Differences Between Crosslinked Polyethylene (PEX) and Polybutylene (PB) Piping Systems for Potable Water Plumbing Applications

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Foreword

DIFFERENCES BETWEEN CROSSLINKED POLYETHYLENE (PEX) AND POLYBUTYLENE (PB) PIPING SYSTEMS FOR POTABLE WATER PLUMBING APPLICATIONS

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 regarding the material and performance differences between PEX and PB piping systems for potable water applications.

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1.0 INTRODUCTION

Just as various types of metals (e.g. steel, copper, and iron) have different properties, various types of plastics also have different properties. Not all metal pipes perform the same, and clearly, not all plastic piping materials perform the same either.

Thanks to modern polymer technology, crosslinked polyethylene (PEX) piping systems perform in ways that provide superior reliability and safety when compared to polybutylene (PB) piping systems used in plumbing and heating applications in Canada and USA until the mid-1990s.

2.0 BACKGROUND

After the introduction of polybutylene (PB) piping systems for hot- and cold-water plumbing into North America in the 1970s, by the 1980s some PB piping systems experienced premature oxidative (brittle) failures in potable water distribution systems. Many failures were attributed to the specific polymer material, polyacetal (also called polyoxymethylene or POM), used to mold the plastic fittings used in those systems. Some failures of the PB tubing material itself were attributed to insufficient resistance to hot chlorinated water. In those days, oxidative attack of chlorinated water to certain types of plastics was not as well understood as it is today, and there was no standardized test method, at the time, used to evaluate a tubing material's resistance to hot chlorinated water.

Due to litigations and class action settlements in North America, PB resin manufacturers chose to stop supplying pipe grade PB resin to all of North America. The PB product standard ASTM D3309 was withdrawn in 2010, and the material has since been removed from plumbing and mechanical codes in USA and Canada. Because of this PB experience, the North American plastic piping industry has implemented additional rigorous testing requirements for PEX piping that were not in place for PB piping systems. PB continues to be a viable plastic pipe material in other parts of the world, and is typically manufactured according to ISO 15876.

3.0 CROSSLINKED POLYETHYLENE

Crosslinked polyethylene (known as “PEX”) is a high-temperature (meaning it may be used above 140°F/60°C), pressure resistant, yet flexible, plastic (polymer) pipe. PEX piping is approved for potable hot- and cold-water plumbing systems and hydronic heating and cooling systems in all model plumbing and mechanical codes across the USA and Canada. PEX piping systems are durable, provide security for drinking water, and use reliable connection systems.

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 copper tube size (CTS). Product standards ASTM F876 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 iron pipe size (IPS), or 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”, are used interchangeably in this document.

PEX piping systems have been used for potable water applications for more than 40 years in Europe and for more than 25 years in North America. Today, the North American PEX industry is thriving, in both residential and commercial construction. Currently, there are more than ten domestic producers of quality PEX piping systems.

The PEX piping industry is highly regulated. Product standards, specifications, test methods and code requirements developed over the past thirty years define tight material and production controls, require hydrostatic temperature ratings at 180°F (82°C), and mandate standardized chlorine resistance testing. Third-party certification agencies also require strenuous quality control testing for PEX systems, including frequent unannounced inspections of plants and annual monitoring and re-testing.

According to product standards from organizations such as ASTM International, CSA Group and NSF International, the testing requirements for PEX piping systems today are far more stringent than for PB systems of the past. Combining these requirements with the robust capabilities of PEX piping and fittings, PEX systems have several key differences and advantages over the polybutylene systems that were sold in North America in the 1970s, 1980s and 1990s:

- **PEX is a crosslinked material**. During production of PEX, the molecules of the high-density polyethylene (HDPE) base material are permanently linked to each other by a process known as crosslinking. Crosslinking gives the PEX material enhanced properties, such as greater long-term stability against internal pressure at very high temperatures, resistance to slow crack growth caused by external damages such as scratches and scuffing, and reduced creep (material flow) under compressive loads at fitting connections. PB material is not crosslinked.

- **PEX tubing has thicker walls than PB tubing**. As required by PEX tubing standards such as ASTM F876, AWWA C904 and CSA B137.5, PEX tubing has a wall thickness up to 22% thicker than the wall thickness of PB tubing (SDR* 9 vs. SDR 11). Although both types of tubing achieved the same pressure rating of 100 psig @ 180°F, the thicker wall of PEX gives better mechanical strength and resistance to damage.

  **SDR = standard dimension ratio, the ratio of tubing outside diameter to wall thickness (see product standards for precise calculations)*

  Note 2: Due to wall thickness differences between PEX and PB tubing, insert fittings are not interchangeable between both types of tubing.

- **PEX pipes are required to demonstrate chlorine resistance.** Unlike PB tubing of the past, mandatory chlorine resistance testing according to ASTM Test Method F2023 requires that all PEX tubing used for plumbing applications shall be tested to meet a minimum extrapolated lifetime of at least 50 years, evaluated for different categories of end-use conditions using aggressive test water.[1] Such testing was not in place for polybutylene tubing or systems used in North America in the 1980s and 1990s.

  Please see PPI TN-53 *Guide to Chlorine Resistance Ratings of PEX Pipes and Tubing for Potable Water Applications* for more information on this topic.

  Similar research testing using chloramines, another potable water disinfectant, indicates that PEX piping is equally or even more resistant to chloramines at the same high levels and test conditions (See PPI Statement A).

- **PEX tubing systems do not use Polyacetal insert fittings.** PEX tubing systems for potable-water plumbing systems use fittings that, as required by ASTM standards, are made from lead-free brass or bronze, copper, stainless steel, or polymers. The prevalent materials used for polymer PEX fittings are polysulfone (PSU) and polyphenylsufone (PPSU), both of which have demonstrated very high levels of chlorine resistance.[2] When required, these fitting materials are tested to the same standards as PEX tubing, and must also be certified by the same third- party testing agencies. *Consult with each PEX tubing manufacturer for recommended fitting(s).*

For more information on PEX piping systems, please refer to PPI Technical Note **TN-17 "Crosslinked Polyethylene (PEX) Tubing"** and "**Design Guide: PEX Water Supply Plumbing Systems**" at www.plasticpipe.org.

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[1] "CHLORINE RESISTANCE TESTING OF CROSS-LINKED POLYETHYLENE PIPING MATERIALS" *P. Vibien, J. Couch and K. Oliphant, Jana Laboratories Inc., Aurora, ON; and W. Zhou, B. Zhang and A. Chudnovsky, University of Illinois at Chicago, Chicago, IL, USA, 60607* http://plasticpipe.org/pdf/jana-report-chlorine-testing-pex-materials.pdf

[2] "OXIDATIVE RESISTANCE OF SULFONE POLYMERS TO CHLORINATED POTABLE WATER" *S. Chung, J. Couch, J.D. Kim, K. Oliphant and P. Vibien, Jana Laboratories Inc., Aurora, ON; and J. Hung, M. Ratnam and W. Looney, Solvay Advanced Polymers, LLC, Alpharetta, GA*http://plasticpipe.org/pdf/jana-report-oxidative-report-suilfone-polymers.pdf