Designation: D4146 – 10 (Reapproved 2022)

Standard Test Method for Formability of Zinc-Rich Primer/Chromate Complex Coatings on Steel[1]

This standard is issued under the fixed designation D4146; 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 test method covers the evaluation of the formability and adhesion of factory applied zinc-rich primer/chromate complex coatings on steel with thicknesses of 0.65 mm to 1.25 mm (0.025 in. to 0.05 in.) typical of those used in the coil coating industry.

1.2 The degree of oil removal prior to forming, the techniques of taping, and differences in adhesive strength of the tape can affect the adhesion rating.

1.3 The values stated in SI units are to be regarded as the standard. The values given in parentheses are for information only.

1.4 *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.* For a specific hazard statement, see Section 7.

1.5 *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]

D3330/D3330M Test Method for Peel Adhesion of Pressure-Sensitive Tape

2.2 *Other Document:*[3]

Pictorial Standards of Coating Defects

3. Terminology

3.1 *Definitions of Terms Specific to This Standard:*

3.1.1 *dome height, n*—the height of the dome formed in the test.

3.1.2 *indenting ball diameter, n*—the diameter of the spherical-ended penetrator (ball) used to deform the specimen.

3.1.2.1 *Discussion*—The 41-mm (1⅝-in.) diameter ball was selected because it minimizes the variability in the localized peak strain. This size ball is commercially available and is as large as most testing machines can accommodate.

3.1.3 *percent strain, n*—the percent elongation of scribed gage lengths after forming. For the draw height of 13 mm (0.512 in.), using a 1⅝-in. diameter ball, the localized peak strain is about 19 % (see Fig. 1).

4. Summary of Test Method

4.1 A coated specimen is biaxially stretched a given distance in an appropriate machine, adhesive tape is applied to the deformed area (dome) and then pulled off, and the amount of coating removed is compared with a photographic standard to determine the coating adhesion rating.

5. Significance and Use

5.1 The results of the combined deformation and tape test are related to the ability of the coated metal to withstand stamping in factory applications.

5.2 This test can be used to control the manufacturing process or in development work to improve the product.

5.3 It should be recognized that variability in the results persist due to the test conditions and forming machine variations.

[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 D01.53 on Coil Coated Metal.

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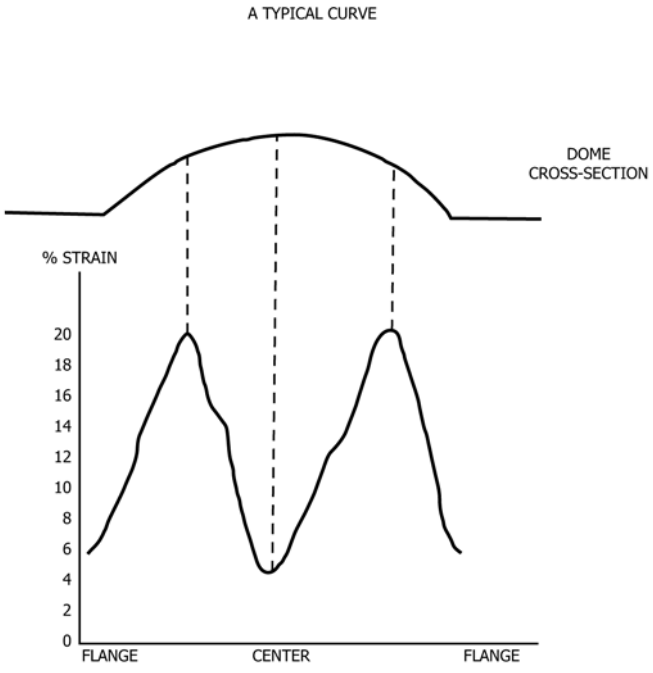
[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

[3] Copies of the pictorial photographic reference standard are contained in the publication *Pictorial Standards of Coating Defects* and may be obtained from the Federation of Societies for Coatings Technology (FSCT), 492 Norristown Rd., Blue Bell, PA 19422-2350, http://www.coatingstech.org. The silver halide gelatin photographs are intended to be the only primary reference standards for this test method. The reproductions of them in this test method are for the purpose of illustration only.



Draw distance 0.512 in. (13 mm) Ball diameter 1⅝ in. (41 mm)

FIG. 1 Survey of Strain Over Biaxially Stretched Dome

6. Apparatus and Materials (see Fig. 2)

6.1 *Forming Machine,* equipped with a spherical-ended penetrator to deform the specimen with appropriate dies, until the required height is obtained, and clamping arrangement to hold the specimen with a minimum pressure of 8.9 kN (2000 lbf).

