SECTION 23 83 16

RADIANT HEATING AND COOLING

1. GENERAL
	1. SUMMARY
		1. Section includes: Hydronic radiant heating and cooling systems.
	2. Related Sections: Hydronic Piping
		1. Section 23 21 13 – Hydronic Piping
		2. Section 23 21 13.13 – Underground Hydronic Piping
	3. REFERENCES
		1. Uponor Inc.
			1. Uponor PEX Piping Systems Installation Guide, current edition.
			2. Uponor PEX Piping Systems Design and Installation Manual, current edition.
			3. Uponor Complete Design Assistance Manual (CDAM), current edition.
			4. Uponor Radiant Cooling Design Assistance Manual, current addition.
			5. Uponor Radiant Floor Installation Handbook, current edition.
		2. ASTM International (ASTM)
			1. ASTM E814 Standard Test Method for Fire Tests of Through-Penetration Fire Stops.
			2. ASTM F876 Standard Specification for Crosslinked Polyethylene (PEX) Tubing.
			3. ASTM F877 Standard Specification for Crosslinked Polyethylene (PEX) Plastic Hot- and Cold-Water Distribution Systems.
			4. ASTM F1960 Standard Specification for Cold Expansion Fittings with PEX Reinforcing Rings for Use with Crosslinked Polyethylene (PEX) Tubing.
			5. ASTM F2389 Standard Specification for Pressure-rated Polypropylene (PP) Piping Systems.
		3. American National Standards Institute (ANSI)/National Sanitation Foundation (NSF):
			1. NSF/ANSI Standard 359 Valves for Crosslinked Polyethylene (PEX) Water Distribution Tubing Systems.
		4. Canadian Standards Association (CSA)
			1. CAN/CSA B137.5 Crosslinked Polyethylene (PEX) Tubing Systems for Pressure Applications.
		5. German Institute for Standardization (DIN)
			1. DIN 4726 Warm Water Surface Heating Systems and Radiator Connecting Systems ‒ Plastics Piping Systems and Multilayer Piping Systems.
		6. International Code Council (ICC)
			1. International Mechanical Code (IMC)
		7. International Association of Plumbing and Mechanical Officials (IAPMO)
			1. Uniform Mechanical Code (UMC)
		8. International Organization for Standardization (ISO)
			1. ISO 15874 Plastics Piping Systems for Hot and Cold Water Installations – Polypropylene (PP).
		9. Plastics Pipe Institute (PPI)
			1. PPI Technical Report TR-4.
	4. SUBMITTALS
		1. Submit under provisions of Section 01 30 00 ‒ Administrative Requirements.
		2. Product data: Submit manufacturer’s product submittal data and installation instructions.
		3. Shop drawings: Provide installation drawings indicating: piping layout, size dimension by installation segment, vault locations, support fixtures and schedules with all details required for installation of the system.
		4. Samples: Submit selection and verification samples of piping.
		5. Quality assurance/control submittals
			1. Test reports: Upon request, submit test reports from recognized testing laboratories.
			2. Submit the following documentation.
				1. Manufacturer’s certificate stating that products comply with specified requirements.
				2. Manufacturer’s flow schedule for the distribution system.
				3. Documentation that the installer is trained to install the manufacturer’s products.
		6. Closeout submittals: Submit the following documents.
			1. Warranty documents specified herein.
			2. Operation and maintenance data.
			3. Manufacturer’s field reports specified herein.
			4. Final as-built piping layout drawing.
	5. QUALITY ASSURANCE
		1. Installer qualifications for PEX: Installer shall have successfully completed the Uponor Piping Systems Training Course and is able to provide proof/verification of the training. Course shall be conducted by the manufacturer or a manufacturer’s representative.
			1. Regulatory requirements and approvals: Ensure the piping distribution system complies with all applicable codes and regulations.
			2. Certifications: Provide letters of certification indicating: Installer uses skilled workers holding a trade qualification license or equivalent, or apprentices under the supervision of a licensed tradesperson.
			3. Pre-installation meetings:
				1. Verify project requirements, excavation conditions, system performance requirements, manufacturer’s installation instructions and warranty requirements.
