Polyurea Technology
Life Expectancy Discussion

A question has recently been asked as to the life expectancy of a polyurea spray elastomer system as it relates to an application in an immersed saltwater environment. While this question is really not new to the technology, it seems that there has not been any published data or information to support any direct claims that may have been made. But we still would like to know, "How Long Will it Last"?

As you are aware, the polyurea spray elastomer technology is relatively new to the industry with respect to conventional polyurethane and epoxy type coating systems. Since the development in 1986 and first commercial use in 1988, true life history is only slightly over 15 years. This has provided somewhat of a "brick wall" if you will as to the real performance of the material. There is data and information available on the technology though that might suggest the long-term performance. This data includes accelerated testing on the technology compared to the basic physical properties.

The first most common testing with regard to accelerated exposure is weatherometer testing. During the development work on the polyurea technology at Texaco Chemical Company, several aromatic based polyurea systems were exposed to ASTM G 53 (Practice for Operating Light- and Water-Exposure Apparatus (Fluorescent UV-Condensation Type) for Exposure of Nonmetallic Materials). This has commonly been referred to as accelerated weatherometer testing. The number of hours exposure can be extrapolated to years of outdoor service.

During that work, the aromatic systems were exposed to a total of 3800 hours, using the UVB-313 bulbs, 50°C. The type bulbs have been shown to give higher UV output, faster testing and improved uniformity in the test. After this exposure, the samples were re-tested and compared to the original physical property data. What was shown was that the physical property retention was at least 80% of the elastomer's original physical property results. While the surface of the elastomer did show discoloration (yellowing) this was only at the surface. There was no chalking or cracking of the elastomer surface after exposure.

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That testing was halted at 3800 hours for no particular reason. The test samples were good the data was just required at that moment. I have attached an original chart of that data as published by Texaco Chemical Company.

We also performed a similar study using the aliphatic-based polyurea spray technology, which is the color stable version. For this, samples were exposed to over 6000 hours under the same test conditions. Elastomer physical property retention here was greater than 90%, with little to no color fade in the elastomer samples.

From this data on the aliphatic polyurea systems, they have then been evaluated for use in automotive interior trim applications. The available test data here suggests that dash and door panels made of the aliphatic system would have a least a 20 year life. That is significantly improved of the conventional plastcized PVC that has been used for years and tends to show cracking after about 5-8 years of exposure. Source of information here is from Goodyear Tire & Rubber.

I have attached a sheet that addresses many of the questions as to how does this data equate to real life data. Though no one will put the information in writing, it has been suggested that 2000 hours equates to about 20 years of exposure.

The other testing that has been done is the ASTM B 117 (Practice for Operating a Salt Spray (Fog) Apparatus). This has commonly been referred to a Salt Spray Testing. For this, similar aromatic polyurea systems were applied to prepared steel substrates and then a crosscut was made through the coating system to the steel substrate. The coated panels were placed in the salt fog cabinet and exposed to the salt environment, 50°C, for a period of 3000 hours. The panels are removed and inspected for corrosion at the scribe, adhesion of the polyurea to the panels and any deterioration of the polyurea samples.

While this test (ASTM B 117) is a comparative test, the results showed that the polyurea systems gave excellent performance after the 3000-hour exposure when compared to comparable polyurethane and epoxy coating systems. It has recently been suggested that the new ASTM G 85 (Practice for Modified Salt Spray (Fog) Testing) is an improved method of testing. This is sometimes referred to a prohesion testing. I know that some work has been done with polyurea system but I have no data as of yet.

Another unique testing procedure is that involving polymer morphology. Polyurea elastomer systems are amorphous in nature, not crystalline like polyurethane systems.

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This amorphous nature is similar to that of epoxy type systems except that polyurea system do not have a true glass transition temperature. Instead, 2 distinct T_g 's can be noted, one corresponding to the melting point of the soft block in the polymer and the other corresponding to the melting point of the hard block in the polymer. From Dynamic Mechanical Spectroscopy evaluations of typical polyurea elastomer systems, a low temperature T_g is noted at about -50°C with a high temperature T_g of about 230°C to 260°C. The response curve between these two points remains relatively flat. This would be the performance range, temperature wise, for a polyurea elastomer system. In lay terms, the polyurea elastomer systems would tend to show some significant stiffening at temperatures less than -50°C with some polymer softening, or possible decomposition, at temperatures above 230°C to 260°C.

