) The system shall be sized to offset the building heat losses through the envelope. The heat losses through walls, windows, roofs, floors, skylights, doors, etc. shall be calculated using an industry-accepted software such as Carrier HAP program or similar.

b) Infiltration loads through static envelope elements (such as window frames, etc) shall not be considered, since the buildings are to be maintained at a slight positive pressure by the ventilation equipment.

c) In areas exposed to high indoor/outdoor traffic, the infiltration rate due to frequent exterior doors opening shall be calculated based on the estimated doors operation, opening areas and temperature differential between indoor and outdoor. The methodology is described in detail in the ASHRAE Fundamentals Manual (Ventilation and Infiltration – Air Leakage Through Exterior Doors).

d) At the latitude of the designer, a safety coefficient can be added to account for the heat losses through the system (un-insulated manifolds, expansion tanks, etc.)

1.2.3. Indoor Setpoints

a) The indoor setpoints will vary with the designation and use of the space where the in-floor heating system is used. Additional variables are the occupied/unoccupied schedules. The default values shall be coordinated with GO Transit for each application.

b) For the purpose of heat loss calculations with radiant heating systems the indoor setpoints noted above may be lowered 1 to 2°C (2 to 4°F) compared to conventional perimeter baseboards or forced-air heating systems.

1.2.4. Maximum Floor Surface Temperatures

a) In order to determine the required floor temperature outside the perimeter band, use the following methodology:

1) Based on the total heat load calculation, calculate the radiant floor heat output requirement in W/m² (Btu/h-ft²) for each thermal zone using the following formula: Floor Heat Output = Total Heat Load/Available Area

2) Available area is normally less than total area. Deduct non-heated areas where heating pipe cannot or should not be installed, such as under walls, vending machines, islands or furniture.

3) Calculate the radiant floor surface temperature that is needed to achieve the required heat output into the room. The floor surface temperature is the temperature at the outer surface of the finished floor. To calculate the floor surface temperature in °C (°F), use the following equation:
Floor Surface Temp = Floor Heat Output/HTC + Indoor Temperature

4) Where the Heat Transfer Coefficient (HTC) is recommended as 11.36 W/m²-K or 2.0 Btu/(hr-ft²-F°)

5) The maximum floor surface temperature shall not exceed 29°C (85°F), except for the 1.0m (3ft) wide perimeter band, where the temperature may be raised up to 32°C (90°F).

6) If the floor surface temperature exceeds the advisable temperature set in these guidelines or the allowable floor covering temperatures (see below), take the following actions:

• Reduce the heat requirements by improving building envelope efficiency

• Increase the radiant surface area to include not only the floor but also walls and/or ceilings

• Use supplemental heat (baseboards, reheat coils)

1.2.5. Maximum Under-Floor Covering Temperature

a) Every floor covering has a thermal resistance. The type and material used for flooring shall be coordinated with the architect. Floor products used with radiant heating systems should have high heat transmission values (low R-values) to achieve the best possible heat transfer from the pipes to the room. Floor coverings should also be as thin and dense as possible and be able to withstand the heat output of the radiant panel;

b) In order to achieve the required Floor Surface Temperature, the temperature of the slab at the underside of the floor covering needs to be higher, in order to overcome the thermal resistance of the floor covering. The thermal resistance of the floor covering shall be calculated taking into account all the layers involved (such as mortar bed, final grout, ceramic tiles, etc.);

c) Floor covering materials have temperature limits dictated by their composition. The calculated temperature at the underside of the floor covering shall not exceed the value recommended by the manufacturer. For specific floor finishes materials and thicknesses, coordinate with the architect;

d) Avoid under-floor covering temperatures in excess of 38°C (100°F). If the under-floor covering temperature resulting from calculations exceeds 39.5°C (103°F), re-select the in-floor pipe diameter and the pipe spacing;

e) Typically, floor and under-covering temperatures are controlled and monitored by embedded temperature sensors.

1.2.6. Thermal Zoning

a) A thermal zone is an area of temperature control. Typically, a group of offices or similar will constitute a separate zone. Larger areas (such as common waiting areas in a GO Transit station) may be subdivided in several thermal zones, based on geographical orientation and proximity to exterior walls.

