Pay the PEX piper say industry experts

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For almost 50 years, PEX pipes have transformed the world of plumbing. A series of technical tests undertaken by the Swedish Research Institute (RISE), has recently endorsed the quality performance of premier PEX pipe brands that are used for delivering drinking water. However, whereas these stringent tests confirmed the high quality of leading brands, a small number of PEX pipe samples achieved very low scores in particular for hygiene testing. Industry expert, Dr. David Walton has called for more clarity in the market. He believes that this can be achieved by a common approach to European standards for mechanical and hygiene performance. Such an approach would eventually help installers and contractors to make a more qualified choice. Meanwhile, his market advice is to deal only with major "tried and trusted" PEX pipe makers.

From January to March 2018, the Swedish Research Institute RISE in Gothenburg and Borås carried out a program to test seven different brands of PEX pipe[1]. These tests focused on brands that are available on the market and specifically used for delivering drinking water to the tap. The emphasis of testing was therefore oriented towards both mechanical characteristics and hygiene performance of the products.

Founded in 1973, RISE is known internationally for industrial research and innovation as well as its testing and certification expertise especially in the field of plastic pipe technology.

Each PEX sample was purchased by RISE on a random basis and on the open market. Five of the seven samples were of the class PEX-A type and the remaining two samples conformed to class PEX-C. It is important to note that there were no PEX-B samples in the final test selection.

There are an estimated 150 different brand types of PEX pipe sold within the EU. According to industry analysts, the manufacturers of the seven tested samples represent approximately 50% of the market for PEX-a and PEX-c drinking water pipes.

Whereas mechanical testing was performed directly by the Swedish Institute, hygiene tests were carried out by the *Hygiene-Institut des Ruhrgebiets* in Gelsenkirchen, Germany. The provenance of each sample was concealed from the German testing personnel and process.

All of the major mechanical tests undertaken by RISE were in accordance with ISO or nationally recognized procedures. However, one particular test with an obvious practical value for installers was used to measure the force needed to bend the pipe during pipe installation (**Figure 1**). This flex for PEX test involved bending a length of pipe into a ring and mounting it upon a tensile testing machine.

[1] The original RISE study included 7 brands of PEX pipes and one PE-RT pipe. For the purpose of full comparability, this article only addresses the results obtained from testing the PEX pipes, and the PE-RT sample in the study is not taken into account.

Installers are well aware of the inherent advantages that high flexibility confers. More so within underfloor heating than plumbing situations. PEX pipe is easier to install than rigid pipe and being available in long coils, it can eliminate the need for extra fittings. High flexibility is therefore a desirable characteristic for underfloor heating or building renovation. Lower flexibility means stiffness and less movement – sometimes a desired characteristic for plumbing installations.

Olle Persson who is a RISE scientist and the project leader for the PEX testing program comments: "Some of the tests, for example flexibility and necking at tensile force are not something that are performed at a regular basis by us and probably not by others. However, the elongation at break, pressure testing and degree of cross-linking are well known and standardized."

"One standard and crucial ISO test was to submit samples to internal pressure. RISE applied every PEX pipe product to the same pressure (± 0.7 %) under identical testing conditions. Most PEX pipes physically resisted such stress for at least 400 hours before testing was discontinued."

A total of nine mechanical tests were employed by RISE and their data analysed by the authors of this article. For the purposes of comparison and presentation, a three-star league table for each mechanical test was devised. In this way, high achievers would be recognized in true Olympic fashion and low achievers would be singled out for their poor performance (see **Figure 2a**). An identical assessment approach was adopted for hygiene testing (see **Figure 2b**).

Figure 1. Tensile testing machine used by RISE to measure PEX flexibility.

Product	In top 3	In bottom 3
1	★★★★★★★	
4	★★★★★★★	★★★★
2	★★★★★★★	★★★★
3	★★★★★★	★★★
5	★★★★	★★★★★★
7	★★	★★★★★★★★★
6	★★	★★★★★★★★★

Figure 2a. Performance Summary of pipe samples subjected to mechanical testing. The column "In top 3" illustrates the number of individual tests where the product qualified as one of the three best performers. Equally the column "In bottom 3" refers to the number of tests where the product was among the worst three performers.

Product	In top 3	In bottom 3
4	★★★★	
1	★★★	
3	★★	★★
5	★★	★★
2	★	★
7	★	★★★
6		★★★★

Figure 2b. Performance Summary of pipe samples subjected to hygiene testing. The column "In top 3" illustrates the number of individual tests where the product qualified as one of the three best performers. Equally the column "In bottom 3" refers to the number of tests where the product was among the worst three performers.

Testing the waters

European and national technical standards for hygiene and water quality are particularly stringent when it comes to anything that involves the transportation of water. Two major tests are of particular value when assessing the performance of pipe systems for the purposes of hygiene and water quality. The Ruhr District Institute of Hygiene applied these tests and in strict accordance with the method set by the German institute for standardisation (DIN).

The first test measures the amount of substances containing carbon that end up in the tap water. This provides a clear indicator of the hygienic quality and cleanliness of the plastic pipes in contact with drinking water.

A sophisticated instrument called a total organic carbon (TOC) analyser is used to measure samples of water over an extremely wide range (from 4 µg/L to 25,000 mg/L). Measurements produced by this equipment are precise enough to pass verdict on any drops of water from the ultrapure to the highly contaminated.

But testing the waters also requires tasting the waters. According to Olle Persson from RISE: "the laboratory conditions for evaluating the appeal of drinking water are more scientific than those explored by the age-old methods of wine tasting."