				2. Review project construction timeline to ensure compliance or discuss modifications as required.
				3. Interface with other trade representatives to verify areas of responsibility.
				4. Establish the frequency and construction phase the project engineer intends for site visits and inspections by the piping manufacturer’s representative.
	6. DELIVERY, STORAGE AND HANDLING
		1. General: Comply with Division 1 Product Requirement Section.
		2. Comply with manufacturer’s ordering instructions and lead-time requirements to avoid construction delays.
		3. Delivery: Deliver materials in manufacturer’s original, unopened, undamaged containers with identification labels intact.
		4. Storage and protection: Store materials protected from exposure to harmful environmental conditions and at temperature and humidity conditions recommended by the manufacturer.
			1. Store PEX piping in cartons or under cover to avoid dirt or foreign material from entering the piping.
			2. Do not expose white or blue PEX piping to direct sunlight for more than one month. Do not expose red PEX piping to direct sunlight for more than six months.
			3. Store piping on a flat surface to prevent unwanted deformation.
	7. WARRANTY
		1. Project warranty: Refer to Conditions of the Contract for project warranty provisions.
		2. Manufacturer's warranty:
			1. PEX-a manufacturer system warranty shall cover piping and fittings from defect for a duration of 25 years from the date of installation. Piping system warranty shall apply to systems constructed of pipe and fitting products sourced from the same manufacturer.
2. PRODUCTS
	1. MANUFACTURERS
		1. Acceptable manufacturer: Uponor, located at: 5925 148th St. W., Apple Valley, MN, 55124; toll-free: 800-321-4739; tel: 952-891-2000;
		email: NAspecifications@uponor.com; web: [uponor.com](http://www.uponor.com).
		2. Substitutions: Not permitted.
		3. Requests for substitutions will be considered in accordance with provisions of Section 01 60 00 — Product Requirements.
	2. CROSSLINKED POLYETHYLENE PEX PIPE AND FITTINGS
		1. Performance requirements:
			1. PEX-a piping and fittings shall meet the following pressure and temperature ratings per ASTM F876:
				1. 200 degrees F (93 degrees C) at 80 psi (551 kPa).
				2. 180 degrees F (82 degrees C) at 100 psi (689 kPa).
				3. 73.4 degrees F (23 degrees C) at 160 psi (1,102 kPa).
			2. PEX-a piping and fittings shall be tested for compliance by an independent third-party agency.
			3. Minimum bend radius (cold bending): Six times the outside diameter.
			4. Show compliance with ASTM E119 and ANSI/UL 263 through certification listings through UL.
				1. UL Design No. L557 1 hour wood frame floor/ceiling assemblies.
				2. UL Design No. K913 2 hour concrete floor/ceiling assemblies.
				3. UL Design No. U372 1 hour wood stud/gypsum wallboard wall assemblies.
				4. UL Design No. V444 1 hour steel stud/gypsum wallboard wall assemblies.
		2. PEX-a (Engel-method crosslinked polyethylene) piping:
			1. SDR 9, ASTM F876 and F877 (CAN/CSA-B137.5) by Uponor (Wirsbo) with an oxygen barrier meeting DIN 4726.
		3. Fittings:
			1. ProPEX®: Elbows, adapters, couplings, plugs, tees and multiport tees (1/2 inch through 3 inch nominal pipe size): ASTM F1960 cold-expansion fittings in brass or engineered polymer (EP) manufactured by the pipe manufacturer, utilizing cold-expansion PEX-a reinforcing rings made of same material as the pipe.
			2. Fittings shall be third-party certified to NSF 14 and ASTM F1960 and shall be listed to ASTM F876 and ASTM F877.
	3. TRANSITION FITTINGS
		1. PEX-to metal transition fittings
			1. Manufacturers: Provide transition fittings from the same manufacturer as the piping.
			2. PEX to threaded transition: Two-piece female brass union nut ProPEX ASTM F1960 cold-expansion end, with PEX-a reinforcing cold-expansion ring.
			3. PEX compression to threaded fitting: two-piece female brass union nut by compression fitting with compression ring listed to ASTM F877.
	4. MANIFOLDS
		1. Brass manifolds
			1. Brass manifold assemblies shall have 1 inch (25mm) or 1-1/4 inch (32mm) barrel, with an R32 union connection on the respective supply and return inlet and outlet.

