Evaluation of Long-Term Hydrostatic Strength for Sulfone-Based Polymers

Plastic piping systems for both residential and commercial plumbing are becoming much more prevalent because of their outstanding corrosion resistance and ability to eliminate potential contamination from heavy metals. These important benefits combined with simpler installation techniques and a lower overall system cost make plastic piping systems an attractive and economical alternative to metal piping systems.

When selecting a material, you must consider how the material will perform when exposed to the expected end-use environment. For pressurized systems, it is important to understand how the material will perform when exposed to constant stress in the presence of water at various temperatures. A study of the long-term hydrostatic strength (LTHS) of several unfilled sulfone-based polymers has been conducted and is reported in this bulletin.

The following materials were evaluated:

1) RADEL® R-5000 polyphenylsulfone (PPSU)
2) ACUDEL® 22000 PPSU blend
3) UDEL® P-1700 polysulfone (PSU)

The life of a component can be affected by many factors in addition to internal pressure. These factors include cyclic pressure load, water chemistry, part design, assembly methods and external environment. Other testing requirements are often specified, usually in national standards or codes, to help determine a component's suitability for use under these varying conditions. Discussion of these test methods is outside the scope of this document.

Test Procedure

The accepted methods[1,2] for determining design stresses for plastics used in pressurized plumbing systems involves the determination of time-to-failure of an extruded or molded tubular specimen under constant internal pressure. Testing is performed at different temperatures to reflect potential operating environments and to allow extrapolation beyond the test period.

To determine time-to-failure, cylindrical parts made from the material are exposed to a constant internal pressure while being maintained at a specific operating temperature. The stress level resulting from the internal pressure is determined from the equation: $\sigma = p(d-t)/2t$

σ = maximum tensile stress

p = internal pressure load

d = outside diameter

t = minimum wall thickness

Multiple samples are tested at varying internal pressures for each temperature condition selected. The time to failure for each test specimen is recorded. Data (failure time, temperature and stress) from these tests are analyzed according to widely accepted standards[3,4] to determine the mean stress that causes failure at various time/temperature combinations.

Results

Testing was performed by independent test laboratories according to European Norm EN 921. Details of test specimens and temperatures are provided in Table 1. Results extrapolated from data following ISO 9080 Method 4 are shown in Table 2.

Table 1

Injection Molded Test Specimen Dimensions and Test Temperatures

	Test Specimen Dimensions (mm)			Test Temperatures (°C)
	Length	Diameter	Thickness	
RADEL R-5000	270	40	3.3	20, 60, 95, 135
ACUDEL 22000	270	40	3.3	20, 110, 135
UDEL P-1700	288	50	4.0	20, 95, 110

Table 2

50-Year Prediction Values and LPL Values Calculated by ISO 9080 Method 4

		RADEL R-500		ACUDEL 22000		UDEL P-1700	
Temp (°C)	**Time (hours)**	**Mean (MPa)**	**LPL (MPa)**	**Mean (MPa)**	**LPL (MPa)**	**Mean (MPa)**	**LPL (MPa)**
20	438,000	41.5	36.6	39.4	33.4	13.4	–
70	438,000	25.4	21,3	18.9	15.2	5.7	–
95	438,000	18.1	14.6	12.3	9.6	–	–
23	100,000	43.2	38,2	40.9	34.8	15.7	–
93	100,000	20,8	17,0	14.0	11.3	4.7	–

The Lower Prediction Limit (LPL) is the stress level at a given time that will not produce failures in 97.5% of the test samples at 50 years.

Complete test reports for each material are available upon request.

Conclusion

Table 2 provides the mean value for the long-term hydrostatic strength for three sulfone-based polymers. Of these materials, RADEL R-5000 has the highest resistance to internal pressure, particularly at elevated temperatures. Although the LTHS values for ACUDEL 22000 and UDEL P-1700 are lower, they are within the acceptable range for many applications.

These data are based on laboratory tests and field performance may vary. These data should be used with an appropriate design safety factor to determine the minimum wall thickness for potable water pipe fittings molded using these sulfone-based polymers. In field applications, stresses induced by loads other than internal pressure may require greater wall thicknesses than would be predicted by these data.

Footnotes

1. ISO 1167 test method for thermoplastic pipes for the conveyance of fluids - resistance to internal pressure
2. ASTM D-1598 standard test method for time-to-failure of plastic pipe under constant internal pressure
3. ASTM D-2837 standard test method for obtaining hydrostatic design basis for thermoplastic pipe materials
4. ISO 9080 test method for plastic piping and ducting systems - determination of the long-term hydrostatic strength of thermoplastic materials in pipe form by extrapolation

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