1.2.7. Thermal Expansion

a) The design must allow for absorption of the movement of the thermal mass of the floor slab. To prevent uncontrolled cracking and/or damage to the embedded piping, the architect shall segment the thermal slab into smaller sections called thermal bays by employing an appropriate arrangement of movement joints. The development of cracks in the floor or distortion in the piping are unacceptable;

b) The layout of the heating pipe and the floor slab joints must be coordinated with the architect and the structural engineer. Pipe circuits are to be planned and installed such that they do not cross movement joints. Movement joints should only be crossed by the connection piping (circuit supply and return tails).

1.2.8. Pipe Spacing

a) Metrolinx recommends the pipe spacing be selected to provide the most comfortable floor surface temperature and the most energy efficient system. Closer pipe spacing improves the uniformity of the floor surface temperature and lowers the heating fluid temperature, resulting in greater energy efficiency.

b) The typical pipe spacing shall be:

• tiled floors: 6" to 8" in the perimeter band and 6" to 9" in the field of the thermal zone (to prevent concentrated hot and cold spots);

• carpeted floors: 6" to 8" in the perimeter band and 6" to 12" in the field of the thermal zone (to prevent concentrated hot and cold spots);

• bare finished concrete: depends of heat loss, up to 18" possible.

1.2.9. Pipe Sizes

a) The embedded pipe sizes shall be selected as follows:

1) 5/8"Ø for circuits up to 400 ft

2) 3/4"Ø for circuits up to 500 ft

3) 1"Ø for circuits larger than 500 ft.

b) The length of a particular circuit shall be based on the area of each thermal zone and the following criteria:

1) pipe spacing 6" - 2 ft pipe length per sq.ft of space.

2) pipe spacing 8" - 1.5 ft pipe length per sq.ft of space.

3) pipe spacing 9" - 1.3 ft pipe length per sq.ft of space.

4) pipe spacing 10" - 1.2 ft pipe length per sq.ft of space.

5) pipe spacing 12" - 1.0 ft pipe length per sq.ft of space.

c) The total resulting length for each circuit shall not exceed the maximum value allowed for a particular pipe diameter

1.2.10. Pipe Layout Guideline

a) Following are some basic pipe layout recommendations:

1) Do not run pipes under built-ins (e.g., cabinets, window seats, large appliances, raised hearths, stairs);

2) Keep pipes a minimum of 15cm (6") away from the edge of the slab, walls and nailing surfaces, and other locations where plates, fixtures or built-ins might be fastened into the floor;

3) Keep balanced circuit lengths within 10% of each other;

4) Design separate circuits for different rooms, allowing better room temperature control;

5) Keep thermal zones reasonably sized;

6) Do not run circuit pipes across movement joints;

7) Select the pipe size that is large enough for the application;

1.2.11. Fluid Heating Temperature

a) Metrolinx recommends the lowest heating fluid temperature that will provide the required panel surface temperature. This will minimize thermal stress on slabs and floor coverings, and minimize overshooting of the desired ambient room temperature;

b) Metrolinx suggests the following criteria:

1) Temperature drop across the embedded circuits: 11°C (20°F);

2) Average fluid temperature (between supply and return): 43.5°C (110°F).

c) To be noted: floor coverings, pipe spacing and selected indoor temperature may have a significant impact on the average fluid temperature. Highly resistive floor coverings (e.g., carpet and padding) require the fluid temperature to be increased to overcome the resistance to heat flow through the floor. Highly conductive floor coverings (e.g., tile) require a lower fluid temperature to provide the same heat output.

d) The heating fluid temperature is also affected by the selected indoor setpoint selected and the pipe spacing. Consultant will check with the equipment manufacturer and make corrections to Metrolinx temperature guidelines if so required. Optimizing the average fluid temperature may require changing previously selected values for pipe size and spacing. The designer will need to reiterate the previous calculations with the newly selected values.