**\*\*NOTE TO SPECIFIER\*\* Remove line item of non-essential manifold requirement**

* + - 1. Manifold assemblies shall have the following options:
				1. Supply and return filter ball valves
				2. Supply and return temperature gauges
				3. Loop isolation valves
				4. Manual balancing valves with visual flow indicators
				5. End cap with vent and drain
				6. Mounting bracket
				7. Loop fitting assemblies
				8. Capable of individual loop actuator
			2. Manifold connections from 5/16 inch (8mm) through 5/8 inch (19mm) PEX tubing.
		1. Engineered polymer (EP) manifolds
			1. Engineered polymer (EP) manifold assemblies shall have 1 inch (25mm) or 1-1/4 inch (32mm) barrel, with an R32 union connection on the respective supply and return inlet and outlet.

**\*\*NOTE TO SPECIFIER\*\* Remove line item of non-essential manifold requirement**

* + - 1. Manifold assemblies shall have the following options:
				1. Supply and return filter ball valves
				2. Supply and return temperature gauges
				3. Loop isolation valves
				4. Manual balancing valves with visual flow indicators
				5. End cap with vent and drain
				6. Mounting bracket
				7. Loop fitting assemblies
				8. Capable of individual loop actuator
			2. Manifold connections from 5/16 inch (8mm) through 5/8 inch (19mm) PEX tubing.
		1. Stainless-steel manifolds
			1. Stainless-steel manifold assemblies shall have 1 inch (25mm) or 1-1/4 inch (32mm) barrel, with an R32 union connection on the respective supply and return inlet and outlet.

**\*\*NOTE TO SPECIFIER\*\* Remove line item of non-essential manifold requirement**

* + - 1. Manifold assemblies shall be furnished and installed with:
				1. Supply and return ball valves with temperature gauges.
				2. Loop balancing and isolation valves.
				3. Supply and return vent and drain connections.
				4. Mounting bracket.
				5. Manual balancing valves with visual flow indicators.
				6. Loop fitting assemblies
				7. Capable of individual loop actuator
			2. Manifold connections from 5/16 inch (8mm) through 5/8 inch (19mm) PEX tubing.
		1. Copper manifolds:
			1. Copper manifolds manufactured from Type L copper, 2 inches (51 mm) by 4 feet (1.2 m), offered by the PEX tubing manufacturer.

