

Crosslinked Polyethylene (PEX) Pipe & Tubing

TN-17/2013

Foreword

This report was developed and published with the technical help and financial support of the members of the Plastics Pipe Institute (PPI). These members are committed to developing and improving quality products by assisting independent standards and user 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 general information on crosslinked polyethylene (PEX) pipe and tubing, how it is manufactured and in what applications it can be used.

The PPI has prepared this technical note as a service to the industry. The information in this report is offered in good faith and believed to be accurate at the time of its preparation, but is offered “as is” without any express or implied warranty, including WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE. Additional information may be needed in some areas, especially with regard to unusual or special applications. Consult the manufacturer or material supplier for more detailed information. A list of member manufacturers is available on the PPI website. PPI does not endorse the proprietary products or processes of any manufacturer and assumes no responsibility for compliance with applicable laws and regulations.

PPI intends to revise this report within 5 years or sooner if required, from the date of its publication, in response to comments and suggestions from users of the report. Please send suggestions of improvements to the address below. Information on other publications can be obtained by contacting PPI directly or visiting the web site.

The Plastics Pipe Institute Inc.

www.plasticpipe.org

This technical note was first issued in June 2001; revised in April 2009 and in February 2013.

105 Decker Court, Suite 825, Irving, TX 75062 P: 469-499-1044 F: 469-499-1063 www.plasticpipe.org

CROSSLINKED POLYETHYLENE (PEX) PIPE & TUBING

1.0 Introduction

The successful use of crosslinked polyethylene (PEX) systems throughout the world, along with the capabilities of PEX piping in cold- and hot-water environments, have generated significant interest and growth in the usage in these materials across North America. To answer common questions about PEX materials from installers, designers, builders and specifiers, as well as the public, this technical note provides an overview of PEX properties and capabilities, the applications and benefits of PEX, and the technical requirements for PEX systems. Several product standards are listed as references.

2.0 What is PEX?

PEX is the acronym for Crosslinked Polyethylene.

2.1 Formal Definition – Crosslinked Polyethylene is a polyethylene material which has undergone a change in molecular structure using a chemical or a physical process whereby the polymer chains are chemically linked. 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.

2.2 Explanation – 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), resistance to slow crack growth (SCG), toughness, and abrasion resistance. Crosslinking also makes PEX a “semi-thermoset” polymer, providing excellent long-term stability.

3.0 How does crosslinking improve properties from HDPE?

Below is a table summarizing the property changes from HDPE to PEX materials in general:

Table 1

Property	Change from HDPE to PEX	Benefit
Tensile Yield Strength @ 73.4°F (23°C) Tensile Yield Strength @ 180°F (82°C)	Typically Unchanged Typically Increases	PEX is suitable for both low- and elevated-temperature applications
Elongation at Break	Unchanged or Increases	Improved flexibility to withstand installation stresses while resisting tensile deformation
Environmental Stress Crack Resistance	Increases	Greater resistance to environmental hazards. Improved toughness and abrasion resistance.
Resistance to Slow Crack Growth	Increases	Greater resistance to environmental hazards such as scratches. Improved toughness and abrasion resistance.
Creep Resistance	Increases	Improved stability over long-term pressurization and loads. The traditional HDPE stress curve “knee-point” is typically eliminated.
Hydrostatic Design Basis (HDB): HDB @ 73.4°F (23°C) HDB @ 180°F (82°C)	Typically Unchanged Increases	HDB is an evaluation of the long-term hoop strength of the material, and is used to develop its pressure ratings. PEX is suitable for both low- and elevated-temperature applications
Hydrocarbon Permeation	Unchanged	Similar performance
Chemical Resistance *	Typically Increases	Similar or improved performance
* The chemical resistance of thermoplastics is complex and is generally a function of the polymer's resistance to applied load, temperature and environment		

4.0 Elevated temperature capabilities

In general, 140°F (60°C) is the typical maximum service temperature for thermoplastic HDPE pressure pipe applications. With PEX, however, the in-service temperature can be raised to at least 180°F (82°C) and sometimes as high as 200°F (93°C), depending on the starting density, degree of crosslinking and type of crosslinking. PEX pipes are also tested to ensure that short-term exposure to a temperature of 210°F (99°C) is also tolerated.

5.0 How is PE Crosslinked into PEX?

Polyethylene can be crosslinked using several technologies or methods. All methods create links or bonds between the single chains of PE to form a dense molecular network through chemical reactions. The number of links between the polyethylene molecules determines the crosslink density, and is an important factor in determining the physical properties of the material.

The three most common methods of crosslinking polyethylene are as follows:

- 5.1 Peroxide – This method employs organic peroxides that, when heated, generate reactive free radicals that splice PE chains together during extrusion. This is sometimes referred to as the *PEX-a Process*.
- 5.2 Silane – This method involves grafting a reactive silane molecule to the backbone of the polyethylene. This is sometimes referred to as the *PEX-b Process*.
- 5.3 Electron beam – This method involves subjecting the extruded PE pipe to a dose of high-energy electrons. This is sometimes referred to as the *PEX-c Process*.

NOTE: The letter designations are not related to any type of performance rating system. PEX pipe produced by each of the three methods must meet the same technical requirements as specified in the relevant PEX standards.

Although the three methods of crosslinking produce slightly different pipe characteristics, all three are commonly used to manufacture approved PEX products. As required in any manufacturing process, procedures for each technology must be established and followed with good quality control checks in place to produce quality products.

6.0 What are the typical configurations of PEX tubing or piping systems?

NOTE: In this document, “tubing” refers to PEX products where the actual OD is 1/8 inch larger than the nominal size, the same as copper tube sizes (CTS) – see ASTM F876. “Pipe” refers to PEX products where the actual OD matches the nominal size – see ASTM F2788. In both cases, specified tolerances apply, as per relevant standards.

- 6.1 PEX tubing – comes in nominal sizes ranging from 1/4 to 3 in. CTS. The wall thickness is based upon standard dimensional ratio (SDR) 9 values, which yield standard hydrostatic pressure ratings of 160 psi at 73.4°F, and 100 psi at 180°F. Additionally, some PEX tubing products are rated to 80 psi at 200°F. Consult the specific PEX manufacturer’s literature and listings for appropriate pressure ratings. PEX tubing is sold in coils and straight lengths.

A wide selection of fittings, constructed of metal or polymer, is available for PEX tubing. PEX fittings are also subject to specific product specifications and standardized test requirements. Some PEX fittings shall only be joined to certain types of PEX tubing, as recommended by the tubing manufacturers. This will be indicated with markings on the tubing.