As you are aware, there is a major construction project in Boston, MA, the CA/T Project or Big Dig as some call it. This is a project under the direction of Bechtel, Parsons & Brinkerhoff, a major engineering firm. In the initial stages of the project, Bechtel decided to use the polyurea spray elastomer technology as the primary waterproofing system for the tunnel section. The polyurea elastomer would be applied to the exterior of the concrete tunnels for both the cut-and-cover sections as well as the harbor immersed tube section. This is a saltwater environment.

Bechtel had required a 75-year life expectancy on the applied coating system and contacted Texaco Chemical Co / Huntsman Corp. While Texaco / Huntsman could not directly supply that information, we did supply all of the above noted information of this letter. Upon review and evaluation of the elastomer physical properties, Bechtel was satisfied that the coating system would provide the expected service of the project. The applied thickness of the polyurea coating system is 100 – 120 mils.

Another major project is the San Mateo Bridge Upgrade project in the San Francisco, CA area. Here, a polyurea system is being applied to the concrete beam and piling to protect from the salt environment corrosion issues. It has been reported that CalTrans has given a 100-year life span on this project. A large part of the decision to complete this work with the polyurea technology was due to the available accelerated testing and elastomer physical property information. Applied thickness of the polyurea coating system here is about 60 – 70 mils.

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While maybe not directly applicable, there is some additional data on some nuclear irradiation evaluation of polyurea spray elastomer systems. The basis of this information has provided for the use of the aromatic polyurea spray elastomer technology in a variety of nuclear facilities, and continues to be used today. This includes Westinghouse Savannah River Works, Hanford Nuclear Site and the Department of Energy.

While this is a considerable amount of data and supporting application work, we still have not fully addressed the question of life expectancy. I am of the opinion that there is no exact answer in general as many factors come into play. However, we should be able to provide for some sort of calculation of such.

It has been shown that polymer durability / toughness is a factor of the elastomer physical properties, applied thickness and environment of exposure. Given that, the best elastomer physical property relationship possible should be used for the application areas. This sounds somewhat confusing but I will explain. Life expectancy of the polyurea system should include not only the physical properties but factors such as long term adhesion, applied film thickness and chemical exposure / environment.

Urea has been described as an organic rock. The polyurea systems are a derivation of that "rock". As the reaction mechanism proceeds without the use of a catalyst, as opposed to polyurethane system, there is no catalytic breakdown evident in the polyurea polymer system like that of a polyurethane.

In addition to the accelerated and other testing done as described in this letter, I would suggest another accelerated test commonly performed with polyurethane foam systems. This is a humid age / thermal age test. The following ASTM methods have been used and are suggested:

ASTM C 1246: "Effects of Heating on Weight Loss, Cracking, and Chalking of Elastomeric Sealants After Cure"

ASTM D 5510: "Heat Aging of Oxidatively Degradable Plastics"

For each of these, the polyurea system would be exposed to an elevated temperature, normally 80°C (175°F), and the elastomer properties monitored over the exposure time. Given the high thermal resistance of the polyurea technology, this nominal temperature will have little to no effect on the polymer. It is suggested that a higher temperature be used, say 100°C (212°F).

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Polyurea systems have also shown excellent results in freeze/thaw cycling testing. This would take the polymer from -20°C to 50°C in 9 cycles.

From the accelerated weatheromter testing, thermal aging and typical performance values for polyurea systems, one could apply the following conservative calculation:

Evaluate the hours until there is 50% loss in elastomer physical properties or other failure;
For every 2000-hours QUV plus 1000-hours thermal aging = 20-year life span

This applies to the polymer, not necessarily the application.

I would feel very comfortable with this calculation and moving into the environment of application of the polyurea system provided the following parameters are met:

1. Applied film thickness is as follows

Pedestrian Traffic	40-60 mils
Vehicular	60-80 mils
HD Vehicular / High Abuse	80-125 mils
Immersion Service	50-100 mils
Walls (non-immersion)	30-60 mils
Below Grade Waterproofing	50-60 mils

2. Proper substrate preparation and application techniques are employed

Base on the available information we have to date, it is felt that a properly formulated and prepared polyurea elastomer system, like that of the "polyurea" product line you are using, would survive a minimum of 75 years in your saltwater application area. This is based on the testing, flexibility of the system, chemical resistance and thermal properties. This does not take into account extraneous circumstances such as high abrasion, undo impact and highly corrosive chemical / solvent introduction into the environment.

I know that I have been somewhat longwinded here but I did want to provide you with sufficient background and information to address your questions. I trust that this information will be of help to you. Please feel free to contact me should you have any additional questions.

Dudley J. Primeaux II, Owner / Consultant 11/05

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