**\*\*NOTE TO SPECIFIER\*\* Remove line item of non-essential manifold requirement**

* + - 1. Manifold loop configurations:
				1. 4 inch on center spacing
				2. Balancing valve with R20 or R25 threaded connection
				3. Ball Valve with R20 or R25 threaded connection
				4. Balancing valve with 5/8 inch or ¾” ProPEX connection
				5. Ball Valve with 5/8” or 3/4 inch ProPEX connection
				6. ProPEX connection 5/8” or 3/4 inch with no balancing or ball valve.
			2. Use manifolds with an isolation valve or a combination isolation and balancing valve on each outlet.
			3. Use manifolds that support 5/8 inch (16 mm) inch or 3/4 inch (19 mm) inch PEX tubing.
			4. Manifold end cap with 1/8 inch (3 mm) FNPT and 1/2 inch (25 mm) FNPT for vent and drain.
			5. Install supply-and-return piping to the manifold in a reverse-return configuration to ensure self-balancing.
			6. If the supply-and-return piping is in direct-return configuration, install and balance flow setters on the return leg of each manifold to the mains.
	1. PREFABRICATED RADIANT ROLLOUT™ MAT
		1. Radiant Rollout™ Mats shall be constructed with Wirsbo hePEX™ tubing, on center spacing as designed by the manufacturer.
			1. Tubing shall be 1/2 inch (13 mm) or 5/8 inch (16 mm).
			2. On center spacing shall be 6 inches (152 mm), 9 inches (229 mm) or 12 inches (304mm).
		2. The mats shall be constructed in nominal widths of 5 feet (1.5 m), with maximum lengths for 1/2 inch loops is 150 feet (46m) or 5/8 inch loops is 225 feet (69 m). The mats shall be custom-designed based on the floor plan to ensure that mat pressure drops at the required flow rates will not exceed the scheduled maximums.
		3. The mats shall be constructed with support strips at every 7 feet (2.1 m) installed perpendicular to the tubing and each loop shall be secured to the support strips.

**\*\*NOTE TO SPECIFIER\*\* Remove Sub-paragraph below if no headers are require for the mats.**

* + 1. Header assembly: In-slab reverse-return header assembly shall be constructed of 3/4 inch (19 mm) Wirsbo hePEX with engineered polymer (EP) ASTM F1960 cold-expansion fittings.
		2. Radiant Rollout Mats shall be pressure tested prior to shipping and shall be delivered to the job site under 20 psi (138 kPa) of pressure. The mats shall be labeled according to the Radiant Rollout Mat schedule.

**\*\*NOTE TO SPECIFIER\*\* Remove paragraphs below not required by the project design specification.**

* 1. HEAT TRANSFER PANELS AND PLATES
		1. Fast Trak™ 0.5 for 5/16 inch (8 mm) tubing: 1/2 inch (13 mm) thick black polystyrene knob mat with self-adhesive backing. Provide Fast Trak edge insulation strips.
		2. Fast Trak 1.3i for 3/8 inch or 1/2 inch (9.5 mm or 13 mm) tubing: 1-1/4 inches (32 mm) thick black polystyrene knob mat with integral R-1.7 expanded polystyrene insulation. Provide Fast Trak edge insulation strips.
		3. Quik Trak® channeled subfloor for 5/16 inch (8 mm) tubing: 1/2 inches (13 mm) thick, 7 inches (178 mm) wide plywood panels with 30-gauge aluminum heat-transfer sheet.
		4. Joist Trak™ heat emission panel (3/8 inch or 1/2 inch (9.5 mm or 13 mm) tubing as scheduled): 4 feet (1.22 m) long by 3-1/2 inches (89 mm) wide extruded aluminum heat transfer panels with snap fit to hold tubing.
	2. PIPING SUPPORTS AND FASTENERS
		1. Fixing wire: 6 inches (152 mm) galvanized steel alloy wire ties shall be used to secure PEX tubing to wire mesh or reinforcing bar.
		2. Plastic cable tie: Minimum 6 inches (152 mm) polyamide 6/6 nylon cable tie. Minimum 20 lb. tensile strength.
		3. Staples for plastic foam insulation:
			1. Black polypropylene staples shall be used to secure 3/8 inch to 5/8 inch (9.5 mm to 16 mm) tubing directly onto rigid foam insulation. Ensure that the proper size staples are used for the insulation thickness. Use 1-1/2 inch (38 mm) staples for 1 inch (25 mm) rigid foam insulation and 2-1/2 inch (63 mm) staples for 1-1/2 inch (38 mm) or thicker foam insulation.
			2. Blue polypropylene staples shall be used to secure 3/8 inch to 3/4 inch (9.5 mm to 19 mm) tubing directly onto rigid foam insulation. Ensure that the proper size staples are used for the insulation thickness. Use 2 inch (51 mm) staples for 1 inch (25 mm) or thicker foam insulation.
		4. Metal staples: 1-1/4 inches (32 mm) steel alloy metal staples shall be used to secure PEX tubing to wood subfloors.
		5. Plastic PEX rails: 1-1/2 inches (38 mm) wide, 1 inch (25 mm) tall polyethylene plastic rails, with snap fit to hold tubing with spacing intervals. Spacing as indicated on approved shop drawings.
		6. PVC bend supports: 90-degree PVC bend supports shall be used to sleeve tubing at slab penetrations. Bend supports shall be sized for appropriate tubing diameter.
		7. PEX stand-up bracket: Secures to deck or concrete forms, for rough in from slab to manifold cabinet.
	3. CONTROLS
		1. Refer to sections “Instrumentation and Control for HVAC”, section “Sequence of Operations for HVAC Controls”, and plans for radiant system controls.
1. EXECUTION
	1. EXAMINATION
		1. Verify that site conditions are acceptable for installation of the radiant system.
		2. Do not proceed with installation of the radiant system until unacceptable conditions are corrected.
	2. MANUFACTURER’S INSTRUCTIONS
		1. Comply with manufacturer’s product data, including product technical bulletins, installation instructions and design drawings.
	3. INSTALLATION
		1. Manifold supply and return piping refer to Section 23 21 13 Hydronic Piping or Section 23 21 13.13 Underground Hydronic Piping.
		2. Install radiant system according to approved shop drawings or coordination drawings.
		3. Comply with manufacturer's product data, including product technical bulletins, installation instructions, and design drawings, including the following.
			1. Uponor PEX Piping Systems Installation Guide, current edition.
			2. Uponor PEX Piping Systems Design and Installation Manual (PDIM), current edition.
			3. Uponor Complete Design Assistance Manual (CDAM), current edition.
			4. Uponor Radiant Cooling Design Manual (RCDM), current edition.
			5. Uponor Radiant Floor Installation Handbook, current edition.
		4. White and blue PEX shall not be installed outdoors where it is exposed to direct sunlight light for more than one month. Red PEX shall not be installed outdoors where it is exposed to direct sunlight light for more than six months.

