

GUIDE TO HIGH-TEMPERATURE APPLICATIONS OF NON-POTABLE CROSSLINKED POLYETHYLENE (PEX) PIPE AND TUBING SYSTEMS

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Foreword

This technical note was developed and published with the technical help and financial support of the members of the Plastics Pipe Institute (PPI). These members have shown their commitment to developing and improving quality products by assisting standards development organizations in the development of standards and also by developing design aids and reports to help engineers, code officials, specifying groups, contractors and users.

The purpose of this technical note is to provide information to the end user regarding the additional evaluation that is required for PEX pipe and tubing to demonstrate suitability for specific high-temperature applications.

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1.0 SCOPE

Crosslinked polyethylene (PEX) pipe and tubing conforming to standards such as ASTM F876, ASTM F2788, ASTM F3253, and CSA B137.5 are suitable for typical heating applications including hydronic radiant heating/cooling, hydronic distribution, snow and ice melting, turf conditioning, and geothermal ground heat exchangers at operating temperatures up to and including 180°F (82°C).

There are certain applications that could experience high-temperature exposures above 180°F, such as residential or commercial hydronic distribution systems including high-temperature radiator/baseboard/convactor piping, district heating piping, solar thermal collection systems, and certain types of waste heat systems. Some of these systems may operate at fluid temperatures between 180°F and 200°F (93°C).

Some PEX manufacturers allow operating temperatures only up to 180°F and not beyond, whereas other manufacturers may allow operation of their material at temperatures up to 200°F.

Certain brands of PEX tubing are listed with the PPI Hydrostatic Stress Board (HSB) or other third-party certification agencies according to the policies of ASTM D2837 or PPI TR-3 with a “Standard Grade” listing for operation at 200°F and have “**80 psi at 200°F**” marked on the tubing or packaging. However, such a marking does not mean that the material is intended for continuous operation at temperatures up to 200°F. In fact, operating PEX pipe or tubing at temperatures above 180°F may affect its design life.

The intent of this Technical Note is to give guidance to the end user for determining appropriate design life calculations of PEX pipe and tubing for non-potable water at operating temperatures above 180°F. Section 3.0 “Background - PEX Test Methods and Evaluation Techniques” is provided to explain how PEX pipe and tubing are tested to ensure resistance to multiple types of oxidative damage through distinct test procedures and evaluations.

Note 1: For PEX materials, “tubing” refers to products whereby the actual outside diameter (OD) is 1/8 inch larger than the nominal size and is described as nominal tubing size (NTS) or copper tube size (CTS). Product standards ASTM F876, ASTM F3253, and CSA B137.5 apply to PEX tubing. “Pipe” refers to products whereby the actual OD matches that of steel pipe of the same nominal size and is described as nominal pipe size (NPS) or iron pipe size (IPS). “Pipe” may also apply to products where the actual OD matches the nominal size. ASTM F2788 applies to PEX pipe. The terms “pipe” and “piping”, as well as “tube” and “tubing”, may be used interchangeably in this document.

Note 2: See PPI TN-53 *Guide to Chlorine Resistance Ratings of PEX Pipes and Tubing for Potable Water Applications* for more information on the use of PEX tubing in hot chlorinated potable water applications.

1.1. Definitions specific to this Technical Note

- **Activation energy** - the minimum amount of energy that is required for atoms or molecules to reach a condition in which they can undergo a specific chemical transformation or physical transport
- **Arrhenius equation** - a formula for the temperature dependence using the activation energy for a specific material
- **Design life** – the length of time that a pipe or tubing material is estimated to operate reliably in a standard and approved application
- **Service life** – the length of time that a pipe or tubing material operates while in service
- **Test life** – the length of time that a pipe or tubing sample operates during testing

2.0 REFERENCED STANDARDS

Where all or part of a national or international standard specification by standards development organizations such as ASTM, CSA, ISO, or NSF is incorporated by reference in this technical note, the referenced standard shall be the latest edition and revision.

