Designation: B489 – 85 (Reapproved 2013)

Standard Practice for Bend Test for Ductility of Electrodeposited and Autocatalytically Deposited Metal Coatings on Metals[1]

This standard is issued under the fixed designation B489; 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 a test procedure for determining the ductility of electrodeposited and autocatalytically deposited coatings on sheet or strip basis metals. The purpose of the test is to determine the resistance of metal coatings to cracking during distortion.[2]

1.2 Test Methods E8 can be used if the coatings are too ductile and require mandrels too small to be practical.

1.3 The values stated in SI units are to be regarded as standard. No other units of measurement are included in this standard.

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

2. Referenced Documents

2.1 *ASTM Standards:*[3]
B177 Guide for Engineering Chromium Electroplating
D1193 Specification for Reagent Water
E8 Test Methods for Tension Testing of Metallic Materials

3. Summary of Practice

3.1 The practice consists of bending a narrow strip of the electroplated or coated article over a mandrel. An elongation measurement is obtained from the smallest diameter mandrel that does not cause the coating to fracture.

4. Significance and Use

4.1 The routine measurement of the ductility of electrodeposited and autocatalytically deposited metal coatings can be useful in process control, especially when the electroplating process is used for decorative and engineering purposes.

5. Apparatus

5.1 *Series of Mandrels,* with diameters from 6 to 50 mm, in 3-mm steps with lengths of 100 to 150 mm so they can be held in a vise.

5.2 *Micrometer,* to measure the thickness of the test specimens.

5.3 *Guillotine Shears* or other device to cut the specimens to size.

5.4 *File or Grinder* to remove burrs and to round or chamfer edges.

5.5 *Vise,* to hold mandrels.

5.6 *Magnifier,* 10×.

6. Test Specimen

6.1 Flat specimens, 10 mm wide, and not less than 150 mm long, shall be cut from the electroplated or coated article if the shape permits, no closer than 25 mm from the edges. Guillotine shears are preferred, but any convenient method may be used. Basis metal thickness and temper shall be suitable to permit bending around the smallest diameter mandrel, if necessary. Low-carbon AISI 1010 to 1025 steel strip or sheet, 0.25 to 1.0 mm thick is usually suitable. Basis metals that have low ductility can initiate cracks that can propagate through the coatings. The procedure indicated in 6.2 shall then be followed.

6.2 When the shape is such that a test specimen cannot be obtained from the part, a test panel may be prepared of appropriate basis metal, such as low-carbon steel (see 6.1), with the same coating system in the same baths. The panel shall be sufficiently large to obtain several pieces after trimming 25 mm from the edges. The specimens shall be prepared in accordance with 6.1. Brass or copper panels may be used instead of copper-electroplated zinc alloy panels.

6.3 The long edges of the test pieces shall be rounded or chamfered by filing or grinding.

[1] This practice is under the jurisdiction of ASTM Committee B08 on Metallic and Inorganic Coatings and is the direct responsibility of Subcommittee B08.10 on Test Methods.

Current edition approved Dec. 1, 2013. Published December 2013. Originally approved in 1968. Last previous edition approved in 2008 as B489 – 85 (2008)ε1. DOI: 10.1520/B0489-85R13.

[2] For a discussion and theory for this test see Mohrnheim, A. F., "The Bend Test for Measuring the Strain Limit of Surfaces," *Plating*, Vol 50, 1963, pp. 1094 – 1099.

[3] 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.

7. Procedure

7.1 Place the largest mandrel in the vise. Bend the test specimen, with the coating outward, over the mandrel so that as the bend progresses the test specimen will remain in contact with the top of the mandrel. Continue bending with slow, steadily applied pressure until the two legs are parallel. If there are no cracks visible under a 10× magnifier, repeat the test, using new specimens, on progressively smaller-diameter mandrels, until cracks appear across or through the coating. Take the preceding mandrel diameter as the value for the ductility determination. If the coating is electrodeposited chromium, the specimens may require heating or aging to overcome temporary hydrogen embrittlement. A procedure to overcome hydrogen embrittlement is covered in Guide B177.

