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Chemical resistance testing

The ultimate laboratory test for a plastic material destined for use in a finished part would be one that measures the performance characteristics of the material over the entire range of temperatures, impact forces, loads, and chemical exposures that the part will be subject to in its actual end-use. Unfortunately such thorough testing is rarely possible or even justifiable. Laboratory tests are instead usually designed to pre-test only certain performance characteristics against those end-use exposures deemed most critical. Collectively, the results from a number of individual tests help predict a plastic material's ultimate performance in a given application.

One important category of laboratory testing is chemical resistance testing. Various chemical resistance tests can be run in the laboratory, one of which is the environmental stress cracking chemical resistance test.

The environmental stress cracking chemical resistance (ESCR) test is designed to evaluate the effect of chemical media and environments (lubricants, adhesives, gasket materials, cleaners, foodstuffs, upholstery materials, etc.) on a plastic material that has structural, load-bearing requirements in its finished part application. In ESCR tests, test bars are bent to specific strain levels (usually 0%, 0.5%, 1.0%, and 1.5% strain) in special test fixtures, and the chemical agent to be tested is then applied to the most highly strained area of the test bars. The bars are kept in constant exposure to the strain and chemical agent for a specified test period, usually seven days. At the end of the test period, the bars are removed from the test fixtures and analyzed for the amount of change experienced in certain material properties. The magnitude of change in these material properties gives a good indication of the subject chemical's severity as a stress cracking agent.

A simplified version of the ESCR test has been developed to allow engineers, processors, designers, etc. to screen candidate materials for an application versus the anticipated chemical environments. Although simplified, this version of the ESCR test has proven useful as an "indicator" of expected performance.

Figure 1 shows a simple test fixture that can be constructed of wood or metal to provide three different levels of bending strain. If standard ASTM 8.50 inch tensile bars are used for the test, the indicated lengths in the fixture will correspond to the following approximate strain levels.

Lengths for various strain levels

- 0.5% strain - 8.42 inches
- 1.0% strain - 8.19 inches
- 1.5% strain - 7.83 inches

These lengths and corresponding strain levels were determined experimentally using a strain-gauged ASTM 8.50 inch tensile bar. The test bars will be bent into an arc when gently forced into the test fixture at the various lengths. In addition to the strained test bars, an unbent or unstrained set of test bars should always be part of the test to serve as the "control" set. Figure 2 shows a test bar bent into the 1.5% strain arc. The length of the test fixture for this strain level is 7.83 inches.

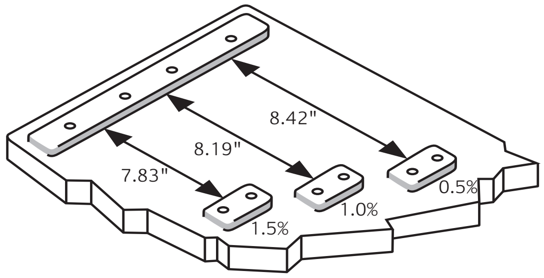

Figure 1. Fixture with opposing slats

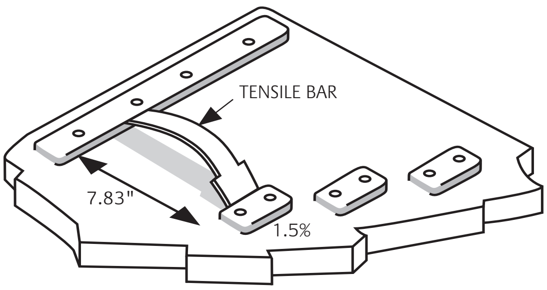

Figure 2. Tensile bar inserted at 7.83 inches or 1.5% strain

Once the test bars have been inserted into the test fixture, the chemical media to be evaluated are applied to the top center of the test bar arc and left exposed for a designated time period (usually seven days) at room temperature. Clean cheesecloth wrapped around the test bar and kept saturated while in contact with the strained area of the bar is the usual means of ensuring exposure to liquid agents. Other agents would be applied directly to the plastic. Volatile agents may require a closed container such as a polyethylene bag to prevent evaporation, thereby maintaining “wet exposure” throughout the test period. Test fixtures should, of course, be thoroughly cleaned after each test series.

The test bars suggested for use in this test are injection molded ASTM tensile bars that measure 8.50 inches x 0.75 inch x 0.125 inch, with a 0.5 inch wide necked down area. This tensile bar is shown in Figure 3. This test can also be performed using bars that are cut from sheet stock or finished parts (providing they are flat and approximately 0.125 inch thick) if the sides of the bars are very smoothly cut and finished. Realize however that testing bars other than the ASTM tensile bars will result in strain levels that are different from 0.5%, 1.0% and 1.5%. Also the test results obtained from cut bars will be more erratic due to the effects of varying specimen orientation and the fact that the sides of the bars are mechanically cut and finished. However, since the purpose of this test is to provide a rough screening test for chemical resistance effects, mechanically cut bars should still provide a sufficient “indication” of performance.

At the end of the predetermined exposure time period, the test specimens should be removed from the fixture, wiped clean, and examined for indications of crazing or embrittlement. If stress whitening, cracking, breakage, or other failure is evidenced for any of the test bars, the medium being evaluated is suspect. If no effects are visible, bend the bars with chemically exposed area in tension (at the outermost point of the bend). If any of the test bars crack, the medium in question is a mild stress cracking agent. If no effects are visible and the bars do not break or seem embrittled, the medium can be considered fairly compatible. Results should be tabulated for each strain level.

The disadvantage of this test is that it is only a seven-day test, obviously limited exposure, and only approximates those stresses and strains to be encountered in the final application. It should also be noted that strain levels of 1.0% and 1.5% exceed the normal design limit for some materials, which is approximately 0.75% strain. The higher strain levels are used in the ESCR test to help simulate the effects of low strain, longer-term exposure. Anyone relying on this simplified ESCR test must be aware of its inherent limitations with respect to more formalized and sophisticated testing. This test should in no way replace the normal end-use testing of the finished product.

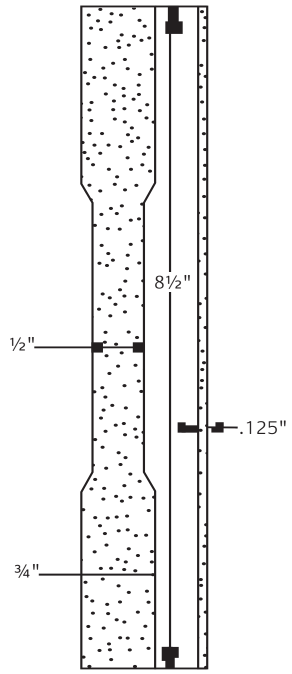

Figure 3
ASTM Tensile Bar 8.5 inch x 0.75 inch x .125 inch neck down to .5 inch