To ensure that all senses were attuned to the delicate task at hand, the Ruhr District Institute of Hygiene in Gelsenkirchen employed a team of three to five water tasters from within the staff of the institute. Their expertise would prove invaluable.

First impressions are important and appearance was their primary concern. Colour, turbidity (clear or cloudy) and any sign of foaming were closely noted. German noses and taste buds were then prepared by exposing them to standard odours and tastes. PEX waters were then rated according to threshold taste and odour numbers (TON).

Their notes as well as the conclusions from across all categories support the basic premise that PEX pipe systems conform to maximum tap water quality and hygiene.

Overall results from hygiene testing were good news for the same PEX pipe makers that topped the mechanical testing league. Their pipes not only stayed within the limits set down by European standards but their waters maintained excellent quality and cleanliness.

However, two of the seven pipes failed to meet the regulatory hygiene requirements. This was particularly evident from the performance of the samples when tested for Total Organic Carbon (TOC). This TOC test is a commonly used parameter for assessing the suitability of plastic pipes for drinking water applications.

These differences are compared in results from TOC testing in **Figure 3**. Two of the samples produced TOC values considerably above the generally applied German hygiene guidelines of 0.5 mg/l. But one sample failed to meet this requirement when tested in two separate temperature conditions.

Given that the remaining products in the test met the required hygiene criteria with a clear margin, it is reasonable to conclude that there are distinct performance differences between brands.

Overview of test results

Albeit a consumer-oriented comparison, the overview was noteworthy. Whereas most of the PEX products performed perfectly, the same two PEX products scored consistently low points when subjected to mechanical

and hygiene testing. The entire summary shows clearly that high-performance products tend to perform well in all tested categories, whereas poor performers are consistently at the bottom of the league in most aspects.

"These tests were significant," explains Dr. Walton. "They confirm that PEX pipes are tough, tried and tested when supplied by major European plastic pipe makers. These firms invest a significant proportion (over ten percent) of their turnover in technical research, manufacturing excellence, quality and pipe material testing and development."

"PEX pipes may be buried or hidden out of sight but their lifelong performance is such that they are expected to endure for at least fifty years. However, one of the difficulties with the PEX market is that all the pipe looks the same whereas the quality of the cross-linking can vary considerably from manufacturer to manufacturer especially if the sample is taken from a wide range of suppliers."

"The quality of the processing significantly effects performance and without fairly sophisticated testing it is difficult to check the pipes. Also, the distributors and users tend to be small companies who are not able to carry out the appropriate checks and have to rely on the markings on the pipe. In this environment it is relatively easy for the pipe manufacturer to take short cuts to significantly cut their costs."

Ludo Debever who is General Manager of The European Plastic Pipes and Fittings Association (http://www.teppfa.eu/) agrees: "PEX Hot & Cold water systems are recognized through their European Product Declarations for their sustainability and low environmental impact. My advice to the building services industry is that installers should refer only to TEPPFA Member Companies for assurance in matters of quality and supply."

Given an overview of RISE results on product performance (see **Figures 2a, 2b and 3**), his advice may not be misplaced. TEPPFA member companies collected gold, silver and bronze medals for their mechanical endurance and hygiene performance. The two lowest PEX pipe makers failed to complete their events.

Conclusive advice

PEX pipe systems continue to deliver the practical and economic benefits for which they were created. Nevertheless, the authors of this article believe that they have spotted a potential kink in the PEX pipes

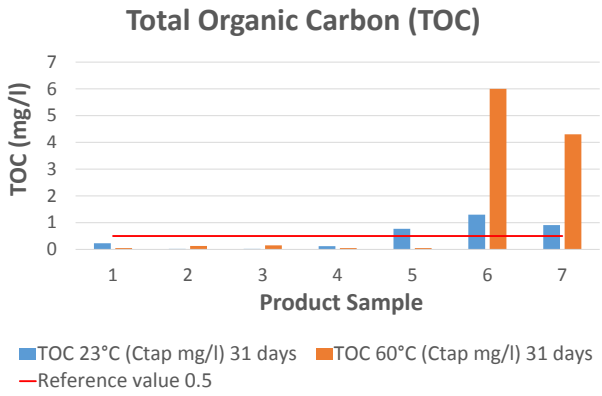

Figure 3. Results from Total Organic Carbon (TOC) testing of product samples. In the absence of common European limit values for TOC, the German KTW Guideline value of 0.5 mg/l is used as a reference for acceptable product performance.

supplied by a very small number of producers. Water authorities expect high standards of the pipes that deliver their precious liquid and the work carried out by RISE suggests that whereas flexibility might be a desirable product characteristic, cutting corners at the manufacturing stage, is certainly not.

Clearly a common approach at European level is required in terms of standards for mechanical and hygiene performance. But Europe is not known for its fast track harmonization of standards. Meanwhile, according to industry experts, installers should pay only the many "tried and trusted" PEX manufacturers in the market. ■

PEX pipes

From the 1970's onwards, installers have warmed literally and figuratively to PEX pipes as a popular way to transport water in hydronic radiant heating systems. The name PEX derives from cross-linking polyethylene (PE) - a molecular process that improves the performance of the pipe material at higher temperatures.

The economic performance and practical benefits of PEX pipes soon opened the door to wider applications than merely transporting hot water from boiler to radiator. Today, PEX piping also supplies underfloor heating systems and delivers Hot and Cold water. Compared to non-plastic piping whose replacement they are increasingly providing, their global market share for new build is estimated at well over 45 %.