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Standard Practice for Testing STRESS-RELAXATION OF PLASTICS[1]

This standard is issued under the fixed designation D 2991; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This practice covers the determination of the time-dependence of stress (stress relaxation) of plastics resisting long-duration constant strains at conditions of constant temperature and relative humidity and negligible vibration.

1.2 *This standard may involve hazardous materials, operations, and equipment. This standard does not purport to address all of the safety problems associated with its use. It is the responsibility of whoever uses this standard to consult and establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Applicable Documents

2.1 *ASTM Standards:*

D 638 Test Method for Tensile Properties of Plastics[2]

D 695 Test Method for Compressive Properties of Rigid Plastics[2]

3. Definitions

3.1 *stress relaxation*—the time-dependent decrease in stress in a solid under given constraint conditions.

3.2 *initial stress*—the stress introduced into a specimen by imposing the given constraint conditions before stress relaxation takes place.

4. Significance and Use

4.1 Data from stress-relaxation tests are useful in predicting the reduction of stress in materials subjected to constant deformation for long times, such as the decrease in tightness of bolted or riveted joints.

4.2 This test is highly sensitive to small changes in material composition and environmental conditions and hence is useful in evaluating the effect of such changes.

5. Grips

5.1 The grips and gripping technique shall be designed to minimize eccentric loading of the specimen. Swivel or universal joints shall be used beyond each end of the specimen. The grips shall be so designed that no slippage of the specimen occurs.

NOTE 1—It is recommended that grips permit the final centering of the specimen prior to applying the strain or load. Grips that permit a displacement of the specimen within the grips during load application are not suitable.

6. Temperature Control and Measurement

6.1 The temperature of the test space, especially close to the gage length of the specimen, shall be maintained within ±2°C by a suitable automatic device and shall be stated in reporting the results.

NOTE 2—The thermal contraction and expansion associated with small temperature changes during the test may produce changes in the apparent relaxation rate especially near transition temperatures. Small changes in temperature near transitions also produce significant changes in relaxation rate.

6.2 Care must be taken to ensure accurate temperature measurements over the gage length of the specimen throughout the test. The temperature-measuring devices shall be checked reg-

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[1] This practice is under the jurisdiction of ASTM Committee D-20 on Plastics and is the direct responsibility of Subcommittee D20.10 on Mechanical Properties.

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[2] *Annual Book of ASTM Standards*, Vol 08.01.

ularly against temperature standards and shall indicate the temperature of the specimen gage area.

6.3 Temperature measurements shall be made at frequent intervals, or continuously recorded to ensure an accurate determination of the average test temperature and compliance with 5.1.

7. Environmental Control and Measurement

7.1 When the test environment is air, the relative humidity shall be controlled to within ±5 % during the test unless otherwise specified, or unless the relaxation behavior of the material under test has been shown to be unaffected by humidity. The controlling and measuring instruments shall be stable for long time intervals and accurate with ±1 %. (The control of relative humidity is known to be difficult at temperatures much outside the range from 10 to 40°C (50 to 100°F).)

7.2 When the environment is other than air, the composition of the test environment shall be maintained constant throughout the test.

7.3 The specimens shall be preconditioned in the test environment for at least 48 h prior to being tested. Those materials whose relaxation properties are suspected to be affected by moisture content shall be brought to moisture equilibrium appropriate to the test conditions prior to testing.

NOTE 3—Changes in such factors as moisture content, plasticizer content, and state of polymerization affect the relaxation behavior of plastics, but these same factors can produce dimensional changes (usually shrinkage at higher temperatures) which may be of such magnitude as to completely overshadow the relaxation phenomena.

8. Vibration Control

8.1 Relaxation tests are quite sensitive to shock and vibration. The location of the apparatus, the test equipment, and mounting shall be so designed that the specimen is isolated from vibration.

9. Load and Strain Measurement

9.1 The accuracy and sensitivity of extension-measuring equipment for determining the strain should be suitable for the purposes for which the materials under test are likely to be applied, and for the amount of relaxation to be expected. The sensitivity should permit measurement of load and strain within 1 % and the zero should not drift with time.

9.2 In order to obtain sufficient sensitivity the gage length of the specimen should be as long as is practical but consistent with other requirements, such as uniformity of temperature distribution along the gage length. It is always desirable and often necessary to use an averaging type extensometer or two extensometers acting on opposite faces of the specimen. The extensometers and load cells should be built of materials that are dimensionally stable at the test temperatures to be encountered and temperature compensated. Extensometers and load cells that impose any appreciable elastic or frictional restraint on the specimen are undesirable.

9.3 The extensometers and load cells should be calibrated against suitable standards under conditions as nearly identical with those encountered in service. This calibration must be independent of time within 1 % throughout the time of test.

10. Time Measurement

10.1 The accuracy of the time-measuring device shall be ±1 % of the duration of the relaxation measurement.

11. Test Specimens and Preparation

11.1 Test specimens may have either circular, square, or rectangular cross sections and may be made by casting, injection, or compression molding, or machining from sheets, plates, slabs, or similar material. The shape specimen given in Test Method D 638 may be employed. The specimen should have a cross-sectional area that is uniform to within ±0.5 % throughout the gage length. For round specimens, diameters of 12.82, 9.06, or 6.40 mm (0.505, 0.357, or 0.252 in.), and a gage length of not less than 50 mm (2 in.) are recommended. Longer gage lengths and the 12.82-mm (0.505-in.) diameter are preferred. Specimens should be straight and free from tool marks and scratches.

11.2 Specimens prepared from sheet or plate should be cut with their axes parallel to each other. When testing materials that may be suspected of anisotropy, duplicate sets of specimens may be prepared and tested: one set with their long axis parallel to the axis of greatest tensile strength, another set with their long axis at 45° to the axis of greatest tensile strength, and an-