Section 23 21 13.33

**Ground-Loop Heat-Pump Piping**

**(RAUGEO Ground Loop Heat Exchange Systems)**

*This draft specification is for ground-loop heat-pump piping systems. REHAU supplies these systems under the name RAUGEO Ground Loop Heat Exchange Systems.*

*This draft specification is provided only as an aid in architect’s/engineer’s development of the final specification and is not intended as a substitute for sound architectural/engineering judgment. The architect/engineer shall be responsible to convert this draft specification into a final specification that meets the functional and aesthetic needs of his/her client, as well as to comply with all applicable codes.*

1. General
	* + 1. Summary
2. Ground loop heat exchange systems, where shown on the Drawings and Schedules, shall include the following:

Crosslinked polyethylene (PEXa) piping.

Distribution manifold(s) with balancing and flow control valves where required.

Pipe-to-manifold national pipe thread fittings.

Cold-expansion fittings using metal compression sleeves.

Electrofusion fittings.

Supervision and field engineering required for the complete and proper function of the system.

* + - 1. Related Sections
1. Section 23 21 23 – Hydronic Pumps
2. Section 31 20 00 – Earth Moving: Excavation and Backfill
	* + 1. References
3. Publications listed here are part of this specification to the extent they are referenced. Where no specific edition of the standard or publication is identified, the current edition shall apply.
4. ASHRAE – American Society of Heating, Refrigerating, and Air-Conditioning Engineers

Ground-Source Heat Pumps: Design of Geothermal Systems for Commercial and Institutional Buildings (Textbook by Kavanaugh and Rafferty)

1. ASTM – American Society for Testing and Materials

ASTM D2513 – Standard Specification for Thermoplastic Gas Pressure Pipe, Tubing, and Fittings

ASTM F876 – Standard Specification for Crosslinked Polyethylene (PEX) Tubing

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

ASTM F1055 – Standard Specification for Electrofusion Type Polyethylene Fittings for Outside Diameter Controlled Polyethylene Pipe and Tubing

ASTM F2080 – Standard Specification for Cold-Expansion Fittings With Metal Compression-Sleeves for Cross-Linked Polyethylene (PEX) Pipe

1. CEN – European Committee for Standardization (Comité Européen de Normalisation)

EN 1555-3 – Plastic piping systems for the supply of gaseous fuels. Polyethylene (PE). Fittings

1. CSA – Canadian Standards Association

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

CSA C448 – Design and Installation of Earth Energy Systems

1. DIN – German Institute for Standardization (Deutsches Institut für Normung)

DIN 16892 – Crosslinked high-density polyethylene (PE-X) pipes - General quality requirements and testing

DIN 16893 – Crosslinked high-density polyethylene (PE-X) pipes – Dimensions

1. IGSHPA – International Ground Source Heat Pump Association

Closed-Loop / Ground Source Heat Pump Systems, Design and Installation Standards

1. ISO – International Organization for Standardization

ISO 15875-1 – Plastic piping systems for hot and cold water installation - Crosslinked polyethylene (PE-X) - Part 1: General

ISO 15875-2 – Plastic piping systems for hot and cold water installation - Crosslinked polyethylene (PE-X) - Part 2: Pipes

ISO 15875-3 – Plastic piping systems for hot and cold water installation - Crosslinked polyethylene (PE-X) - Part 3: Fittings

ISO 9001 – Quality Management Systems - Requirements

ISO 14531-2 – Plastic pipes and fittings - Crosslinked polyethylene (PE-X) pipe systems for the conveyance of gaseous fuels. Fittings for heat-fusion joining

* + - 1. Definitions
1. “The closed-loop portion [ground loop heat exchange] of a ground source heat pump system consists of a long plastic pipe buried below the earth’s surface. This plastic pipe is buried in the ground, or ground coupled, to allow heat transfer between the fluids and the earth. The heat pump transfers thermal energy to and from the closed, buried pipe and the building’s thermal load. The system consists of a closed-loop buried pipe, a water source heat pump, and an air [or water] distribution system for directing heated or cooled air [or water] to specific locations in the building.” (IGSHPA Installation Guide, p1).
2. Crosslinked polyethylene, or PEX is a modified polyethylene material, typically high-density polyethylene (HDPE), which has undergone a change in the molecular structure using a chemical or a physical process whereby the polymer chains are permanently linked to each other. This crosslinking of the polymer chains results in improved performance properties such as elevated temperature strength, chemical resistance, environmental stress crack resistance (ESCR), slow crack growth (SCG) resistance, toughness and abrasion resistance. Crosslinking also makes PEX a “semi-thermoset” polymer, providing excellent long-term stability.

This specification requires PEX to be designated as PEXa and be manufactured by the high-pressure peroxide method.