**\*\*NOTE TO SPECIFIER\*\* Retain, edit or delete paragraph that pertains to the project specification for a thermally isolated slab.**

* + 1. Slab-on-grade with under-slab and edge insulation
1. Fasten the tubing to flat wire mesh or reinforcing bar in accordance with the PEX tubing manufacturer's installation recommendations.
2. Install the vertical edge insulation along the perimeter of the slab and down to a minimum of 12 inches (305mm) below the slab depth.
3. The structural engineer determines the vertical compressive strength of the high-density foam insulation board. The radiant design determines the required insulation resistance value (R-value).
4. The submitted radiant design specifies the tubing on-center distance(s) and loop lengths. On-center distances will not exceed 12 inches (305mm).
5. Do not install tubing closer than 6 inches (152mm) from the edge of the heated slab.
6. Install the tubing at a consistent depth below the surface elevation as determined by the project engineer. Tubing installation will ensure sufficient clearance for all control joint cuts.
7. Expansion joints
8. In areas where tubing must cross metal expansion joints that occur in the concrete, the tubing shall pass below the metal expansion joints.
9. Fibrous expansion joints may be penetrated following the PEX tubing manufacturer’s and structural engineer’s recommendation.
10. Metal or plastic bend supports will be used to support the tubing when departing from the slab in a 90-degree bend.

