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AMERICAN SOCIETY FOR TESTING AND MATERIALS
1916 Race St. Philadelphia, Pa 19103

Standard Test Method for Semi-Guided Bend Test for Ductility of Metallic Materials[1]

This standard is issued under the fixed designation E 290; 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 Department of Defense to replace method 231.1 of Federal Test Method Standard No. 151b. Consult the DoD Index of Specifications and Standards for the specific year of issue which has been adopted by the Department of Defense.

1. Scope

1.1 This test method covers a semi-guided bend test for ductility of metallic materials by bending through a specified angle and to a specified inside radius of curvature. When complete fracture does not occur, the criterion for failure is the number and size of cracks found on the tension surface of the specimen after bending.

NOTE 1—Exceptions to the provisions of these test methods may need to be made in individual specifications or test methods for a particular material.

1.2 The values stated in inch-pound units are to be regarded as the standard. SI values given in parentheses are for information only.

NOTE 2—For additional information see American Welding Society Standard D1.1, Structural Welding Code, Steel.[2]

1.3 *This standard does not purport to address all of the safety problems, 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 Document

2.1 *ASTM Standard:*

E 6 Terminology Relating to Methods of Mechanical Testing[3]

3. Summary of Test Method

3.1 The bend test is made by applying a force transversely to the specimen in the portion that is being bent, usually at the midlength. Bending forces are applied through one of three general arrangements illustrated in Figs. 1, 3, and 4. When complete fracture does not occur, the convex surface of the bent specimen is examined for cracks.

NOTE 3—For some materials and conditions of test, the results obtained by the three arrangements may not be exactly the same.

NOTE 4—A definition of the term angle of bend as used in this standard appears in Terminology E 6.

3.1.1 *Arrangement A* involves holding one end of the specimen and, by applying a force transversely near the free end as in Fig. 1, bending the specimen around a stationary pin, mandrel, or roller of specified radius until failure occurs or until the specified angle of bend has been achieved. An alternative arrangement sometimes used is indicated in Fig. 2.

3.1.2 *Arrangement B* is similar to Arrangement A except that the specimen is bent around a stationary pin or mandrel by a force applied by a mandrel or roller as in Fig. 3. (This is sometimes referred to as a "wrap-around" test but should not be confused with the "wrap-around" test for wire described in Terminology E 6.)

3.1.3 *Arrangement C* involves supporting the specimen on pins, rollers, or radius flats near each end and applying a load through a pin or mandrel midway between the two supports, as in Fig. 4. The test may be completed to failure or through the specified angle of bend as illustrated in Fig. 5.

4. Significance and Use

4.1 The semi-guided bend test is used to evaluate the quality of metals or welds as a function of ductility as evidenced by their ability to resist cracking during bending.

5. Apparatus

5.1 Various devices are suitable for each method of loading. Basically, the apparatus shall provide these features:

5.1.1 *Arrangement A*—A method of holding one end of the specimen; a reaction pin or mandrel to bear at an intermediate location, usually the midlength; and a device to apply the bending force near the free end of the specimen.

NOTE 5—Equipment for an alternative procedure is indicated in Fig. 2.

5.1.2 *Arrangement B*—A method of holding one end of the specimen; a reaction pin or mandrel; and a rotating device to apply the bending force on the opposite side of the specimen and making it conform to the pin or mandrel.

5.1.3 *Arrangement C*—A pair of pins, rollers, or radius flat supports; a pin or mandrel for applying the bending force directly at the mid-length.

NOTE 6—If this test must be finished through a 180-deg bend, the fixture indicated in Fig. 5 may be used to complete the bend.

5.2 The radius of the pin, mandrel or roller in each arrangement shall differ not more than ±2 % from the nominal value.

5.3 The length of all pins, rollers, mandrels and radius flats must exceed the width of the specimen; they must be strong enough and sufficiently rigid to resist significant deformation.

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[1] This test method is under the jurisdiction of ASTM Committee E-28 on Mechanical Testing and is the direct responsibility of Subcommittee E28.02 on Ductility and Flexure.

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[2] Available from the American Welding Society, 2501 N.W. 7th St., Miami, FL 33125.

[3] *Annual Book of ASTM Standards*, Vols 03.01 and 08.03.

6. Sampling

6.1 Sampling is performed in accordance with the requirements of relevant specifications and codes.

7. Test Specimens

7.1 Specimens shall be selected from the material to be tested, in one of the following manners:

7.1.1 *Full-Section Specimens*—Whenever practicable for materials not exceeding 1½ in. (38 mm) in the smallest cross-section dimension, the specimen shall be of the full section of the material and of sufficient length to permit bending to the angle specified.

7.1.2 *Full-Thickness Specimens*—Whenever not practicable to test full-size specimens but when still practicable to test full-thickness specimens from materials not exceeding 1½ in. in nominal thickness, the specimens shall be of the thickness of the material and the ratio of width to thickness shall be 2:1, provided that in no case shall the width be less than ¾ in. (20 mm). For steel, however, a width of 1½ in. may be used for all thicknesses. The length shall be sufficient to permit bending to the angle specified.