* + - 1. Submittals
1. Comply with Section 01 33 00, Submittal Procedures. Approval and/or acceptance of all submittals is required prior to fabrication.
2. Product Data: Submit manufacturer's Technical Manual, submittal forms, catalog cuts, brochures, specifications, and installation instructions. Submit data in sufficient detail to indicate compliance with the contract documents.

Submit manufacturer's instructions for installation.

Submit data for equipment, fittings, fasteners and associated items necessary for the installation of the piping and manifolds.

1. Submit computer-generated ground loop heat exchange system design indicating total pipe required, ground loop configuration (i.e. borehole, single pipe horizontal, slinky, horizontal, etc), pipe diameter, borehole or trench separation, ground thermal conductivity and diffusivity, and entering and leaving water temperatures. Ground loop heat exchange design calculations shall be performed on industry recognized software.
2. Drawings: Provide plans drawn to scale for all installation areas.

Indicate dimensions, descriptions of materials, general construction, component connections, and installation procedures.

Indicate design, schematic layout of system, including equipment, critical dimensions and piping/slab penetration details as well as details for protecting exposed PEXa piping.

1. Maintenance Instructions: Submit instructions for maintenance.
	* + 1. Quality Assurance
2. Comply with Section 01 43 00, Quality Assurance.
3. Manufacturer: Must be a company specializing in the Work of this Section with a minimum of 5 years documented experience.
4. Pipe shall be manufactured in a facility whose quality management system is ISO 9001 certified.
5. Pipe and fittings shall be IGSHPA approved.
6. Pipe and U-bends shall be certified to CSA C448 by a third-party certification body.
	* + 1. Delivery, Storage, and Handling
7. Comply with Section 01 60 00, Product Requirements.
8. Deliver and store piping and equipment in shipping containers with labeling in place.

Pipe shall be kept in original shipping packaging until required for installation.

1. Store piping and equipment in a safe place, dry, enclosed, under cover, in a well-ventilated area.

Do not expose pipe to ultraviolet light beyond exposure limits recommended by manufacturer.

Protect piping and manifolds from entry of contaminating materials. Install suitable plugs in open pipe ends until installation.

Where possible, connect pipes to assembled manifolds to eliminate possibility of contaminants and cross-connections.

Piping shall not be dragged across the ground or other surfaces, and shall be stored on a flat surface with no sharp edges.

1. Protect materials from damage by other trades.
2. Pipe shall be protected from oil, grease, paint, direct sunlight and other elements as recommended by manufacturer.
	* + 1. Warranty
3. Provide manufacturer's standard written warranty.

The pipe manufacturer shall warrant the crosslinked polyethylene pipe to be free from defects in material and workmanship for a period of twenty-five (25) years.

1. Products
	* + 1. Acceptable Manufacturer
2. RAUGEO™ Ground Loop Heat Exchange System for geothermal applications as manufactured by REHAU Construction LLC, 1501 Edwards Ferry Road, NE; Leesburg, VA 20176; email: rehau.mailbox@rehau.com; website: na.rehau.com; upon whose products and equipment these specifications are based.
3. No Substitutions allowed.
	* + 1. Piping
4. Ground loop heat exchange pipe shall be high-density crosslinked polyethylene manufactured using the high-pressure peroxide method of crosslinking (PEXa). Pipe shall conform to (a) ASTM F876 and (b) CSA B137.5 and (c) CSA C448 or (d) ISO 15875-1:2003, 15875-2:2003 or (e) DIN 16892 and 16893
5. Pipe shall be rated for continuous operation of 100 psi gauge pressure at 180°F (690 kPa @ 82°C) temperature, and 160 psi gauge pressure at 73.4°F temperature (1,103 kPa @ 23°C).
6. Horizontal Heat Exchanger:

The minimum bend radius for cold bending of the pipe shall be no less than five (5) times the outside diameter. Bends tighter than this minimum shall require the use of a bending template, as supplied by the pipe manufacturer, and hot air.

1. Vertical Borehole Heat Exchanger:

The vertical borehole heat exchanger tip shall be manufactured of one continuous pipe, with no joints in the borehole or shall be manufactured from coated stainless steel components manufactured to the ASTM F2080 standard.

The vertical borehole heat exchanger shall be a single U-bend or a double U-bend system, consisting of 2 single U-bend pipes attached together.

The vertical borehole heat exchanger tip shall be covered in a GRP resin or a rubber coating.

