

Cross-Linked Polyethylene PEX in Residential Plumbing Systems

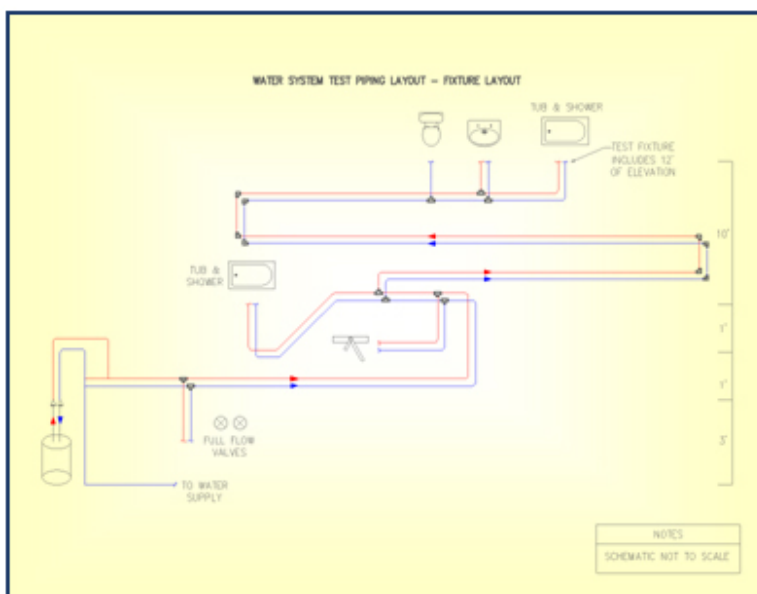
BUILDER TECHNOTE

Flexible PEX tubing is made from a plastic created from molecules of high-density polyethylene that have been permanently linked together by a process called cross-linking. PEX tubing can be installed for domestic hot and cold water supply systems for both new construction and remodeling projects.

The unique properties of PEX tubing allow it to be configured in a number of different plumbing system designs including the typical trunk and branch system, but also in more innovative designs that include the home-run and remote manifold systems. The trunk and branch design has a large main line that feeds smaller pipes to each fixture. The home-run design utilizes a central manifold to distribute dedicated lines to each fixture. The remote manifold system runs trunk lines to small manifolds at grouped fixtures, such as a bathroom. The remote manifolds can be flow-through or closed ended. The different system designs offer opportunities to optimize the performance of the plumbing system, reduce the installed cost, and increase overall customer satisfaction and acceptance.

In order to quantify the differences between the PEX system designs, each system was tested at the NAHB Research Center's laboratory to provide a similar set of conditions under which the systems are installed and operated. Actual residential plumbing fixtures, piping layouts with fittings, and elevation changes were incorporated in the test setup. This provided a consistent comparison between system designs, as well as an indication of the minimum performance characteristics of each system.

Figure 1- Diagram of Fixture Layout for Laboratory Testing



A test system was constructed for each type of plumbing design described above. A primary test fixture, represented by a tub/shower unit, was installed and instrumented to measure flow rate and flow pressure on the hot and cold lines, as well as outlet water temperature. This shower test fixture was the furthest fixture, located 100 feet from the hot water tank. It represents the "worst case" characteristics of the full system. Figures 1 and 2 illustrate the fixtures and setup for the trunk and branch design.

Two sets of tests were performed for each plumbing design. One test recorded pressure and flow data at the test fixture. A second set of tests measured the length of time it took for hot water to reach the test fixture. This second test was started after both the cold and hot water piping was stabilized to the incoming cold water temperature.

Figure 2 - Laboratory Test Setup for Trunk and Branch System with five fixtures and hot water tank



Plumbing System Pressure and Flow Test Results

The performance data for each of the three system designs shows very similar results. Figures 3 and 4 illustrate that all three systems performed adequately at pressures ranging from 40 to 80 psi.