NOTE 7—For thin sheet, it may be impractical to use test specimens with a width-to-thickness ratio of 2:1. In this case, width-to-thickness ratio should be maintained greater than 8:1. Results from tests of thin sheet may not be compared to results from tests of plate because test specimen width-to-thickness ratio affects bend ductility.[4]

7.1.3 *Machined Specimens*—For materials exceeding ½ in. (13 mm) in nominal thickness, diameter, or distance across flats, the specimen may be machined from the material when full-section or full-thickness specimens are not used. The diameter or thickness of the specimen shall be at least ½ in., the ratio of width to thickness of rectangular specimens shall be 2:1, and the length sufficient to permit bending to the angle specified. In rectangular specimens of reduced thickness, one major surface shall be an as-fabricated surface of the section. When machined specimens must be bent around a stated axis with respect to the major dimensions of the product (see 8.1.3), the axis of bending shall be suitably marked on the specimen. When samples are taken by core drilling, a ½ by ½-in. section may be taken from the core.

7.2 *Finishing Specimen*—The longitudinal edges of a rectangular specimen may be rounded to a radius not exceeding 1/16 in. (1.5 mm) for specimens 2 in. (50 mm) and under, and not exceeding ⅛ in. (3 mm) for specimens over 2 in. in thickness. Flame-cut surfaces shall be machined to remove metal affected by the flame cutting. Sheared surfaces shall be either machined or smoothed with a belt sander, file, etc., to remove metal affected by the shearing.

7.3 *Direction of Specimens of Wrought Materials:*

7.3.1 In a longitudinal specimen its length shall be parallel to the direction of rolling, forging, drawing, or extrusion, as indicated in Fig. 6.

7.3.2 In a transverse specimen its length shall be at an angle of 90° to the direction of rolling, forging, drawing, or extrusion, as indicated in Fig. 7.

7.3.3 Unless stated otherwise the length and width of rectangular specimens shall be in the plane of the two major dimensions of the product.

7.4 *Marking*—Specimens shall be stamped or otherwise suitably identified. The identification shall be at or near the end of the specimen when practicable.

7.5 *Aging*—Unless otherwise specified, it shall be permissible to age steel bend-test specimens. The time-temperature cycle employed must be such that the effect of previous processing will not be materially changed. It may be accomplished by aging at room temperature 24 to 48 h, or in shorter time at moderately elevated temperatures by heating in boiling water, oil, or in an oven.

8. Procedure

8.1 *Direction of Test:*

8.1.1 In tests of longitudinal specimens, the axis of the bend shall be at an angle of 90° to the direction of rolling, forging, drawing, or extrusion, as shown in Fig. 6.

8.1.2 In tests of transverse specimens, the axis of the bend shall be parallel to the direction of rolling, forging, drawing, or extrusion, as shown in Fig. 7.

8.1.3 If required in tests of round specimens machined from sections other than round sections, the axis of bending shall be in the plane of the two major dimensions of the product.

8.2 In tests of reduced-thickness specimens, the tension surface shall be an as-fabricated surface of the section.

8.3 The procedure for making the test shall follow one of these general methods:

8.3.1 *Held-End Arrangements:*

8.3.1.1 Securely hold one end of the specimen so that the axis of bending lies on the centerline of the reaction pin or roller.

8.3.1.2 Bend the specimen by employing a fixture embodying the features shown in either Fig. 1 or Fig. 3.

8.3.1.3 Apply the bending load smoothly, without shock.

8.3.1.4 Continue bending until failure occurs or until the specified angle of bend is achieved.

8.3.2 *Alternative Held-End Arrangement for Thin Materials:*

8.3.2.1 Securely hold one end of specimen adjacent to bend die in a vise, as indicated in Fig. 2.

8.3.2.2 Hammer the specimen by hand over the rounded edge of the die with a mallet faced with a nonmetallic material such as rawhide, plastic, or wood. Do not strike the specimen in the area that will form part of the bend.

8.3.2.3 Continue bending until failure occurs or until the specified angle is achieved.

8.3.2.4 In case of dispute, test in accordance with 8.3.1.

8.3.3 *End Support Arrangement:*

8.3.3.1 Place the specimen over two rounded supports separated by a clearance, C, equal to $(2r + 3t) \pm t/2$ as defined in Fig. 4. Bend the specimen by applying a load through a pin or mandrel in contact with the specimen at the mid-length on the opposite side of the specimen from the end supports. Apply the bending load smoothly, without shock.

8.3.3.2 Continue bending until failure occurs or until the specified angle of bend or maximum angle for the fixture is achieved.

[4] Sangdahl, G. S., Aul, E. L., and Sachs, G., *Proceedings of the Society for Experimental Stress Analysis*, Vol 6, No. 1, p. 1, 1948; and Dieter, G. E., *Mechanical Metallurgy*, McGraw Hill, 1961, p. 560.

