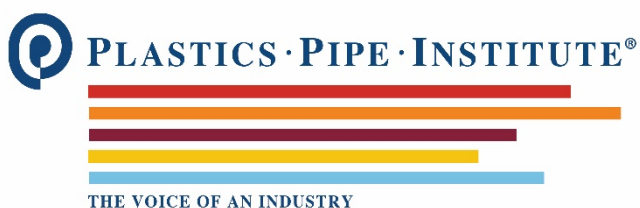


EROSION STUDY ON BRASS INSERT FITTINGS USED IN PEX PIPING SYSTEMS

TN-26

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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 information on a test program to evaluate the effects of flowing water on copper alloy insert fittings used in crosslinked polyethylene (PEX) hot and cold water distribution tubing systems, and to provide information to aid in the design of PEX plumbing systems sized using model plumbing codes.

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1.0 INTRODUCTION

Many PEX plumbing systems are installed using some form of insert fitting, primarily produced from engineered polymers, as well as brass or other copper alloys. Because the insert portion of the fitting has a smaller diameter than the tube, the velocity of the water through the fitting is higher than the velocity of the water in the tube. Therefore, PEX systems delivering the same volume of water will have higher flow velocities in the tube and fittings than copper systems of the same nominal tube size.

Many plumbing codes have maximum recommended flow velocities for copper or copper alloys to prevent erosion of the material by the flowing water. Millions of brass insert fittings have been installed in PEX plumbing and heating systems over the past 40 or more years in Europe and North America. In that time, we are unaware of any erosion-induced failures of PEX piping systems.

To evaluate the subject of erosion corrosion of PEX copper alloy fittings, the Building & Construction Division of the Plastics Pipe Institute funded a test program at Materials Performance Inc. (MPI) in College Station, TX for performance testing of several designs of brass alloy PEX fittings. This testing was conducted in 1997 and 1998, but the findings are still considered relevant today.

Note 1: PE-RT tubing was not part of this study because it was not in use in North America during this time. It has since been approved in model plumbing and mechanical codes in the USA. PE-RT tubing is produced to the same dimensions as PEX tubing and product standards from ASTM International and CSA Group allow it to be approved for use with the same types of fitting systems and materials as PEX tubing. Brass fittings complying with the standards listed in this TN may also be used with PE-RT tubing.

2.0 OBJECTIVE

The objective of this test program was to subject various brass insert fittings for PEX plumbing systems to flow velocities of hot, chlorinated water that represented the maximums that could occur if a plumbing system was sized according to the 2000 version of the IAPMO Uniform Plumbing Code.

Testing at these velocities continued until the accumulated volume was equivalent to 40 years of service in a typical single family residence.

The test was intended to demonstrate that these fitting designs and materials would resist erosion corrosion and flow-accelerated corrosion in typical residential plumbing applications.

3.0 TECHNICAL DEFINITIONS

The following definitions are provided for reference:

Corrosion: Chemical attack on the surface of a metal, forming a more stable ionic material, most commonly the electrochemical oxidation of metal through attack by oxygen, chlorine, sulfur, or other oxidizing agents.

Erosion: The process of gradual destruction of a material or surface through wear or surface abrasion, sometimes caused by excessive flow velocities in piping systems.

Erosion Corrosion: Degradation of a surface due to mechanical action coupled with a secondary corrosion element. Often caused by abrasion from suspended solids, cavitation, or turbulent fluid flow wearing away the passivation layer protecting an underlying material and causing rapid damage to the material through both physical wear of the material and further chemical attack.

Flow-accelerated Corrosion: A corrosion mechanism occurring when fast flowing fluid dissolves the passivation layer on metal surfaces and the metal again creates a passivation layer which is subsequently dissolved and the cycle repeats, resulting in rapid damage to the metal through bulk dissolution in the fluid stream.

pH: *potential of Hydrogen*, a measure of acidity or alkalinity of water. A pH value is a number from 0 to 14, with 7 defined as neutral. Values below 7 indicate acidity with increasingly acidic solutions as the number decreases, with 0 being the most acidic. Values above 7 indicate alkalinity which increases as the number increases, with 14 being the most alkaline or “basic”. The scale is logarithmic, with each number change indicating the solution is ten times different from the prior number (i.e. a pH of 3 is ten times as acidic as a pH of 4).”

“Lead-free” fitting: a fitting made of a material with a weighted average of not more than 0.25% lead calculated across the wetted surfaces of a pipe fitting, plumbing fitting, or fixture. Lead cannot be added intentionally to such materials. See Section 1417 of the 2014 Safe Drinking Water Act (SDWA) of the United States.

4.0 TEST DESCRIPTION

The test program given to the lab is listed in Appendix. It is considered to be aggressive relative to most plumbing installations for the following reasons:

- 4.1. The water temperature was maintained at 140°F (60°C) for the duration of the test. In a normal residential plumbing system, some flows occur at lower temperatures on the hot-water side of the system because the water temperature decreases when the line is not in use.
- 4.2. In the test, the total volume of water was flowing at the elevated temperature. In a normal residential system, the total flow for the structure is divided between the hot and cold sides of the system. The only fittings that actually have the total volume of the water being used by a residence passing through them are the fittings on the cold-water inlet line before flow splits at the water heater.
- 4.3. The pH of the water was maintained between 6.5 and 6.7. This pH is corrosive to most metals and is lower and more aggressive than the average pH of 7.7 found in public water systems.
- 4.4. The water velocity used for the entire life of the test assumed all fixtures on a line would be open to their maximum flow capacity at the same time. In normal systems, usually only a small percentage of the maximum possible flow is experienced at one time, so most of the water flows at velocities that are much lower than the possible maximum.
- 4.5. The chlorine level of the water was maintained between 2.5 and 3.0 ppm for the duration of the test. The average chlorine level for public water systems in the U.S. is approximately 1.1 ppm. It would be an unusual circumstance for a residence to experience chlorine levels equal to the test condition for an extended period of time.

Three different fitting types, based on alloys and manufacturing techniques for use with PEX tubing, were tested:

- Fittings machined from brass rod Alloy C36000 produced to ASTM Standard Specification F1807
- Fittings machined from forged brass Alloy C37700 produced to ASTM Standard Specification F1807
- Fittings machined from forged brass Alloy C37700 produced to ASTM Standard Specification F1960

Note 2: Brass fittings made to ASTM Standard Specification F2080 were not included in the study reported in this TN. However, brass fittings made to ASTM F2080 have the same inside diameter and are produced from the same brass alloys as are used for ASTM F1960 brass fittings. Therefore, the conclusions based on test results for F1960 fittings would be expected to be the same for F2080 fittings.