6.1.1 The speed of forming shall be between 4.8 mm⁄min and 25 mm/min (0.2 in.⁄min and 1.0 in./min). The speed is usually slowed to measure more accurately the final height as shown on the dial indicator, but the final punch speed shall be controlled at 6 mm (0.24 in.)/min maximum.

6.2 *Indenting Ball,* with a diameter of 41 mm (1⅝ in.), a Rockwell hardness number not less than 61 on the Rockwell C scale (HRC), and a smooth surface finish not exceeding 4 µm (160 µin.). The indenting ball shall not deform during the test. The ball and holder shall move through the centerline of the top and bottom dies. The ball shall be clean and free of oil, grease, oxide buildup, rust, dirt, nicks, or damage.

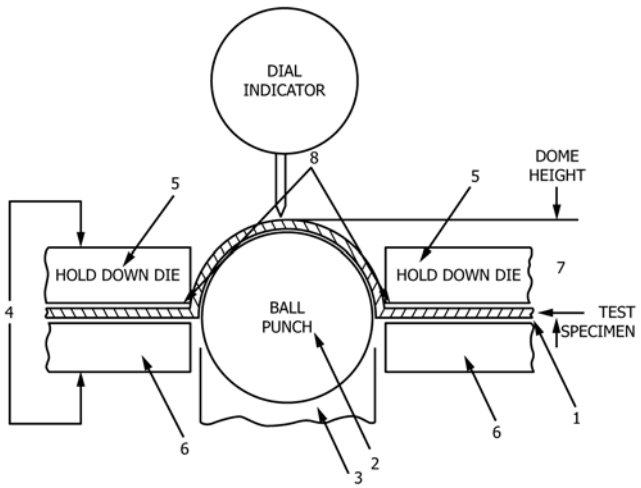
6.3 *Ball Holder,* to hold the ball in its seat during the test. Most ball holders are removable so that other ball punch deformation tests can be done in the same machine.

6.4 *Upper and Lower Dies* with a hardness of 56 HRC or higher. The upper die shall have an approach radius of 1.6 mm ± 0.05 mm (0.0625 in. ± 0.002 in.). The diameter of the opening in the upper and lower die shall be 42 mm (1.64 in.). In most machines, these dies are removable.

6.5 *Dial Indicator,* riding on the surface of the forming sheet to monitor the movement of the penetrator (ball) and graduated so that the displacement, or ball height, can be measured at least to 60 µm (±0.0025 in.) but preferably to 25 µm (±0.001 in.).

6.6 *Adhesive Tape,* 25 mm (1 in.) wide, transparent, high-tack, pressure-sensitive tape with an adhesive strength to steel of 50 g/mm (45 oz/in.) of width when tested in accordance with Test Method D3330/D3330M, and a tensile strength of 500 g⁄mm (28 lb/in.) of width.

6.7 *Photographic Standard*[4]—Steps in rating from 10 (good, no removal) to 0 (poor, complete removal) to rate visually the adhesion of the coating after forming and tape removal by comparison with the adhesive-backed tape.



Key	Dimensions	
	Inch-Pound	Metric
1 Test specimen	—	—
2 Spherical-ended penetrator (ball)	1⅝ in.	41 mm
3 Ball holder	—	—
4 Clamp force (minimum)	2000 lbf	8.9 kN
5 Upper die; bore diameter	1.64 in.	42 mn
6 Lower die; bore diameter	1.64 in.	42.mn
7 Dome height	0.512 in.	13 mn
8 Upper die corner radius	0.0625 in.	1.6 mn

FIG. 2 Tooling for Forming Test

7. Hazards

7.1 There are possible hazards to personnel when performing tests on any hydraulic equipment. Stand free when machine is operating.

8. Sampling and Test Specimens

8.1 *Sampling*—The coated steel coil is cut, usually at the head or tail of the coil, into a sheet sample, which can be easily handled.

8.2 *Specimen Size*—The specimens may be square or rectangular but not narrower than 90 mm (3.5 in.) in either dimension. Strips of full width of the coil can be tested if precautions are taken not to nick or damage the adjacent dome in the machine.

[4] The photographic reference standards that are part of this test method and are provided in the *Pictorial Standards of Coating Defects Handbook*[3] are representative of the adhesion ratings. The photograph shown in Fig. 3 is for illustration proposes only and should not be used for evaluation.