8.3.3.3 The test may be completed by pressing the specimen between suitable platens until the specified conditions of bend are obtained (see Fig. 5). Apply the load smoothly, without shock. Where it is desired not to exceed 180°, a spacer having a thickness twice the required bend radius may be placed between the two legs of the specimen before bending is complete.

8.4 When the bending is completed, the minimum radius throughout the angle of bend, under no load unless specified otherwise, shall not exceed the required value.

8.5 The specimen may be removed at any time during the bending for inspection of the convex surface for cracks.

8.5.1 The test is complete when significant cracks appear or when the specified conditions of bend are achieved. Cracks occurring on the corners of the bent portion shall not be considered significant unless they exceed the size specified for corner cracks.

8.5.2 In tests required by product specifications, the test may be considered completed whenever the acceptance conditions have been met.

NOTE 9—Experience has shown that the End Support Method may be a more severe test on some materials than the Held-End arrangement, for the same bend radius.

9. Evaluation

9.1 Examine the convex surface of the bent specimen for cracks or other open defects.

9.1.1 When the test is conducted as an acceptance criterion, the allowable crack size shall be specified by the code or specification requiring the test.

9.1.2 When the test is conducted for informational purposes, report the size and location of all cracks visible to the unaided eye.

10. Report

10.1 The report shall include the following:

10.1.1 Specimen identification,

10.1.2 Specimen type and size (Section 7),

10.1.3 Type of test (Section 8),

10.1.4 Radius and angle of bend, and

10.1.5 Whether specimen passed or failed to meet requirements.

11. Precision and Bias

11.1 Precision and bias statements are not made for this test method because the test result is a nonumerical report of success or failure based on criteria specified in relevant standards.

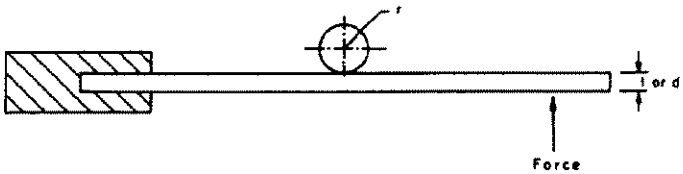


FIG. 1 Schematic Fixture for Semi-Guided Bend Test, Arrangement A—One End Held, Force Applied Near Free End

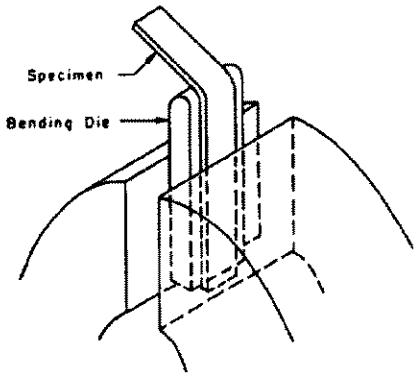


FIG. 2 Alternative Arrangement A for Semi-Guided Bend Test of Thin Specimens—One End Held

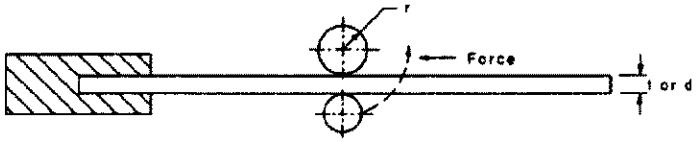


FIG. 3 Schematic Fixture for Semi-Guided Bend Test, Arrangement B—One End Held, Force Applied Near Mandrel

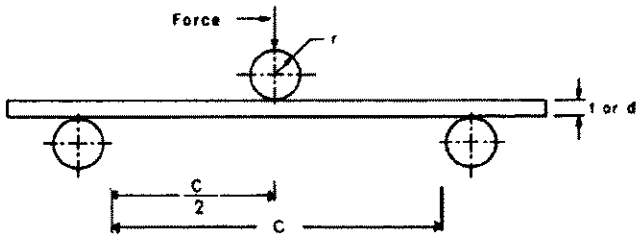


FIG. 4 Schematic Fixture for Semi-Guided Bend Test, Arrangement C—End Supported

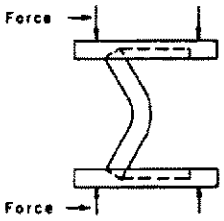
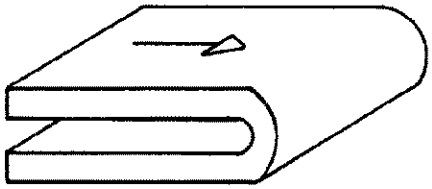
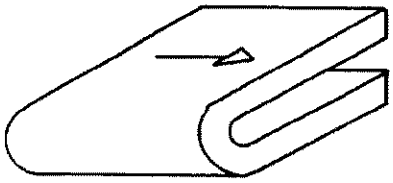


FIG. 5 Schematic Fixture for Completing Semi-Guided Bend Test Started as Shown in Fig. 4



NOTE—Arrow indicates direction of rolling.

FIG. 6 Longitudinal Bend Test



NOTE—Arrow indicates direction of rolling.

FIG. 7 Transverse Bend Test