Figure 3 shows the pressure data for each system at 40, 60, and 80 psi static pressure measured at the base of the riser. The riser flowing pressure was taken at the same location once the test fixture was operating. All systems had a higher flow pressure on the cold side than on the hot due to the lower flow rate on the cold water supply. When the test fixture was operating alone, the trunk and branch and remote manifold systems had a slightly higher flow pressure than the home-run system. However, any differences were minimal, less than 5.3 psi, and overall performance was acceptable for all system designs.

The flow pressure for TF + Group represents the flow pressure at the test fixture while the other shower, kitchen faucet, lavatory, and water closet were operating to capture “worst case” simultaneous flow data. All systems responded similarly to simultaneous flow events, with maximum difference of 0.8 psi.

Figure 3 – Test Fixture Pressure Data for Each System

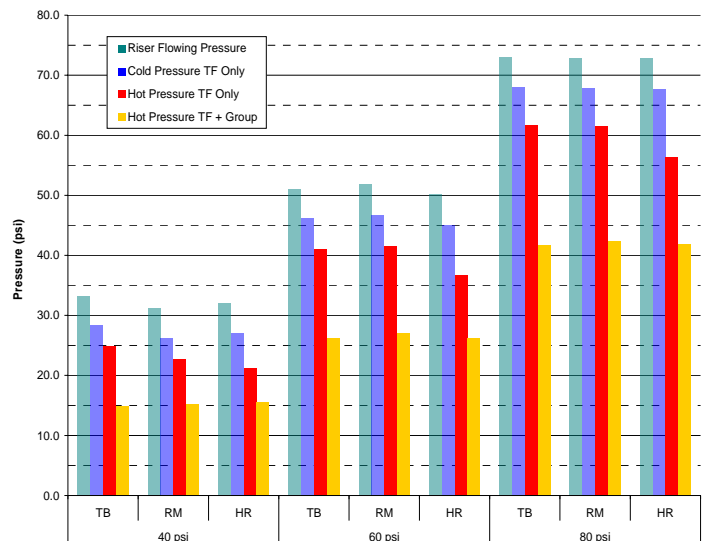
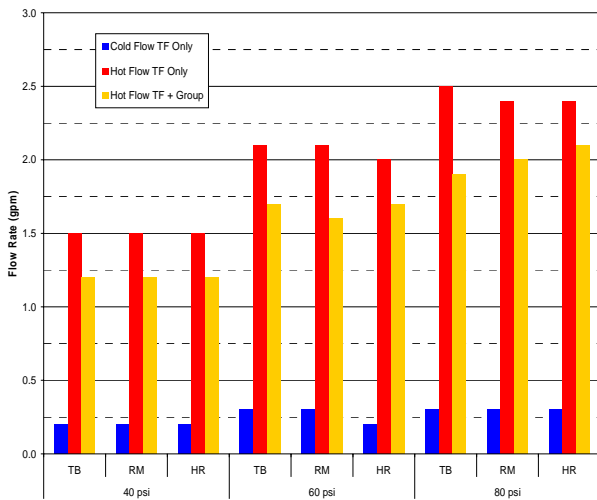


Figure 4 shows the flow performance for the same systems and pressures described above. The flow rate was measured when the shower was operating in full flow mode; therefore, the hot flow rate was considerably higher than the cold.

The trunk and branch system had slightly higher flow rates than the other two systems. The flow rate for TF + Group represents the flow rate of the test fixture while the other shower, kitchen faucet, lavatory, and water closet were operating to capture simultaneous flow data. Again, any differences were minimal, less than 0.2 gpm, and overall performance was acceptable for all system designs.

Figure 4 – Test Fixture Flow Rate Data for Each System



With the test fixture operating alone, the flow rate and flow pressure were slightly higher for the trunk and branch and remote manifold systems. However, with the test fixture flowing in conjunction with other fixtures operating, the flow rate and flow pressure were slightly higher for the home run system.