1.2.12. Manifold Sizing

a) When sizing a manifold, several criteria must be taken into account:

1) Manifolds are selected according to the pipe size, number of circuits and circuit flow rates. Smaller manifolds (up to 6 circuits), in various building locations, are usually preferred to a large, central manifold (such as 10, 11, 12 or more circuits);

2) With large manifolds, the designer should consider the effect of manifold location on the radiant heating system design and the impact of bringing numerous pipes in to one area. For example, a 12 circuit manifold has 24 inlet/outlet pipes which result in a congested pipe layout and an excessively warm area near the manifold.

b) Based on the above, determine the number of circuits for each manifold. Zoning the building usually increases the number of circuits resulting in manifolds with more outlets.

c) Preferably, a manifold will serve multiple thermal zones with similar heating requirements (such as exterior zones facing East, etc.). Avoid connecting core areas and perimeter areas to the same manifold.

d) The fluid flow for each thermal zone shall be calculated based on the heat output of the respective circuit, the nature of the fluid used (water, glycol) and the temperature differential (usually 11.1°C or 20°F).

e) The fluid flow through the manifold shall be calculated as the sum of all the circuits flows served by the respective manifold.

f) Verify fluid velocities through each pipe section; ensure that no pipe section conveys fluid at more than 1.37m/s (4.5 fps).

1.2.13. Manifold Location

a) Identify the manifold location before beginning the pipe layout.

b) Use the following criteria:

1) Manifolds must always be installed within the heated space, and not be located in an unheated area;

2) Manifolds should be installed close to the heating zones in a convenient location for both the installation and for future accessibility (to reduce the length of pipe tails);

3) Ensure that the manifolds fit in the available space;

4) Review the proximity to the heat source to minimize the distribution piping;

5) Review the area security to prevent tampering, especially areas open to the public;

6) Review maintenance clearances;

c) Typical manifold locations include mechanical rooms, closets (behind an access panel), below subfloors (mounted horizontally), underneath stairwells, inside cabinetry, in window boxes or benches or hallways (in a recessed manifold cabinet).

1.2.14. Piping Layout

a) Circuit connections branch off from the manifold headers and balancing valves shall control the flow rate to each circuit connection. A valve actuator shall be installed to the header balancing valve to open and close the circuit;

b) Heat requirements are higher near exterior walls and windows and diminish toward the center of the room. A 1.0m (3ft) wide band along the perimeter area of the building shall be supplied by separate supply and return manifolds and maintain a higher slab temperature; for the perimeter band, it is permitted to serve multiple thermal zones from a single pair of dedicated manifolds, provided they face the same geographical orientation;

c) Following are some basic pipe layout recommendations:

1) Do not run pipes under built-ins (e.g., cabinets, window seats, large appliances, raised hearths, stairs);

2) Keep pipes a minimum of 6 in (15 cm) away from the edge of the slab, walls and nailing surfaces, and other locations where plates, fixtures or built-ins might be fastened into the floor;

3) Keep balanced circuit lengths within 10% of each other;

4) Design separate circuits for different rooms, allowing better room temperature control;

5) Keep area types reasonably sized;

6) Do not run circuit pipes across movement joints;

7) Select the pipe size that is large enough for the application;

d) Counter Flow Spiral Pattern: with fewer bend radius constraints, counter flow spirals allow closer pipe spacing and distribute heat more evenly than serpentine patterns;

e) Serpentine Pattern: provides more heat to the perimeter areas than to the interior of the room, where occupants are more likely to gather;

f) Typically, the most effective way to heat a room is to use a serpentine pattern at the edges and a counter flow spiral pattern in the middle.

1.2.15. Control Strategies

a) The temperature of the slab is controlled and limited by separate embedded sensors, to prevent damage to the slab and floor coverings;

b) The heating output of the circuits served by each manifold is determined by a 3-way mixing valve at the interface between the in-floor heating secondary loop and the heating plant primary loop. The valve can combine fluid returning from the under-floor loop with fluid supplied by the primary heat source, to maintain the optimum median fluid temperature in the under-floor piping system. The goal is to maintain the supply fluid at the pre-determined under-floor covering temperature and the optimum temperature differential between the supply and return manifolds at between 10°C to 12.5°C (18°F and 22°F);

c) The comfort level in each thermal zone is maintained by a space sensor; the space sensor has the ability to close or open a 2-way valve associated with each circuit within a manifold. The two-way valve may be 2-position or modulating type;

d) Outdoor weather compensating controls (outdoor reset controls) shall adjust the rate of heat delivered by the primary source to more closely match the heat loss of a building, allowing the indoor air temperature to remain relatively constant. The outdoor reset control measures the outdoor air temperature, then calculates the target supply fluid temperature for the radiant system. This target supply temperature is constantly updated throughout the day as outdoor conditions change. The control can operate upon the heat source, upon a primary/secondary loop mixing valve or a variable speed injection pump to adjust the heating fluid temperature toward the calculated target value.