- ASTM D2837 *Standard Test Method for Obtaining Hydrostatic Design Basis for Thermoplastic Pipe Materials or Pressure Design Basis for Thermoplastic Pipe Products*
- ASTM F876 *Standard Specification for Crosslinked Polyethylene (PEX) Tubing*
- ASTM F2023 *Standard Test Method for Evaluating the Oxidative Resistance of Crosslinked Polyethylene (PEX) Pipe, Tubing and Systems to Hot Chlorinated Water*
- ASTM F2657 *Standard Test Method for Outdoor Weathering Exposure of Crosslinked Polyethylene (PEX) Tubing*
- ASTM F2788 *Standard Specification for Metric and Inch-sized Crosslinked Polyethylene (PEX) Pipe*
- ASTM F3253 *Standard Specification for Crosslinked Polyethylene (PEX) Tubing with Oxygen Barrier for Hot- and Cold-Water Hydronic Distribution Systems*
- CSA B137.5 *Crosslinked Polyethylene Tubing Systems for Pressure Applications*
- EN 15632 *District heating pipes – Factory made flexible pipe systems*
- ISO 9080 *Plastics piping and ducting systems - Determination of the long-term hydrostatic strength of thermoplastics materials in pipe form by extrapolation*
- ISO 10508 *Plastics piping systems for hot and cold water installations – Guidance for classification and design*
- ISO 15875 *Plastics piping systems for hot and cold water installations- Crosslinked polyethylene (PE-X)*

3.0 BACKGROUND – PEX TEST METHODS AND EVALUATION TECHNIQUES

It is a basic requirement for most plastic pressure pipes¹ to undergo a hydrostatic pressure test or tests to prove their long-term hydrostatic strength (LTHS) at various temperatures and pressures. “Hydrostatic” simply means constant water pressure inside a pipe. Hydrostatic testing involves testing multiple pipe specimens to ductile failure at various temperatures and pressures; when a dataset of failure times at multiple temperatures and pressures is generated, a ductile failure curve is plotted and evaluated mathematically. This provides a method to predict pipe endurance at the specific operating pressures for each temperature.

Procedures for conducting long-term hydrostatic testing and evaluating the results were originally developed decades ago by groups such as ASTM, ISO, and PPI’s Hydrostatic Stress Board (HSB). Today, these LTHS procedures are trusted to predict the long-term hydrostatic capabilities of crosslinked polyethylene (PEX) pipe and tubing, which achieves pressure ratings at various temperatures through extensive hydrostatic strength testing in accordance with the governing standards and policies such as ASTM D2837 and PPI TR-3².

The long-term hydrostatic strength of a specific PEX material is independent of any outside environmental factor which could cause degradation or failure. Examples of environmental factors are oxidation from excessive thermal exposure, oxidation from excessive UV exposure, or oxidation from excessive exposure to hot chlorinated water. Therefore, in addition to LTHS testing, in North America, there are standardized testing and evaluation methods to establish the resistance of PEX pipes to oxidation that could be caused by these environmental factors.

For example, mandatory requirements within ASTM F876, ASTM F3253, ASTM F2788, and CSA B137.5 include evaluating the resistance to thermal oxidation through stabilizer functionality testing; ASTM F2657 is the test method used for evaluating the effects of outdoor weathering and ultraviolet (UV) exposure*; and ASTM F2023 is the test method used for evaluating the effects of hot chlorinated water*.

*These tests are mandatory for PEX pipe and tubing intended for potable water applications

¹ The alternative to a long-term hydrostatic strength (LTHS) test is a long-term hydrostatic pressure-strength (LTHSp) test, usually applied to multi-layer or composite piping products.

² PPI TR-3 *Policies and Procedures for Developing Hydrostatic Design Basis (HDB), Hydrostatic Design Stresses (HDS), Pressure Design Basis (PDB), Strength Design Basis (SDB), Minimum Required Strength (MRS) Ratings, and Categorized Required Strength (CRS) for Thermoplastic Piping Materials or Pipes*