

AWWARF LOOKS AT PVC PIPES' LONG-TERM PERFORMANCE

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What can we expect in 110 years from PVC pipes installed today?

Sustainability considerations and asset management principles are driving the need for better performance information regarding the components employed in our water systems. In order to progress toward achieving sustainability, it is critically important to improve performance measurement and benchmarking. Through quantification of how well products and materials are performing, conclusions can be reached as to whether they are appropriately sustainable. Furthermore, performance data can be used to project longer-term performance and the overall life expectancy of individual asset components.



Considering the extensive and widespread use of PVC pipe by the drinking water industry, the American Water Works Association Research Foundation (AwwaRF) and the Australian Commonwealth Scientific and Industrial Research Organization



(CSIRO) co-funded a research project to evaluate the long-term performance of PVC water pipes. Actually, this was AwwaRF's fourth project that examined the performance of plastic pipes. Titles of the earlier reports are *Review of Water Industry Plastic Pipe Practices* (1987, #90516), *Water Utility Experience with Plastic Service Lines* (1992, #90953), and *Evaluation of Polyvinyl Chloride (PVC) Pipe Performance* (1994, #90644). PVC pipes scored very well in these previous evaluations.

AwwaRF's newest and most extensive report on PVC pipe is titled *Long-term Performance Prediction for PVC Pipes* (2005, #2879). The principal investigators were Stewart Burn, Paul Davis, Tara Schiller, Bill Tiganis, Grace Tjandraatmadja, Mark Cardy, Scott Gould, Paul Sadler, and Alan Whittle. The Project Manager from AwwaRF was Jian Zhang. Total funding for the project was \$610,342.

The study's primary objectives were to benchmark the performance of PVC water pipes and develop a long-term performance prediction model under a range of conditions. The study also examined water quality issues, pipe standards, and fracture properties.

CONTINUED ON PAGE 4

CONTINUED FROM PAGE 3

Forty-four water utilities from the United States, Canada, and Australia were surveyed to obtain historical field performance data. In addition, historical data from twenty-one water utilities from the United Kingdom was reviewed. That data was analyzed to plot average failure rate per 100 miles/year vs. pipe age. To the extent possible, installation and operating conditions were also considered. Fracture properties were evaluated using single edge notch bend and C-ring tests.

PVC pipe failure rates in the U.S. and Canada were reported as being lower than those obtained from other nations. The maximum rate of failure reported by a U.S. water utility was 2.7 per 100 miles/year. This low failure rate also compares very favorably with the failure rates for other water pipe products as published in other reports.

The lower failure rate of North American PVC pipes is attributed to superior slow crack growth resistance and fracture toughness. PVC pipes manufactured in the United States and Canada

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exhibited an increased resistance to crack initiation, slow crack growth, fatigue crack growth, and ultimate brittle fracture when the researchers compared them with PVC pressure pipes manufactured outside of North America. The fracture toughness tests' surfaces exhibited greater ductility on the U.S. pipe samples. The researchers concluded that the North American pipes' increased resistance to fracture failure is due to better processing during manufacture, which results in better material fusion. This explains why North American PVC pipes out performed those manufactured elsewhere.



The researchers succeeded in developing a predictive failure model for PVC pipes. Since PVC pipes are not subject to aging from corrosion, the model assumes inherent defects in the pipe and variation in maximum defect size. The researchers developed a computer program to implement the model. Estimates of average failure rates vs. age for a range of operating conditions are included in the report. Perhaps the most significant result is that PVC pipe failure rates increase gradually with age, rather than accelerating as is the case with corrosion-prone metal pipes.

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Getting back to the question of what to expect from PVC water pipes after 110 years in service, the researchers carefully analyzed 40+ years of available in-service pipe performance information. Their model projects that water utilities should expect a minimum service life of 100 years from PVC pipe when properly designed and installed. From the relatively low failure rates that the researchers project for PVC pipes in service for up to 110 years, PVC pipe is arguably a best-practice option for achieving sustainable water distribution/transmission systems. Moreover, it is reasonable to expect that recent and continuing improvements in the manufacturing of PVC pipe will result in even lower failure rates than those predicted using historical data.

It is most gratifying to be able to point to yet another independent assessment of PVC pipes' excellent performance. This AwwaRF report will give the water industry greater confidence in PVC pipe use and have a very positive influence on long-term asset management and the achievement of sustainability.