

# **Erosion Study on Brass Insert Fittings Used in PEX Piping Systems**

**TN-26/2013**



## Foreword

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The purpose of this technical note is to provide information on a test program to evaluate the effects of flowing water on copper alloy fittings 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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## EROSION STUDY ON BRASS INSERT FITTINGS USED IN PEX PIPING SYSTEMS

### **Background:**

Most PEX plumbing systems are installed using some form of insert fitting. These fittings are usually made from brass or some other copper alloy. 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. 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 size. Many plumbing codes have maximum recommended flow velocities for copper or copper alloys in plumbing systems to prevent erosion of the system from the flowing water. Millions of brass insert fittings have been installed in PEX plumbing and heating systems over the past 20 or more years in Europe and the United States. In that time, we are unaware of any erosion induced failures of PEX piping systems

In order to more fully evaluate this subject, the Building Construction Division of the Plastics Pipe Institute funded a test program at Materials Performance Inc. in College Station, TX.

### **Objective:**

The objective of this test program was to subject different brass insert fittings for PEX plumbing systems to flow rates that represented the maximums that could occur if a plumbing system was sized according to the 2000 version of the Uniform Plumbing Code and then flowing enough hot, chlorinated water through them to be equivalent to 40 years of service in typical single family residence.

### **Results:**

None of the brass insert fittings for PEX systems failed during this test. Weight losses were less than 3% for all fittings. Internal diameter increases due to erosion were less than 1%. 3/4" copper sweat elbows with straight pieces of copper tube attached were subjected to the same condition as the 3/4" brass insert fittings for PEX and these did not fail either.

### **Conclusions:**

The results indicate that very little erosion occurs at the test conditions chosen. The water conditions chosen were at the severe end of normal potable water conditions and the water flow rates were the maximum that should be experienced when all fixtures on a given line are open and flowing at capacity. No failures occurred and based on these results, failures due to internal erosion of brass insert fittings in PEX plumbing systems would not be expected over a normal lifetime of a plumbing system. PEX piping systems with brass insert fittings can be sized following the tables published in the model codes without undue concern for erosion of the fittings in normal plumbing applications.

**Discussion:**

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

1. The water temperature was maintained at 140F 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-cooled off when the line was not in use.
2. In the test, the total volume 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.
3. The pH of the water was maintained between 6.5 and 6.7. This is corrosive and much lower than the 6.9 to 7.1 range that is common for water systems.
4. The water velocity for the entire life of the test was at a velocity that assumed all fixtures on a line would be open to their maximum 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.
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 water systems in the U.S. is about 1.0 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 were tested.

- A. Fittings machined from brass rod, Alloy C36000, to ASTM F1807
- B. Fittings machined from forged brass, Alloy C37700, to ASTM F1807
- C. Fittings machined from forged brass, Alloy C37700, to ASTM F1960

The total water flow through each size fitting during the test is listed below.

| Size | Water Flow        |
|------|-------------------|
| 3/8" | 700,125 gallons   |
| 1/2" | 1,400,250 gallons |
| 3/4" | 4,200,750 gallons |

The water velocities for each type of fitting are listed below.

| Size | ASTM F1807  | ASTM F1960  |
|------|-------------|-------------|
| 3/8  | 19.3 ft/sec | 13.8 ft/sec |
| 1/2" | 16.7 ft/sec | 13.4 ft/sec |
| 3/4" | 21.8 ft/sec | 16.7 ft/sec |

The results are tabulated and illustrated in the following tables and graphs.

|         |                                                                    |
|---------|--------------------------------------------------------------------|
| Table 1 | Weight loss of $\frac{3}{4}$ " fittings at end of test.            |
| Table 2 | Weight loss versus gallons of flow through $\frac{3}{4}$ " elbows. |
| Table 3 | Weight loss of $\frac{1}{2}$ " fittings at end of test.            |
| Table 4 | Weight loss of $\frac{3}{8}$ " fittings at end of test.            |

Because the  $\frac{3}{4}$ " fittings had the highest flow velocities, the  $\frac{3}{4}$ " elbows were selected to be checked for weight change at 1,000,000 gallon intervals during the test. As would be expected, the weight loss did trend up as the amount of water flowing through the fittings increased.

Table 4 does not have any  $\frac{3}{8}$ " fitting data from F1960 type fittings because they were not available at the time of the test.

The fittings of each type with the largest weight loss were sectioned and examined for signs of pitting. There were no signs of localized pitting that would indicate a probability of early fitting perforation due to localized material loss.

Because of the very aggressive conditions during the test, a section of  $\frac{3}{4}$ " PEX tube was also evaluated for any dimensional changes at the end of the test. There was no measurable change in the PEX tube.

Based on these results, it seems unlikely that PEX plumbing systems using brass insert fittings, sized according to the tables in the Uniform Plumbing Code for copper tubing, will fail from erosion of the fittings caused by high water velocities in normal residential applications.