**\*\*NOTE TO SPECIFIER\*\* Retain, edit or delete paragraph that pertains to the project specification for a lateral thermally isolated slab.**

1. Slab-on-grade construction with edge insulation only
	1. Fasten the tubing to flat wire mesh or reinforcing bar in accordance with the PEX tubing manufacturer's installation recommendations.
	2. Install the vertical edge insulation along the perimeter of the slab and down to a minimum of 12 inches (305mm) below the slab depth.
	3. The structural engineer determines the vertical compressive strength of the high-density foam insulation board. The radiant design determines the required insulation resistance value (R-value).
	4. The submitted radiant design specifies the tubing on-center distance(s) and loop lengths. On-center distances will not exceed 12 inches (305mm).
	5. Do not install tubing closer than 6 inches (152mm) from the edge of the heated slab.
	6. Install the tubing at a consistent depth below the surface elevation as determined by the project engineer. Tubing installation will ensure sufficient clearance for all control joint cuts.
	7. Expansion joints.
2. In areas where tubing must cross metal expansion joints that occur in the concrete, the tubing shall pass below the metal expansion joints.
3. Fibrous expansion joints may be penetrated following the PEX tubing manufacturer's and structural engineer’s recommendation.
	1. Metal or plastic bend supports will be used to support the tubing when departing from the slab in a 90-degree bend.

**\*\*NOTE TO SPECIFIER\*\* Retain, edit or delete paragraph that pertains to the project specification for a slab over slab.**

* + 1. Slab over existing slab construction with edge and under-slab insulation
			1. When using high-density foam insulation board, install the tubing by stapling the tubing to the insulation board with Uponor PEX foam staples.
			2. The structural engineer determines the vertical compressive strength of the high-density foam insulation board. The radiant design determines the required insulation resistance value (R-value).
			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 radiant design specifies the tubing on-center distance(s) and loop lengths. On-center distances will not exceed 12 inches (305mm).
			5. Do not install tubing closer than 6 inches (152mm) from the edge of the heated slab.
			6. Install the tubing at a consistent depth below the surface elevation as determined by the project engineer. Tubing installation will ensure sufficient clearance for all control joint cuts.
			7. Fibrous expansion joints may be penetrated following the PEX tubing manufacturer's and structural engineer’s recommendation.
			8. Metal or plastic bend supports will be used to support the tubing when departing from the slab in a 90-degree bend.

**\*\*NOTE TO SPECIFIER\*\* Retain, edit or delete paragraph that pertains to the project specification for a cap pour over pre-stressed.**

* + 1. Cap pour over pre-cast plank construction with edge and under-slab insulation
			1. When using high-density foam insulation board, install the tubing by stapling the tubing to the insulation board with Uponor PEX foam Staples.
			2. The structural engineer determines the vertical compressive strength of the high-density foam insulation board. The design determines the required insulation resistance value (R-value).
			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 radiant design specifies the tubing on-center distance(s) and loop lengths. On-center distances will not exceed 12 inches (305mm).
			5. Do not install tubing closer than 6 inches (152mm) from the edge of the heated slab.
			6. Install the tubing at a consistent depth below the surface elevation as determined by the project engineer. Tubing installation will ensure sufficient clearance for all control joint cuts.
			7. Fibrous expansion joints may be penetrated following the PEX tubing manufacturer's and structural engineer’s recommendation.
			8. Metal or plastic bend supports will be used to support the tubing when departing from the slab in a 90-degree bend.
		2. Slab over steel deck construction with under-deck insulation
1. Fasten the tubing to flat wire mesh or reinforcing bar in accordance with the PEX tubing manufacturer's installation recommendations.
2. The submitted radiant design specifies the tubing on-center distance(s) and loop lengths. On-center distances will not exceed 12 inches (305mm).
3. Do not install tubing closer than 6 inches (152mm) from the edge of the heated slab.
4. Install the tubing at a consistent depth below the surface elevation as determined by the project engineer. Tubing installation will ensure sufficient clearance for all control joint cuts.
5. Expansion joints.
6. In areas where tubing must cross metal expansion joints that occur in the concrete, the tubing shall pass below the metal expansion joints when practical.
7. Fibrous expansion joints may be penetrated following the PEX tubing manufacturer's and structural engineer’s recommendation.
8. Install Insulation beneath the deck by using either fastened high-density board or foam sprayed-on insulation.
9. The radiant design determines the required insulation resistance value (R-value).
10. 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.
11. Metal or plastic bend supports will be used to support the tubing when departing from the slab in a 90-degree bend.
	* 1. Wood construction installation
			1. For wood subfloor applications, install tubing in channeled subfloor panels. Use interlocking panels with U-bend returns at each end. Install per manufacturer's recommendations.
			2. For installation below wood joists, install tubing using aluminum heat emission plates. Maintain minimum 1/4 inch (6 mm) spacing between panels to allow for thermal expansion. Install per manufacturer's recommendations.
			3. System shall be pressure-tested per the manufacturer's recommendations at a pressure no less than 40 psig (152 kPa). Maintain minimum 40 psig (152 kPa pressure during the concrete pour for 24 hours during curing.
		2. Manifold installation
			1. Mount manifolds per the approved shop drawings.
			2. Install piping using manufacturer recommended fittings and adapters.