1.2.16. Piping to be as follows:

a) for pipe inside building and aboveground, Schedule 40 black steel, or Type "K" hard temper copper;

b) for floor grid piping, PEX pipe installed in continuous lengths.

1.2.17. Refer to Section 23 21 18 - Glycol Solution Snow Melting System.

1.2.18. Design requirements are also 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 20 05 55 - Firestopping and Smoke Seal Systems.

1.3.5. Section 23 20 00 – HVAC Piping and Pumps.

1.3.6. Section 23 21 18 - Glycol Solution Snow Melting System.

1.3.7. Section 23 52 22 – Condensing Hot Water Boilers.

1.4. REFERENCE STANDARDS

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

1.4.2. CSA B214, Installation Code for Hydronic Heating Systems.

1.4.3. CAN/CSA B137.5, Crosslinked Polyethylene (PEX) Tubing Systems for Pressure Applications.

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

1.4.5. ASTM F877, Standard Specification for Crosslinked Polyethylene (PEX) Hot and Cold Water Distribution Systems.

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

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

1.4.8. CAN/ULC S102.2, Standard Method of Test for Surface Burning Characteristics of Flooring, Floor Coverings, and Miscellaneous Materials and Assemblies.

1.4.9. Local governing building code.

1.5. TRAINING

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

1.5.2. Include for 3 training sessions of maximum 7 hours duration per session for 6 Metrolinx people per session.

1.5.3. Refer to Section 20 05 05 for additional general requirements.

1.6. WARRANTY

1.6.1. Submit, at Substantial Performance of the Work, a non-prorated transferable repair or replacement warranty in name of Metrolinx, issued by and signed by system component manufacturer covering materials against failure due to defects in material and/or workmanship as follows:

a) PEX tubing and fitting system, minimum 25 years;

b) manifold assemblies, minimum five years;

c) controls and electrical components, minimum two years.

1.7. DELIVERY, STORAGE AND HANDLING.

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

1.8. SUBMITTALS

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

1.8.2. Submit shop drawings and/or product data sheets for following:

a) cross-linked polyethylene (PEX) floor heating grid tubing, fittings and accessories, manifold assembly, control components and controls;

b) copy of system manufacturer’s loop layout design indicating water flows and temperatures, floor profiles with floor covering(s), and heating outputs;

c) certified tubing and piping layout and schematic for each system zone;

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

e) letter from system component manufacturer stating system components proposed meet all requirements of Specification;

f) copy of manufacturer’s training certificate.

1.8.3. Submit, prior to application for Substantial Performance of the Work, start-up or test data specified in Part 3 of this Section.

1.8.4. Submit letters of installation certification from system manufacturer’s representative as specified in Part 3 of this Section.

1.8.5. Submit shop drawings/product data sheets as follows:

a) to regulatory authority for review and approval prior to submitting to Consultant.

b) copies of all calculations, stamped and signed by same engineer who signs layout drawings, and a listing of all design data used in preparing the calculations, system layout and sizing requirements.

1.8.6. Product Data

a) Submit product data sheets 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.

1.8.7. Shop Drawings

a) Submit shop drawings indicating:

1) capacity and ratings;

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

3) applicable control components and control wiring schematic.

1.8.8. 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.

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

1.8.9. Commissioning Closeout Package:

a) 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 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, including product SDS of all chemical components in the system.

   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.

   x) any relevant permits or inspection records for radiant floor heating components.

1.9. QUALITY ASSURANCE

1.9.1. Products and work are to comply with codes, regulations and standards listed above and applicable local codes and regulations.

1.9.2. Site personnel are to be licensed in jurisdiction of the work and under continuous supervision of a foreman who is an experienced system installer.

1.9.3. PEX tubing used is to be listed and rated (temperature and pressure) for radiant floor heating applications.

1.9.4. Prior to installation of system components, meet on-site with system component manufacturer's representative and trades whose work is related to successful installation of system(s) to confirm floor areas involved are ready for tubing installation.

1.9.5. Manufacturers Qualifications:

a) Manufacturer shall be 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 (minimum of 5) installations with similar product shall be provided demonstrating compliance with this requirement.

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

1.9.6. Installers Qualifications:

a) Installers for work to be performed by or work under licensed Mechanical Contractor.

b) Installers to be journeyman tradesmen with a minimum of three years successful installation of PEX radiant floor system components supplied by manufacturer of components.

c) Installers shall furnish all labor, materials, tools, equipment, appliances and services necessary to deliver and install all hydronic radiant dimensions to the hydronic radiant manufacturer.