7.1.1 Small cracks not greater than 1.5 mm long, confined to the edges of the test specimen do not signify failure.

7.1.2 At times, no single crack may develop over the convex surface. If jagged cracks, or a series of shorter cracks develop (excluding edges), they signify failure.

7.2 In multiple coatings, cracking may occur in the outer coatings only. In the case of nickel, cracks may extend through the nickel to an intermediate copper layer or to the basis metal. Methods for determining this are provided in the Appendix. A positive test for copper or iron signifies failure.

7.3 Except for very ductile coatings, the apparent ductility is an inverse function of the thickness. If the test is to be used to evaluate the electroplating or autocatalytic process by periodically testing the ductility of coatings produced by the process, all specimens used must have approximately the same coating and total thickness.

8. Calculation

8.1 Determine the elongation as follows:

$$E = 100\,T/(D+T)$$

where:

E = percent elongation,
T = total thickness of the basis metal and deposit, and
D = diameter of the mandrel.

NOTE 1—To calculate percent elongation, E, the dimensions of T and D must be identical.

9. Precision and Bias

9.1 This practice is a useful one for routine control of the ductility of metallic coatings. The largest source of error is in the detection of crack initiation. The precision and bias for this practice have not been statistically determined.

10. Keywords

10.1 autocatalytic deposits; ductility tests; electrodeposits

APPENDIX

(Nonmandatory Information)

X1. COPPER AND IRON DETECTION—SPOT TEST TECHNIQUE

X1.1 Apparatus

X1.1.1 *Spot Test Plate.*

X1.1.2 *Dropping Pipets (Medicine Droppers).*

X1.1.3 *Wash Bottle.*

X1.1.4 *Glass Stirring Rod.*

X1.2 Reagents

X1.2.1 The solutions shall be made with water conforming to Specification D1193, Type IV.

X1.2.2 *Acetic Acid Mixture*—Prepare the mixture by adding to 45 mL of glacial acetic acid 5 mL of wetting agent, such as 1 % solution of sodium lauryl sulfate.

X1.2.3 *Hydrogen Peroxide*—Use 30 volume % solution.

X1.2.4 *Zinc Acetate Solution*—Prepare the zinc acetate solution by using 1 mass % of ASC reagent grade material.

X1.2.5 *Ammonium Mercuric Thiocyanate Solution*—Add 8 g of ASC reagent grade mercuric chloride and 9 g of ASC reagent grade ammonium thiocyanate to 100 mL of water.

X1.2.6 *Nitric Acid* (1+4)—Add 1 part of concentrated nitric acid (HNO_3, sp gr 1.42) to 4 parts of water by volume.

X1.2.7 *Potassium Thiocyanate Solution*—Use a 10 mass % solution.

X1.3 Copper Detection in the Presence of Nickel and Chromium

X1.3.1 Using a dropping pipet, apply 1 drop of the acetic acid mixture and 1 drop of hydrogen peroxide to the bent and cracked surface. Permit the solution to remain for about 1 to 2 min, avoiding its contact with the cut edges.

X1.3.2 Transfer the drop of reagent from the test part with a pipet to a cavity in the spot test plate. Wash the test spot with a drop of water, and add the wash solution to the liquid in the spot plate.

X1.3.3 Add 1 drop of zinc acetate solution and 1 drop of ammonium mercuric thiocyanate solution to the solution in the spot plate cavity.

X1.3.4 Gently agitate the spot plate or stir the solution. A violet colored precipitate indicates the presence of copper.

X1.4 Iron Detection in the Presence of Chromium, Nickel, or Copper

X1.4.1 Apply 1 drop of HNO_3 (1+4) to the bent surface to be tested.

X1.4.2 Allow the acid to remain in contact with the surface for about 1 min.

X1.4.3 Transfer the drop of HNO_3 with a dropping pipet to a cavity in the spot plate. At no time should the acid come in contact with the cut edges.

X1.4.4 Add 1 drop of potassium thiocyanate solution to the solution in the spot plate cavity.

X1.4.5 Gently agitate the spot or stir the solution. The appearance of a blood red color indicates iron.