**\*\*NOTE TO SPECIFIER\*\* Delete paragraph if manifold cabinets are not required.**

* + - 1. Install manifold cabinets, as required, in accordance with manufacturer's recommendations.
				1. Coordinate door panel finish with architectural finish schedule.
		1. Piping shall be labeled with loop numbers marked on pipe wall before connecting to manifold using a permanent tag. Verify actual loop length for each loop on a manifold. All loops shall be identified to allow for future balancing.
		2. Coordinate slab tubing layout with other devices (electrical conduits and boxes, telecommunication conduits and boxes, plumbing penetrations, construction and furniture supports) and all other services within or attaching to the slab. Zones designated on the drawings shall be kept clear of all radiant floor tubing.
		3. Glycol/water solution
			1. Tubing manufacturer recommends premixed or site mixed glycol/water solutions that do not exceed 50% concentration.
				1. Mix the glycol/water solution to proper concentration levels to protect the system freezing during operation shutdown.
				2. System circulators must operate continuously for a minimum of 30 days after the system is filled to ensure the glycol and water does not separate in a static system.
			2. Refer to Division 23 Section “Hydronic Piping” for glycol requirements.
	1. FIELD QUALITY CONTROL
		1. Site tests
			1. To ensure system integrity, pressure test the system before covering tubing in concrete or when other trades are working in the vicinity of the tubing.
			2. Test all electrical controls in accordance with respective installation manuals.
			3. Provide provisions to cover white and blue PEX pipe if exposure to direct sunlight is greater than one month. Provide provisions to cover red PEX pipe if exposure to direct sunlight is greater than six months.
			4. Ensure that no glues, solvents, sealants, or chemicals come in contact with the PEX tubing or fittings without prior permission from the PEX manufacturer.
	2. ADJUSTING
		1. Balancing across the manifold.
			1. Balance all loops across each manifold for equal flow resistance based on actual loop lengths and total manifold flow.
			2. Balancing is unnecessary when all loop lengths across the manifold are within 3 percent of each other in length. Install the supply and return piping to the manifold in a reverse-return configuration to ensure self-balancing.
		2. 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.
		3. Adjust all system controls after the system has stabilized to ensure proper operation in accordance with the system design.
	3. CLEANING
		1. Remove temporary coverings and protection of adjacent work areas.
		2. Repair or replace damaged installed products.
		3. Clean the installed products in accordance with manufacturer's instructions prior to owner's acceptance.
		4. Clean all filters, strainers on pumps.
		5. Remove construction debris from project site and legally dispose of debris
	4. DEMONSTRATION
		1. Demonstrate operation of radiant system to owner’s personnel.
		2. Advise the owner’s representative about the type and concentration of glycol/water solution used in the hydronic system.
			1. The owner monitors the solution effectiveness through an established maintenance program as outlined by the glycol manufacturer.
	5. PROTECTION
		1. Protect installed work from damage caused from subsequent construction activity.

END OF SECTION