Wait Time for Hot Water

A significant benefit of PEX piping systems is the opportunity to reduce water and energy waste by reducing the amount of time to deliver hot water to the outlet from the water heater. Tests were performed on each of the three designs to compare the time it takes for hot water to be delivered to the test fixture.

Figure 5 shows the results of delivery hot water to the shower fixture after the pipes were flushed with cold (city) water. The results were normalized to keep the flow rates and temperature from the hot water tank constant for all systems.

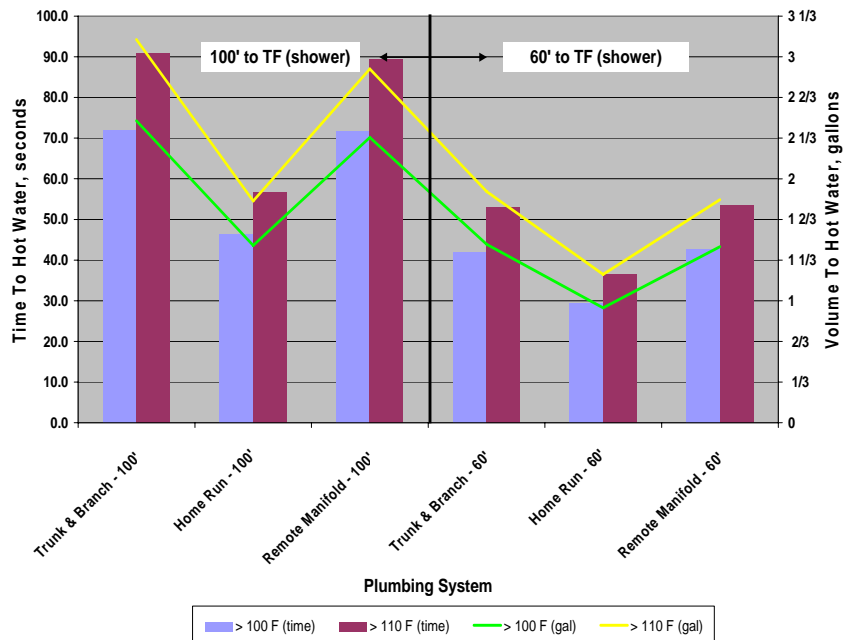
Water and time savings of between 30 percent and 40 percent were identified based on this analysis of the home-run system over either the trunk and branch or remote manifold system designs.

Summary of Test Results

Evaluation of the performance results indicates the following system design characteristics:

- Trunk and branch system will supply one fixture at a slightly higher pressure.
- Home-run system will supply a more stable pressure to each fixture when operating simultaneous fixtures.
- Home-run system will deliver hot water to the outlet quicker, especially when the pipes are at room temperature.
- All three system designs will supply sufficient flow and pressure to the outlets even when the base riser pressure is 40 psi and the length to the farthest outlet is 100 feet.

Figure 5 – Time to Hot Water at Shower



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A summary of the test results is provided in tabular form.

Performance Summary, 100' Maximum Distance

System	Test Fixture Only		Test Fixture With Simultaneous		Test Fixture Only	
	Flow Rate Hot (gpm)	Pressure Hot (psi)	Flow Rate Hot (gpm)	Pressure Hot (psi)	Time to >100 F Hot Water (sec)	Time to >110 F Hot Water (sec)
40 psi Static					from 53° F	
T&B - 100'	1.5	24.9	1.2	14.9	71.9	90.9
RM - 100'	1.5	22.8	1.2	15.3	71.6	89.3
HR - 100'	1.5	21.3	1.2	15.6	46.3	56.8
60 psi Static						
T&B - 100'	2.1	41.0	1.7	26.3		
RM - 100'	2.1	41.5	1.6	27.1		
HR - 100'	2.0	36.7	1.7	26.3		
80 psi Static						
T&B - 100'	2.5	61.7	1.9	41.7		
RM - 100'	2.4	61.5	2.0	42.3		
HR - 100'	2.4	56.4	2.1	41.9		