Designation: D2370 – 16

Standard Test Method for Tensile Properties of Organic Coatings[1]

This standard is issued under the fixed designation D2370; 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.

This standard has been approved for use by agencies of the U.S. Department of Defense.

1. Scope

1.1 This test method covers the determination of the elongation, tensile strength, and stiffness (modulus of elasticity) of organic coatings when tested as free films.

1.2 The values stated in SI units are to be regarded as standard. The values given in parentheses are mathematical conversions to inch-pound units that are provided for information only and are not considered standard.

1.3 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

D823 Practices for Producing Films of Uniform Thickness of Paint, Varnish, and Related Products on Test Panels

D882 Test Method for Tensile Properties of Thin Plastic Sheeting

D1005 Test Method for Measurement of Dry-Film Thickness of Organic Coatings Using Micrometers

D3980 Practice for Interlaboratory Testing of Paint and Related Materials (Withdrawn 1998)[3]

D4708 Practice for Preparation of Uniform Free Films of Organic Coatings

3. Terminology

3.1 *Definitions of Terms Specific to This Standard:*

3.1.1 *elongation at break, n*—the increase in specimen length from the point of initial load application to the point of film rupture in a tension test.

3.1.2 *gage length, n*—the initial length of the test specimen between the jaws of the tensile tester.

3.1.3 *stiffness (modulus of elasticity), n*—the load per unit area required to elongate the film 1 % from the first point in the stress-strain curve where the slope becomes constant.

3.1.4 *stress-strain curve, n*—the curve resulting from a plot of tensile load against the distance of jaw separation (elongation of specimen).

3.1.5 *tensile strength (nominal), n*—the load per original unit area at which a specimen fails or yields in a tension (pull) test.

4. Summary of Test Method

4.1 Free unsupported films of the materials to be tested are prepared in accordance with Test Method D4708. The tensile properties of the free films are determined by means of a tensile testing apparatus.

5. Significance and Use

5.1 Tensile properties determined by this method are of value in studying the behavior of coatings subjected to environmental stresses, such as those produced by aging and weathering. (See Refs. **(1-10)**.)[4]

5.2 Tensile properties may vary with specimen thickness, method of preparation, gage length, rate of load application, tensile tester response, and type of grips used. Consequently, where precise comparative results are desired, these factors must be carefully controlled.

6. Apparatus

6.1 Equipment for applying films of uniform thickness as described in Practices D823.

6.2 *Micrometer Film Thickness Gage* as described in Test Method D1005.

[1] This test method is under the jurisdiction of ASTM Committee D01 on Paint and Related Coatings, Materials, and Applications and is the direct responsibility of Subcommittee D01.23 on Physical Properties of Applied Paint Films.

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[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

[3] The last approved version of this historical standard is referenced on www.astm.org.

[4] Boldface numbers in parentheses refer to the list of references at the end of this standard.

6.3 *Tensile Tester* of the constant rate of jaw separation type, equipped with load cells having capacities of 1 to 50 N (0.2 to 10 lb), and equipped with computer with tester controlling software, or optionally an indicating device such as an electronic constant speed chart recorder, a digital device that displays numerical values, or a printer that records the numerical values. Tensile tester can also be equipped with a video-extensometer and environmental chamber, when higher accuracy of test is required and testing is conducted at an elevated or low temperature.

6.4 *Precision Specimen Cutter* having a double blade with a foot to hold the sample in place[5] or other suitable sharp cutter blade.

7. Test Specimens

7.1 The test specimens shall be free films having a width that is between 13 and 25 mm (½ and 1 in.). No specimen shall vary by more than ±2 % in width along its entire gage length. The length shall be at least 50 mm (2 in.) longer than the gage length selected for the test.

7.2 Prepare free films by one of the procedures described in Test Method D4708.

8. Calibration

8.1 Balance, zero, and calibrate the load weighing and recording system of the tensile tester in accordance with methods specified by the manufacturer.

8.2 If video-extensometer is used, calibrate instrument according to manufacturer's instructions.

9. Conditioning

9.1 Specimens must be fully dried and cured before testing according to manufacturer specification. Unless otherwise agreed upon between the producer and the user, condition the test specimens for at least 24 h at 23 ± 2°C (73.5 ± 3.5°F) and 50 ± 5 % relative humidity and test in the same environment.

10. Procedure

10.1 Select a mutually agreed upon gage length in the range of 25 to 125 mm (1 to 5 in.).

10.2 Prepare 10 test specimens for each material to be evaluated. These specimens should not exhibit any nicks or flaws and should be inspected under 10× magnification for the presence of potential defects. Measure the thickness of each specimen to ±0.1 µm (0.04 mil) with a micrometer in accordance with Test Methods D1005, taking five measurements within the gage length area. If a video-extensometer is used, apply markings on the sample within the distance of gage length selected. The markings on the sample must be readable by the instrument being used. These will vary between manufacturer and models. The material and method of making the marks must not affect the characteristics of the sample.

10.3 Set the jaw separation of the tensile tester at the gage length selected. Place the test specimen in the grips of the testing machine, taking care to align the long axis of the specimen with an imaginary line joining the points of attachment of the grips to the machine. Tighten the grips evenly and firmly to the degree necessary to minimize slipping of the specimen during test.

NOTE 1—Mounting is facilitated by the use of air activated jaws. Line-type jaws will minimize slippage and breakage. The application of pressure-sensitive cloth to the ends of the film can improve jaw grip. Special self-tightening grips designed to be used with thin films could also be used.

10.4 Select a mutually agreed upon rate of elongation (strain rate) that is in the range of 5 to 100 %/min. Set the crosshead speed of the tensile tester to provide this rate for the gage length chosen.

NOTE 2—A rate of elongation should be selected that is optimum for testing the types of materials to be evaluated. For relatively brittle films, elongation rates of 5 to 20 % are suggested. For relatively extensible films, elongation rates of 50 to 100 % are suggested. (Refer to Test Methods D882 for relation of elongation rate to elongation at break).

10.5 Elongate the test specimen until rupture of the film occurs and evaluate the stress-strain curve as follows:

10.5.1 Determine the specimen elongation from video-extensometer data or by measuring the increase in jaw separation from the point of original load application to the point of rupture.

10.5.2 Measure the tensile pull in Newtons (lb) required to rupture the film.

10.5.3 If stiffness is desired, determine the tensile stress in MPa to elongate the film 1 % from the first point in the stress-strain curve where the slope becomes constant or allow the computer to calculate the appropriate tensile modulus.

10.6 Using the procedures in 10.1 – 10.5, run ten test specimens for each material under test.

11. Calculations

11.1 Allow the computer software to calculate for each specimen elongation at break (EB), tensile strength at break (TS) and modulus of elasticity (if desired) from electronically stored test data points.

11.2 If a manually operated tensile tester is used, for each specimen compute the following:

11.2.1 The elongation at break *EB*, in percent from the following equation:

EB

$$E = 100\left(\frac{\Delta L}{L}\right) \quad (1)$$

where:

ΔL = increase in specimen length to break, and
L = initial specimen length (gage length).

11.2.2 The tensile strength, TS, in MPa (lb per sq. inch), from the equation:

$$TS = (P_R)/(TW) \quad (2)$$

[5] The sole source of supply of the JDC precision cutter known to the committee at this time is the Thwing-Albert Instrument Co., 10960 Dutton Rd., Philadelphia, PA 19154. If you are aware of alternative suppliers, please provide this information to ASTM International Headquarters. Your comments will receive careful consideration at a meeting of the responsible technical committee,[1] which you may attend.