Expanding Piping Options

Crosslinked PolyEthylene accepted in revised CSA C448 Standard. **BY LANCE MACNEVIN**

Over the past several years, geothermal industry experts from across Canada collaborated to develop a new edition of Standard CSA C448 - Design and Installation of Earth Energy Systems. The revised C448/13 standard, which was released last July, recognizes crosslinked polyethylene (PEX) piping for use in earth energy heat pump and thermal energy storage systems throughout Canada.

The goal of the revised standard is to ensure customers receive heating and cooling systems that perform to design efficiency expectations and deliver long-term value. The standard incorporates significant experience acquired through installation practices in Canada over several decades, and adopts the latest technological advances and best practices in the industry. Among these advances is recognition of a wider range of piping materials.

EXPANDED SELECTION OF PIPING MATERIALS

One of the most significant changes in Section 5 Equipment, Materials, Handling and Installation is Clause 5.3, "Underground and Underwater piping system requirements (closed loop)." This section specifies the range of piping and fitting choices now available to designers and installers for the ground heat exchanger, which is the closed-loop piping through which a heat-transfer fluid travels to and from a heat pump. Under the previous version of C448 only one type of polyethylene piping was allowed. C448/13 expands the options to include polyethylene "PE" piping (Clause 5.3.2) and crosslinked polyethylene "peroxide method" piping (Clause 5.3.3) for open- and closed-loop systems.

Just now coming into its own in geothermal applications, PEX has been used as geothermal ground loop piping in Europe for more than a decade.

To ensure that the standard covers further innovations in piping, an alternative piping system not listed directly in the standard may now be specified by an engineer if it meets or exceeds specified performance criteria. These obligatory performance requirements include corrosion resistance, chemical resistance, flexibility, impact resistance, pressure capability and temperature resistance.

The minimum requirements for polyethylene (PE) pipes have increased. C448/13 requires that PE pipe for ground heat exchangers shall be "manufactured from PE compound with the minimum cell classification of 345464C or 345464E..." This ensures that the latest PE pipe technology, which offers improved resistance to slow crack growth, is specified. PE fittings are also specified.

The inclusion of PEX as an approved piping material allows engineers, designers and installers to take advantage of this pipe's properties and capabilities, as demonstrated in radiant, snow melting, plumbing and other hydronic applications across Canada since the 1980s.

CROSSLINKING AND GEOTHERMAL PERFORMANCE

In 2008, PEX piping (produced using the peroxide extrusion method, known as PEXa) was accepted for use as geothermal ground loop piping in the U.S. when it was added to the 2008 IGSHPA Design and Installation Standards.

WHAT IS PEX?

The formal definition of crosslinked (X) PolyEthylene is "a polyethylene product which has undergone a change in molecular structure using a chemical or a physical process whereby the polymer chains are chemically linked with each other to increase molecular weight and form a three-dimensional network." – C448

According to publication TN-17 from the Plastic Pipe Institute, "Crosslinking of polyethylene into PEX for pipes results in improved properties such as elevated temperature strength and performance, chemical resistance and resistance to slow crack growth." These are some of the most important criteria for ground heat exchangers.

Pioneered in Germany more than 40 years ago, PEX piping has been used in radiant heating/cooling, snow and ice melting, water service and plumbing applications in Canada for more than 25 years.

PEXa pipes were approved for this demanding application due to a high degree of crosslinking, which provides benefits such as:

- Suitability for very low and elevated temperature applications;
- Improved flexibility to ease installation;
- Resistance to slow crack growth (abrasion), crucial for buried pipes in rocky soils;
- Impact resistance and toughness;
- Chemical resistance equal to or better than HDPE pipes; and
- Proven hydrostatic strength and long-term stability.

The high degree of crosslinking improves the resistance of PEXa to slow crack growth and notches. With outstanding notch resistance, PEXa pipes are typically approved for direct burial in rocky soil, as found in horizontal heat exchanger trenches in many regions of Canada. This may allow engineers to forego the normal sand backfill, required for other heat exchange pipes, thereby improving system thermal efficiency, since native soil is usually a better conductor than dry sand backfill.

PEXa's notch resistance also provides increased security for horizontal directional drilling applications where pipes are pulled through the earth, or certain inclined drilling applications where pipes are pushed into the earth.

All PEX pipes intended for C448 applications must comply with CSA B137.5 Crosslinked polyethylene (PEX) tubing systems for pressure applications and be produced with special markings on the print line.

DOUBLE U-BENDS EXTRACT MORE ENERGY

One feature of peroxide PEX is its ability to be heat-formed to produce tight-radius bends without kinking. PEXa piping systems for vertical borehole applications can be factory-fabricated with the 180-degree U-bend in the middle of the coil length without joints or connections. This eliminates joints at the bottom of the borehole.

Some PEXa U-bends are encased in special thermoset polymer "probe tips" that allow for nesting one U-bend inside another. This makes the use of double U-bends possible, allowing designers to place twice as much pipe inside a vertical borehole. Field thermal conductivity testing has shown that the double U-bends can increase borehole thermal conductivity (and reduce borehole thermal resistance), generating more energy potential per borehole. With double U-bends, designers may be able to reduce the amount of borehole footage by 10 to 30 per cent, depending on thermal conductivity of the borehole, grout type and soil conditions. This helps to reduce drilling and grouting costs, and can result in a more compact borehole field.

By taking advantage of the unique properties of peroxide PEX, system designers can often achieve a given amount of heat exchange with reduced costs for the outside ground loop piping work. The high flexibility of PEXa pipes and the use of engineered pipe spacers, which allow installation of the tremie pipe (for grouting) with the double U-bends, make the system practical and economical.

PEX FITTING OPTIONS

CSA C448 also allows two choices of fittings for PEX piping: electro fusion fittings, which comply with ASTM F1055, and brass cold-expansion compression-sleeve fittings, which comply with ASTM F2080 and CSA B137.5. The preferred option is F2080-style fittings that have been used with PEXa piping in North America for more than 20 years in high-temperature applications, and are approved for use even in the ground, when fittings are necessary. This fast joining method can be performed under any weather conditions with manually powered tools. In contrast, socket- and butt-fusion fittings used to join PE piping require specialized electrically powered fusion equipment that requires clean and dry conditions where the joints are being made.

The second option for PEX fittings is electro fusion fittings, made of polyethylene with embedded resistance wiring that generates heat when connected to a special machine. These fittings can be compatible with PEX pipes, even in cold installation temperatures, and are another option for field joints.

DEMAND FOR RENEWABLE ENERGY SOLUTIONS

Rising fuel costs and supply challenges of traditional energy sources, along with various incentives through governments and utilities, have elevated interest in renewable energy technologies and made earth energy heating and cooling a popular choice for residential and commercial building owners. CSA C448/13 creates uniform design and installation requirements to provide a strong regulatory foundation for increased market penetration of these technologies.

The inclusion of PEX piping systems into C448/13 increases the material choices for specifiers and installers, with reliable high-performance options, which are already popular for indoor hydronic applications with mechanical contractors across Canada. <>

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