* + - 1. Fittings
1. All buried fittings shall be of a permanent design.
2. Cold-expansion compression-sleeve fittings shall conform and be third-party certified to ASTM F2080, and CSA B137.5.
3. Cold-expansion compression-sleeve fittings shall be manufactured of brass or stainless steel and shall be supplied by the piping manufacturer as part of a proven cataloged system.
4. All electrofusion fittings intended for ground loop heat exchange applications shall conform to ASTM F1055 or EN 1555-3.
	* + 1. Manifolds
5. Material: Distribution manifolds shall be manufactured of brass or polypropylene and be supplied by the piping manufacturer as a part of a proven cataloged system.
6. Brass manifolds shall be produced from extruded brass round pipe with tapped holes for connections, and be pre-assembled by the manufacturer. 100% of manifolds used shall have been air tested by the manufacturer with no indication of leaks.
7. Polypropylene manifolds shall be produced from extruded polypropylene SDR 11 pipe containing a fiber layer to restrict thermal expansion. Holes shall be tapped for connections. Outlet ports shall be fusion welded onto the body of the manifold, with integrated fittings for connection to the borehole field. Fusion welding shall be done in a factory setting to ensure quality of the manifold. Manifold shall be supplied by the manufacturer with all components pressure tested and with no indication of leaks.
8. Balancing Manifolds

Where required by design, manifolds shall be equipped with supply and return manifold isolation valves, integral thermometer and manometer housings, and air vent/fill ports.

Where required by design, each circuit shall be supplied with circuit isolation valves, integral visual flow gauges and brass cold expansion compression-sleeve fittings to connect to IGSHPA-approved PEXa pipe.

1. Execution
	* + 1. Acceptable Installers
2. Installation shall be performed by qualified laborers trained in the procedures of ground loop heat exchange systems and have IGSHPA certification.
	* + 1. Examination
3. Examine areas and conditions under which work of this Section will be performed. Correct conditions detrimental to timely and proper completion of Work. Do not proceed until unsatisfactory conditions are corrected.
4. Beginning of installation means acceptance of existing conditions.
	* + 1. Thermal Conductivity Test
5. Soil thermal conductivity test shall be performed according to IGSHPA Closed-Loop / Geothermal Heat Pump Systems, Design & Installation Standards, 2008.
	* + 1. Preparation
6. Coordinate with related trades and manufacturer’s recommendations with regard to installation in conjunction with:

Drilling

Excavation

Pipe fusion

Heat pump location

* + - 1. Installation
1. Install in accordance with manufacturer's published installation manual and/or published guidelines and final shop drawings.
2. Mount manifolds in the locations previously prepared or in previously installed cabinets, if used. Manifolds shall be mounted as level as possible, with the venting device on the uppermost section.
3. Route piping in an orderly manner, according to layout and spacing shown in final shop drawings.
4. At connections and fittings, use a plastic pipe cutter to ensure square and clean cuts, and join pipes immediately or cap ends of pipe to seal from contaminants. Where compression-sleeve fittings are installed within the ground, they shall be wrapped in a heat-shrink material approved by the manufacturer.
5. Piping that shall pass through expansion joints shall be covered in protective polyethylene convoluted sleeving (flexible conduit) extending 15 inches (40 cm) on each side of the joint. Sleeving shall be secured on pipe to prevent movement during installation of thermal mass.
6. Where piping exits the thermal mass, a protective conduit shall be placed around the pipe, with the conduit extending a minimum of 6 inches (15 cm) into the floor and exiting by a minimum of 6 inches (15 cm). For penetrations at manifolds, use rigid PVC bend guides secured in place to prevent movement.
7. At the time of installation of each circuit of pipe, connect the pipe to the correct manifold outlet and record pipe length for balancing. If manifold is not installed, cap the end of the pipe and label the pipe's circuit numbers along with S for supply and R for return. Connect pipes to manifold as soon as possible and record circuit lengths. Circuits shall be labeled to indicate circuit length and serviced area.
	* + 1. Field Quality Control
8. Filling, Testing & Balancing: Tests of ground loop heat exchange systems shall comply with authorities having jurisdiction, and, where required, shall be witnessed by the building official.
9. Pressure gauges used shall show pressure increments of 1 psig and shall be located at or near the lowest points in the distribution system.
10. Air Test

Charge the completed, yet unconcealed pipes with air at a minimum of 40 psig.

Do not exceed 150 psig.

Use liquid gas detector or soap solution to check for leakage at manifold connections.

1. Water Test

Purge air from pipes.

Charge the completed, yet unconcealed pipes with water.

Take necessary precautions to prevent water from freezing.

Check the system for leakage, especially at pipe joints.

1. Perform a preliminary pressure test pressurizing the system to the greater of 1.5 times the maximum operating pressure or 100 psig for 30 minutes.

As the piping expands, restore pressure, first at 10 minutes into the test and again at 20 minutes.

At the end of the 30-minute preliminary test, pressure shall not fall by more than 8 psig from the maximum, and there shall be no leakage.

1. After successfully performing the preliminary test, perform the main pressure test immediately.

The main pressure test shall last 2 hours.

The test pressure shall be restored and shall not fall more than 3 psig after 2 hours.

 No leakage shall be detected.

* + - 1. Protection
1. Protect installation throughout construction process until date of final completion.
2. Replace components that cannot be repaired.

END OF SECTION