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.

1.9.7. Regulatory Requirements:

a) Products and work to comply with applicable local governing authority regulations, bylaws and directives.

b) Include for required inspections and certificate of approvals of installation work from local governing authorities.

2. PRODUCTS

2.1. SYSTEM MATERIALS

2.1.1. Uponor Inc or approved equivalent, radiant floor heating system components as follows:

a) cross-linked polyethylene (PEX) tubing to CAN/CSA B137.5, ASTM F876 and F877, and SDR-9 requirements with oxygen barrier in accordance with German Standard DIN 4726, flame spread and smoke developed ratings in accordance with CAN/ULC S102 and ASTM E84, supplied in coils, and with characteristics and accessories as follows:

1) Plastic Pipe Institute certified temperature and pressure ratings of 550 kPa at 93 °C (80 psi at 200 °F), 690 kPa at 82 °C (100 psi at 180 °F), and 1100 kPa at 23 °C (160 psi at 74 °F);

2) where required, "ProPEX" cold expansion type fittings in accordance with ASTM F877, CAN/CSA B137.5, and ASTM F1960, each consisting of barbed adapter with o-ring and an applicable sized PEX ring;

3) minimum bend radius of 6 times the tubing OD, with factory supplied bend supports required for tubing with a bend radius less than 6 times tubing OD;

4) required installation and connection accessories to suit floor construction, provided in accordance with tubing manufacturer's instructions and factory supplied with tubing.

b) Package type copper or brass supply and return manifold assembly to suit number of heating zones, factory assembled and equipped with wall mounting brackets and following:

1) main supply and return full flow ball type isolating valves, zone pipe connection couplings, and fill/drain valves for both supply and return manifolds;

2) supply manifold automatic air vent, and zone on/off valves with 24 volt AC actuators to suit control system;

3) return manifold pressure balancing by-pass valve, and zone balancing valves and flow rate indicators;

4) combination pressure gauge and thermometer for each manifold, and individual zone return piping thermometers for accurate visual zone balancing by zone temperature drops;

5) other required fittings and connection accessories.

c) Controls in accordance with drawing control diagram and sequence.

2.1.2. Standard of quality assurance manufacturers are:

a) Uponor Inc.;

b) Watts Radiant Inc.;

c) Rehau Inc;

d) or approved equivalent.

3. EXECUTION

3.1. RADIANT FLOOR HEATING INSTALLATION

3.1.1. Provide hydronic radiant floor heating zones and piping manifold assemblies. System installation is to be in strict accordance with manufacturer's instructions.

3.1.2. Piping to be as follows:

a) for pipe inside building and aboveground, Schedule 40 black steel, screwed, ASTM A53, Grade B, ERW, or Type "K" hard temper copper with forged copper solder type fittings and 95% tin / 5% Antimony solder joints, all in accordance with Section 23 20 00 - HVAC Piping and Pumps;

b) for floor grid piping, PEX pipe installed in continuous lengths with required support and installation accessories.

3.1.3. Provide a strainer in piping to manifold supply header and clean strainer screen when system balancing is to commence.

3.1.4. Perform pressure testing of grid piping with Consultant present. Testing times to be acceptable to Metrolinx and reviewed with Consultant.

3.1.5. Ensure grid tubing has been successfully pressure tested prior to concealment. Be present when covering is being placed over grid tubing to ensure integrity of tubing is not compromised during placement of remainder of floor construction.

3.1.6. Where tubing and/or piping penetrates fire rated construction, provide firestopping in accordance with requirements specified in Section 20 05 55 - Firestopping and Smoke Seal Systems.

3.1.7. Prior to system flow balancing, purge air from system and ensure system operates successfully at design temperatures and pressure for a minimum of two days. Supply system manufacturer's software for final balancing flow adjustment settings. Document system operation and submit copy to Consultant.

3.1.8. Refer to Section 20 05 10 for equipment/system start-up requirements.

3.1.9. Refer to Section 20 05 10 for equipment/system manufacturer certification requirements. Ensure system manufacturer inspects grid tubing installation prior to concealment and certifies each zone correct in writing. Submit a copy of each certification letter prior to application for Substantial Performance of the Work.

END OF SECTION