Designation: D522/D522M – 17 (Reapproved 2021)

Standard Test Methods for Mandrel Bend Test of Attached Organic Coatings[1]

This standard is issued under the fixed designation D522/D522M; 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 These test methods cover the determination of the resistance to cracking (flexibility) of attached organic coatings on substrates of sheet metal or rubber-type materials.

1.2 The values stated in either SI units or inch-pound units are to be regarded separately as standard. The values stated in each system are not necessarily exact equivalents; therefore, to ensure conformance with the standard, each system shall be used independently of the other, and values from the two systems shall not be combined.

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, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.4 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

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

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

D2370 Test Method for Tensile Properties of Organic Coatings

D7091 Practice for Nondestructive Measurement of Dry Film Thickness of Nonmagnetic Coatings Applied to Ferrous Metals and Nonmagnetic, Nonconductive Coatings Applied to Non-Ferrous Metals

3. Summary of Test Method

3.1 The coating materials under test are applied at uniform thickness to panels of sheet metal or rubber-type materials. After drying or curing the coated panels are bent over a mandrel and the resistance to cracking of the coating is determined. In Test Method A the coated panels are bent over a conical mandrel. In Test Method B the coated panels are bent over cylindrical mandrels of various diameters.

4. Significance and Use

4.1 Coatings attached to substrates are elongated when the substrates are dimensionally unstable, or are bent during the manufacture of articles or when the articles are abused in service. These test methods have been useful in rating attached coatings for their ability to resist cracking when elongated. They have been useful in evaluating the flexibility of coatings on flexible substrates. The elongation of coating films may also be tested using Test Method D2370. The correlation between elongation determined in accordance with Test Methods D522/D522M and D2370 is unknown.

5. Test Specimen

5.1 *Substrates:*

5.1.1 If the purpose of the test is to determine the percent of elongation of the coating material, the substrate shall be cold-rolled steel strip 0.8 mm [1⁄32 in.] (22 gage) thick.

5.1.2 If the purpose of the test is to rate the coated material for resistance to cracking, the substrate may be any type of sheet metal or rubber-type material (for example, steel, aluminum, tinplate, or synthetic rubber). The thickness of the sheet metal may be less than 0.8 mm [1⁄32 in.] and the thickness of the rubber-type materials may be as great as 13 mm [½ in.].

5.1.3 The recommended panel size is 100 mm [4 in.] in width and 150 mm [6 in.] in length. The maximum size that the conical mandrel can accommodate is 115 mm [4½ in.] wide and 190 mm [7½ in.] long.

5.1.4 The surface preparation of the substrate shall be agreed upon between the purchaser and the seller. Prior to the

[1] These test methods are under the jurisdiction of ASTM Committee D01 on Paint and Related Coatings, Materials, and Applications and are 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.

application of the coating, round slightly the edges of metal panels to remove burrs in order to eliminate anomalous edge effects.

NOTE 1—If elongations are to be determined for coatings applied to substrates other than 0.8 mm [1/32 in.] thick cold-rolled steel, they must be measured with a special mandrel jig as described in X1.2.

5.2 *Coated Panels:*

5.2.1 Apply uniform coatings of the materials under test to the substrates in accordance with Practices D823 and air dry or bake under conditions mutually agreeable to the purchaser and the seller. If percent elongation is to be measured, a minimum thickness of 25.4 µm [1.0 mil] is required on 0.8 mm [1/32 in.] thick cold-rolled steel. Perform a minimum of three determinations of coating thickness on each of the specimens in accordance with Test Method D1005 or Practice D7091.

5.2.2 From precoated sheets cut at least three specimens of the size given in 5.1.3. Use only plane (flat) sheets and round the edges of the panels slightly as in 5.1.4. The coating surface shall be free of oil and other foreign matter that might increase the flexibility of the coating or interfere with the observation for cracking. Measure the film thickness as in 5.2.1.

6. Conditioning and Number of Tests

6.1 Condition the test specimens for at least 24 hours at 23 ± 2 °C [73.5 ± 3.5 °F] and 50 ± 5 % relative humidity, and test in the same environment or immediately on removal therefrom unless otherwise specified by the purchaser and seller.

6.2 Test at least three replicate specimens in Test Method A and at least two replicate specimens in Test Method B at each mandrel diameter of interest.

TEST METHOD A—CONICAL MANDREL TEST

7. Apparatus

7.1 *Conical Mandrel Tester,* consisting of a metal cone, a rotating panel-bending arm, and panel clamps, all mounted on a metal base as illustrated in Fig. 1.

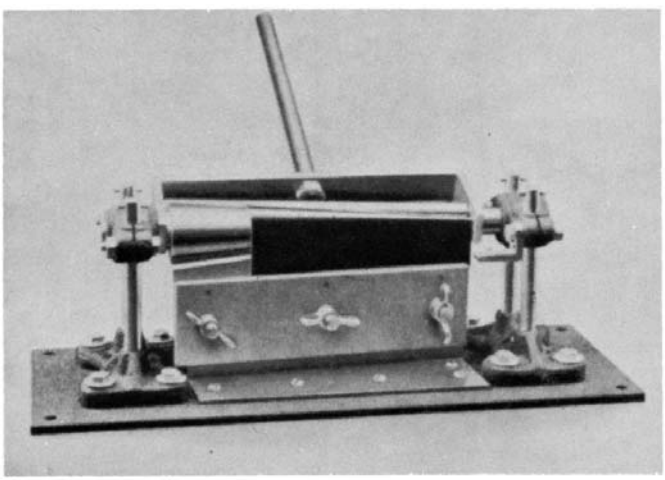

FIG. 1 Conical Mandrel Test Apparatus

7.1.1 *Cone,* smooth steel, 200 mm [8 in.] in length, with a diameter of 3 mm [⅛ in.] at one end and a diameter of 38 mm [1½ in.] at the other end.

8. Procedure

8.1 With the operating lever of the apparatus in a horizontal position, slip the test specimen between the mandrel and the drawbar with the finish side towards the drawbar. Rigidly clamp the specimen in a vertical position adjacent to the mandrel by placing the long edge behind the clamping bar in such a manner that the panel is always set up to the narrow end of the mandrel. Slip two sheets of No. 1 brown Kraft wrapping paper, substrate 30, thoroughly lubricated on each side with talc, between the specimen and the drawbar and hold in position only by the pressure of the drawbar against the paper.

8.2 Move the lever through about 180° at uniform velocity to bend the specimen approximately 135°. If the purpose of the test is to measure elongation, the bend time should be 15 seconds. To determine crack resistance under more simulated use conditions, the bend time should be about 1 second unless an alternative time is agreed upon between the producer and the user.

8.3 Examine the bent surface of the specimen immediately with the unaided eye for cracking. Having determined and suitably marked the end of the crack farthest from the small end of the mandrel, which shall be considered as the end point, bring the drawbar to the starting position and remove the panel from the mandrel. Measure the distance from the farthest end of the crack to the small end of the mandrel. This distance is used to compute the elongation. The mandrel diameter at which cracking ceased is taken as the resistance to cracking value.

NOTE 2—In some cases, the measured distance is used as a measure of crack resistance.

9. Calculation

9.1 When required, determine the elongation of the finish from the plotted curve in Fig. 2. This curve represents the relationship between the percent elongation and the diameter of the conical mandrel for a 25.4 µm [1.0 mil] coating thickness.

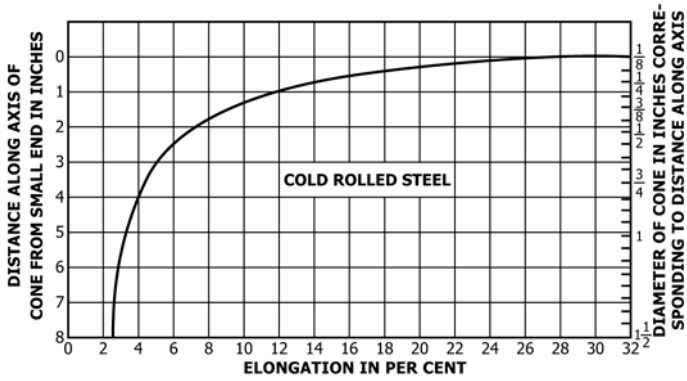

FIG. 2 Distance Along Cone and Corresponding Mandrel Size versus Percent Elongation for Specimens on Cold-Rolled Steel 0.8 mm [1/32 in.] in Thickness